Kognitif
Jurnal Riset HOTS Pendidikan Matematika
Volume- 5 No- 3 Halaman 1314 – 1329
ISSN 2776-9704 P-ISSN 2776-9984
https://doi.org/10.51574/kognitif.v5i3.3644

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How to cite : Sekarsari, A., & Karimah, S. (2025). Development of Scratch-Based Interactive Quiz Learning Media on Statistics to Enhance Students' Learning Outcomes. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, *5*(3), 1314–1329. https://doi.org/10.51574/kognitif.v5i3.3644

To link to this artcle : https://doi.org/10.51574/kognitif.v5i3.3644

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v5i3.3644 Volume 5, No 3, Juli - September 2025, pp. 1314– 1329

Development of Scratch-Based Interactive Quiz Learning Media on Statistics to Enhance Students' Learning Outcomes

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Article Info

Article history:

Received Jul 15, 2025
Accepted Aug 29, 2025
Published Online Sep 20, 2025

Keywords:

Instructional Media
Interactive Quiz
Scratch
Learning Outcomes

ABSTRACT

Low student achievement in statistics is often attributed to the use of learning media that lack innovation and interactivity. This study aims to develop Scratch-based interactive quiz learning media and to examine its validity, practicality, and effectiveness in improving students' learning outcomes. The research employed a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The study involved 28 students from Grade XI Health Analyst (experimental group) and 26 students from Grade XI Computer and Network Engineering 2 (control group). Research instruments included expert validation sheets, student response questionnaires, and learning achievement tests. Data were analyzed both qualitatively and quantitatively, including a t-test to evaluate effectiveness. The validation results reached a score of 80% (valid category), while student responses reached 78% (practical category). The t-test revealed a significant difference ($p < 0.05$) between the mean learning outcomes of the experimental group (88.29) and the control group (82.77), indicating that the developed media was effective in enhancing student achievement. These findings suggest that Scratch-based learning media has the potential to serve as an innovative alternative for teaching statistics and can be further developed for other topics by utilizing more complex Scratch features to strengthen learning interactivity.

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Introduction

Mathematics is an essential subject that must be learned by students at every level of education. Mathematics learning plays an important role in developing students' logical, critical, and structured thinking, as well as their analytical and creative skills (Pratama & Waskitoningtyas, 2020). Nevertheless, many students still perceive mathematics as a difficult,

monotonous, and intimidating subject because it is associated with numbers, symbols, and formulas that require abstract understanding (Ratnamutia & Pujiastuti, 2020). This negative perception affects students' motivation and interest, which subsequently influences their engagement in the learning process. Active student engagement, however, is crucial to achieving learning objectives, as it contributes to conceptual mastery, the development of critical thinking, and improved learning outcomes (Maretiamy & Januari, 2023).

Learning outcomes, as described by Hidayah et al. (2021), are changes in student behavior resulting from the learning process, encompassing cognitive, affective, and psychomotor domains. Learning outcomes can serve as indicators of success for both teachers and students. One of the key factors influencing learning outcomes is the method and media used in the learning process. Engaging and non-monotonous learning can increase students' focus and participation. Therefore, teachers, as facilitators in the classroom, are required to create interactive and meaningful learning experiences (Octavia & Yulianti, 2022).

Based on preliminary observations at SMK Muhammadiyah Karanganyar, mathematics learning was still dominated by lecture and discussion methods, in which teachers explained the material, provided examples, and assigned exercises to be completed individually or in groups. The learning media used were limited to printed books. Such learning patterns result in less innovative instruction and limited active student involvement. This condition leads to low material comprehension and suboptimal learning outcomes. Preliminary data showed that the average mathematics scores of Grade XI Health Analyst students were 63.15, and Grade XI Computer and Network Engineering 2 students were 58.76, both still below the Minimum Mastery Criteria (KKM).

To overcome these problems, innovation is needed in learning methods and media that can enhance students' engagement and learning outcomes. One potential approach is the drill and practice method, which has been proven effective in strengthening memory, improving accuracy, and accelerating understanding through repetitive practice (Aliwarman et al., 2024). Astuti (2022) stated that this method can create more meaningful learning and positively impact achievement. The use of engaging learning media such as images, videos, and visual aids also plays an important role in increasing students' attention and participation (Bagasputera et al., 2023).

