

Fostering Statistical Reasoning and Numeracy Literacy: The Role of Scratch-Based Interactive Multimedia in Seventh-Grade Mathematics

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Abstract: Interactive learning multimedia is needed to improve students' numeracy literacy skills. Based on this, this study aims to analyze the validity, practicality, and effectiveness of interactive learning multimedia assisted by Scratch to improve students' numeracy literacy skills. Based on this, this study aims to develop and evaluate interactive multimedia learning assisted by Scratch to improve students' numeracy literacy skills. This study used a Research and Development (R&D) method based on the ADDIE model. In this study, the sample comprised 32 students from class VII A at SMP Negeri 2 Temanggung. The Sampling technique used was cluster random sampling. Data collection techniques used questionnaires, interviews, completing test questions, and observations. The novelty of this research lies in the development of interactive multimedia using Scratch, a tool that has not previously been used to improve numeracy literacy skills. The multimedia developed was categorized as very valid, with material validity of 85.64% and media validity of 85.78%. Its practicality was also rated very high, as indicated by student responses of 85.94% and teacher responses of 90%. The multimedia also proved effective in improving numeracy literacy skills, as indicated by the N-Gain score of 0.5550 (moderate category) and significant differences between pretest and posttest results ($t = 9.554$, $df = 31$, $p < 0.05$). Interactive multimedia learning assisted by Scratch was also found to be very practical, with 85.94% of students responding positively in the student response questionnaire and 90% in the teacher response questionnaire. Thus, it can be concluded that interactive multimedia developed using Scratch is valid, practical, and effective in improving students' numeracy literacy skills.

Keywords: numeracy literacy, interactive multimedia, scratch.

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■ INTRODUCTION

All aspects of human life are influenced by mathematics (Dele-Ajayi et al., 2019). As a fundamental science and a necessity, mathematics is used in daily life (Pamungkas, 2019). Various disciplines and the enhancement of human thinking also require the role of mathematics (Masriana & Wandini, 2023). As a result, students at all educational levels are required to study mathematics (Yulianisa & Sudihartinih, 2022). In fact, junior high school pupils still have difficulty solving common mathematical problems (Pamungkas & Franita, 2019). In education, the

subject of mathematics requires several important skills. One of these is numeracy literacy. Students must develop their numeracy literacy to become accustomed to dealing with a variety of challenges, including those in mathematics and other academic subjects, as well as increasingly complex problems in daily life (Azgara et al., 2024).

In terms of health, this ability is useful for calculating drug dosages, extracting health-related information, reading food packaging, and understanding statistical data (Heilmann, 2020). Numeracy skills are important in medical decision-making because low numeracy skills

increase the risk of misinterpreting health data (Rolison et al., 2020). Good numeracy skills can help prevent diseases (Sektiwulan & Nindiasari, 2024).

One essential component of numeracy literacy is the ability to read, interpret, and present data. This competency is vital because daily life increasingly demands the capacity to understand information presented in tables, diagrams, or statistical summaries. At the junior high school level, these skills begin to be systematically developed through the data presentation material in grade VII. This topic serves as an entry point for building students' statistical reasoning, which forms the foundation of more advanced numeracy literacy. Therefore, difficulties in understanding data presentation not only indicate obstacles in a single topic but also reflect fundamental weaknesses in students' overall numeracy literacy development.

In daily life, numerical literacy helps interpret statistical data. Statistics is covered in the mathematics lessons' statistics section. In this section, one topic is learned in the second semester of grade VII: data presentation. The data presentation material explores several techniques for presenting data using tables, line charts, bar charts, and pie charts (Ramadhany & Prihatnani, 2021).

In this material, students often have difficulty analyzing and classifying data types and displaying them in bar charts or tables (Maryati & Priatna, 2017). According to teachers, the problem in this material is that students' mathematical understanding and effort to comprehend it tend to decrease compared to students in previous years. This problem can be addressed with good numeracy literacy skills.

Nevertheless, according to PISA data, students' numeracy skills in Indonesia remain low. Although Indonesia's ranking in the PISA data has improved by five ranks in reading literacy and mathematics literacy, and by six ranks from the

previous year in science literacy. However, the PISA 2022 reading score decreased by 12 points, from 371 in 2018 to 359. The mathematics score decreased by 13 points to 366 from the previous 379. Meanwhile, the science score declined by 13 points to 383, down from 396.

This aligns with the preliminary tests of numeracy literacy abilities. According to the test, the average score for grade VII students was 31 out of 100. Based on the school's KKTP (Minimum Competencies Standard), which is 75-80, this average score is categorized as low. Based on the students' answers, it is evident that students struggle to understand the essence of story problems and convert them into mathematical models.

Students' low numerical literacy skills can be attributed to several factors. One is that students in Indonesia are not adequately trained to solve contextual problems that require logic, reasoning, and creativity (Panjaitan et al., 2023). Learning that still depends on the teacher, namely conventional learning, results in a one-way learning process, leading students to be less active (Ambarwati & Kurniasih, 2021). The lack of student activity in learning is one of the causes of low numeracy and literacy skills. This ability will improve if teachers act as facilitators and students take a more active role in the learning process (Ndakularak et al., 2023).

