## | RESEARCH ARTICLE

# Integration Of Computational Thinking In Mathematics Learning Based On Scratch Interactive Media

**Atik Prihatini, Utami Dewi, Surya Amami Pramuditya, Neneng Aminah**
*Mathematics Education, Universitas Swadaya Gunung Jati, Cirebon Indonesia*
**Corresponding Author**: Surya AmamiPramuditya, **E-mail**: amamisurya@ugj.ac.id

## | ABSTRACT

Computational Thinking (CT) is an essential skill in the digital era, especially for solving complex problems in mathematics education. CT includes decomposition, pattern recognition, abstraction, and algorithms, which help students understand mathematical problems better. This research aims to integrate CT in mathematics learning using Scratch, an interactive media that dynamically visualizes mathematical concepts. The research method is descriptive qualitative, collecting data through observation, interviews, and test results. The results show that using Scratch helps improve students' understanding of sequence and series concepts as well as problem-solving and algorithmic thinking skills. Pretest and posttest data showed significant improvement after the intervention. Interviews also show that students are more motivated and easily understand mathematical concepts with the help of visualization from Scratch. However, some students struggle to understand complex code, emphasizing the need for additional guidance. This research highlights Scratch's great potential in strengthening mathematical understanding through challenging and fun problem-solving. Further research is needed to explore integrating other mathematical concepts with programming.

## | KEYWORDS

*Computational Thinking (CT); Interactive Media; Scratch; Mathematics Learning*

## | ARTICLE DOI:

## I. INTRODUCTION

The development of information technology is predicted to make computational thinking (CT) an essential competency for students in the future [1], [2]. In general, CT includes an introduction to computational aspects of everyday life as well as the use of tools and techniques from computer science to understand natural and artificial processes and systems [3]. More specifically, CT is defined as the ability to solve problems, design systems, and understand human behavior through computational concepts and processes [4]. A critical perspective regarding CT states that CT can be considered as a new form of literacy that has the potential to be applied in various subjects, contexts, and fields. To construct a practical operational framework, it is important to delimit the main components of computational thinking. CT is more complex than just programming; programming is an application of CT and is often used to achieve it [5], [6]. Therefore, [7] considers the basic concepts of computing and logic-syntax in programming to measure how students master computational thinking. Computational concepts include primary sequences, loops, iteration, conditionals, functions, and variables.

The emergence of computational thinking, which is still developing, can create ambiguity in the field of education. Many teachers are unfamiliar with CT and need help linking it to the educational curriculum, which leads to a lack of agreement regarding the best way to integrate CT into the educational process [8]. As a result, diverse views translate into uncoordinated actions and policies, making CT development difficult. In addition, there is a need for a standard definition regarding the applicability of CT results in variations in study measurements, making results less accurate and more accessible to compare between studies [9], [10]. Although there are challenges in integrating computational thinking into teaching, various studies show the benefits of learning computational concepts [11]. CT's mastery is associated with an increased ability to think and solve daily problems in various learning areas [12]. Computational thinking brings educational benefits through abstraction and reasoning skills, which strengthen intellectual capacity and can be applied to various domains [13]. CT elements such as loops, conditions, or algorithm development are also related to students' effectiveness in solving various problems. The relationship between activities designed to develop students' cognitive skills and increase their ability to divide problems into simpler sub-problems or create algorithms with a higher level of abstraction [14].

However, more empirical research is needed to link computational thinking to mathematics learning in K-12. Several studies show the benefits of developing mathematical thinking through Scratch. According to [15], Scratch allows students to learn computational thinking concepts and develop valuable products as an in-class exercise. The Scratch coding environment can encourage students to discover new representations of mathematical ideas and relationships. Mathematics activities using Scratch allow teachers to adapt teaching methods to individual student characteristics and teach mathematical concepts and CT [16]. Based on the explanation above, it should be noted that although some research supports the use of programming activities in teaching mathematics, little research still discusses how these activities influence learning in certain areas of mathematics. This research focuses on mathematical concepts that, to the best of our knowledge, have never been discussed through programming activities in visual languages. In particular, this research highlights the concepts of sequences and series and solves problems involving sequences and series, which are elementary-level mathematics topics that students often experience. The main objective of this research is to assess the potential of programming activities using Scratch in encouraging high school students to understand mathematical concepts and computational thinking. Therefore, this research offers a new perspective on mathematics learning by integrating technology and computational thinking concepts to improve problem-solving abilities. This research analyzes how students act during mathematics learning, which utilizes technology to solve problems.