Several learning media can be used in mathematics learning, including GeoGebra, Maple, Scratch, Tinkercad, and Mapcitymath (Aminah et al., 2023). Scratch, in particular, is a block-based programming environment that is easy to use for developing interactive learning media. It allows users to create animations, games, or educational quizzes (Sudihartinih et al., 2021), and it can be accessed both online and offline (Lestari & Sudihartinih, 2022). Using simple programming logic, Scratch can be designed as an interactive quiz medium that integrates the drill and practice method.

Previous studies have shown that the use of Scratch in mathematics learning has a positive impact on students' interest and learning outcomes. Irawan et al. (2023) reported that Scratch-based media are feasible for use in learning. Aulia et al. (2021) found that Scratch can enhance students' learning interest, which correlates positively with achievement. Mylida et al. (2024) also demonstrated that Scratch-based interactive media meet the criteria of validity, practicality, and effectiveness. However, no study has specifically developed Scratch-based interactive quiz media with a drill and practice approach in teaching statistics at vocational high schools (SMK), which directly aims to improve students' learning outcomes.

Based on the above description, it can be concluded that innovative, interactive, and contextual learning media are needed to address the problem of low student achievement in statistics. Therefore, this study aims to develop Scratch-based interactive quiz learning media incorporating the drill and practice method that are valid, practical, and effective in improving students' learning outcomes.

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https://doi.org/10.51574/kognitif.v5i3.3644 Volume 5, No 3, Juli - September 2025, pp. 1314– 1329

Method

Type of Research

This study employed a Research and Development (R&D) design using the ADDIE model developed by Branch (Permatasari et al., 2022). The ADDIE model consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. This model was chosen because it provides a structured and systematic framework for developing instructional media (Fayrus & Slamet, 2022). The stages of the ADDIE model applied in this study are presented in Table 1.

Table 1. Stages of the ADDIE Model in This Study

Stage	Description
Analysis	At this stage, observations, interviews, and needs-assessment questionnaires were conducted to identify learning problems and determine the requirements for developing the interactive quiz media.
Design	The researchers designed the product specifications, developed the statistics material blueprint, and created research instruments (expert validation and student response questionnaires) using a 5-point Likert scale.
Development	A prototype of the Scratch-based interactive quiz media was created and validated by experts, with results indicating that the product fell into the valid category (average score of 80%). Revisions were made based on validators' suggestions before the trial phase.
Implementation	The product was tested on a limited scale, where students were asked to complete response questionnaires to measure its practicality. The results showed that the product was in the practical category (average score of 78%).
Evaluation	A comparison of learning outcomes between the experimental class (using the media) and the control class (using conventional quizzes) was conducted to determine effectiveness. This evaluation included the Liliefors normality test, Bartlett's homogeneity test, and a one-tailed t-test.

Samples

This study involved Grade XI students at SMK Muhammadiyah Karanganyar, consisting of 28 students from the Health Analyst class as the experimental group and 26 students from the Computer and Network Engineering 2 class as the control group.

Instruments and Data Collection

The instruments used for data collection consisted of observations, interviews, questionnaires, and learning outcome quizzes. Observations and interviews were conducted to obtain preliminary data, while the questionnaires were administered to determine the validity and practicality of the developed product. Specifically, three types of questionnaires were employed: a needs-assessment questionnaire, distributed to students to gather information about the learning materials to be developed and to identify the need for learning media based on those currently used by teachers; a product validation questionnaire, designed to assess the validity of the product; and a student response questionnaire, aimed at evaluating the practicality of the product. All instruments were validated by eight experts in mathematics education to ensure content validity, appropriateness, and feasibility, until they were deemed suitable for use without further revision.

Table 2. Interview Guide

No	Question
1	How do you usually conduct learning activities during your classes?
2	How active are the students during the learning process?
3	What teaching materials do you use for classroom instruction?
4	What challenges do you encounter during the teaching and learning process?
5	How do you overcome these challenges?
6	Do you apply any interactive learning media during your lessons?
7	What difficulties do you face when using interactive learning media?
8	How do students respond to the interactive learning media you use?
9	What is your opinion about using Scratch-based interactive quiz media for teaching statistics to improve students' learning outcomes?
10	Do you think Scratch-based interactive quiz media is feasible to be developed at SMK Muhammadiyah Karanganyar to improve students' learning outcomes?