In addition to the still-conventional learning, interactive learning media have not been developed (Bernard & Setiawan, 2020). The assertion is consistent with the observed finding that media created to support the learning process do not use sophisticated technologies. The conventional media used is insufficient to support numeracy literacy, as evidenced by students' difficulties understanding the material, even though the teacher has provided contextual examples. As a result, teachers have to repeat explanations and provide additional examples or analogies,

which can waste time and reduce learning efficiency.

The situation can be resolved by using interactive learning media. Technology-based learning media can be an option. Based on the media needs analysis questionnaire, 100% of the class's students have a mobile phone and can use it. In this digital era, the use of learning media can enhance the quality level of learning (Rohati et al., 2018).

The learning media can be in the form of interactive multimedia. Interactive multimedia for learning can be created using an application called Scratch. Students who used Scratch scored higher on collaboration and communication, creative thinking, and academic performance (Shen & Qi, 2020). Scratch enables easy, effective, and engaging learning of mathematics (Iskrenovic-Momcilovic. Compared to pen and paper, Scratch provides a more creative environment for students to test and iteratively develop their ideas and their mathematical understanding of geometry, arithmetic, and coordinates (Olsson & Granberg, 2024). Scratch, a block-based programming environment, has demonstrated effectiveness in supporting the acquisition of computational thinking by enabling learners to focus on logical structures and problem solving without the burden of syntactic complexity (Cárdenas-cobo et al., 2025). Scratch is an educational programming language that allows beginner programmers, including students, to program easily (Park & Shin, 2019). Specifically, the use of Scratch fosters the development of critical, metacognitive, and reflective skills in mathematics (Rodríguez-martínez et al., 2019). Students' interest in learning can be increased by using Scratch-based learning media, which will also help them better understand mathematics (Ningrum & Novtiar, 2023). The Scratch application successfully helps students understand the material in mathematics lessons (Nikmah & Ellianawati, 2019). This

application helps students easily understand the material as a whole and in meaningful ways, enabling them to work together in groups (Bernard & Setiawan, 2020). Another study mentioned that learning with Scratch can eliminate boredom and enhance curiosity (Chiang & Qin, 2018). Scratch can also help develop students' computational thinking skills (Calder, 2018). Park and Shin (2019) found that studying Scratch can enhance computational thinking skills. The study by Jiang and Li (2021) also shows that learning with Scratch is a promising approach to improving students' high-level computational thinking, especially creativity, collaboration, and critical thinking. Project-based learning using Scratch media can develop students' creative thinking, logical reasoning, and collaborative skills, which are highly needed in the 21st century (Winarko & Cahyono, 2024).

Based on previous researches, Scratch has a positive impact on mathematics learning. However, the use of Scratch is still rare in education (Satriana, 2019). The learning remains monotonous and boring because it still relies on conventional media (Nugraha et al., 2022). Using an inappropriate learning model will make it difficult for students to understand and master the material (Rivai & Mohamad, 2021). This affects students' low motivation and enthusiasm for learning. In line with the classroom observation results, learning media are not used during classroom instruction.

Scratch has been shown to have a positive impact on mathematics learning. However, its use is still rare in education (Satriana, 2019). Classroom learning tends to be monotonous and boring due to the continued use of conventional media (Nugraha, Trisniawati, & Rhosyida, 2022). The use of inappropriate learning models also makes it difficult for students to understand and master the material (Rivai & Mohamad, 2021), resulting in low motivation and enthusiasm for learning. These findings align with classroom

observations, which indicate that learning media are not yet utilized in the learning process.

In fact, Scratch supports the development of a range of student learning skills and competencies (Pérez-Jorge & Martínez-Murciano, 2022). However, research on the use of Scratch as a learning medium to improve numeracy literacy skills is still limited. Therefore, this study developed interactive learning multimedia supported by Scratch to improve students' numeracy literacy. Moreover, this study analyzes the validity, practicality, and effectiveness of interactive learning multimedia assisted by Scratch to improve students' numeracy literacy skills.

■ METHOD

Participants

In this study, the researcher used a population of 255 seventh-grade students from SMP Negeri 2 Temanggung. The sampling technique in this study was cluster random sampling. The sampling technique in this study

was purposive sampling. Purposive sampling is a technique that employs specific sampling methods to obtain a sample from a data source (Sugiyono, 2016). In this study, the researcher used a sample of 32 students from class VII A of SMP Negeri 2 Temanggung, as this class had numeracy literacy test results that remained low, indicating a need for improvement.

Research Design and Procedures

This research is a type of research and development (R&D). Development research is oriented towards developing and validating a product (Bardi & Jailani, 2015). The development model to be used is the ADDIE model. This model is suitable for developing educational learning products. The ADDIE instructional model is divided into several phases, namely analysis, design, development, implementation, and evaluation, which are dynamic in nature (Cahyadi, 2019). The ADDIE development model has several stages, as shown in Figure 1.

