Contents lists available at Universitas Muhammadiyah Lampung

Hipotenusa Journal of Research Mathematics Education

Journal homepage: https://journal.uml.ac.id/index.php/HT/index

Development of "petualangan matematika" learning media using scratch on probability material

Hatimah[a, 1] , S Djamilah[a,*], A G Nugroho[a]

[a] *Undergraduate Program in Mathematics Education, Faculty of Teacher Training and Education, Muhammadiyah University of Banjarmasin, South Kalimantan 70111, Indonesia*

A R T I C L E I N F O

Keywords:
Educational game;
Scratch programming;
Probability learning;
Smartphone-based learning;
Mathematics education

A B S T R A C T

Mathematics, especially the topic of probability, is often considered abstract, complicated, and boring by students, which leads to low interest in learning. This condition is exacerbated by the use of monotonous conventional teaching methods. This study aims to: (1) provide an overview of the feasibility of developing an educational game titled "Petualangan Matematika" based on smartphones using the Scratch platform for the topic of Probability, (2) explain the validity of the educational game as assessed by expert validators, and (3) describe the practicality of the smartphone-based educational game in supporting the learning process of mathematics, specifically on the topic of Probability. The research employed the Research and Development (R&D) method by adopting the ADDIE development model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The visual design of the game was created using Canva, while the development of the educational game itself was carried out using the Scratch platform. The final product is an educational game that can be accessed and played on smartphone devices. The research subjects consisted of 27 students, divided into two groups: a small group of 5 students who participated in the readability test, and a larger group of 22 students who took part in the practicality test. The instruments used to assess both validity and practicality were questionnaires utilizing a Likert scale. The data analysis techniques involved evaluating the results of the readability and practicality tests. The results of the study concluded that: (1) the product, a smartphone-based educational game titled "Petualangan Matematika" for the topic of Probability, is categorized as highly feasible for use in learning activities; (2) the validity level of the game is very high, as evidenced by expert assessments: media expert validation yielded a score of 81.25%, while two subject matter experts provided scores of 93.75% and 100%, respectively; and (3) the game demonstrated a very high level of practicality, indicated by a 92% score in the readability test conducted with the small group and a 97.125% score in the practicality test with the larger group.

1. Introduction

Rapidly advancing technological innovation has penetrated all aspects of life, particularly education. The development of Information and Communication Technology [1] has impacted various areas of life, including learning technology .

* Corresponding author.
E-mail address: soraya29.sd@gmail.com (S Djamilah).
[1] These authors contributed equally to this work.

https://doi.org/10.36269/hjrme. v9i1.3779
Received 12 November 2025; Received in revised form 09 December 2025; Accepted 20 December 2025
Available online 5 February 2025
2723-486X/Published by Universitas Muhammadiyah Lampung.

The use of technology in the learning process requires competent human resources. By equipping every individual with adequate digital skills, we not only prepare them to face future challenges, but also open up wider opportunities to actively participate in diverse aspects of life, including economic, social, and cultural aspects [2]. According to press release No. 662/HM/KOMINFO/10/2024, Indonesia's vision is to become the center of the gaming industry in Southeast Asia. The national gaming industry is showing rapid progress, with over 150 million gamers, making Indonesia one of the largest markets in the region.

Next year, Indonesia is targeted to become a center for talent and creativity development in the gaming industry [3]. Educators can take advantage of this opportunity by developing flexible and effective digital learning media via smartphones [4].

Digital transformation in education has changed the role of learning media from merely presenting information to facilitating interaction, exploration, feedback, and independent learning. In mathematics education, digital media can provide multiple representations of concepts through text, images, animation, simulation, and interactive exercises. These features are important because mathematical concepts are not always easily understood through verbal explanations and static examples alone. Technology-based learning media can therefore help teachers present abstract concepts in a more concrete, visual, and accessible form while allowing students to learn according to their own pace [2].

The use of smartphones as learning devices is increasingly relevant because students are generally familiar with mobile applications and digital entertainment. Smartphones offer portability, flexible access, touchscreen interaction, and the ability to combine different types of media within a single application. These characteristics allow learning to take place beyond the physical classroom and regular school schedule. Smartphone-based learning media can consequently function as supplementary resources through which students review materials, complete exercises, and strengthen their understanding independently. Nevertheless, the educational value of smartphones depends on the quality of the learning design, the relevance of the content, and the ease with which students can operate the developed application [4].

One of the main obstacles in learning mathematics is students' perception that mathematics is complicated and uninteresting, which causes a lack of interest and enthusiasm in learning it [5]. As a result, students tend to lose focus, are less involved, and their learning achievements decline, especially on abstract material. One of the materials that is considered difficult is the concept of probability, which requires visualization and simulation to make it easier to understand [6] To overcome this problem, the steps that need to be taken are to use media [7]. The use of technology-based media is an innovative solution to increase interest and motivation in learning mathematics [8].

Probability is one of the mathematical topics closely related to situations encountered in everyday life, including games, weather forecasting, health risks, population data, and decision-making under uncertain conditions. Learning probability is expected to help students reason about possible events, interpret uncertainty, compare outcomes, and make conclusions based on available information. Therefore, probability education is not limited to calculating numerical answers but also involves the development of logical reasoning, interpretation, and problem-solving skills.

Despite its importance, probability is frequently perceived as difficult because it involves abstract terms and relationships, such as sample spaces, events, possible outcomes, theoretical probability, experimental probability, and expected frequency. Students may be able to memorize formulas without fully understanding why a particular formula is used or how a probability value relates to an actual event. Misunderstandings can also occur when students have difficulty listing all possible outcomes, distinguishing certain and impossible events, or relating probability values to repeated experiments [5,6].

The concept of expected frequency presents an additional challenge because students must connect probability values with the number of trials performed. This process requires students not only to use formulas but also to understand the proportional relationship between the likelihood of an event and the frequency with which that event is expected to occur. Conventional explanations using textbooks and teacher demonstrations may provide limited opportunities for repeated experimentation. Consequently, students need interactive learning activities that allow them to observe different outcomes, answer contextual questions, and receive feedback regarding their reasoning.

Visualization and simulation can support probability learning by showing how random events occur and how the distribution of outcomes may change when an experiment is repeated. Through

interactive media, students can explore probability situations more actively than when they only read explanations or solve written exercises. Digital learning media can also present several forms of representation simultaneously, such as illustrations, numbers, animations, questions, and response feedback. Such representations can help students connect symbolic calculations with contextual meanings and gradually build a more comprehensive understanding of probability concepts [6].

Probability is a fundamental component of mathematics education because it develops students' ability to interpret uncertainty, evaluate possible outcomes, and make decisions based on quantitative information. Nevertheless, students frequently experience difficulties in identifying sample spaces, distinguishing between theoretical and experimental probability, and interpreting the concept of expected frequency. These difficulties may arise because random events are dynamic and cannot always be represented adequately through static explanations, formulas, or textbook examples. Therefore, learning media that enable students to observe repeated trials, compare different outcomes, and connect numerical results with probability concepts are needed to support meaningful conceptual understanding [6].