Table 3. Product Needs Assessment Questionnaire

No	Question
1	Does your teacher always use the school textbook for mathematics learning?
2	Do you find it difficult to study mathematics using the textbook?
3	Do you seek other resources besides the school textbook to help you understand mathematics?
4	Does your teacher use learning media during mathematics lessons?
5	Do you have access to other learning media that make it easier for you to understand mathematics?
6	Do you face difficulties in solving statistics problems related to real-life situations?
7	Are you enthusiastic about learning statistics in mathematics classes?
8	Do you find it difficult to understand and solve mathematics problems using the teaching materials and methods applied by your teacher?
9	Have you ever learned mathematics using web-based interactive quiz media?

Table 4. Student Response Questionnaire

No	Item
	Ease of Use
1	The content presented in this media is easy for me to understand.
2	This media helps me master the material.
3	This media can be used for independent study.
	Usefulness
4	This media helps me practice problem-solving skills in real-life situations.
5	This media helps me connect the material to everyday life.
6	This media expands my knowledge of statistics.
	Time Flexibility
7	This media can be used anytime and anywhere.
	Attractiveness
8	The design of this media is visually appealing.
9	This media prevents me from feeling bored during statistics lessons.
10	The problems presented in this media are attractively packaged based on real-life contexts.
11	The explanations of the material in this media are clearly readable.

In this study, a learning outcome test was used in the form of a quiz consisting of 15 items, including 5 multiple-choice questions, 5 short-answer questions, and 5 matching questions. The quiz was administered under the following conditions: (1) the experimental group completed the quiz interactively using Scratch-based media, while the control group completed the quiz on paper; (2) the duration of the quiz was the same for both groups; and (3) the quiz was given at the end of a lesson after the completion of one topic as part of the treatment.

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Table 5. Sample Items of the Learning Outcome Quiz

No	Sample Item	Question Type
1	A bookstore "Gemar Membaca" recorded book sales for seven days: Monday: 14; Tuesday: 18; Wednesday: 16; Thursday: 20; Friday: 22; Saturday: 25; Sunday: 25. Which measure of central tendency is the most appropriate to identify the most frequently sold book? Options: Mean, Median, Mode, Range.	Multiple-choice
	Based on the data, calculate the correct value of that measure.	Short-answer
	Match the following statements with the correct answers: (a) The median value after the data is arranged; (b) Formula for the mean; (c) Total number of books sold; (d) The mode of the data.	Matching
2	Five Culinary students baked sponge cakes with heights (cm): 8, 12, 7, 8, and 10. Which measure of central tendency is most appropriate to calculate the average cake height? Options: Mode, Median, Mean, Quartile.	Multiple-choice
	Calculate the average cake height.	Short-answer
	Match the following: (a) Ordered data; (b) Formula for mean; (c) Median value; (d) Frequency formula.	Matching
3	A basketball coach recorded his player Rian's scores in 10 matches: 15, 20, 18, 22, 25, 20, 16, 20, 21, 23. Which measure of central tendency is appropriate to determine the middle value? Options: Mean, Median, Mode, Standard Deviation.	Multiple-choice
	Find the median of the ordered data.	Short-answer
	Match the following: (a) Total score; (b) Ordered data; (c) Mean score.	Matching
4	A PE teacher recorded the weights of 30 students and grouped them into intervals. The interval 60–64 kg had the highest frequency. Which frequency distribution table best represents the data? (Options a–d provided).	Multiple-choice
	Identify the modal class.	Short-answer
	Match the following: (a) Formula for mean; (b) Total ∑xif i; (c) Average weight.	Matching
5	A school cooperative recorded daily profits (in thousands of rupiah) for 50 days. The interval 25–29 showed the highest frequency. Which distribution best represents the data? (Options a–d provided).	Multiple-choice
	Identify the modal class.	Short-answer
	Match the following: (a) Formula for mean; (b) Total ∑xif i; (c) Average profit.	Matching

Analysis

Data analysis was conducted using Microsoft Excel. The analysis procedures consisted of three main stages: product validation analysis, student response analysis, and effectiveness testing.

