

THE USE OF SCRATCH CODING-BASED GAMES AS AN INNOVATIVE MEDIUM TO INCREASE STUDENTS' MOTIVATION TO LEARN MATHEMATICS

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Abstract :

This study aims to analyse the effectiveness of using Scratch coding-based learning media in increasing primary school students' motivation to learn mathematics. The study used a qualitative descriptive approach with six fourth-grade students from MI IT Nurul Iman Punung as subjects. Data were collected through observation, practical tests, and questionnaires assessing aspects of attention, active participation, perseverance, confidence, and enjoyment of learning. The results showed that the use of Scratch significantly increased the motivation to learn mathematics in all students. Male students excelled in programming logic and technical exploration, while female students excelled in visual creativity and social collaboration. An important finding from this study is that Scratch-based learning is able to create an interactive, enjoyable, and meaningful learning atmosphere, thereby changing students' perceptions of mathematics from a difficult subject to an interesting and contextual activity. The conclusion of the study confirms that Scratch is effective as an innovative learning medium for fostering intrinsic motivation, logical thinking, and creativity in students in 21st-century learning.

Keywords : Learning Motivation; Educational Games; Scratch; Mathematics Learning; Coding

Abstrak :

Penelitian ini bertujuan untuk menganalisis efektivitas penggunaan media pembelajaran berbasis game coding Scratch dalam meningkatkan motivasi belajar matematika siswa sekolah dasar. Penelitian menggunakan pendekatan deskriptif kualitatif dengan subjek enam siswa kelas IV MI IT Nurul Iman Punung. Data dikumpulkan melalui observasi, tes praktik, dan angket yang menilai aspek perhatian, partisipasi aktif, ketekunan, kepercayaan diri, dan kesenangan belajar. Hasil penelitian menunjukkan bahwa penggunaan Scratch berhasil meningkatkan motivasi belajar matematika secara signifikan pada seluruh peserta didik. Siswa laki-laki menunjukkan keunggulan pada aspek logika pemrograman dan eksplorasi teknis, sementara siswa perempuan menonjol dalam kreativitas visual dan kolaborasi sosial. Temuan penting dari penelitian ini adalah bahwa pembelajaran berbasis Scratch mampu menciptakan suasana belajar yang interaktif, menyenangkan, dan bermakna, sehingga mengubah persepsi siswa terhadap matematika dari pelajaran yang sulit menjadi kegiatan yang menarik dan kontekstual. Simpulan penelitian menegaskan bahwa Scratch efektif sebagai media pembelajaran inovatif untuk menumbuhkan motivasi intrinsik, berpikir logis, dan kreativitas siswa dalam pembelajaran abad ke-21.

Kata Kunci: Motivasi Belajar; Game Edukatif; Scratch; Pembelajaran Matematika; Coding

INTRODUCTION

Mathematics is one of the core subjects that must be studied at every level of formal education, from primary school to university. Mathematics is not only important in an academic context, but also plays a major role in everyday life as

it helps individuals solve various problems logically and systematically. According to Safari (2024), mathematics is also an important foundation in the development of information technology, so mastering mathematical concepts from an early age is a necessity that cannot be ignored. This is in line with the opinion of Gusteti & Neviyarni (2022), who emphasise that learning mathematics equips students with critical thinking and logical skills, as well as the ability to make decisions to deal with real-life situations. Thus, mathematics learning in primary school is not only aimed at enabling students to master simple calculation concepts, but also at shaping rational thinking patterns and instilling strong learning motivation as preparation for facing developments in science and technology.

Despite its very important role, the reality is that many primary school students consider mathematics to be a difficult and boring subject. This negative view has an impact on students' low motivation to learn when studying mathematics. Sulistyarningsih in Firdaus et al (2022), states that students' mathematical connection skills are generally still low, which affects the quality of the learning process and results in low achievement and motivation. Furthermore, Wiryana & Alim (2023), found that most students categorise mathematics as a difficult subject to understand, which reduces their enthusiasm to actively participate in learning. This condition is in line with the author's observations in class IV of MI IT Nurul Iman, where there are still some students who appear to be unfocused, unresponsive when the teacher asks questions, and do not show seriousness in working on the problems given. In fact, learning motivation is one of the determining factors for student success in achieving learning objectives. Novitasari (2023) emphasises that motivation is the most important element in the learning process, as it can stimulate students' internal drive to be more enthusiastic, diligent, and confident in facing academic challenges. Thus, low learning motivation in mathematics is a serious problem that needs to be addressed immediately through more innovative and engaging learning approaches.