Game-based learning offers a relevant approach to addressing these challenges because it integrates learning objectives with challenges, immediate feedback, repetition, rewards, and progressive levels of difficulty. These elements can encourage students to remain actively involved in the learning process and provide opportunities to correct mistakes without creating excessive academic pressure. When designed in accordance with curriculum objectives, educational games are not merely sources of entertainment but can also function as interactive environments for concept reinforcement, problem-solving practice, and independent learning [8,9]. Consequently, the integration of game elements into probability learning may help transform abstract concepts into more concrete and engaging learning experiences.

Scratch is particularly suitable for developing such learning media because its block-based visual programming environment allows developers to integrate text, animation, sound, characters, scoring systems, and interactive feedback without requiring complex programming syntax. In probability learning, these features can be utilized to visualize random events, present contextual problems, simulate repeated experiments, and provide immediate responses to students' answers. Previous studies have demonstrated that Scratch can support interactive mathematics learning and probability instruction. However, many existing Scratch-based products remain primarily designed for computer-based use and have not fully addressed flexible access through smartphone devices [11,12].

During the School Field Practice at MTs Muhammadiyah 3 Al-Furqan, researchers observed that many students preferred learning outside the classroom. Students felt bored with conventional methods that lacked variety, leading to a tendency to lose focus during learning. Researchers also found playing games on smartphones to be their favorite activity. However, the ban on smartphone use in schools limits the use of technology-based learning media.

The restriction on smartphone use during school hours indicates that the implementation of mobile learning should consider the regulations and learning context of the school. In this situation, smartphone-based media can be positioned as a supplementary learning resource rather than as a replacement for classroom instruction. The developed game may be introduced and explained by the teacher at school, while students can access it outside school hours to review the material and complete additional exercises. This approach allows technology to extend the duration and location of learning without conflicting with school policies.

Independent learning through smartphones may also provide students with greater control over the learning process. Students can repeat materials, replay specific levels, and attempt questions several times according to their individual needs. This flexibility is particularly valuable when students have different levels of initial understanding. Students who require additional explanation can spend more time reviewing the content, whereas students who understand the material more quickly can proceed to subsequent challenges. Therefore, smartphone-based educational games have the potential to support differentiated and self-paced learning.

One approach that can accommodate these learning needs is game-based learning. Educational games combine instructional content with game components such as objectives, challenges, rules, levels, scores, rewards, characters, and immediate feedback. The combination of these components can create an environment in which students participate in learning activities while experiencing the enjoyment associated with playing a game. Game-based learning may therefore reduce monotony and encourage students to devote more attention to learning tasks [9].

Immediate feedback is an important element of educational games because it informs students

whether their answers or actions are appropriate. When students make an error, feedback can encourage them to reconsider their reasoning and attempt the problem again. Repetition in a game environment may feel less burdensome than repetition through conventional worksheets because it is integrated into challenges and progression between levels. In this way, educational games can provide opportunities for practice, error correction, and conceptual reinforcement within an engaging learning experience.

However, the inclusion of game elements does not automatically guarantee meaningful learning. An educational game should be designed by aligning the storyline, challenges, questions, feedback, and rewards with clearly defined learning objectives. Excessive visual or entertainment features may distract students when they are not directly connected to the material. Therefore, the development of an educational game requires a balance between attractiveness, ease of use, technical functionality, and the accuracy of the instructional content. In the present study, game components were designed to support students' engagement with probability and expected-frequency problems rather than functioning solely as entertainment.

From a pedagogical perspective, restrictions on smartphone use during regular classroom activities do not necessarily eliminate the potential value of mobile learning. Instead, such restrictions shift the role of smartphone-based educational games toward supplementary learning outside formal classroom hours. Students can use the developed media to review learning materials, practice probability problems, and receive immediate feedback independently at home. Thus, the smartphone-based format in this study is not intended to replace teacher-led instruction but to extend learning opportunities beyond the classroom and provide students with more flexible access to mathematics learning resources [4,8].

Despite the ban on smartphone use in schools, the potential for integrating educational games remains open. This game is designed to help eighth-grade MTs students understand the concept of probability interactively, with examples and a variety of practice questions available outside of school hours. Educational games are an interesting learning medium because they combine elements of play and learning to create an interactive and fun learning experience [9]. Researchers used the Scratch platform because it supports visual and interactive design according to learning needs. The creation of the "Mathematical Adventure" game was based on three reasons: (1) the material on probability requires a contextual and visual approach, (2) this media takes advantage of students' interest in smartphones, and (3) the challenge elements in the game are designed to increase motivation to learn mathematics.

Scratch was selected as the development platform because it provides a visual block-based programming environment that enables the creation of interactive digital products without requiring complicated programming syntax. Through Scratch, developers can organize the movement of characters, display learning materials, create navigation systems, provide scores, arrange questions, and generate feedback based on students' responses. Its visual programming structure also allows each command to be examined and revised more easily during the development and evaluation process.

In mathematics education, Scratch can facilitate learning activities that involve visualization, sequencing, logical reasoning, and interaction. The platform allows mathematical content to be embedded within stories, simulations, animations, and problem-solving activities. For probability material, these capabilities can be used to present possible events, contextual questions, repeated challenges, and expected-frequency calculations in a more dynamic form. Students are not only presented with formulas but are also guided through situations in which probability concepts are applied.

Previous studies have demonstrated the potential of Scratch for developing interactive mathematics learning media [11,12]. Nevertheless, the practical implementation of Scratch-based products may differ according to the topic, device, student characteristics, and design of the learning activities. Some products are developed primarily for computers and require access to school laboratories, which may limit their use outside formal learning sessions. Developing a Scratch-based game that can be accessed through smartphones can therefore expand the flexibility of its use and provide students with additional opportunities to learn independently.

Furthermore, many educational media development studies emphasize expert validity but provide limited evidence concerning how students perceive the readability and practicality of the final product. A technically functional application may still be difficult to use when its instructions, navigation, text, or learning sequence are unclear. Therefore, student involvement through readability and practicality testing is necessary to determine whether the developed media can be understood and operated by its intended users. This consideration underlies the inclusion of small-group and larger-

group trials in the present study.

Based on these considerations, there is a need for educational media that combines relevant probability content, an engaging game structure, smartphone accessibility, clear instructions, and interactive feedback. The development of "Mathematical Adventure" was intended to address this need by presenting probability and expected-frequency materials through an adventure-based educational game created with Scratch. The product was developed systematically using the ADDIE model and evaluated in terms of expert validity, student readability, and practicality.

The novelty of this research compared to research [10], which developed an Android-based educational game with Construct 2, lies in three things: the use of the beginner-friendly Scratch platform, the design of the "Math Adventure" game with story elements to increase motivation, and its design specifically for access via smartphone. Research [11] also emphasizes the potential of Scratch as an interactive learning medium, but is still limited to the topic of quadratic equations and has not yet targeted the material on probability or its use on smartphone devices. Meanwhile, research [12] proves the feasibility of Scratch in probability learning with a high level of validity, but its accessibility still depends on computers in schools. Departing from the limitations of these studies, this research is present with a focus on probability material which is often considered difficult, presented interactively to make it easier to understand, and can be accessed via smartphone to support fun independent learning at home. Thus, the title of this research is: Development of Smartphone-Based Educational Game Learning Media "Mathematical Adventure" Using the Scratch Platform on Probability Material.

2.Method

2.1. Research design

This study employed a Research and Development (R&D) method using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The objective of the study was to develop a smartphone-based educational game, *Mathematical Adventure*, and to examine its validity and practicality in mathematics learning, particularly on probability and expected frequency topics.