Product Validation Analysis

The product validation data assessed by experts were analyzed using a Likert scale (Gulo & Harefa, 2022) to convert qualitative data into quantitative data, as shown in Table 6.

Table 6. Criteria for Product Validation Rating Scale

No	Rating Category	Score
1	Excellent (SB)	5
2	Good (B)	4
3	Fair (CB)	3
4	Poor (KB)	2
5	Very Poor (SKB)	1

The validation scores were then processed and categorized based on Table 7 and the percentage formula proposed by Hasanah & Nurfalah (2020):

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

where P = percentage score, $\sum$x = total indicator score per aspect, and $\sum$xi = maximum total score for each aspect.

Table 7. Criteria for Product Validation Scores

No	Achievement Level (%)	Category
1	80% < score ≤ 100%	Very Valid
2	60% < score ≤ 80%	Valid
3	40% < score ≤ 60%	Fairly Valid
4	20% < score ≤ 40%	Less Valid
5	0% < score ≤ 20%	Very Poor Validity

Student Response Analysis

Student responses were analyzed using a Likert scale (Gulo & Harefa, 2022) to convert qualitative data into quantitative data, as shown in Table 8.

Table 8. Criteria for Student Response Rating Scale

No	Rating Category	Score
1	Strongly Agree (SS)	5
2	Agree (S)	4
3	Neutral (CS)	3
4	Disagree (TS)	2
5	Strongly Disagree (STS)	1

The response data were then processed and categorized according to Table 9 and the same percentage formula (Hasanah & Nurfalah, 2020).

Table 9. Criteria for Student Response Scores

No	Achievement Level (%)	Category
1	80% < score ≤ 100%	Very Practical
2	60% < score ≤ 80%	Practical
3	40% < score ≤ 60%	Fairly Practical
4	20% < score ≤ 40%	Less Practical
5	0% < score ≤ 20%	Very Poor Practicality

Effectiveness Analysis

The effectiveness of the product was measured using a learning outcome test in the form of a quiz administered to two groups: the Grade XI Health Analyst class as the experimental group (quiz delivered via Scratch-based interactive media), and the Grade XI Computer and Network Engineering 2 class as the control group (quiz delivered in paper form). The test results were analyzed using an independent t-test to compare the mean learning outcomes between the experimental and control groups (Budiyono, 2016). Prior to hypothesis testing, prerequisite tests were conducted, including the Liliefors normality test to ensure data normality and Bartlett's homogeneity test to verify the homogeneity of variances between groups.

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Results

Analysis Stage

At the analysis stage, observations and interviews were conducted at SMK Muhammadiyah Karanganyar. The results revealed that the Grade XI curriculum followed the *Merdeka Curriculum*, with teachers primarily using printed textbooks as instructional materials. Classroom instruction was still dominated by lecture and discussion methods, in which teachers typically provided practice exercises on paper without automatic feedback. This condition potentially affected students' understanding and learning outcomes due to the lack of interactive practice opportunities.

The analysis of the needs-assessment questionnaire showed that 58% of students admitted to experiencing difficulties in understanding the material through the instructional resources and methods applied by their teachers. In addition, 85% of students reported using the internet as supplementary learning media to support their understanding of the material. Therefore, the application of appropriate methods and media is highly necessary. Khoirunisa et al. (2022) noted in their study that the drill and practice method can be implemented to improve mathematics learning outcomes. This served as the basis for developing the Scratch-based interactive quiz learning media, which integrates technology and the drill and practice method to enhance student learning outcomes. The content for the interactive quiz media was aligned with the competency standards of the school curriculum.

Design Stage

The design stage included the determination of product specifications to facilitate the design process and the outline of the product content, which consisted of presenting the material and statistics quizzes. The statistical material presented was aligned with the *Learning Outcomes* applied at SMK Muhammadiyah Karanganyar. In addition, relevant textbooks were consulted as references in the development of the media. The researchers then developed the research and validation instruments. The assessment instruments for the Scratch-based interactive quiz media consisted of a product validation questionnaire and a student response questionnaire, both designed in checklist form using a 5-point Likert scale with the following scoring: 5 (very good), 4 (good), 3 (fair), 2 (poor), and 1 (very poor). After the research instruments were developed, they were validated by experts. The results indicated that the product validation questionnaire was relevant and feasible for use, although revisions were recommended in certain aspects of the validation relevance items. Meanwhile, the student response questionnaire was deemed relevant and feasible without any revisions. Subsequently, revisions were made to the items that were considered less relevant, as assessed by the experts, as presented in Table 10.

