



Examining the Impact of Block-Based Visual Programming in Programming Education: A Systematic Review

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ABSTRACT

Learning programming requires creative, logical, and computational thinking skills, which are key for students to face the challenges of the 21st century. However, many learners find it difficult to learn programming due to the complexity of the syntax and structure of the program, which can reduce their motivation to learn. To address this, block-based Visual Programming Language (VPL) approaches, such as Scratch, are used to simplify programming concepts. VPL allows beginners to learn with an intuitive visual interface, reducing the need to memorize syntax and focusing more on understanding the basic logic of programming. This study conducted a systematic literature review (SLR) on studies that have examined the effectiveness of block-based programming learning in improving learning outcomes. This research involved searching articles from various databases with established inclusion and exclusion criteria. The results showed that the use of block-based programming could improve basic programming understanding, motivation, creativity, problem-solving skills, and self-efficacy of students in understanding programming concepts. This study concludes that the block-based programming approach has a positive impact on the development of students' computational skills holistically.

ARTICLE INFO

Article History:

Submitted/Received 12 Sep 2024

First Revised 19 Oct 2024

Accepted 28 Dec 2024

First Available online 29 Dec 2024

Publication Date 01 Mar 2025

Keyword:

Block-based programming,
Programming education,
Scratch,
Systematic literature review,
Visual programming language.

1. INTRODUCTION

Learning programming requires students to have the ability to be creative, solve problems, and think logically and also computationally. Therefore, students must have the ability in this programming, especially to face the challenges of the 21st century (Hu, 2024). However, learning this programming is judged by learners as something difficult and makes them less motivated to learn, due to the syntax and structure of the program that is too complicated (Özmen & Altun, 2014). The programming process is not only complex in terms of syntax, but also includes algorithm design, error detection, selection of the right data structure, problem domain complexity, and code maintenance (Sayginer & Tüzün, 2018). Therefore, programming languages for beginners should have a simple syntax, a structured way of writing, and easy-to-understand algorithm design explanations.

The idea to overcome the problem of abstract and complex syntactic language emerged, namely the idea of visualization in the form of a visual programming language (VPL). Learning basic programming for people who have never done programming/beginners, it will be easier to form the concept using intuitive, visual images so as not to be immediately burdened by the complexity of code syntax (Whitley & Blackwell, 2001). Block-Based Visual Programming provides a visual interface that facilitates users to manipulate program elements graphically. In addition, Block-Based Visual Programming allows users to understand mathematical logic and computer programming. Thus, computer programming can be understood easily and fun with an attractive appearance (Kurihara *et al.*, 2015).

Scratch is one of the most popular block-based visual programming languages (Batni *et al.*, 2025). Various other visual programming tools, such as Alice, MIT App Inventor, and Blockly have been developed to help beginners learn programming. This use of Block-Based Visual Programming offers programming learning that is easier to understand concepts, especially for beginners because it allows users to "write" by dragging and dropping graphic blocks to develop simple programs that, in turn, allow them to create games, interactive stories, or simulations (Sun *et al.*, 2024). The focal point of learning using Block-Based Visual Programming is semantics rather than syntax (Mladenovic *et al.*, 2018). In other words, code consisting of blocks of various shapes and colors reduces learners' efforts to remember code, pour their ideas into code, or memorize syntax (Weintrop & Wilensky, 2019). Indirectly, this invites people to learn programming by combining two worlds, namely games and programming. Using this way, beginners are motivated to learn programming because it's like playing puzzles.

In this study, we analyzed several literature from journal journals that have researched the use of Block-based programming in programming learning, and whether it is effective in producing student learning outcomes in programming.

2. METHODS

This study used the Systematic Literature Review (SLR) method. The keyword of this method was to search, review, and summarize findings related to the topic discussed (Santoso *et al.*, 2020). This research method was carried out by reviewing journals in a structured manner with predetermined steps. The first step in this Systematic Literature Review research is the Research Question (RQ). The question in this study was how the application of Visual Block Programming in programming learning affects the effectiveness of learning and student learning outcomes.

The second step was the search process. In this stage, the search process was carried out to obtain data that matches the research question. The search process was carried out with

the help of the software Publish or Peris using Google Scholar, Crossref, and Scopus databases by searching for various articles about Visual Block Programming in 2020-2024. Then, the third step was the inclusion and exclusion criteria. This criterion was used to find whether the data obtained was by the SLR research or not.

The inclusions in this study were international articles on the research topic and articles published in 2020-2024. The exclusion in this study was the opposite, namely those that were not by the topic of this research. In addition, the title, abstract, content, and journal index were considered in the selected study process. The Quality of Studies process assessed articles based on the quality of the article and determined whether or not the article was in line with the research objectives. Then, the articles were synthesized to answer research questions in the research at the stage of synthesis results.

3. RESULTS AND DISCUSSION

Based on the stages of the SLR that have been carried out, articles that have been processed are obtained from 16 international and national articles obtained from the Google Scholar database. The research data is presented in **Table 1**.

Table 1. Research on the influence of visual block programming on programming learning on learning effectiveness and student learning outcomes.