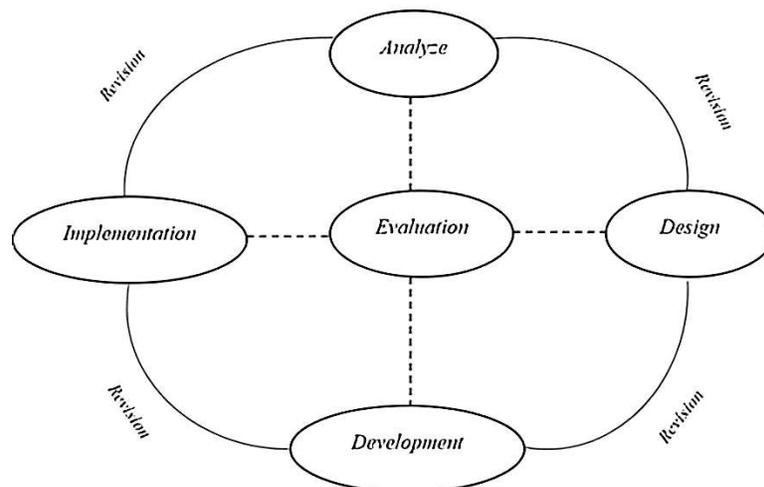


Figure 1. Stages of the ADDIE development model

In the analysis phase, several tasks were carried out: analyzing multimedia needs by distributing questionnaires to students, analyzing the learning process through classroom observations, and interviewing students about

their impressions of the mathematics learning conducted at school. These observations and interviews were used for initial analysis. In the next phase, the design stage, several steps are taken, including material assessment, flowchart

creation, and storyboard development. Material assessment was conducted to determine the content to be covered in the interactive multimedia. The creation of flowcharts aims to facilitate the production and design process. Additionally, storyboards were created to organize the multimedia content, making it more structured. Canva and the Scratch program are used to design interactive multimedia for learning.

During development, several activities were carried out, including creating instruments and multimedia content, conducting expert validation tests, and testing the product. The instruments created included questions and questionnaires; the researcher then designed multimedia and had it validated by media and materials experts. After validation, the next step was to evaluate the practicality of the multimedia during implementation. This stage involved applying the learning media supported by Scratch in two 40-minute sessions, which included students interacting with the multimedia for 30–35 minutes, a 10-minute explanation by the teacher on how to use the media, 20–25 minutes of independent or group exploration, and 10 minutes for discussion. The Scratch multimedia was designed with a structured learning scenario that includes an apperception phase, a menu of materials and sample questions, and an interactive quiz. Each activity in the multimedia provided automatic feedback, such as notifications for correct or incorrect answers, hints, and conceptual explanations, to aid understanding. A character named Pak Rama guides or explains the material throughout the multimedia. During this stage, pretests and posttests were conducted to measure students' numeracy skills. Additionally, the researcher distributed practicality questionnaires to teachers and students to gather their responses to the interactive multimedia supported by Scratch. The next stage is the evaluation phase, which consists of two parts. The formative evaluation occurs at each stage of

development, with improvements made to content, animation, and images based on feedback from expert validators. The summative evaluation is conducted after all previous stages are complete to enhance the overall effectiveness of the instructional materials.

Instrument

The research instruments in this study consisted of test instruments (pretest and posttest questions) and non-test instruments (questionnaires, interview guidelines, and observation sheets). The questionnaires used include a media needs analysis questionnaire, a validation questionnaire, and a practicality questionnaire. The media needs analysis questionnaire contains statement items regarding the mathematics learning process associated with media needs. This questionnaire aims to observe whether this interactive multimedia learning supported by Scratch is actually needed by students. The validation questionnaire includes a media expert validation questionnaire, an instrument question validation questionnaire, and a content expert validation questionnaire. These three questionnaires used a Likert scale with five response options. The media expert validation questionnaire includes aspects such as appearance, interactivity, functionality, relevance to the material, and clarity of instructions and guidelines. The validation questionnaire for the numeracy literacy ability test includes material, clarity, accuracy of content, and language. Meanwhile, the expert material validation questionnaire addresses the suitability of the content and language.

The practicality questionnaire consists of teacher and student response questionnaires. The practicality questionnaire includes aspects of appearance, including indicators of the attractiveness of menus in multimedia, the attractiveness of images and tables, the clarity of images and tables, and the readability of letters

and text in multimedia. In addition, this questionnaire includes content indicators of ease of operating multimedia, ease of understanding the material, and the suitability of the material to students' conditions.

The interview guidelines are directed towards students. The purpose of the student interview guidelines is to gather data regarding the process of studying mathematics and the students' perceptions of it at SMP Negeri 2 Temanggung. This research uses initial observation sheets and implementation observation sheets. The initial observation sheet is used to observe the classroom learning process and to assess the use of learning media during it. The implementation observation sheet is used to understand the learning process as the multimedia is developed. The observer fills out this sheet during the research.

The test instruments used consist of pretest and posttest questions, each containing two questions with six indicators of numeracy literacy skills. The six indicators of numeracy literacy are contained in each question. Each question consists of six questions (a, b, c, d, e, and f). Question a measures students' communication skills in determining the known elements in the question. Question b measures students' mathematical skills by asking them to describe the question in mathematical form or as a model. Question c measures representation skills by connecting mathematical forms to a problem to find a solution. Question d measures students' ability to use mathematical language to represent known elements. Question e is used to measure students' ability to choose problem-solving strategies and use appropriate steps to solve the problem. Question f measures students' ability to provide reasons and conclusions based on the reasoning in the solution. Before testing, the test instruments were validated by experts. Questions can be used if the validity is at least high ($V > 0.8$); if it falls into the medium category, a re-

evaluation of the instruments is necessary (Fajaruddin et al., 2021). Reliability testing was also conducted using Cronbach's alpha. Test items were considered suitable for use if their reliability coefficient was at least in the fairly good category (Lestari & Yudhanegara, 2017). Based on the reliability test, the questions meet the minimum reliability threshold and are quite suitable for use.