## II. METHODOLOGY

### 2.1. Method and Subject

This research uses mixed methods with an exploratory sequential design, which begins with qualitative data collection followed by quantitative data collection. This exploratory approach produces inductive generalizations about the group, process, activity, or situation under study and then develops a fundamental theory to explain the object of study. This research was conducted on 36 class X high school students in Cirebon, Indonesia.

### 2.2. Data Collection

The data in this study include answer sheets for students' problem-solving ability tests in written format, which were analyzed using an assessment guide based on the basic concepts of computational thinking (CT). In addition, the data collected includes the results of observations and interviews. The research instruments include problem-solving ability test questions, observation sheets in field notes, and interview guidelines. Interviews were conducted to explore processes that required additional explanation from test answer sheets and direct observation.

### 2.3. Data analysis

Researchers observed student activities during the learning process with the help of observers in the field. Activity notes are taken, and student portfolios are collected. An introductory session on the material was conducted, and individual mathematical problem-solving ability tests were administered before and after several activities. Qualitative data analysis begins with organizing and describing the data. For quantitative analysis, data from observations during learning using the Scratch program and test results of students' problem-solving abilities were analyzed using the SPSS program. The research was carried out in three stages. The first stage is an initial test to measure student abilities. Then, intervention was carried out to observe student activities during learning using Scratch and the computational thinking (CT) approach to solving problems. After that, an in-depth analysis of student activities is carried out. In the final stage, triangulation was carried out through in-depth interviews to obtain additional information from test results and observations. Statistical tests measure changes in students' abilities and success before and after intervention.

## III. RESULTS AND DISCUSSION

### 3.1. Results

The research process begins with introducing the concept of sequences and series to students using a Scratch-based learning approach. In the first stage, students are given an initial test to assess their understanding of the basic concepts of sequences and series. The test results show varying levels of understanding, with the lowest score being 20 and the highest 65. This initial test is important to determine students' abilities before starting Scratch-based learning. Next, students are invited to learn the Scratch tool, especially the relevant features for creating simple mathematical simulations. The teacher gives an example of a simple program illustrating arithmetic concepts as a number sequence. At this stage, students are asked to understand the logic behind the program and try to modify the program to suit the given task, for example, creating an arithmetic sequence with a general formula. $U_n=a+(n-1)\,b$.

In the second meeting, the focus shifted to exploring using Scratch to solve arithmetic series problems. The teacher gives more complex problems, such as determining the number of terms of an arithmetic series. Students become familiar with using Scratch to calculate values in series and test their understanding of the concept through interactive simulations. This activity aims to strengthen students' algorithmic thinking skills, an essential part of computational thinking. The learning process uses a decomposition approach, where students are taught to break down significant problems into smaller, more manageable steps. They learn to identify essential elements in mathematical problems and design solutions in organized blocks of Scratch code. For example, students break down the calculation of a number series into several stages, from determining the first term to calculating the total number of terms.

The final meeting emphasized the final evaluation. Students are asked to solve problems involving arithmetic sequences and series and enter the results into Scratch. They should also be able to explain their thought processes verbally during the interview session. The final results show that most students can use Scratch well to visualize and solve sequence and series problems.

**FIGURE 1.**
**SCRATCH OPERATION**


Quantitative data in this research was obtained from the results of tests on students' mathematical problem-solving abilities before and after the learning intervention using Scratch. The test is given twice: an initial test (pretest) before learning and a final test (posttest) after all learning sessions are completed. The test questions focus on arithmetic sequences and series, with assessment indicators including understanding concepts, ability to solve problems, and use of effective problem-solving strategies.

Pretest and posttest scores were analyzed using statistical tests to see significant changes in students' problem-solving abilities. Data were calculated using the SPSS program, with t-test calculations for paired samples (paired sample t-test) to compare the differences in average pretest and posttest scores.

**TABLE 1.**
**PRETEST AND POSTTEST ANALYSIS RESULTS**

| Ffgtri86 | Statistic | df | Say. |
|---|---|---|---|
| Ies Experiments | .116 | 23 | .200* |
| Experiment Posttest | .113 | 23 | .200* |
| Control Pretest | .145 | 22 | .200* |
| Control Stations | .128 | 22 | .200* |
| | | | |

The normality test results using Kolmogorov-Smirnov showed that the data in each group, both pretest and posttest, were normally distributed. These two significance values are greater than 0.05, indicating that the data in the experimental group meets the normality assumption. Likewise, in the control group, the statistical value for the pretest was 0.145, and the posttest was 0.128, with a significance value of 0.200. This shows that the pretest and posttest data in the control group are also normally distributed. Thus, the normality assumption is met for the entire data group.