Table 10. Revisions of the Product Validation Questionnaire Items

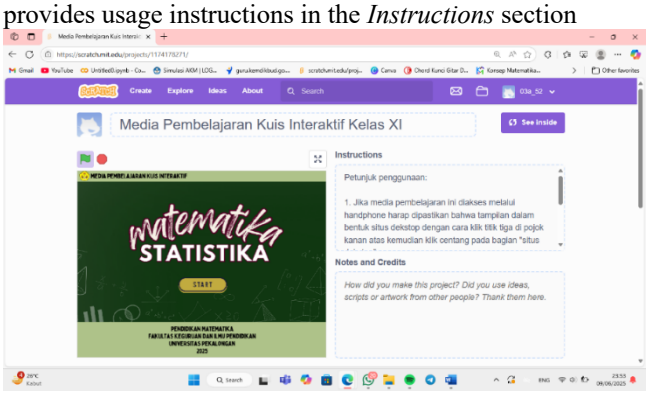
Suggestion	Before Revision	After Revision
Statement no. 7 should be separated into two sentences	7. Supports conceptual understanding and memory reinforcement through varied question formats and repetition	7. The material presented supports conceptual understanding 8. The practice exercises support memory reinforcement through varied question formats and repetition
Clarify the wording	13. Student involvement in learning 15. The material presented is accompanied by feedback to support student understanding	13. Student involvement in learning 15. The material presented is accompanied by feedback to support student understanding

	16. Ability to motivate students 18. Evaluation is equipped with motivating feedback 19. Understanding of information 27. Interaction between media and users	16. Ability to motivate students 18. Evaluation is accompanied by motivating feedback 19. The material and practice exercises are accompanied by informative feedback 29. The learning media is able to respond to user interaction
Add one statement under the aspect of supporting material presentation	10. Appropriateness of images in material explanation 11. Appropriateness of practice exercises at the end of the material 12. Appropriateness of answer keys for practice exercises	11. Appropriateness of images in material explanation 12. Appropriateness of practice exercises at the end of the material 13. Appropriateness of answer keys for practice exercises 14. Adequacy of the number of exercises at the end of the material

Development Stage

The Scratch-based interactive quiz learning media was developed based on the initial design, consisting of several components as presented in Table 11.

Table 11. Development Stage Specifications

Section	Component	Description
Initial	Cover Page	The initial part of the media consists of a cover page, which includes the start menu and usage instructions. The cover page contains several buttons with their respective functions: (1) Green flag, to run the media; (2) Stop button (red circle), to stop the media; (3) Start button, to display the main menu; (4) Grow button, to enlarge the display. In addition, the cover page displays the title *"Scratch-Based Interactive Quiz Media for Grade XI"* and provides usage instructions in the *Instructions* section 
Main	Main Menu	The main menu consists of several sub-menus: learning material, quizzes, instructions, references, and author profile. **1) Learning Material Menu**: This menu displays an interaction page containing introductory dialogues and stimulus questions related to the topic. It also presents the learning outcomes, learning objectives, and statistical materials (mean, median, and mode for both ungrouped and grouped data).