Data Analysis

The data analysis techniques used include validity, practicality, and effectiveness analyses. Validity analysis is used to determine the feasibility of the product to be developed. Validity analysis was conducted by scoring responses according to the following criteria: Very Feasible (score 5), Feasible (score 4), Moderately Feasible (score 3), Less Feasible (score 2), and Not Feasible (score 1). The validators consisted of two mathematics education lecturers at Tidar University and a mathematics teacher at SMP Negeri 2 Temanggung. The product developed was assessed the practicality. Practicality analysis is conducted by scoring responses according to the following criteria: Strongly Agree (score 5), Agree (score 4), Unsure (score 3), Disagree (score 2), and Strongly Disagree (score 1). Practicality assessment was carried out by teachers and students of class 7A at SMP Negeri 2 Temanggung. The validity and practicality of the questionnaire items for the statements were developed by the author based on previous research. Effectiveness analysis was conducted by first performing a normality test using the Lilliefors test. The paired-samples t-test is part of the hypothesis-testing used to determine whether there is a difference in the average scores for numeracy literacy skills after treatment with the developed multimedia. In addition, the N-Gain test was used to assess the effectiveness of the interactive learning multimedia product assisted by Scratch. In addition, researchers conducted an N-Gain test on each question item per

indicator to assess the effectiveness of interactive learning multimedia products assisted by Scratch.

■ **RESULT AND DISCUSSION**

Analysis

In the analysis stage, activities include analyzing the background for developing this interactive multimedia learning, including the multimedia needs and the learning process. In this analysis stage, the target group's needs are analyzed (Spatioti & Kazanidis, 2022). Similarly, this research's media needs analysis was conducted through a questionnaire on media needs completed by the students. The purpose of this analysis is to determine whether the multimedia learning developed is truly needed by the students. The results of the media needs analysis show that the majority of students are interested in mathematics lessons, even though they also experience difficulties in understanding them. All students have smartphones and can use them, but most use them only for playing games and social media, as they prefer to learn directly in class with the teacher. The lecture-based learning method is still a favorite, but students tend to be more enthusiastic when the learning is varied, for example, using PPTs or games. Scratch is still not well known among students and has never been used in class, although most students show interest in learning math with it in the future.

Several students were interviewed about their experiences throughout the classroom learning process, and the implementation of mathematics instruction was observed to analyze the learning process. Based on the observation, mathematics learning is conducted through a lecture method because the teacher and students are currently focused on preparing for the odd-semester exams; no media or technology is used. In the 9th grade, learning media were used, but not in the 7th grade due to the dense curriculum that needed to be completed. Teachers used

textbooks as the main teaching materials, but students were allowed to seek other learning resources. Learning was also supported by various types of practice questions, both in numerical form and word problems. The comfortable classroom environment that supports group discussions facilitates the learning process. Teaching aids were not used in this meeting because the focus of the learning was preparing for ASAS. The interviews with the students yielded several pieces of information. "Mathematics is difficult but fun if you understand how to do it," was the statement from all the students interviewed when asked for their opinions about mathematics lessons. The author again asked several of the interviewed students about the problems they experienced in mathematics. "Not being thorough enough when answering practice problems" was the answer from four of the interviewed students. Another student said he had difficulty memorizing formulas. When asked for further information on how to overcome these problems, all students responded the same way: by increasing the number of practice problems and asking the teacher if there was anything they didn't understand. These students also felt that they had not been studying mathematics well. According to them, they can learn to learn mathematics well through games like Quizizz. One student also mentioned the teacher's engaging delivery of the material as a key factor in effective math learning. When asked about their preference for learning with direct teacher explanations, games, or interactive PowerPoint presentations, all interviewed students agreed that games were engaging and helped them understand the material. Some students find mathematics fun but challenging, and it becomes more enjoyable when the teacher delivers the material in an engaging way. Students also mentioned that learning with technology, such as Quizizz or game-based media, would increase students' interest

in learning mathematics. The disruptions students experience during learning include difficult material, imprecision, and lack of focus. To overcome this, students choose to study at home while listening to music and to study in groups in class. Outside of class hours, students utilize smartphones to access learning materials and instructional videos, although some prefer books because they are more practical for finding materials and practice questions.

Theoretically, this study offers new insights into how visual programming environments such as Scratch can serve as mediating tools that bridge the gap between abstract mathematical concepts and practical numeracy literacy. Existing literature has emphasized Scratch’s ability to foster computational thinking, yet its role in supporting numeracy literacy, particularly in the context of statistical representation, remains underexplored. This research offers a conceptual model in which Scratch-based interactive multimedia enables students to visually manipulate, organize, and interpret data, thereby linking symbolic mathematical procedures with real-world data interpretation tasks. Through this mechanism, the

learning activities designed in Scratch are expected to strengthen students’ understanding of data presentation while simultaneously developing essential numeracy literacy competencies such as reading graphs, identifying patterns, and drawing evidence-based conclusions. Thus, this study advances the theoretical understanding of how visual programming tools can serve as a pedagogical bridge between formal mathematical instruction and applied numeracy demands.