2.2.Research Setting and Participants

The research was conducted at MTs Muhammadiyah 3 Al-Furqan, located at Jalan Cemara Ujung, North Banjarmasin, Banjarmasin City, South Kalimantan, from January to May 2025.

The participants consisted of students and expert validators. Student participants were divided into two groups:

1. Small-scale trial: 5 students from class IX B (for readability testing).
2. Large-scale trial: 22 students from class VIII C (for practicality testing).

Expert validators included:

1. One media expert, who assessed media design and technical aspects.
2. Two material experts, who assessed the relevance and quality of the learning content.

2.3.Development Procedure (ADDIE Stages)

The development process followed the ADDIE stages as described below:

1. Analysis
   A needs analysis was conducted with 22 students to identify preferences for educational game features, including theme, feedback, level options, visual design, and technical accessibility (online/offline access, file size, and touchscreen control).
2. Design
   At this stage, the game concept, storyboard, interface layout, and learning flow were designed. Visual assets such as menus, characters, backgrounds, navigation buttons, and score icons were created using Canva.
3. Development
   All designed assets were exported from Canva and integrated into Scratch as sprites and backdrops. Visual block coding was then developed to enable interactivity, navigation, and gameplay flow according to the storyboard. The product was subsequently validated by one media expert and two material experts.
4. Implementation
   The media was tested in two stages: (a) a small-scale readability test involving 5 students, and (b) a large-scale practicality test involving 22 students to assess usability and learning support.
5. Evaluation
   Formative evaluation was conducted throughout all stages. Revisions were made based on expert suggestions and student responses to improve language clarity, learning flow, media presentation, and technical functionality.

2.4.Instruments and Data Collection

The data collection instruments used were validation and practicality sheets [13] ,the instruments were arranged using a 4-point Likert Scale (SA=4, A=3, D=2, SD=1). The media assessment aspects included content quality, evaluation/exercises, language, and storyboard, while the material aspects included display, language, material presentation, and textbook suitability. Data were analyzed using descriptive quantitative analysis by converting

scores into percentages using the formula:

The assessed aspects included:

- Media validation: content quality, evaluation/exercises, language, and storyboard clarity.
- Material validation: display, language, material presentation, and textbook suitability.
- Student response (practicality/readability): clarity of instructions, readability, ease of use, attractiveness, and contribution to concept understanding.

2.5.Data Analysis

Data were analyzed using descriptive quantitative analysis by converting scores into percentages with the formula

$$P = \frac{\sum X}{N} \times 100\%$$

Information :
$P = Validity\ percentage$
$\sum X = Total\ score\ obtained$
$N = Expected\ maximum\ score$ [14]

The percentage results were interpreted using the following criteria Table 1:

Table 1
Test Criteria

Criteria	Category	Information
75%<P≤100%	Very Valid/Practical	Development continues
50%<P≤75%	Valid/ Practical	Small scale revision
25%<P≤50%	Less Valid/ Practical	Repair
0%≤P≤25%	Invalid/ Impractical	Repair

3.Results and discussion

3.1. Analysis Stage

Based on a needs analysis of 22 students from class VIII C, all students showed a high interest in educational media in the form of adventure-themed educational games. The students liked games that had interesting themes, immediate feedback, difficulty level options, material repetition features, attractive visual displays, and interactive animations. This indicates a need for media that is enjoyable, adaptive, and contextual to strengthen their understanding of concepts [15]

From a technical perspective, most students have Android-based devices and want games that can be accessed both offline and online, are small in size, and are easy to control via a touchscreen [16]. They also hope for a variety of questions and a discussion feature. Therefore, the development of educational games needs to consider content diversity, material relevance, attractive visuals, as well as ease of access and use, so that the resulting media provides an optimal learning experience [17].

The findings of the needs analysis also indicate that the development of the educational game was based on the characteristics and actual preferences of its intended users rather than solely on the researchers' assumptions. Students' preference for adventure themes, interactive animations, immediate feedback, and different levels of difficulty suggests that learning media should combine pedagogical content with game elements that sustain attention and encourage active participation. Immediate feedback is particularly important in probability learning because it allows students to identify errors, reconsider their reasoning, and strengthen their understanding through repeated practice. Therefore, the needs-analysis results became an important foundation for determining the game structure, visual design, navigation system, and types of learning activities included in "Mathematical Adventure."

The students' preference for media that can be accessed through Android-based devices also reflects the importance of technological accessibility in the development of digital learning resources. A learning medium may contain appropriate materials and attractive visual elements, but its educational value can be reduced when students experience difficulties accessing or operating it. For this reason, considerations such as file size, touchscreen compatibility, simple navigation, and offline accessibility were incorporated into the product design. These features are expected to support more flexible learning, particularly when students use the game independently outside regular classroom hours.

The correspondence between the findings of the needs analysis and the features incorporated into the final product demonstrates the application of a user-centered development approach. Students' preferences for an adventure theme, immediate feedback, interactive animation, repeated practice, and multiple difficulty levels were translated into specific design decisions within the game. This alignment is important because educational media are more likely to be accepted when their presentation and operation correspond to the characteristics of their intended users. At the same time, the inclusion of student preferences should remain subordinate to the learning objectives so that the game does not become visually attractive but pedagogically superficial.

The adventure theme was selected not only to attract students' attention but also to provide a structured sequence for presenting the learning activities. Each stage of an adventure can represent progress from introductory concepts to more complex probability and expected-frequency problems. Such sequencing may help students perceive learning as a gradual process rather than as

a collection of unrelated questions. The use of levels may also provide a sense of progress and achievement, which can encourage students to complete subsequent tasks. Nevertheless, the difficulty of each level should be calibrated carefully so that students experience appropriate challenges without becoming frustrated or completing the activities without meaningful cognitive engagement.

The students' preference for immediate feedback is particularly relevant to the characteristics of probability learning. Students may arrive at incorrect answers because they misunderstand the sample space, omit possible outcomes, or apply formulas without interpreting the problem context. Immediate feedback can alert students to these errors before misconceptions are reinforced through repeated practice. However, feedback should ideally explain why an answer is correct or incorrect instead of merely displaying a score. Explanatory feedback can direct students to reconsider their reasoning and connect the numerical answer with the underlying probability concept.

The need for both online and offline access also reflects the diversity of students' technological conditions. Offline functionality allows the game to be used without continuous internet connectivity and can reduce potential interruptions during independent learning. This feature is particularly relevant when the product is intended for use outside classroom hours. Nevertheless, future implementation should examine whether the application performs consistently across different smartphone specifications, screen sizes, storage capacities, and operating-system versions. Technical accessibility should therefore be evaluated as an ongoing component of product quality rather than as a feature confirmed only during the initial trial.

The needs-analysis findings further suggest that students expect educational media to combine attractiveness with usability. Attractive visuals may encourage initial engagement, but clear navigation and relevant learning content determine whether students can continue using the application effectively. Therefore, the development process required a balance between visual complexity and functional simplicity. Excessive animation, text, or decorative elements could increase cognitive demands and distract students from the mathematical content, especially when the game is displayed on a relatively small smartphone screen.