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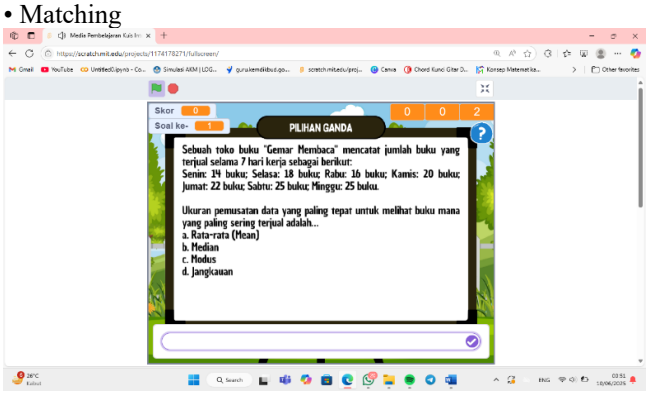
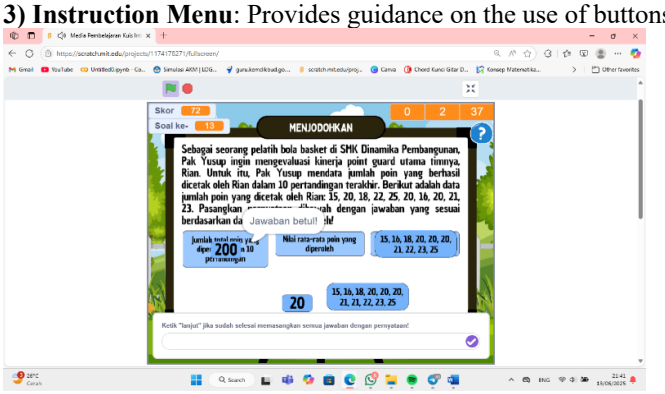
2) Quiz Menu: This menu displays quiz instructions, an animated teacher that explains the functions of various buttons when clicked, and a start button to begin the quiz (see Figure 4). The quiz consists of 15 items with different question types developed using Scratch and applying the drill and practice method. Students cannot proceed to the next item until they answer correctly. The quiz also provides automatic feedback. The item types include:

- Multiple-choice
- Short-answer
- Matching



3) Instruction Menu: Provides guidance on the use of buttons within the media.



4) Author Profile Menu: Contains biographical information about the author of the Scratch-based interactive quiz media.

5) References Menu: Contains relevant references used in the development of the Scratch-based interactive quiz media for statistics.

During the initial development, several suggestions from the supervisors were incorporated. After initial revisions, the product was evaluated by expert validators using validation sheets and was subsequently revised according to material and media aspects.

Implementation Stage

The fourth stage was the implementation of the product in schools. After the product had been validated and revised according to expert suggestions, it was tested in the trial class. Following the trial, students were given a response questionnaire to determine the practicality of the Scratch-based interactive quiz learning media. The results of the product validation assessment are presented in Table 12.

Table 12. Results of Product Validation Assessment

No	Assessment Component	Percentage Score	Classification
1	Material Quality Aspect	80%	Valid
2	Presentation Aspect	82%	Very Valid
3	Language Aspect	74%	Valid
4	Media Accessibility Aspect	80%	Valid
5	Graphic Feasibility Aspect	80%	Valid
Conclusion		**80%**	**Valid**

The percentage scores from the validation showed: (1) Material Quality at 80% (valid); (2) Presentation at 82% (very valid); (3) Language at 74% (valid); (4) Media Accessibility at 80% (valid); and (5) Graphic Feasibility at 80% (valid). The overall average score was 80%, indicating that the Scratch-based interactive quiz learning media met the criteria of validity. In addition, during this stage, an analysis of student responses to the product was conducted, as presented in Table 13.

Table 13. Results of Student Response Assessment

No	Assessment Component	Percentage Score	Classification
1	Ease of Use	73%	Practical
2	Usefulness	77%	Practical
3	Time Flexibility	84%	Very Practical
4	Attractiveness	81%	Very Practical
Conclusion	—	**78%**	**Practical**

The percentage scores from student responses to the developed product indicated: (1) Ease of Use at 73% (practical); (2) Usefulness at 77% (practical); (3) Time Flexibility at 84% (very practical); and (4) Attractiveness at 81% (very practical). Overall, the Scratch-based interactive quiz learning media was classified as practical based on student responses. Therefore, the media can be considered practical for use in mathematics learning.

Evaluation Stage

The fifth stage was the evaluation stage, which served as a comprehensive process integrated into all previous stages. According to Jones (Purba et al., 2021), evaluation is conducted repeatedly at the end of each stage. In the analysis stage, evaluation ensured that the product needs were properly identified. In the design stage, evaluation confirmed that the product design aligned with the goals and objectives. In the development stage, evaluation was carried out to revise and analyze the validity of the product. During the implementation stage, evaluation was conducted to observe the application of the developed product and analyze its practicality. In addition, evaluation was also conducted to determine the effectiveness of the product. The results of the effectiveness analysis are described below:

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Normality Test

The Liliefors test was used with the following hypotheses:

- H_0: The sample comes from a normally distributed population.
- H_1: The sample does not come from a normally distributed population.