Design

The second stage is the design stage, which involves creating a task analysis that lists the main steps learners must take, along with a flowchart that maps the training process (Castro, 2019). In the design stage, several steps are taken, namely material assessment, making a flowchart, and storyboarding. Material assessment is conducted to determine the content to include in interactive multimedia learning. The material chosen and used in the scratch-assisted interactive learning multimedia is data presentation. Table 1 below displays the learning objectives for the data presentation content.

Table 1. Learning objectives of data presentation material

No	Learning Objectives
1.	Collecting data systematically
2.	Presenting the collected data in an appropriate format
3.	Analyzing data to obtain appropriate conclusions
4.	Using bar charts and pie charts to present data visually
5.	Interpreting data presented in the form of bar charts and pie charts

The creation of a flowchart is intended to facilitate the process of making and designing. Meanwhile, the storyboard is created to include the content that will be included in the learning multimedia. The storyboard is designed to ensure that multimedia production is more structured. This interactive multimedia was developed using the Scratch and Canva applications. The Scratch application is used to code the elements in the

learning multimedia so that users can operate them more easily. Meanwhile, the Canva application is used to design and select the elements for the interactive multimedia being developed.

Development

The development stage begins with the creation of instruments, including several things such as the validation questionnaire for the test

instrument, validation questionnaire for content experts, validation questionnaire for media experts, practicality questionnaire for media (responses from students and teachers), teaching modules, observation sheets for the implementation of learning, and test questions for literacy and numeracy skills used for both pretests and posttests. The validation questionnaire for the test instrument contains 13 statements divided into four aspects: content accuracy, clarity, content validity, and language. The expert validation questionnaire for content consists of two aspects: content feasibility and language, each comprising 13 statement items. The expert validation questionnaire for media consists of 15 statement items across five aspects: appearance, interactivity, functionality, relevance to the material, and clarity of instructions and guidelines. The practicality questionnaire contains 20 statement items regarding student and teacher responses to the use of interactive multimedia learning assisted by Scratch.

The test instrument, in the form of pretest and posttest questions, was created based on the indicators of numeracy literacy skills. There are six indicators of numeracy literacy skills, including the ability to read and explain questions, the ability to apply mathematical concepts to depict events in questions as mathematical models, the ability to represent a mathematical form and connect it to a problem in order to find a solution, the ability to use various definitions and mathematical rules related to language and mathematical symbol operations, the ability to choose and apply various solutions to resolve a problem, and the ability to provide logical reasoning for the obtained solutions. The validation results of the pretest and posttest instruments are high, thus allowing testing of construct validity, the distinguishability index, reliability, and difficulty level. The construct validity results of the pretest and posttest instruments are in the valid category. The reliability analysis of the pretest and posttest questions falls

into the high category. For the distinguishability index, pretest question 1 is categorized as poor, 2 as sufficient, and 3 as good, while posttest question 1 is categorized as poor and questions 2 and 3 as sufficient. As for the difficulty level, the pretest questions 1 and 2 are easy, and question 3 is medium; in the posttest, question 1 is easy, and questions 2 and 3 are medium. The difficulty level of the posttest questions 1 and 2 is categorized as easy. Based on the analysis of the pretest and posttest questions, only two were used in the study. The next stage is product design. The product is designed using Scratch and Canva.

The design was created using the Canva application. The finished design is imported into Scratch and arranged as needed. This interactive multimedia learning includes explanations of the material, interactive exercise questions, a summary, example questions, and quizzes. The exercise questions and quizzes included in the multimedia are based on numeracy literacy indicators. The quiz display is shown in Figure 2.

Before conducting product trials, the developed product must be validated first (Bahri et al., 2021). The results of validation from content experts serve as evidence that the content in the developed multimedia learning aligns with the intended learning outcomes and goals; the accuracy of the concepts and theories explained in the content; the systematic writing of the content is coherent; examples of questions, practice questions, and quizzes presented are related to numeracy literacy; and the language used is easy to understand, clear, and without ambiguous meanings. However, the validators offer some suggestions for improving the multimedia content before it is tested with students.

In addition to validation by content experts, the developed multimedia is also validated by media experts. The results of the multimedia validation by media experts fall into the very valid category, indicating that the Scratch-assisted