Title	Author(s) and Year	Title Identify	Result
The effects of block-based visual and text-based programming training on students' achievement, logical thinking skills, and motivation	(Sayginer & Tüzün, 2023).	Journal of Computer-Assisted Learning	The results show that the use of <i>Block-Based Visual Programming</i> in programming training contributes positively to the development of students' logical thinking skills, and motivation to learn programming. On the contrary, there is evidence that this training makes no difference to programming success.
Exploring the effectiveness and moderators of block-based visual programming on student learning: A meta-analysis.	(Hu et al., 2021)	Journal of Educational Computing Research	The results of this study showed a significant small to moderate positive overall mean effect size (fixed effect model $g = 0.37$; random effect model $g = 0.47$) of the use of <i>this Block-Based Visual Programming programming tool</i> about the academic achievement of students. However, there are other things, that support the whole significantly, which are influenced by the stage of education, the programming tools used, the treatment of experiments, and the location of the school. Discussions and implications based on the findings are provided.

Table 1 (continue). Research on the influence of visual block programming on programming learning on learning effectiveness and student learning outcomes.

Title	Author(s) and Year	Title Identify	Result
Can computational thinking be improved by using a methodology based on metaphors and scratch to teach computer programming to children?	(Pérez-Marín <i>et al.</i> , 2020)	Computers in Human Behavior	The results showed that the use of metaphors and Scratch was useful for teaching computer programming concepts to Basic Education students, and for improving students' CT, which was evidenced by longitudinal pre- and post-test quasi-experiments that gave positive answers.
Impact of used programming language for K-12 students' understanding of the loop concept.	(Mladenović <i>et al.</i> , 2020)	International Journal of Technology Enhanced Learning	The results of the study showed that students obtained higher scores when using the Scratch programming language, which is <i>Block-based programming</i> . This is evidenced by the fact that students obtained higher scores when using Scratch compared to the pre-test, while students who programmed in Logo and Python obtained lower results compared to the pre-test.
Project-based programming learning to develop children's computational thinking skills.	(Nurhopipah <i>et al.</i> , 2021)	Jurnal Pengabdian Kepada Masyarakat.	The results of the study showed that the increase in the knowledge aspect of participants reached 22.83% and the increase in the interest aspect of participants by 8%. The assessment of the participants' enthusiasm of 88% indicates that the participants like and enjoy the learning process and shows that the activity has gone well and satisfactorily.
Application of Differentiated Integrated ADLX-Based Learning to Improve Learners' Learning Outcomes of Scratch Programming Algorithms.	(Kusumawati & Lestari, 2024).	PTK: Jurnal Tindakan Kelas	The results of the study show that the average learning outcomes of algorithms and programming of students increased from 71.88 (pre-cycle) to 82.76 (cycle 1) and 86.16 (cycle 2). This means, with <i>Block-Based Visual Programming</i> , students' learning outcomes in programming increase

Table 1 (continue). Research on the influence of visual block programming on programming learning on learning effectiveness and student learning outcomes.

Title	Author(s) and Year	Title Identify	Result
Coding Training Using Scratch for Students of SD Negeri 100 Central Maluku.	(Hehanussa <i>et al.</i> , 2023)	Pattimura Mengabdi : Jurnal Pengabdian Kepada Masyarakat	The results of the study show that coding training using Scratch, which is <i>Block-Based Visual Programming</i> , is effective in improving students' understanding of programming concepts and their ability to create interactive projects using Scratch. In addition, this training also improves the critical thinking skills, creativity, and cooperation of students.
The implementation of game applications using Scratch in improving learning outcomes and learning motivation of students.	(Hardiansyah <i>et al.</i> , 2023)	J-ABDI: Jurnal Pengabdian kepada Masyarakat	The results of the study show that the use of the Scratch application, which is <i>Block-Based Visual Programming</i> , can improve learning outcomes and student motivation. This is shown by the percentage of completeness of student learning outcomes of 25.7% in pre-cycle, 71.4% in cycle 1, and 94.3% in cycle 2. Meanwhile, the percentage of student motivation was 40.3% in pre-cycle, 75.1% in cycle 1, and 83.9% in cycle 2.
The Effect of Scratch Programming Language on Informatics Subjects to Improve Self-Efficacy of Grade VIII Students at SMP 8 Padang.	(Azaharani <i>et al.</i> , 2024)	Indo-MathEdu Intellectuals Journal	The results of the study show that learning programming algorithm material with scratch programming language can have a significant effect on the <i>self-efficacy</i> of students in the informatics subject of grade VIII SMP 8 Padang. With a significance value of 0.001. This means a significant t-value ($p = 0.001 < 0.005$). In the N-gain test, it was known that the rate of change in the self-efficacy score in the experimental class experienced a score change of 0.54, including in the medium category.

Table 1 (continue). Research on the influence of visual block programming on programming learning on learning effectiveness and student learning outcomes.

