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A Review: The Impact of Micro: Bit-Assisted STEM Education

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Abstract. BBC micro:bit is seen to enhance students' creativity especially in solving interdisciplinary problems such as STEM Education. However, there is limited literature that examines the effect of BBC micro:bit-assisted STEM learning. Thus, this study seeks to present a review of the characteristics of micro:bit-assisted STEM research, the effect of micro:bit-assisted STEM learning on student learning outcomes, and opportunities for micro:bit-assisted STEM research. This study reviews empirical research results from 12 papers published over the past five years. The papers are generally from Scopus and web of science indexed journals. Apparently, a lot of micro:bit-assisted STEM education research was conducted in 2022. The respondents came from primary school, secondary school, elementary school, and teachers. BBC micro:bit is implemented in STEM, STEAM, informatics, robotics, and technology learning content. Micro:bit-assisted STEM learning can improve students' 21st-century skills, attitudes, and knowledge that are meaningful to themselves and the environment. In addition, there are many opportunities to develop micro:bit-assisted STEM learning strategies such as looking at the performance of male and female students after solving problems with micro:bit.

Keywords: Micro: bit, STEM, Micro: bit-assisted STEM

INTRODUCTION

BBC micro:bit is a pocket-sized computer operated with coded programs mainly using the block coding system or Micropython (see figure 1)(Fojtík et al., 2023; Voštinár & Knežník, 2020). Micro:bit is part of the BBC which was created in 2014 in collaboration with 29 expert companies and institutions such as Microsoft, Lenovo Foundation, Nominet, and others (Cheng et al., 2021). Since 2016, micro:bit has been distributed to 11-12-year-old students in the UK. The Micro:bit is cost-effective, online coding, and requires no installation, allowing projects to be simple or complex through advanced code and periphery units (Digranes et al., 2021; Videnovik et al., 2018). Micro:bit was developed to enhance the digital skills of youth. Micro:bit supports STEM education, especially for primary and secondary school students. Diversifying students who choose STEM subjects as they progress in school and in their careers is the goal of micro:bit. An estimated 44 million young people from 60 countries have benefited from learning with micro:bit. Micro:bit is a great help for young people in mastering digital skills especially those who want to pursue a career in STEM.

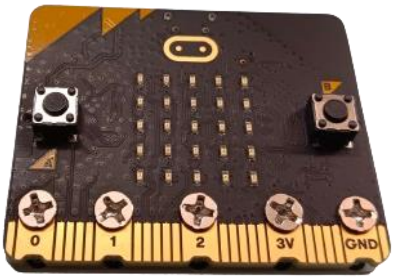

Figure 1. Micro:bit display

Teachers and students in England have widely recognized that micro:bit has a positive impact on students. There are several reasons England chooses micro:bit for learning, namely: student motivation is increased even for students who come from different backgrounds (Krnac et al., 2020). When creating projects with micro:bits there is often cooperation between equipment and nature (Krnac et al., 2020). Various complex and challenging tasks can train students to work together in teams naturally. Another advantage is to train students to solve STEM interdisciplinary problems. Many students recognize that micro:bit is useful for solving programming problems and creating real-world classifications (Krnac et al., 2020). In addition, students can also make connections between devices and STEM fields (Krnac et al., 2020). Therefore, micro:bit encourages students to think more complexly in solving problems.

Micro:bit supports STEM learning, especially science. STEM learning incorporates physical computing applications, microcontroller boards, digital components, sensors, motors, and other technological tools to encourage active learning of STEM topics through individual and group projects (Garcia-Ruiz et al., 2021). Previous research has reviewed the effect of micro:bit on student learning outcomes. Students and teachers had favorable attitudes towards micro:bit, showed enthusiasm, and found it interesting. Students think it encourages creativity and can help them understand conceptual and procedural knowledge related to computational thinking and problem-solving (Kalogiannakis et al., 2021). However, the research has not focused on STEM fields. Another similar study identified several challenges associated with the use of Micro:bit in science education, such as the lack of teacher training and support, limited access to technology, and the need for further research into its effectiveness (Quyen et al., 2023). However, these studies have not provided an overview of the influence of micro:bit on student performance and only focus on the field of science. Therefore, it is interesting to review the literature on the effect of BBC micro:bit-assisted STEM education. Hopefully, future teachers and researchers will be able to develop effective interdisciplinary learning strategies that suit the needs of students.