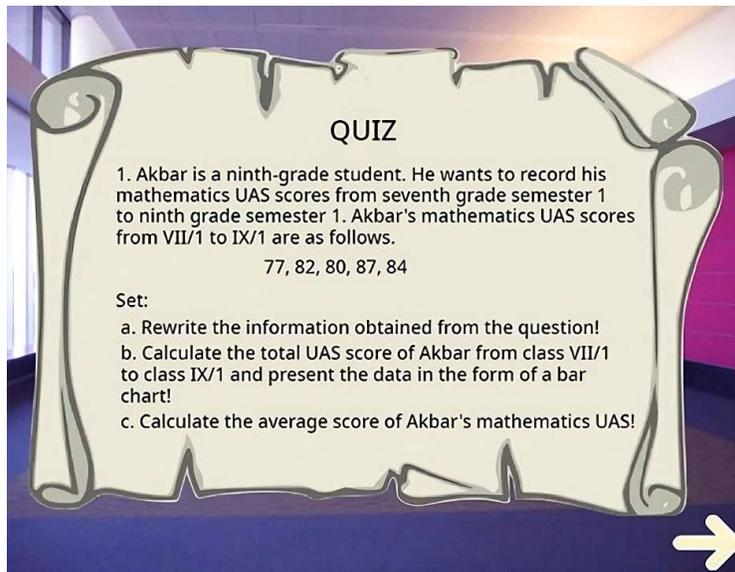


Figure 2. Quiz page display

interactive learning multimedia is appropriate and can be used in mathematics education. Overall, the media expert validators evaluated media appearance, multimedia interactivity, multimedia functionality, multimedia suitability with the material, and the clarity of instructions and guidance in multimedia. The advantage of interactive multimedia for learning is that it can be designed anywhere and at any time, without being limited by space or time (Elok et al., 2023). Interactive learning multimedia has advantages because it is more effective and enjoyable (Maesaroh & Mulyadiprana, 2020). In learning activities, interactive multimedia can create a meaningful, engaging, and enjoyable learning atmosphere (Elok et al., 2023). One of the validators stated that the developed multimedia learning can already be used to improve students' numeracy literacy skills in data presentation materials; however, a suggestion was made to add navigation to return to the previous menu or to the main menu during the explanation of the material. The validity of the multimedia comes from its appropriate appearance, the ease of the buttons used, the ability of the multimedia to explain the material so that it is easy for students to understand, the suitability of the multimedia with

the learning objectives, and the user instructions for the multimedia that are easy to understand. However, before being used, to make the developed multimedia even better, it must be revised in accordance with the validator's enhancement recommendations.

Implementation

The implementation stage was carried out by conducting mathematics learning on data presentation material using interactive multimedia assisted by Scratch in an experimental class, namely class VII A of SMP Negeri 2 Temanggung. Four meetings were necessary to complete this stage. A pretest was conducted in the first meeting; learning was carried out through interactive multimedia supported by Scratch in the second and third meetings; and a posttest was conducted in the fourth, or last, meeting. Learning was conducted through direct instruction. In the application of direct learning, there are five phases involved. Delivering learning objectives and preparing students is done in the first phase. This is followed in the second phase by demonstrating knowledge and skills. Guided practice is carried out in the third phase. In the fourth phase, understanding was assessed, and feedback was

provided. Providing opportunities for further practice and applying it is done in the fifth or final phase. The learning implementation was observed by the observer during the second and third meetings. The observers consist of the teacher and one student from Tidar University. The purpose of the observation is to assess how well the implementation of mathematics learning on data presentation uses interactive multimedia assisted by Scratch.

This is the implementation phase of the planned work. The researcher ensured that students received information about the material, the teaching aids or media to be used, the number of meetings, and the dates of the learning sessions. During the implementation stage, the researcher verified whether the students had read the instructions for using the media and the information about the media they would use. In addition, researchers must ensure that the classroom is located in an area with easy internet access so that learning can proceed without obstacles.

In the first meeting, students worked on pretest questions for one lesson hour. The pretest

results were analyzed to assess students' numeracy literacy skills based on their scores. In the second meeting, the learning process lasted for two lesson hours. This session utilized interactive multimedia learning assisted by Scratch. The learning was conducted individually using each student's mobile phone. The meeting held in classroom VII A discussed how to use interactive multimedia for presenting data, including tables and bar charts. In the third meeting, the learning took place in the computer lab for 2 hours, using an LCD and a projector. The material studied in this meeting is data presentation using pie charts and group quizzes. In the fourth meeting, students were asked to complete a practicality questionnaire, which collected student responses on learning with interactive multimedia supported by Scratch. After completing the questionnaire, students were asked to take a post-test. The post-test results were analyzed to assess students' numerical literacy skills.

Based on Figure 4 and the pretest-posttest analysis of 32 students, the average score for each indicator increased. The most significant increase

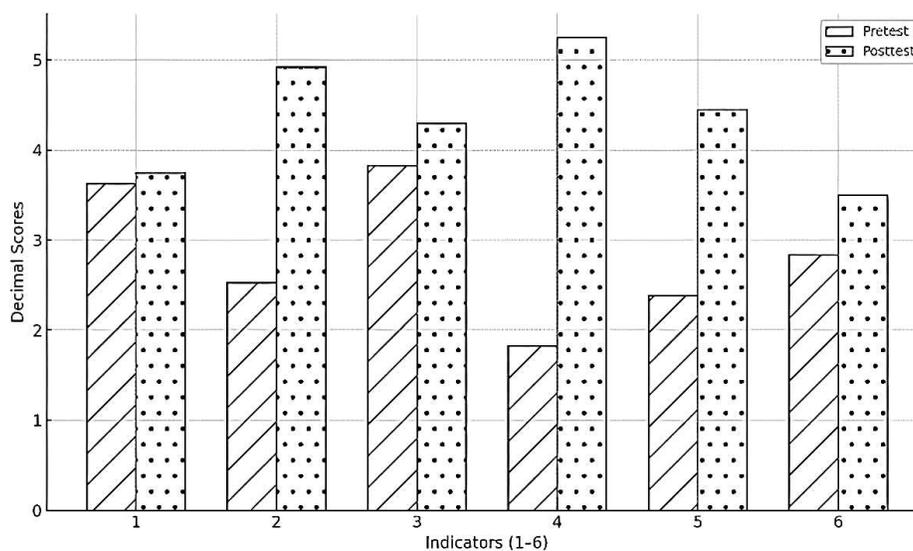


Figure 4. The results of pretest and posttest for each indicator (1) identification (2) modeling (3) connection (4) representation (5) strategy (6) reasoning