The decision criterion was that H_0 would be accepted if $L_{calculated} < L_{table}$. The results are shown in Table 14.

Table 14. Results of the Normality Test

No	Group	$L_{calculated}$	L_{table}	Decision
1	Experimental	0.10077	0.164	H_0 accepted
2	Control	0.15636	0.170	H_0 accepted

Based on Table 14, the experimental group had Lcalculated = 0.10077 with a significance level of 5% and n = 28, resulting in L_{table} = L(0.05;28) = 0.164. Since $L_{calculated} < L_{table}$, H_0 was accepted, indicating that the sample was normally distributed. Similarly, the control group had $L_{calculated}$ = 0.15636 with a significance level of 5% and n = 26, resulting in L_{table} = L(0.05;26) = 0.170. As $L_{calculated} < L_{table}$, H_0 was also accepted, indicating that this sample was normally distributed.

Homogeneity Test

The Bartlett test was used with the following hypotheses:

- H_0: $\sigma_1^2 = \sigma_2^2$ (the populations have homogeneous variances).
- H_1: $\sigma_1^2 \neq \sigma_2^2$ (the populations have different variances).

The decision criterion was that H_0 would be accepted if χ^2calculated < χ^2table. The results are presented in Table 15.

Table 15. Results of the Homogeneity Test

χ^2calculated	χ^2table	Decision
0.341	3.841	H_0 accepted

Based on Table 15, χ^2calculated = 0.341 with a significance level of 5% and df = 1, yielding χ^2_{table} = χ^2(0.05;1) = 3.841. Since $\chi^2_{calculated} < \chi^2_{table}$, H_0 was accepted, indicating that the populations had homogeneous variances.

Hypothesis Testing

To evaluate the effectiveness of the Scratch-based interactive quiz media, a right-tailed independent *t*-test was used with the following hypotheses:

H_0: $\mu_1 \leq \mu_2$ (the mean learning outcomes of students using the Scratch-based interactive quiz are not higher than those of students using conventional paper-based quizzes).

H_1: $\mu_1 > \mu_2$ (the mean learning outcomes of students using the Scratch-based interactive quiz are higher than those of students using conventional paper-based quizzes).

The decision criterion was that H₀ would be rejected if tcalculated > ttable. The results are presented in Table 16.

Table 16. Results of the t-test

$t_{calculated}$	t_{table}	Decision
2.259	1.675	H₀ rejected

Based on Table 16, $t_{calculated}$ = 2.259 with a significance level of 5% and df = 52, yielding ttable = t(0.05;52) = 1.675. Since $t_{calculated} > t_{table}$, H₀ was rejected. It can therefore be concluded that the mean learning outcomes of students using the Scratch-based interactive quiz media were higher than those of students using conventional paper-based quizzes. The summary of mean scores is presented in Table 17.

Table 17. Recapitulation of Students' Mean Learning Outcomes

No	Group	n	Mean
1	Experimental	28	88.29
2	Control	26	82.77

Discussion

This study produced an instructional medium in the form of a Scratch-based interactive quiz that met the criteria of validity, practicality, and effectiveness in improving student learning outcomes. The validity of the media was obtained from expert assessments with a score of 80% (valid category), while its practicality was based on student responses with a score of 78% (practical category). The effectiveness of the media was demonstrated by a significant difference in the mean learning outcomes between the experimental group and the control group, with the experimental group that used the Scratch-based interactive quiz media achieving higher scores.

These findings are consistent with the study of Mylida et al. (2024), who developed Scratch-based interactive learning media on the topic of systems of linear equations in two variables. Their results showed that the developed media were valid, practical, and effective in enhancing student learning outcomes, and they recommended its use in mathematics learning. Similarly, Irawan et al. (2023) emphasized that Scratch-based learning media are highly feasible, particularly in supporting student engagement in the learning process. Furthermore, Fadila & Ramadhani (2024) argued that Scratch-based media are not only relevant as instructional tools in the classroom but also useful as independent learning resources for students.