3.2.Design Stage

This design phase utilized the Canva application intensively for creating visual assets, with the support of the premium version to gain full access to all elements and icons without limitations, and to avoid the presence of watermarks on the design results [18].

This tool was chosen because of its ease of use and the completeness of its graphic elements that can be tailored to learning needs. The following are the steps that have been carried out:

a) Accessing and installing the desktop version of the Canva application, then creating an account via email.
b) Designing the main screen display, game menu, main character, background objects, and other supporting elements such as navigation buttons and score icons.
c) Using the templates available in Canva as a design basis, which were then modified to fit the adventure theme by using elements, icons, shapes, and illustrations to enrich the visual design.

An example of the visual design results, specifically the opening page with the game title and a "start" button, can be seen in the following Fig. 1.

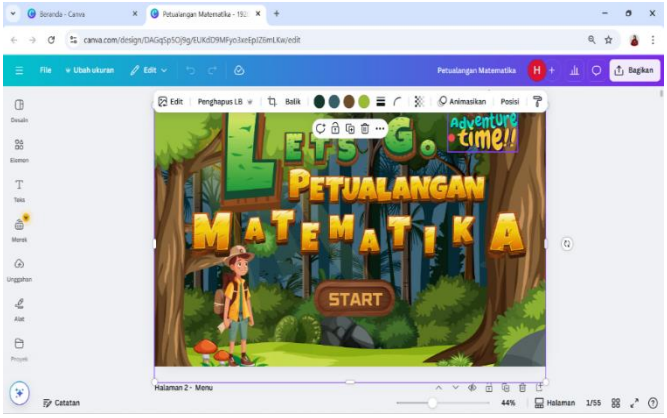


Fig. 1. Design View in Canva.

3.4 Development Stage

The development stage was carried out in several steps as follows:

a) All assets (character images, navigation buttons, backgrounds) that were designed in Canva were exported and uploaded into Scratch.
b) The assets were imported as sprites or backdrops and named according to their function to make it easier to manage the code (for example, the learning outcome button was named LO, etc.).The uploaded sprites and backdrops can be seen in the Fig. 2.
c) The game's flow was developed according to the designed storyboard.
d) To make the navigation buttons move, it was necessary to add programming for interaction by inserting visual blocks in Scratch.
e) The visual programming blocks can be seen in the following Fig. 3.
f) Media Expert to assess the design, technical, and interactivity aspects of the media.
g) Material Expert to assess the suitability of the content with the curriculum and the students' level

of understanding.

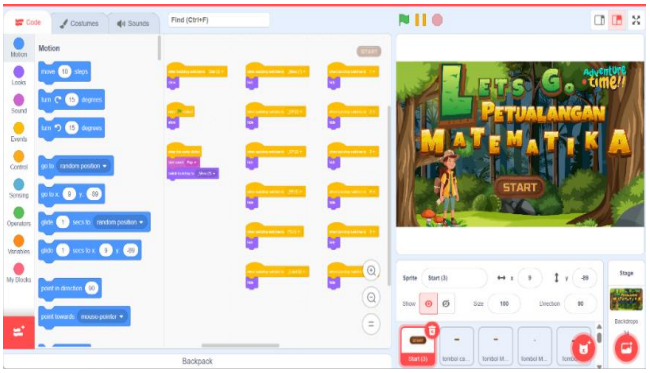


Fig. 2. Development Process View

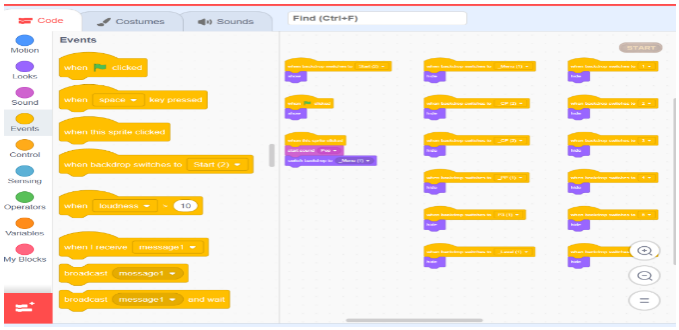


Fig. 3. Visual Scratch Programming Blocks View

The validation process was conducted using an assessment instrument that was prepared based on guidelines for developing interactive learning media. The validated product was then ready to be tested in the field. The integration of Canva and Scratch provided complementary functions during the development process. Canva was used to create consistent and visually attractive graphic assets, whereas Scratch was used to organize the interaction between characters, learning materials, questions, scores, and navigation buttons. This combination enabled the researchers to transform the storyboard into an operational educational game without relying on complex text-based programming. The use of visual block programming also facilitated revisions because individual commands and interactions could be identified and modified directly during formative evaluation.

From an instructional perspective, the visual and interactive design of the game was intended to reduce the abstract nature of probability material. The adventure storyline, animated characters, sequential levels, and practice questions provided a contextual framework through which students could engage with probability concepts. Nevertheless, the visual attractiveness of the media was not treated as an independent objective. Each visual and interactive element was designed to support the presentation of materials, guide students through the learning sequence, and provide feedback on their responses. Thus, the development process sought to maintain a balance between entertainment elements and the intended mathematics learning outcomes.

3.5 Implementation Stage

Implementation was carried out on a small scale as an initial step before a wider trial. The main focus of this stage was a legibility test, covering the game instructions, language, text, and the flow of both the learning and the gameplay. Five students who had already studied the probability material were involved as respondents. The results from this stage became the basis for assessing the feasibility of using the game or determining the need for improvements based on the feedback from the initial users [19].

3.6 Evaluation Stage

The evaluation and revision phase was conducted at every stage of development to ensure the educational game ran optimally up to the validation stage. The evaluation performed was a formative evaluation, carried out progressively from the needs analysis and design to the implementation phase [20]. The assessment covered the game's design and the selection of elements such as videos, audio, materials, quizzes, and game levels, involving material experts, media experts, and a small-group legibility test. During the implementation phase, student responses were used as the basis for improvements [21].

The formative evaluation conducted throughout the ADDIE stages enabled the product to be improved progressively rather than only after the development process had been completed. Feedback obtained during the analysis stage influenced the selection of the adventure theme, touchscreen controls, feedback mechanisms, and accessibility options. During the design and development stages, the evaluation focused on the consistency of the storyline, the clarity of navigation, the suitability of visual elements, and the relationship between the game activities and the intended probability-learning objectives. This iterative process helped ensure that technical improvements remained connected to the pedagogical purpose of the educational game.

The results also demonstrate the importance of maintaining alignment among learning objectives, instructional content, game activities, and assessment questions. In “Mathematical Adventure,” the storyline and game levels were not designed as separate decorative elements but as structures that guided students through the material and practice activities. The questions, feedback, and scoring system were incorporated into the gameplay to encourage students to engage continuously with probability and expected-frequency concepts. This alignment is important because educational games may lose their instructional function when entertainment components dominate the intended learning activities.

The availability of the game in an offline format is another relevant outcome of the development process. Offline accessibility may reduce students’ dependence on continuous internet connections and allow the product to be used in learning environments with varying levels of

digital infrastructure. It also supports more flexible use outside school hours, particularly because smartphone use is restricted during regular learning activities at the research site. However, offline accessibility alone does not guarantee successful implementation. Device compatibility, storage capacity, operating-system differences, and students' ability to install and operate the application should also be considered in future product testing.