occurred in indicator 4, which saw a 3.42 increase. These results indicate an improvement in test scores before and after using interactive learning multimedia supported by Scratch. Based on the pretest and posttest analyses of 32 students, the average scores were 67.66 and 85.34, respectively. These results indicate

improvements in test scores before and after the use of interactive multimedia learning supported by Scratch. In addition, improvements can be observed in the achievement of each indicator, as indicated by the pretest and posttest results. The achievement of each indicator is shown in Figure 5.

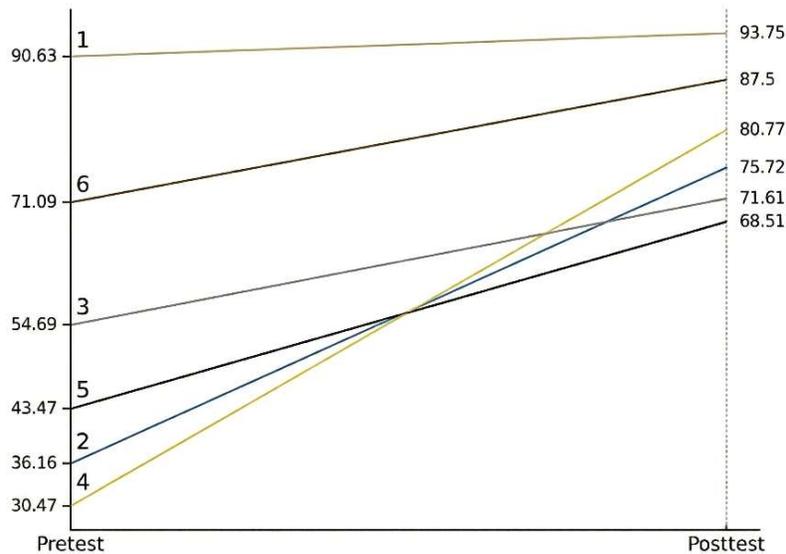


Figure 5. Percentage of achievement of numeracy literacy indicators

Based on Figure 5, indicator 1, which states communication skills, achieved 90.63% in the pretest and 93.75% in the posttest. The increase in this indicator is 3.12%. Indicator 2, which states that mathematical abilities reached 36.16% in the pretest and 75.72% in the posttest. In this indicator, the increase is 39.56%. Indicator 3 states that representation skills increased from 54.69% in the pretest to 71.61% in the posttest. The increase in this indicator is 16.92%. Indicator 4, which assesses the ability to use mathematical language, reached 30.47% in the pretest and 80.77% in the posttest. In this indicator, an increase of 50.30% occurred. Indicator 5, which assesses the ability to choose problem-solving strategies, reached 43.47% in the pretest and 68.51% in the posttest. The increase in this indicator was 25.04%. Indicator 6, which assesses the ability to provide reasons, reached

71.09% in the pretest and 87.50% in the posttest. In this indicator, an increase of 16.41% occurred.

The percentage scores for each numeracy literacy indicator increased both before and after using Scratch-assisted interactive multimedia learning, as shown in the image. In addition, the pretest and posttest data were also subjected to hypothesis testing. Before conducting hypothesis testing, a normality test is needed to determine whether the data are normally distributed. Based on the calculations, the Liliefors value for the pretest and posttest data is smaller than the critical value in the Liliefors table; thus, H_0 is accepted. If H_0 is accepted, then the pretest and posttest data are normally distributed. Since both data sets are normally distributed, the researcher uses parametric hypothesis testing. This hypothesis test aims to determine the effectiveness of the developed multimedia in learning. The parametric

hypothesis test used is the paired sample t-test. The result shows that the calculated t value is greater than the table t value; thus, H_0 is rejected. The test findings demonstrate that the average score for numeracy literacy skills following treatment with multimedia-based learning is higher than it was prior to treatment. To assess the extent of improvement in numeracy literacy skills, the researcher used the N-Gain test on the pretest and posttest scores.

The N-gain test results showed that the developed multimedia was most effective in improving the ability to use mathematical language in indicator 4, with an N-gain score of 0.82. Meanwhile, the less effective improvement occurred in the communication ability aspect in indicator 1, with an N-gain score of 0.33. The results of the N-Gain test are shown in Table 2.

The N-Gain test results show a moderate improvement in students' numeracy literacy skills.