Technological developments in the world of education today have brought about major changes in the way teachers and students interact in the teaching and learning process. Entering the era of Society 5.0, technological advances such as the Internet of Things (IoT), artificial intelligence (AI), and big data have become an important part of everyday life, including in supporting learning (Runisah, 2021). This situation requires teachers to come up with

learning strategies that are not only conventional but also able to utilise technology as an innovative medium. One alternative that has been widely developed is the use of educational games, which are considered effective in increasing students' interest and motivation to learn. Febrianingsih (2022) states that creative media-based learning can foster students' creative thinking skills through fluency, flexibility, originality, and elaboration. In line with this, Yunus Anis et al (2023) emphasises that Scratch, as a coding-based medium, has a wide range of applications, from developing mathematical ideas and learning illustrations to animations and educational games. With its interactive and attractive display, this medium is able to create a more enjoyable learning atmosphere, thereby encouraging students to be more enthusiastic about learning mathematics, which was previously considered difficult. Therefore, the use of educational games such as Scratch can be an innovative solution to increase students' learning motivation while fostering the creative thinking skills needed in the digital age.

Scratch is a block-based visual programming language designed to be user-friendly for children and beginners in the world of coding. This programme allows users to arrange commands in the form of blocks that can be combined like a jigsaw puzzle, making it easier to understand programming concepts without having to write complex syntax. According to Saputra et al (2024), Scratch is a simulation programme that can be used to design and analyse concepts through simple animations to demonstrate the basic principles of learning. Furthermore, Supriadi in Puteri (2024) explains that Scratch can be used for various purposes, such as creating animations, educational games, and visualising mathematical ideas. With its attractive and interactive display, Scratch can be a fun medium for learning mathematics because students not only understand the material but are also actively involved in the process of creating digital projects. The use of Scratch in learning is expected to create a more varied learning atmosphere, increase interest, and motivate students to explore mathematics further through creative learning experiences.

Previous studies have shown that the use of Scratch in learning has a positive impact, particularly in enhancing students' creativity and computational thinking skills. Fitriani (2019) emphasises that Scratch is an effective tool for helping students develop creative thinking skills, practise reasoning, and produce interesting digital projects. Similarly, research conducted by Supriadi (2018) shows that Scratch has a wide range of applications, both in the

development of mathematical ideas, educational animations, and interactive games that can enrich students' learning experiences. However, studies that specifically highlight the influence of Scratch on increasing motivation to learn mathematics are still minimal. In fact, learning motivation is a key factor in determining students' success in understanding and mastering mathematical concepts. This research addresses this gap by offering a novel focus on the use of Scratch as an educational game medium to increase primary school students' motivation to learn mathematics. Thus, this research not only reinforces previous findings regarding the role of Scratch in developing creativity but also fills a gap in research related to learning motivation.

Based on the above description, this study aims to analyse the use of the Scratch coding-based game as an innovative medium for increasing primary school students' motivation to learn mathematics. Theoretically, this study is expected to contribute to the development of learning media studies, particularly related to the integration of coding-based technology in mathematics education. This study also enriches the literature on the effectiveness of creative digital media in influencing learning motivation, which has been relatively limited. Practically, the results of this study are expected to provide input for mathematics teachers in developing more interesting, interactive learning strategies that are in line with technological developments. Thus, teachers have alternative learning media that can be used in the classroom to create a more enjoyable learning atmosphere while encouraging students to be more motivated in understanding mathematical concepts.

RESEARCH METHOD

This study utilises a qualitative descriptive method, which aims to describe phenomena occurring in their natural context and in line with the perspective of the subjects being studied in detail. Qualitative research does not aim to test hypotheses, but rather to explore and understand the meaning behind a person's behaviour, actions, and experiences. This method is considered most appropriate for the use of Scratch-based games as an innovative medium to increase primary school students' motivation to learn mathematics.

According to Nawawi (1985), descriptive research aims to solve problems by describing the state of the subject or object of research based on observable facts. This is reinforced by Sugiyono (2015), who states that qualitative research is used to examine natural conditions, the results of which will be analysed with the aim of finding meaning from the actual data.

The subjects in this study were six students in the fourth grade of madrasah ibtidaiyah. Fourth-grade students were chosen because they are at a stage of cognitive development where they are beginning to be able to think more abstractly and critically. At this age, students also tend to be more open to the use of interactive and enjoyable learning media. The location of the study was MI IT Nurul Iman, Mendolo Lor Village, Punung District, Pacitan Regency. This location was chosen because the school still faces challenges in mathematics learning, especially related to low student interest in mathematics. In addition, this school has a conducive learning environment and teachers who provide support and opportunities for researchers to conduct research. The relatively small number of students also made it easier for researchers to conduct in-depth observations of the learning process. The research was conducted over a period of two months, from September to November 2025.