From a development perspective, the use of Canva and Scratch provided an accessible combination for producing visual and interactive learning media. Canva facilitated the preparation of consistent graphic assets, while Scratch enabled the researchers to organize navigation, animation, scoring, feedback, and question sequences through block-based programming. This development process indicates that teachers and educational researchers with limited experience in conventional programming may still be able to produce interactive learning resources. Nevertheless, sufficient attention must be given to instructional design so that the ease of using the development platform does not reduce the accuracy, coherence, or depth of the mathematical content.

At this stage, the educational game "Mathematical Adventure" for smartphones can be accessed offline. It can be downloaded via the QR code in the following Fig. 4. Data description of the answers to the product validity problem formulation.

The validation results from the **media expert** show that the smartphone-based educational game "Mathematical Adventure" received a feasibility percentage of **81.25%**, placing it in the **"Very Valid"** category and making it suitable for use as a learning medium. The assessment covered four main indicators: the suitability of the content with the curriculum for 8th-grade MTs students, the completeness of the evaluations and their discussions, the use of proper and correct Indonesian language, and the ease of understanding the storyboard. All indicators received high scores, indicating that the media substantially and technically meets quality standards [22].

Table 1
Validity Test Results

No	Indicator	Score
1.	The smartphone-based educational game learning media "Mathematical Adventure" has content quality that is appropriate for MTs grade VIII material.	3
2.	The smartphone-based educational game learning media "Mathematical Adventure" has complete evaluation/practice with discussion.	4
3.	The smartphone-based educational game learning media "Mathematical Adventure" uses good and correct Indonesian.	3
4.	*The storyboard of the smartphone-based educational game learning media "Mathematical Adventure" is easy to understand.*	3
	Total	13
	Percentage	81,25%
	Category	Very Valid

Next, the assessment of the learning media by Material Expert 1 shows that the product received a feasibility score of 93.75%. This percentage falls into the "Very Valid" category, which means the media has met this quality exceptionally well and is suitable for use in the learning process. The high scores on every indicator show that the material content within the media has been accurately and communicatively structured, and is relevant to the needs of the students.



Fig 4. Math Adventure App QR Code

The assessment of the "Mathematical Adventure" educational game by Material Expert 2 showed very satisfying results, with a score of 100%, which falls into the "Very Valid" category. This result indicates that the media has met all aspects of material feasibility exceptionally well. All indicators received the maximum score, signifying that the content is highly suitable and appropriate for use in mathematics learning.

Table 2
Research results of material expert I

No	Indicator	Score
1.	The material and questions for the smartphone-based educational game learning media "Mathematical Adventure" are presented clearly.	4
2.	The smartphone-based educational game learning media "Mathematical Adventure" uses good and correct Indonesian.	3
3.	The smartphone-based educational game learning media	4

	"Mathematical Adventure" presents the material appropriately.	
4.	The outline of the learning media material for the smartphone-based educational game "Mathematical Adventure" has been presented and is in accordance with the textbook.	4
	Total	15
	Percentage	93,75%
	Category	Very Valid

When the assessments of the three validators are considered collectively, the findings demonstrate that the developed media fulfilled both technical and instructional feasibility criteria. The media expert score of 81.25% indicates that the product was already highly valid, although some aspects, particularly language accuracy, content presentation, and storyboard clarity, could still be refined. Meanwhile, the material expert scores of 93.75% and 100% indicate strong agreement regarding the clarity, relevance, and curriculum suitability of the probability content. The difference between the media expert score and the material expert scores suggests that further development should focus primarily on improving presentation and technical communication rather than substantially revising the mathematical content.

Table 3
Assessment from material experts 2

No	Indicator	Score
1.	The material and questions for the smartphone-based educational game learning media "Mathematical Adventure" are presented clearly.	4
2.	The smartphone-based educational game learning media "Mathematical Adventure" uses good and correct Indonesian.	4
3.	The smartphone-based educational game learning media "Mathematical Adventure" presents the material appropriately.	4
4.	The outline of the learning media material for the smartphone-based educational game "Mathematical Adventure" has been presented and is in accordance with the textbook.	4
	Total	16
	percentage	100%
	Category	Very Valid

Expert validation is an essential stage in educational media development because a product should not be tested with students before its content and technical components have been examined. The high validation results suggest that "Mathematical Adventure" contains appropriate probability materials, understandable language, relevant exercises, and a logical learning sequence. These findings are consistent with previous studies reporting that Scratch can be used to develop valid interactive mathematics learning media [11,12]. However, the present study extends those findings by adapting the Scratch-based product for smartphone access and by incorporating an adventure-based storyline specifically for probability and expected-frequency material.

The three validation results provide complementary evidence regarding the feasibility of the developed product. The media expert focused primarily on technical presentation, language, content organization, and storyboard clarity, whereas the two material experts assessed the accuracy, relevance, presentation, and curriculum suitability of the probability content. The scores of 81.25%, 93.75%, and 100% demonstrate that all validators categorized the product as very valid, although their assessments differed in magnitude. This difference is reasonable because each validator examined the product from a different area of expertise.

The comparatively lower score provided by the media expert indicates that the technical and communicative dimensions of the product offered more room for refinement than its mathematical content. In particular, the scores presented in Table 2 suggest that content quality, language use, and storyboard clarity did not receive the maximum value. These aspects are important because students' interaction with digital learning media depends not only on the correctness of the material but also on whether the instructions, navigation, and sequence of activities can be understood easily. Minor improvements in wording, visual consistency, and transitions between game sections may therefore further strengthen the overall quality of the product.

In contrast, the high scores from the material experts indicate strong agreement that the content and exercises were appropriate for Grade VIII students and consistent with the relevant mathematics materials. The result from Material Expert 1, however, shows that language remained an aspect requiring minor improvement. The difference between the language assessments of the two material experts suggests that language clarity may be interpreted differently depending on the validator's expectations and experience. Therefore, the final revision should not rely only on the numerical average but should also consider the specific qualitative comments provided by each validator.

The convergence of the validation results supports the conclusion that the product was sufficiently feasible to proceed to student testing. Expert validation reduced the possibility that students would encounter substantial conceptual errors, inappropriate questions, or major technical obstacles during the trials. It also provided evidence that the educational game had achieved an acceptable balance among content accuracy, visual presentation, interaction, and curriculum relevance.

These findings are consistent with previous research demonstrating that Scratch can be used to produce valid interactive mathematics learning media [11,12]. The present product, however, adds an adventure-based structure and smartphone-oriented access to support learning outside conventional computer laboratories. This distinction is important because the usability of

digital media is influenced not only by its content but also by the device through which students access it. By adapting the game for smartphone use, the study attempts to expand the flexibility and potential reach of Scratch-based probability learning.

The differences among the three validation scores should be interpreted according to the aspects evaluated by each expert rather than combined into a single average. The media expert evaluated technical presentation, language, content organization, and storyboard clarity, whereas the material experts focused more strongly on mathematical accuracy, curriculum relevance, and the suitability of the exercises. Therefore, the score of 81.25% from the media expert does not necessarily contradict the scores of 93.75% and 100% from the material experts. Instead, it indicates that the mathematical content was evaluated more positively than several aspects of media presentation.