Table 2. The results of the N-Gain test

Indicator	Pretest	Posttest	N-Gain	Category
1	232	240	0.33	Medium
2	162	315	0.53	Medium
3	245	275	0.15	Low
4	117	336	0.82	High
5	153	285	0.66	Low
6	182	224	0.57	Medium

Based on the results of parametric hypothesis testing and the N-Gain test, it is concluded that interactive learning multimedia assisted by Scratch is effective in improving students' numeracy literacy skills. In addition, interactive learning multimedia assisted by Scratch can enhance students' learning outcomes. This aligns with the research of Hadisaputra, Gunawan, & Yustiqvar (2019), which found that one of the positive impacts of interactive multimedia in learning is improved learning outcomes. The Scratch application helps students easily understand the material in a comprehensive and meaningful way, allowing them to work together in groups (Bernard & Setiawan, 2020). In the third meeting, a group quiz was conducted to test numerical literacy. Group work is intended to help students communicate with each other and exchange opinions to solve the issues in the questions.

The practicality of the media can be assessed from teachers' and students' responses regarding the multimedia used for learning. These responses can be seen in the practicality

questionnaire completed by students and teachers. The questionnaire overall contains information about multimedia design, text readability on multimedia, the benefits of multimedia, and the ease of operating multimedia. The researcher distributed the questionnaire to obtain responses from students and teachers; the results will be used to evaluate the practicality. The completion rates for the questionnaire among students and teachers were 85.94% and 90%, respectively. This indicates that the interactive multimedia learning assisted by Scratch falls into the very practical category for use in mathematics education.

Evaluation

The evaluation stage comprises two phases: formative and summative evaluation. Formative evaluation is carried out at each development stage by improving aspects that need correction related to content, animation, and images to make them more appealing. This evaluation is conducted while developing the product, during which

multimedia is revised based on suggestions and feedback from validators. Summative evaluation is an evaluation conducted after all previous stages have been completed by making improvements to the teaching materials as a whole to enhance the effectiveness of the teaching materials. This evaluation is performed to ensure the feasibility of the developed multimedia. The evaluation results indicate that responses from teachers and students fall into the “very practical” category, and no further revisions were required for the interactive multimedia developed with Scratch. Quantitative findings also show an improvement in students’ numeracy literacy scores from pretest to posttest. However, because this study employed a one-group pretest–posttest design without a control group, the observed improvement cannot be conclusively attributed solely to the multimedia intervention. The results should therefore be interpreted as preliminary evidence of potential effectiveness, not definitive proof. Further research using more rigorous experimental or quasi-experimental designs is required to validate and strengthen the findings from this study. The evaluation results show that responses from teachers and students are very practical, and no improvements are needed for the interactive multimedia developed with the assistance of Scratch. Based on the research design, the developed multimedia learning has the potential to improve students’ numeracy literacy skills, especially in data presentation materials. Multimedia has also been shown to be effective in enhancing students’ numeracy literacy skills. Thus, it can be concluded that students can effectively use interactive multimedia assisted by Scratch to study mathematics, particularly in the topic of data presentation.

■ CONCLUSION

Interactive multimedia learning assisted by Scratch has been proven valid, practical, and effective in enhancing numeracy literacy skills in

data presentation materials. This is because Scratch presents material, example questions, practice questions, and interactive quizzes that are easy to understand, thereby increasing students’ interest and motivation to learn. Teachers can consider multimedia as teaching material focused on numeracy literacy skills. Additionally, this multimedia can be used by teachers, students, and readers to study data presentation material.

This study shows that the Scratch application offers a significant opportunity to improve the quality of mathematics learning, especially by enhancing students’ numeracy literacy skills. However, this interactive learning multimedia has limitations, including the absence of a pause button, which prevents students from temporarily stopping the learning flow. Students who miss instructions from the sprites (Mr. Rama) must repeat the learning flow from the beginning by clicking the green button. In addition, Scratch cannot automatically collect quiz scores, so the quiz answers are corrected and collected manually. Another limitation of this multimedia is that it is in the form of a link, which requires a signal. If the smartphone’s storage is full, it can sometimes hinder access to multimedia learning links. The researcher’s recommendation to other researchers is to develop similar interactive multimedia for mathematics learning with a more attractive, innovative, and creative design, and to be more careful in creating questions tailored to the skill indicators to be improved.

This study demonstrates that Scratch-assisted interactive learning multimedia is valid, practical, and has the potential to improve students’ numeracy literacy skills in data presentation. The easy-to-understand presentation of material, sample problems, exercises, and interactive quizzes can increase students’ interest and motivation to learn. Furthermore, the n-gain scores for each indicator show varying improvement, indicating that, when viewed from pretest and posttest scores, the developed multimedia is highly effective in

improving specific ability indicators, but less effective in improving others. These findings confirm that the use of Scratch-based multimedia positively contributes to the mathematics learning process and can be a relevant, innovative alternative learning resource that supports improving classroom learning quality, particularly by strengthening numeracy literacy.

This research has important implications for education, both theoretically and practically. Theoretically, the results of this study strengthen the study of the effectiveness of interactive multimedia in enriching the learning experience and supporting the development of numeracy competencies. In practice, teachers can use Scratch-based multimedia as engaging, accessible teaching material to help students understand data presentation more meaningfully. However, this study has several limitations, including a single-group pretest-posttest design without a control group, which limits the strength of causal inferences regarding multimedia effectiveness, and a low instrument reliability coefficient of 0.4-0.6. This reliability coefficient may affect the accuracy of measuring improvements in student achievement. These limitations should be considered when interpreting the study's results. They can serve as a reference for future research to develop more comprehensive multimedia using a more robust research design.

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