Unlike these previous studies, which generally focused on developing interactive media in a broader sense, the present study specifically integrated Scratch-based interactive quiz media with the drill and practice method. This combination was designed to provide structured exercises and repeated reinforcement of concepts, which theoretically strengthens students' mastery of the learning material. Harlia et al. (2021) demonstrated that drill and practice can significantly contribute to improving learning outcomes, while Khoirunisa et al. (2022) asserted that learning outcomes are a key indicator of instructional success. In addition, Astuti (2022) explained that drilling not only affects achievement but also fosters motivation and student engagement in learning activities.

Drill and practice is a learning approach that emphasizes repeated exercises to help students retain concepts and acquire mathematical skills (Mutmainnah et al., 2024). In the context of Scratch-based mathematics learning, this method facilitates repeated exposure to mathematical problems in a more engaging and interactive way, incorporating various types of items such as short-answer, multiple-choice, and matching questions. Roblyer, as cited in

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Nasrina et al. (2021), suggested that software can serve as a practice tool that provides students with immediate feedback on their performance. In line with this, the Scratch-based media developed in this study also provided automated feedback that allowed students to instantly identify and correct their mistakes, thereby improving their understanding and mastery of the material (Mustika Wati & Dian Sumadi, 2025).

Thus, this study not only reinforces prior research affirming the feasibility of Scratch as a learning medium but also fills a research gap by introducing a more specific and applicable approach: the development of Scratch-based interactive quiz media integrated with the drill and practice method in the teaching of statistics at vocational high schools (SMK). This focus represents a significant contribution to the advancement of digital learning media that are more adaptive to the procedural and conceptual nature of mathematics learning.

Nevertheless, this study has several limitations: (1) it was conducted in only one school; (2) it did not assess students' learning retention over a longer period; (3) the developed material was limited to the topic of measures of central tendency; and (4) the media itself remained relatively simple. Future research is therefore recommended to: (1) expand trials to larger samples across multiple schools; (2) develop similar Scratch-based media for other mathematics topics; (3) examine the effectiveness of the media in improving students' long-term learning retention; and (4) explore the utilization of advanced features in Scratch to enhance the complexity and interactivity of the developed media. Such efforts would enable the creation of more comprehensive, engaging, and challenging instructional media for students.

Conclusion

Based on the findings, it can be concluded that the Scratch-based interactive quiz learning media with a drill and practice approach developed in this study has proven to be valid, practical, and effective in improving students' learning outcomes on the topic of measures of central tendency. Expert validation yielded a score of 80% (valid category), while student responses reached 78% (practical category). The effectiveness of the media was demonstrated by a significant difference between the mean scores of the experimental group (88.29) and the control group (82.77), indicating that the media had a positive impact on students' achievement. This study, however, has several limitations: it was conducted in only one school and did not examine students' learning retention over a longer period. Moreover, the developed material focused solely on the topic of measures of central tendency. Therefore, future studies are recommended to develop similar Scratch-based media for other mathematics topics, conduct trials on larger samples across multiple schools, investigate the effectiveness of the media in enhancing students' long-term retention, and explore the use of advanced features in Scratch to increase the complexity and interactivity of the developed media. In this way, the media holds strong potential to serve as an innovative alternative to support the improvement of mathematics learning quality at the vocational high school (SMK) level.

Conflict of Interest

The authors declare that there is no conflict of interest.

Authors' Contributions

A.S. was fully responsible for instrumentation, design, conceptualization, data collection, processing, analysis, presentation of results and discussion, revision, and adjustment of all

information in this article. Meanwhile, S.K. contributed to the theoretical development and approved the final version of the manuscript. The authors' contributions to the conceptualization, preparation, and revision of this article were: A.S.: 55% and S.K.: 45%.

Data Availability Statement

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

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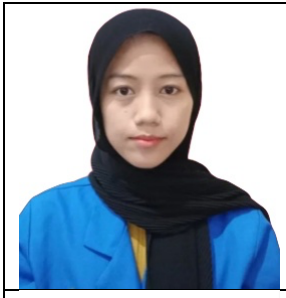	**A’isyah Sekarsari** is a student of the Mathematics Education Study Program, Faculty of Teacher Training and Education, Universitas Pekalongan. Email: aisyahhskrsrr@gmail.com
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