The pattern of scores provides useful information for determining revision priorities. The non-maximum scores for language, content presentation, and storyboard clarity indicate that improvements were still possible even though the product had entered the "very valid" category. For example, lengthy instructions could be simplified, navigation labels could be made more consistent, and transitions between the storyline, learning material, and practice questions could be clarified. These revisions are important because technically minor weaknesses may influence how independently students can use the game.

The maximum score provided by Material Expert 2 indicates that the validator considered the material, questions, language, presentation, and consistency with the textbook to be fully appropriate. However, a perfect validation score should be interpreted cautiously. It represents the judgment of one expert based on the assessment instrument used and should not be understood as evidence that the content cannot be improved further. Validation remains a formative process, and additional review by other mathematics educators may identify different strengths or limitations.

The use of only three validators also needs to be considered when interpreting the findings. Their assessments provide important evidence of initial feasibility, but they may not represent the full range of perspectives among mathematics teachers, instructional-media specialists, curriculum experts, and educational-technology practitioners. Future product development may involve a larger and more diverse panel of experts. Inter-rater agreement could also be examined to determine the consistency of expert judgments across different assessment dimensions.

Another methodological consideration is that percentage categories may conceal variations among individual indicators. Two products may obtain similar overall percentages while having different strengths and weaknesses. For this reason, the interpretation of validation results should consider both the total score and the score for each indicator. In the present study, indicator-level analysis revealed that language and storyboard clarity required more attention than the mathematical suitability of the material. This information is more useful for product revision than the overall category alone.

The expert-validation results also demonstrate that media quality and content quality are interdependent. Accurate probability material may not be learned effectively when instructions, visual organization, or navigation are unclear. Conversely, an attractive and technically functional game cannot be considered educationally appropriate when its mathematical content contains errors or is inconsistent with the curriculum. The high assessments from both media and material experts indicate that "Mathematical Adventure" achieved an acceptable integration of these two dimensions.

These findings reinforce previous research showing that Scratch can support the development of valid interactive mathematics media [11,12]. However, the current study differs by combining probability and expected-frequency content with an adventure-based structure and smartphone-oriented access. The contribution of the product therefore lies not merely in using Scratch as a development tool but in adapting its visual programming functions to the learning characteristics, technological conditions, and independent-learning needs of the students.

3.7 Results of Small Group Test (Readability) and Large Group Test (Practicality)

The legibility test results for the educational game "Mathematical Adventure," involving 5 students, showed an average score of 92%, falling into the "very practical" category. The assessment was based on five aspects: understanding instructions, clarity of language, narrative, text readability, and learning flow. The highest score (95%) was obtained in the aspects of language clarity, text, and flow, indicating that students could follow the game's content well. The lowest score (85%) was in the narrative aspect, which still needs minor improvements. Overall, the media has met the legibility criteria very well.

Table 4
Readability Test Results

No	Aspect	Score 5 Students
1.	I can understand the game instructions easily.	90%
2.	The language used in the game is easy to understand.	95%
3.	The in-game instructions or narrative are not confusing.	85%
4.	The text displayed is easy to read (font size, color, etc.).	95%
5.	I can understand the learning flow in the game clearly.	95%
	Average	92%
	Category	Very Practical

The readability score of 92% indicates that students

were generally able to understand the instructions, language, text display, and learning flow presented in the game. This result is important because readability in digital learning media involves more than the linguistic simplicity of the materials. It also includes the visibility of text, consistency of navigation, clarity of commands, and students' ability to understand the relationship between the storyline and the learning activities. When these components are clear, students can focus more effectively on solving probability problems rather than spending excessive cognitive effort understanding how to operate the application.

Table 5
Results of practicality test

No	Indicator	Big Score 22 Students
1.	The smartphone-based educational game learning media "Mathematical Adventure" has an attractive appearance.	100%
2.	The smartphone-based educational game learning media "Mathematical Adventure" is easy to play.	98,8%
3.	The smartphone-based educational game learning media "Mathematical Adventure" makes learning varied and fun.	94,3%
4.	The smartphone-based educational game learning media "Mathematical Adventure" helps students understand the material on probability and expected frequency.	95,4%
	Average	97,125%
	Category	Very Practical

Although the overall readability result was categorized as very practical, the narrative indicator received the lowest score of 85%. This finding suggests that some parts of the storyline or game instructions may still require minor improvement. The narrative should be concise, directly connected to the learning objectives, and presented in language appropriate to the students' level. Consequently, revisions to the narrative may include shortening lengthy instructions, using more familiar vocabulary, and separating procedural directions from mathematical explanations. Such revisions could further improve students' ability to follow the game independently.

The results of the readability and practicality tests complement the expert-validation findings by providing evidence from the perspective of the intended users. Expert assessments can determine whether the media is technically and academically appropriate, but students' responses are necessary to identify whether the product is understandable, attractive, and manageable in actual use. The readability score of 92% and practicality score of 97.125% therefore indicate that the product was positively evaluated both by experts and by students.

The readability results show that the clarity of language, text visibility, game instructions, and learning sequence was generally strong. Three indicators—language clarity, text readability, and learning-flow clarity—received scores of 95%. These results suggest that the students could understand most of the information presented and follow the progression of the game with limited difficulty. Clear navigation and readable text are particularly important in smartphone-based learning because the smaller screen size may create additional challenges in presenting instructions and mathematical symbols.

The lowest readability score was recorded for the clarity of the in-game narrative, at 85%. Although this score remains within the very practical category, it reveals a specific area that should receive attention. Some students may have experienced difficulty distinguishing narrative information from instructions or mathematical explanations. The storyline may therefore be improved by reducing unnecessary text, dividing longer instructions into shorter steps, and using consistent visual markers to differentiate dialogue, directions, learning content, and feedback. Improving this aspect may help students concentrate more effectively on the mathematical tasks.

The practicality-test results demonstrate that visual appearance was the strongest component of the product, receiving a score of 100%. This result indicates that the characters, backgrounds, menus, icons, and overall adventure theme successfully attracted students' attention. Visual attractiveness may support initial engagement, but it should remain connected to the learning purpose. In this game, visual elements can function as cues that guide navigation, indicate changes between levels, and distinguish learning materials from exercises.

Ease of use received a score of 98.8%, showing that most students could operate the game and understand its controls without substantial assistance. This finding is particularly relevant for independent learning because a supplementary application should not require continuous teacher guidance. Simple navigation, touchscreen-compatible controls, and clearly labeled buttons may have contributed to this positive assessment. However, the study did not report detailed information about operating-system versions, screen sizes, installation problems, or device performance. Future trials should therefore include a technical-compatibility analysis across a broader range of smartphones.

The indicator concerning varied and enjoyable learning obtained a score of 94.3%, which was the lowest among the four practicality indicators. Although this score is still very high, the difference suggests that visual attractiveness and ease of use were evaluated slightly more positively than the enjoyment and variety of the learning experience. This may indicate a need for a wider range of question formats, challenges, feedback messages, or difficulty levels. Repetition of similar

activities may reduce students' interest when the game is used over a longer period. Future development could incorporate randomized questions, branching challenges, additional levels, achievement badges, or different forms of probability experiments to maintain engagement.