In this study, the researcher used three main techniques to collect data, namely observation, tests, and questionnaires. Observation is the act of observing to obtain data and information that is recorded in the form of field notes (Creswell J. W., 2016). Observation in this study was carried out through active participation, where the researcher was involved in the activities to obtain more in-depth data. According to Arifin Z (2016) , a test is a technique used for measurement activities, which includes various questions or a series of tasks that must be completed or answered by students to measure aspects of student behaviour. In this study, the practical test was conducted once using a laptop as a tool. The practical test in this study was conducted by the researcher explaining how to use Scratch in front of the class, then instructing the students to follow the steps as explained by the researcher. After the project was completed, the students were instructed to work on the questions that had been prepared. Sugiyono (2015), explains that a questionnaire is a data collection technique carried out by providing a set of written statements and questions to respondents to answer. The student questionnaire was used to measure the impact of this approach on improving students' communication skills and confidence using the Likert scale theory with four answer choices for the questionnaire, which was divided into positive and negative questions.

This research is qualitative data research and is analysed using several data analysis techniques. The data analysis technique used in this research is the Miles Huberman data analysis model. The activities in data analysis are data reduction, data display, and conclusion drawing/verification.

RESULTS AND DISCUSSION

Results

The research began with the creation of a multiplication quiz game using Scratch. The teacher guided the students in arranging simple code blocks, while the students followed along on their own computers. At this stage, the students paid close attention to the teacher's instructions and tried to understand the function of each code block used. Documentation of this activity is shown in *Figure 1*.



Figure 1. The process of creating a Scratch multiplication quiz game (*Source: Research documentation*)

Once the program structure was complete, the students played the quiz game. The game displayed random multiplication questions, such as " $9 \times 6 = \dots$ ", and students were asked to enter their answers in the input column. When students answered correctly, the game provided feedback in the form of a message saying "Hore, you got it right!", and if they answered incorrectly, a message saying "Oops, try again!" appeared. The atmosphere of the activity when students play the game is shown in *Figure 2*.



Figure 2. Students playing the multiplication quiz game and answering maths questions in the game (*Source: Research documentation*)

Both pieces of documentation show that students not only participated in the game development process, but were also active in playing the game and solving the multiplication problems provided.

Comparison of Pre- and Post-Learning Motivation

Before using Scratch, students showed varying levels of focus, participation, and enthusiasm. After creating multiplication quiz games and

playing them, the students' conditions in each motivation indicator changed. The pre-post summary is shown in Table 1.

Table 1. Comparison of Pre- and Post-Learning Learning Motivation Conditions

Motivation Indicators	Pre-Condition (Before Scratch)	Post-Condition (After Scratch)
Attention	Some students were unfocused and passive in their responses	All students are in the high or very high category
Participation	Limited participation, rarely ask questions	Students actively follow instructions, ask questions, and collaborate
Perseverance	Some students give up easily	5 students very high, 1 student high
Self-confidence	Hesitant to answer and show work	4 students very high, 2 students high
Enjoyment of learning	Mathematics is perceived as difficult and uninteresting	4 students are high, 2 students are very high
Attitude towards mathematics & technology	Mixed attitudes, low self-confidence	All students are high or very high

Observation Results

Observations were conducted during Scratch-based learning activities. The data recorded included student attention, participation, perseverance, and confidence. A summary of the observation results is presented in Table 2.

Table 2. Summary of Observation Results

Students	Attention	Participation	Perseverance	Self-confidence	Description
RHN	High	Active	High	Increasing	Meticulous and focused on following instructions
FAZ	High	Highly active	High	Stable	Quick to understand and exploratory
RKA	Moderate	Active	Moderate	Increasing	Initially passive, then involved
SLF	High	Consistent	High	Stable	Meticulous in following steps
AFQ	High	Active	High	High	Creative and cooperative

MRV	Moderate	Active	Moderate	Increasing	Confident after trying the game
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Practical Test Results through the Scratch Quiz Game

The practical test was conducted in two stages: (1) students participated in creating a multiplication quiz game with the teacher, and (2) students played the game and answered the multiplication questions that appeared. There were 10 basic multiplication questions in the game. A summary of the test results is presented in Table 3.

Table 3. Scratch Quiz Game Practical Test Results

Students	Participating in Game Creation	Playing the Game	Question	Correct	Explanation
RHN	Good	Successful	10	8	Focused and meticulous
FAZ	Very good	Very Active	10	10	Fast and accurate
RKA	Sufficient	Active	10	6	Improved after playing
SLF	Good	Consistent	10	8	Consistent
AFQ	Very Good	Active	10	10	Enthusiastic and meticulous
MRV	Good	Active	10	8	Increasingly confident

Learning Motivation Questionnaire Results

The questionnaire was administered to assess students' perceptions after participating in Scratch-based learning. The results show that all students fall into the high and very high motivation categories.