Title	Author(s) and Year	Title Identify	Result
Introduction to Programming Basics with Scratch for Elementary School Children at Sanggar Keadilan SMH-Indonesia.	(Wayahdi & Ruziq, 2024)	JIPITI: Jurnal Pengabdian kepada Masyarakat, 1(2), 1-7.	The results of the study showed that based on the results of formative and summative assessments, it was known that there was an increase in basic programming knowledge and skills in children at the SMHIndonesia Justice Center. Children are able to understand the basic concepts of programming, use Scratch which is <i>Block-Based Visual Programming</i> to create animations, games, and interactive stories, and complete programming projects independently.
Introduction to Programming Algorithms Using Scratch Applications for SD 13 Mataram Students.	(Zubaidi et al., 2021)	Jurnal Begawe Teknologi Informasi (JBegaTI)	The results of the study showed that the questionnaire showed that there was an increase in students' knowledge from before and after this activity was carried out. Of the 15 students, all of them did not understand algorithms and programming before the activity and increased by 80% after the activity.
A Comparative Study of the Use of Scratch Applications and Blockly Applications in Informatics Subjects for Students of SD Islam Al-Azhar 32 Padang.	(Sukri et al., 2024)	Indo-MathEdu Intellectuals Journal.	The results of the study show that learning programming language material with scratch applications can have a significant effect on students' Informatics learning outcomes.
Introduction to Programming Using Scratch for Students of Mizan School and Orphanage-Depok City.	(Irmanda et al., 2022).	ABDIKOM: Jurnal Ilmu Komputer, 1(1).	The results of the study showed that the average pretest score was 58.6, and the average posted score was 96.6, so an N-gain of 89.3 was obtained. The N-gain value obtained is classified into a high category which means that there is an increase in understanding in the introduction of Programming using Scratch which is <i>Block-Based Visual Programming</i> for Students of Mizan School and Orphanage - Depok City.

Table 1 (continue). Research on the influence of visual block programming on programming learning on learning effectiveness and student learning outcomes.

Title	Author(s) and Year	Title Identify	Result
Development of computational thinking through basic programming with MIT App Inventor.	(Santoso <i>et al.</i> , 2020)	Jurnal Pengabdian Masyarakat	The results of the research showed with a questionnaire that 50% of the participants strongly agreed and agreed that this activity improved their programming and computational thinking skills. Meanwhile, 25% of participants felt neutral and another 25% disagreed.
Coding training as an effort to improve students' computational thinking.	(Darmayanti <i>et al.</i> , 2023)	SELAPARANG: Jurnal Pengabdian Masyarakat Berkemajuan, 7(2), 833-838.	The results of the study show that MIT App Inventor, which is <i>Block-Based Visual Programming</i> , is quite helpful for students in solving the problem of making program blocks, and makes it easier for students to understand coding because of its nature that has provided small program fragments which students only complete by learning to reason.

The results of several articles show that the use of Block-Based Visual Programming, especially with platforms such as Scratch, plays a significant role in improving students' understanding and motivation to learn at various levels of education. The use of Block-Based Visual Programming was able to improve students' logical thinking skills and motivation in learning programming, although there was no significant difference in overall achievement (Saygıner and Tüzün, 2023). Block-Based Visual Programming showed a moderately positive effect on students' academic performance, which was influenced by factors such as education stage and programming tools used (Hu *et al.*, 2021). In addition, research (Pérez-Marín *et al.*, 2020) showed that the use of Scratch with a metaphor-based approach has proven to be effective in teaching basic programming concepts to Basic Education students, which also has a positive impact on improving their computational thinking skills. Another study by Mladenović *et al.* (2020) showed that learners who used Scratch had a better understanding of the concept of loops in programming compared to learners who used other programming languages such as Logo and Python. This indicates that a block-based visual approach can support the understanding of certain programming concepts more effectively compared to text-based programming languages.

Research in the context of education in Indonesia also underscores the importance of visual-based programming in improving student motivation and learning outcomes. The game-based learning approach with Scratch can increase students' understanding and interest in learning programming. This is reinforced by the other research (Hardiansyah *et al.*, 2023) which noted a significant increase in learning outcomes and student motivation after using Scratch in learning. With the percentage of completeness of learning outcomes continuing to increase from pre-cycle to subsequent cycles, Scratch has proven to make a positive contribution in deepening the understanding of algorithms and programming among students.

The research results from the various articles above underline that Block-Based Visual Programming, especially with Scratch, is not only beneficial for improving basic programming skills, but also contributes to building students' learning motivation, creativity, and critical thinking skills at various levels.

4. CONCLUSION

Overall, based on the results of the literature analysis, the block-based programming approach not only improves academic achievement but also supports the development of computational skills and motivation of students holistically. The disadvantage of this study is that it does not examine the whole such as previous programming learning experience, existing programming knowledge, types of learning strategies, and also block-based visual programming tools used. For example, learning strategies are considered essential for effective learning with block-based visual programming tools. This visual programming learning connects two environments, namely the game or visual environment and the regular programming environment which is more often focused on coding. Often, learners have difficulty transferring programming concepts between these two environments and focus more on the rules of writing code than on understanding the basic programming concepts that should be applied in both environments. We believe that the right teaching approach or learning strategy will also affect programming learning outcomes, a teacher can help students to transfer programming concepts from one environment to another more easily.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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