The score of 95.4% for support of probability and expected-frequency understanding indicates that students perceived the game as helpful for learning the material. The interactive exercises and immediate feedback may have allowed students to connect probability calculations with the situations presented in the game. Nevertheless, this finding represents students' perceptions rather than an objective measurement of conceptual improvement. Students may feel that a game is helpful or enjoyable even when changes in learning achievement have not been measured directly.

Taken together, the results indicate that the product satisfied three important development criteria: validity, readability, and practicality. The expert-validation scores demonstrate that the game was appropriate in terms of content and media design; the readability test indicates that students could understand its instructions and presentation; and the practicality test shows that students found it attractive, easy to use, and supportive of learning. The consistency among these results strengthens the argument that "Mathematical Adventure" is suitable as a supplementary learning medium.

The findings also have practical implications for mathematics teachers. The game may be used to introduce probability contexts, provide additional practice, support homework activities, or facilitate independent review outside the classroom. Teachers can use students' experiences in the game as a starting point for classroom discussions about sample spaces, probability values, experimental outcomes, and expected frequency. However, the game should complement rather than replace teacher explanations, collaborative discussion, and structured mathematical reasoning.

Several limitations should be considered when interpreting these findings. First, the student trials involved only 27 participants from one school, consisting of five students in the small-group test and 22 students in the larger-group test. The findings may therefore reflect the characteristics, technological familiarity, and learning environment of this particular group. Second, the study relied primarily on questionnaire-based responses, which may be influenced by students' enthusiasm for new technology or their desire to provide positive responses. Third, the study did not report observational data, interviews, gameplay records, completion times, or error patterns that could provide deeper information about students' actual interactions with the media.

Most importantly, the study did not conduct an effectiveness test. No pretest, posttest, control group, or inferential statistical analysis was used to determine whether the game improved students' probability achievement. Consequently, the findings should not be interpreted as evidence of causal improvement in learning outcomes. They demonstrate that the game is feasible and positively received, but its educational effectiveness remains an open question.

Future research should involve larger and more diverse samples, including students from different schools, achievement levels, and technological backgrounds. An experimental or quasi-experimental design could compare students who use "Mathematical Adventure" with those who receive conventional instruction or use alternative digital media. Future studies should also examine learning motivation, conceptual understanding, retention, cognitive load, and students' patterns of interaction with the game. Collecting log data, such as the number of attempts, time spent at each level, and frequently incorrect responses, could provide valuable evidence for improving both the game design and the instructional content.

4. Conclusion

Based on the research and development findings, it can be concluded that the smartphone-based educational game, "Mathematical Adventure," built on the Scratch platform for the topic of probability, is suitable for use, as demonstrated through the ADDIE model of development, which included a needs analysis, the design of the storyline and visual assets using Canva, product development with Scratch, implementation through small- and large-group trials, and evaluation at every stage. The media's validity was rated as "very valid" by experts, with scores of 81.25% from the media expert, 93.75% from material expert 1, and 100% from material expert 2, confirming its suitability in terms of content quality, material relevance, presentation, and language. Additionally, the legibility test with an average score of 92% and the practicality test with an average of 97.125% show that the game is highly practical, easy to use, visually appealing, and capable of making learning more varied and enjoyable for students, although a limitation of this study is the lack of an effectiveness test, which future research is advised to address by directly evaluating the game's impact on student learning outcomes.

These findings indicate that the "Mathematical Adventure" educational game has the potential to serve as a supplementary learning medium for probability and expected-frequency topics. Its smartphone-based format provides students with flexible access to learning materials and practice activities outside regular classroom hours, while its adventure storyline, visual elements, interactive exercises, and immediate feedback contribute to a more engaging learning experience. The positive responses from experts and students also demonstrate that the integration of Scratch and Canva can support the development of accessible, attractive, and curriculum-relevant mathematics learning media.

However, the conclusions of this study are limited to the validity, readability, and practicality of the developed product. The study did not directly

measure changes in students' conceptual understanding, learning achievement, motivation, or long-term retention. Furthermore, the trial involved a relatively small number of participants from a single school. Future research should therefore evaluate the effectiveness of the game using larger and more diverse samples, pretest–posttest measurements, and experimental or quasi-experimental designs. Further development may also include additional probability topics, adaptive difficulty levels, learning-progress records, and improved offline functionality to strengthen the game's usefulness for independent and classroom-supported mathematics learning.

Overall, this study contributes to the development of digital mathematics learning media by demonstrating how visual programming, game-based learning, and mobile accessibility can be integrated into a single educational product. The use of the ADDIE model ensured that the development of "Mathematical Adventure" was based on students' needs, systematically designed, validated by experts, and evaluated by its intended users. The consistently high results across the validation, readability, and practicality assessments indicate that the product achieved an appropriate balance among mathematical content, visual presentation, technical operation, and user experience.

The findings also show that student involvement is essential in the development of educational technology. Expert validation confirmed the accuracy and appropriateness of the content, whereas student testing revealed how the game was perceived in terms of clarity, attractiveness, ease of use, and learning support. The combination of these perspectives provided a more comprehensive evaluation of the product than relying exclusively on expert judgment. In particular, the lower score for narrative clarity compared with the other readability indicators demonstrates that even a highly rated product may still contain specific components that require further refinement.

From a practical perspective, "Mathematical Adventure" can be used by teachers as an enrichment activity, an independent practice resource, or a supplementary medium for reviewing probability and expected-frequency concepts. Its offline and smartphone-oriented design may allow students to access the material more flexibly, particularly outside regular classroom hours. Teachers may also integrate the game with classroom discussions, written exercises, and reflective activities so that the interactive experience is followed by more formal mathematical explanation and reasoning.

The development process further indicates that Scratch can be utilized not only as a tool for teaching programming but also as a platform for producing interactive mathematics learning media. Its block-based programming structure enables learning materials, animations, questions, scores, and feedback to be organized without requiring advanced text-based coding skills. This feature may encourage teachers and prospective teachers to develop contextual digital learning resources that are adapted to the needs of their own students. Nevertheless, appropriate instructional planning and content validation remain necessary to ensure that technological and entertainment features support rather than distract from the intended learning objectives.

Although the developed game received highly positive evaluations, broader implementation should be undertaken cautiously. Differences in smartphone specifications, students' digital literacy, school regulations, internet availability, and teacher readiness may influence how the product is used in other educational settings. Further testing should therefore examine the stability, compatibility, and usability of the application across different devices and student populations. Feedback from mathematics teachers should also be included to assess the feasibility of integrating the game into lesson plans and classroom assessment practices.

In conclusion, "Mathematical Adventure" represents a feasible and promising form of supplementary digital media for probability learning. The study provides a foundation for subsequent research aimed at moving beyond product feasibility toward evidence of instructional effectiveness. By combining technological development with stronger experimental evaluation, future research can determine whether the game produces significant and sustained improvements in students' conceptual understanding, problem-solving ability, motivation, and learning achievement.

Credit authorship contribution statement

Hatimah: Conceptualization, Methodology, Software, Investigation, Data curation, Formal analysis, Writing – original draft. **S Djamilah**: Supervision, Validation, Methodology, Formal analysis, Writing – review & editing, Project administration **A G Nugroho:** Investigation, Resources, Data curation, Visualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgment

The authors gratefully acknowledge MTs Muhammadiyah 3 Al-Furqan, Banjarmasin, for supporting the implementation of this research. The authors also thank the media and material experts for their constructive feedback during the validation process, and all student participants involved in the small-scale and large-scale trials of the *Mathematical Adventure* educational game.