Table 4. Summary of Learning Motivation Questionnaire

Students	Attention	Perseverance	Self-confidence	Enjoyment	Attitude
RHN	High	Very High	Very High	High	High
FAZ	Very High	Very High	Very High	Very High	Very High
RKA	High	High	High	High	High
SLF	Very High	Very High	Very High	Tinggi	Tinggi
AFQ	Very High	Very High	Very High	Very High	Very High
MRV	High	Very High	High	High	High

Discussion

The results of the study indicate that the use of Scratch in multiplication learning can create a more engaging learning environment and increase student involvement. During the process of creating and playing the multiplication quiz game, students appeared to be more focused, actively followed instructions, and showed greater perseverance compared to previous lessons. Students also appeared more confident when they successfully answered questions that appeared in the game, making learning more enjoyable and meaningful for them. These findings indicate that the use of simple game-based media can strengthen learning motivation and make students more involved in the mathematics learning process.

This phenomenon can be explained through the theory of *constructionism*, which emphasises that students learn more effectively when they are involved in the process of building a digital product. In this context, the collaborative creation of Scratch games allows students to experience the process of *learning by making*, i.e. learning through creation. In addition, the Self-Determination theory of motivation Ryan & Deci (2017) also supports these findings, as games provide challenges, freedom to try, and immediate feedback that increases students' intrinsic motivation. The combination of creative activities and play experiences makes students feel in control of the learning process, which in turn strengthens their interest and confidence.

The findings of this study are in line with previous studies which state that Scratch can improve elementary school students' understanding of basic concepts, creativity, and interest in learning. Rahmawati (2023) found that Scratch-based learning can increase student engagement in classroom activities. Haryanto & Friana (2018) also showed that multimedia-based educational games can increase student motivation to learn. The findings of Azmi & Hasan (2022) reinforce this by emphasising that educational game media can increase student participation and interest in mathematics. However, this study has a special characteristic because the game development process was carried out through *guided coding* with teachers. This shows that Scratch can still be applied effectively even if students do not yet have independent coding skills, as long as teachers provide appropriate guidance.

In line with these findings, this study has several important implications for learning practices. The use of Scratch can be an alternative medium for mathematics learning that not only focuses on mastery of the material, but also

on increasing student engagement, creativity, and confidence. Creating games together can be a solution when students' initial abilities or school facilities do not yet support independent coding. In addition, multiplication quiz games can be used as a more student-friendly formative assessment, as they provide opportunities for learning and playing at the same time. The integration of technology such as Scratch also provides early exposure to digital literacy, which is an important competency in today's learning.

However, this study has several limitations that need to be considered. The process of creating games together with teachers can cause bias, because students' success in completing the games is partly influenced by the teachers' assistance. In addition, students' prior abilities in mathematics and digital literacy also influence how they respond to learning activities; students who are more familiar with computers seem to master coding and playing games more quickly. School context factors, such as device facilities and internet network conditions, also constitute technical limitations that affect the smooth running of activities. The limited number of subjects means that the results of this study cannot be generalised widely, so that further research with a larger scope or comparative design will provide a more comprehensive understanding. Nevertheless, the findings of this study still provide an important overview of the potential of Scratch as a medium for mathematics learning in primary schools.

A critical reflection on the research process shows that several factors may have influenced the results beyond the use of Scratch itself. First, teacher assistance during the game-creation stage may have inflated students' motivation scores because part of their engagement was likely driven by direct scaffolding rather than genuine independent exploration. This suggests that the positive effects observed might partially reflect the novelty of teacher-guided activities rather than the intrinsic impact of Scratch. Second, differences in students' prior abilities both in basic mathematics and digital literacy could bias the results, as students who were already more confident with computers tended to show stronger improvements in participation and test performance. This means that the intervention may work differently in heterogeneous classrooms or in schools with minimal technology exposure. Third, contextual factors such as limited devices and unstable connectivity may have disrupted the flow of learning, potentially reducing the consistency of students' experiences. These considerations highlight that the observed improvements should be interpreted cautiously, as they are shaped not only by the learning media but also by

instructional support, student background, and school infrastructure.

CONCLUSION

This study shows that the use of Scratch in multiplication learning can increase student engagement, attention, perseverance, and confidence. The process of creating games together and playing multiplication quiz games provides a more interesting learning experience and makes students more active in participating in activities. The results of observations, practical tests, and learning motivation questionnaires show that all students responded positively to Scratch-based learning.

Learning with Scratch has important implications for the learning process in primary schools, especially in creating a more interactive and enjoyable learning environment. This medium can be an alternative in mathematics learning because it is able to integrate technology, games, and conceptual understanding simultaneously. In addition, this approach provides opportunities for students to develop basic digital literacy and increase their intrinsic motivation.

Based on the results of this study, it is recommended that teachers consider using Scratch or similar media to support mathematics learning, especially for material that requires operational understanding. Further research could expand the number of subjects, use a comparative design between learning models, or explore students' independent coding abilities to gain a more comprehensive understanding of the effectiveness of Scratch in learning.

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