**TABLE 2.**
**RESULTS OF THE EQUALITY OF VARIANCES TEST**

| | | F | Say. |
|---|---|---|---|
| quatt | Equal variances assumed | .094 | .761 |
| | Equal variances are not assumed. | | |

The results of Levene's test to test the equality of variances (Levene's Test for Equality of Variances) show that the F value is 0.094 with a significance value of 0.761. Since the significance value is more significant than 0.05, it can be concluded that there is no significant difference in variance between the two groups. Thus, the assumption of equality of variances is met, and subsequent analyses can use methods that assume equal variances between groups.

The results of interviews with participants regarding using Scratch media in mathematics learning show that most students feel that Scratch is a very effective and exciting tool. They appreciate how Scratch's interactive and visual features make it easier to understand math concepts through projects they design themselves. With Scratch, students can be creative in making projects relevant to mathematics, such as games or simulations, which makes the learning process more fun and practical. Students felt that the ability to see immediate results from the code they created helped clarify the math concepts being taught and increased their motivation and engagement in the lesson.

However, some students report challenges when using Scratch, such as difficulty understanding more complex code or starting a project from Scratch. They also noted that some mathematical concepts were more accessible to translate with adequate guidance into the Scratch projects they created. Despite this, students generally feel that the benefits of using Scratch, including improved problem-solving skills and understanding of mathematical concepts, far outweigh the challenges. They recommend that using Scratch in learning be improved and supported with more resources and guides to help overcome technical difficulties and maximize its benefits in mathematics learning.

### 3.2 Discussion

This research explores the effectiveness of using Scratch media in learning the concept of mathematical sequences and series and its impact on students' problem-solving abilities. The research process begins with introducing students to the basic concepts of sequences and series through Scratch-based learning, followed by an initial test to assess their understanding. Pretest results show variations in students' levels of understanding, essential for assessing basic abilities before learning interventions begin. During the learning process, students are introduced to the Scratch tool and allowed to develop their understanding by modifying simple programs that illustrate arithmetic concepts. In this context, Scratch aims to strengthen students' algorithmic thinking skills through activities that encourage them to break down problems into small steps that can be organized and implemented in the form of code blocks.

The final evaluation shows that most students can use Scratch well to visualize and solve problems related to sequences and series. Quantitative data from the pretest and posttest show that using Scratch positively impacts students' understanding of mathematical concepts, with results showing normality of data distribution and equality of variance between groups. The Kolmogorov-Smirnov and Levene's Test results show that the assumptions of normality and equality of variance are met, which supports the validity of further statistical analysis. The t-test for paired samples, which was carried out to compare the average pretest and posttest scores, indicated a significant increase in students' problem-solving abilities after the learning intervention.

From interviews with students, it was revealed that they felt Scratch was a very effective and exciting tool for learning mathematics. The interactive and visual features of Scratch help students understand math concepts in a more fun and practical way. However, some students faced challenges understanding more complex code and starting projects from Scratch, indicating a need for additional support. These difficulties highlight that although Scratch offers many benefits, additional guidance and resources are essential to overcome technical barriers and ensure that all students can exploit the full potential of this medium. By overcoming these challenges, integrating Scratch into mathematics learning can be more optimal and benefit students.

Overall, this research shows that using Scratch in mathematics learning is effective in improving concept understanding and strengthening students' problem-solving skills. This research recommends increased support and guidance for students to maximize the benefits of using Scratch and overcome challenges encountered during the learning process.

## IV. CONCLUSION

This research shows that using Scratch media in learning mathematical sequences and series significantly positively impacts students' understanding and motivation. The results of quantitative analysis from the pretest and posttest show a significant increase in students' problem-solving abilities after the learning intervention using Scratch. The data obtained showed normal distribution and equality of variances, supporting the validity of the statistical analysis. Interviews with students revealed that they found Scratch to be an effective and engaging tool, making them understand mathematical concepts more interactively; some students faced technical challenges in understanding complex code and starting projects, indicating a need for additional support.

To address this issue, it is recommended that there be an increase in the support and guidance available to students, such as in-depth tutorials and additional training sessions. The integration of Scratch in mathematics curricula should be expanded and supported by teacher training to maximize its effectiveness. In addition, teaching materials need to be evaluated and adjusted periodically to ensure their relevance and effectiveness. The development of more comprehensive guidance regarding the application of Scratch to various mathematical concepts is also essential. Further research is needed to explore the long-term impact of Scratch on learning and how individual factors influence student learning outcomes. By implementing these recommendations, Scratch can provide more significant and optimal mathematics learning benefits.

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