References

1. Agustina, R. D., and Yuwaningsih, D. D. A. (2023). Pengembangan E-Modul Matematika Berbasis Android Dengan Pendekatan Problem Solving Pokok Bahasan Matriks.
2. Ambarwati, D., Wibowo, U. B., Arsyiadanti, H., and Susanti, S. (2021). Studi Literatur: Peran Inovasi Pendidikan Pada Pembelajaran Berbasis Teknologi Digital, *Jurnal Inovasi Teknologi Pendidikan*, Vol. 8, No. 2, 173–184. doi:10.21831/jitp.v8i2.43560.
3. Kementrian Komunikasi dan Digital. (2024). Optimisme IGDX 2024, Jadikan Indonesia Pusat Industri Gim Asia Tenggara.
4. Zuhlina, Z. (2023). Pengembangan Media Pembelajaran Game Edukasi Android Menggunakan Construct 3 Pada Materi Sistem Pencernaan Manusia Kelas XI SMA.
5. Ayu, S., Ardianti, S. D., and Wanabuliandari, S. (2021). Analisis Faktor Penyebab Kesulitan Belajar Matematika, *Aksioma: Jurnal Program Studi Pendidikan Matematika*, Vol. 10, No. 3, 1611. doi:10.24127/ajpm.v10i3.3824.
6. Kairuddin, P., Samosir, M. I., Sitorus, G. E., Sihotang, H. M. W., and Tanjung, J. Y. (2024). Penerapan Media Pembelajaran Menggunakan Papan Peluang, Dadu, Dan Multimedia Pembelajaran Interaktif Dengan Pendekatan RME Di SMA Swasta PAB 8 Saentis, *Mandalika Mathematics and Education Journal*, Vol. 6, 585. doi:10.29303/jm.v6i2.7821.
7. Saputra, D. A., Tiara, I., and Sari, Y. (2025). Pengembangan Media Pembelajaran Bangun Ruang Sisi Datar (Pemeran Barista) Berbasis Video Pembelajaran Untuk Meningkatkan Pemahaman Konsep Pada Siswa SMP Kelas VIII.
8. Firmadani, F. (2023). Media Pembelajaran Berbasis Teknologi Sebagai Inovasi Pembelajaran Era Revolusi Industri 4.0, *Prosiding Konferensi Pendidikan Nasional*, 93–97.
9. Nahampun, H. S. (2024). Efektivitas Metode Pembelajaran Berbasis Game Dalam Meningkatkan Motivasi Belajar Siswa Sekolah Dasar, *Sinar Dunia: Jurnal Riset Sosial Humaniora Dan Ilmu Pendidikan*, Vol. 3, No. 3, 63–68. doi:10.58192/sidu.v3i3.2415.
10. Mardiyah, J., Khotimah, H., Susilo, G., and Balikpapan, U. (2024). Pengembangan Game Edukasi Besarang (Bermain Sambil Belajar Peluang) Menggunakan Software Construct 2 Pada Siswa Kelas VIII SMP Muhammadiyah 2 Balikpapan Tahun Ajaran 2023/2024.
11. Irawan, E., Kusumah, Y. S., and Saputri, V. (2023). Pengembangan Multimedia Interaktif Menggunakan Scratch: Solusi Pembelajaran Di Era Society 5.0, *Aksioma: Jurnal Program Studi Pendidikan Matematika*, Vol. 12, No. 1, 36. doi:10.24127/ajpm.v12i1.6226.
12. Rani, H., and Wintarti, A. (2022). Media Pembelajaran Berbasis ICT Menggunakan Software Scratch Pada Materi Peluang Di SMPN 18 Banjarmasin, *Edu-Mat: Jurnal Pendidikan Matematika*, Vol. 10, No. 1, 95. doi:10.20527/edumat.v10i1.12936.
13. Norhaliza, N., Nurmeidina, R., and Djamilah, S. (2022). Pengembangan Lembar Kerja Peserta Didik Berbasis Etnomatematika Banjar Materi Segiempat Dan Segitiga, *Hipotenusa Journal of Research Mathematics Education (HJRME)*, Vol. 5, No. 2, 105–118. doi:10.36269/hjrme.v5i2.980.
14. Chandra, F. N., Rahaju, R., and Yuwono, T. (2023). Pengembangan E-LKPD Interaktif Materi Himpunan, *JIPMat*, Vol. 8, No. 1, 90–101.
15. Prastowo, R., Huda, S., Umam, R., Jermsittiparsert, K., and Eko, A. (2019). Academic Achievement and Conceptual Understanding of Electrodynamics : Applications Geoelectric Using Cooperative Learning Model, *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, Vol. 8, No. 2, 165–175. doi:10.24042/jipfalbiruni.v0i0.4614.
16. Sumarni, S., and others. (2019). Behavior in Early Childhood (2-3) Years: A Case Study on the Use of Gadgets in Social Environments, *Int. J. Innov. Creat. Chang.*, Vol. 8, No. 8, 384–404.
17. Sumarni, S., Ramadhani, R., Sazaki, Y., Tria, R., Andika, W. D., and Prasetiyo, A. E. (2019). Development of ``Child Friendly ICT'' Textbooks to Improve Professional Competence of Teacher Candidates: A Case Study of Early Childhood Education Program Students, *Journal for the Education of Gifted Young Scientists*, Vol. 7, No. 3, 643–658. doi:10.17478/jegys.596095.
18. Baba, M. El, Kayastha, P., Huysmans, M., and Smedt, F. De. (2020). Evaluation of the Groundwater Quality Using the Water Quality Index and Geostatistical Analysis In, *Water (Switzerland)*, Vol. 12, No. 262, 1–14. doi:10.3390/w12010262.
19. Munifah, M., Romadhona, A. N., Ridhona, I., Ramadhani, R., Umam, R., and Tortop, H. S. (2019). How to Manage Numerical Abilities in Algebra Material?, *Al-Jabar : Jurnal Pendidikan Matematika*, Vol. 10, No. 2, 223–232. doi:10.1017/CBO9781107415324.004.
20. Yasin, M., Huda, S., Putra, F. G., Syazali, M., Umam, R., and Widyawati, S. (2020). IMPROVE Learning Model and Learning Independence: Influence and Interaction on Mathematics Problem-Solving Abilities in Islamic Boarding School, *Journal of Physics: Conference Series*, Vol. 1467, No. 1. doi:10.1088/1742-6596/1467/1/012003.

21. Ridwanulloh, M. U., Huda, S., and Umam, R. (2022). Innovative Leadership Management: The Pattern of School Quality Development at {SMP} Muhammadiyah 2 Inovasi Malang, *Progres. J. Pemikir. Dan Pendidik. Islam*, Vol. 11, No. 01, 25–42. doi:10.22219/progresiva.v11i01.20742.
22. Saregar, A., Sunyono, Haenilah, E. Y., Hariri, H., Putra, F. G., Diani, R., Misbah, and Umam, R. (2022). International Journal of Educational Methodology Natural Disaster Education in School : A Bibliometric Analysis with a Detailed Future Insight Overview, *International Journal of Educational Methodology*, Vol. 8, No. 4, 743–757. doi:10.12973/ijem.8.4.743.