RESEARCH OBJECTIVES

1. What are the characteristics of micro:bit-assisted STEM research?
2. How does micro:bit-assisted STEM affect student learning outcomes?
3. What are the opportunities of micro:bit-assisted STEM research for future studies?

METHODOLOGY

To assess the current use of BBC micro:bit in STEM education, we conducted a systematic review from 2020 to 2024. The first database source was the Researchrabbit website with the keywords micro:bit, STEM, and education with a total of 2 papers search results. The second source, namely a search via Google Scholar using the keywords micro:bit and STEM, obtained 1,400 search results. The criteria for accepted papers are English language, full paper available, empirical research, and The studies should be in the field of STEM education with the support of micro:bit. The study steps are deleting duplicate papers, reading the title and abstract deleting papers that do not meet the criteria, reading the full paper, and deleting papers that do not meet the criteria. Finally, there were 12 papers that met the criteria for review that had been published over the last five years. These papers generally came from Scopus-indexed journals (n = 8 papers), Web of Science (n = 3 papers), and non-indexed journals (n = 1 paper). Detailed information about the papers analyzed can be found in Appendix 2 including the country of origin of the first author and journal index.

RESULTS AND DISCUSSION

Characteristics of micro:bit studies

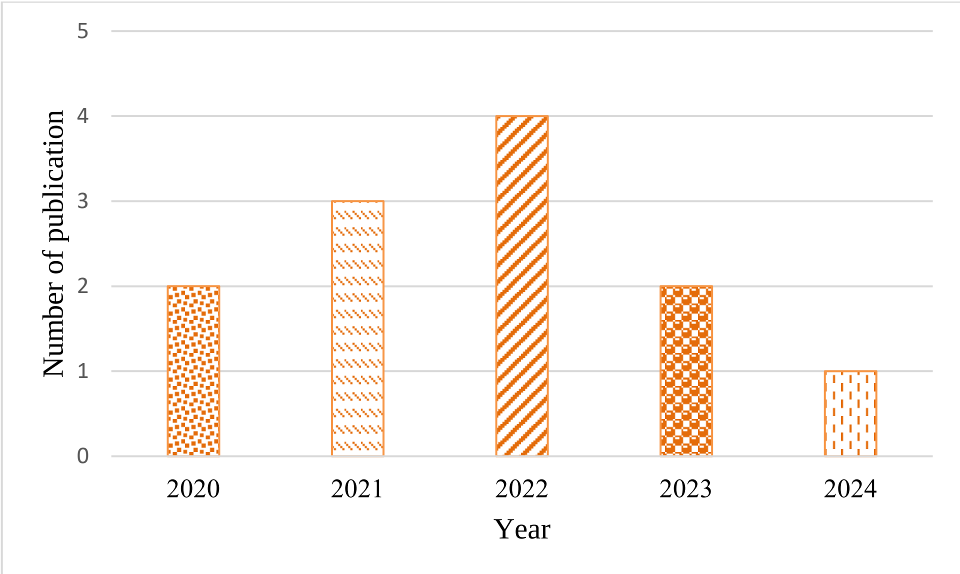

Figure 2. Existence of literature on micro:bit research, spanning the last five years

Science learning assisted by micro:bit has appeared since 2020. Based on Figure 2, the most research on the application of micro:bit in learning was carried out in 2022, namely 4 publications. From 2021 to 2022, research on micro:bit increases and decreases again in 2023. In 2020-2021 and 2023-2024 research on micro:bit is quite stable.

Table 1. Characteristics of Micro:bit assisted STEM Learning

First Author	Education level	Sample	Instructional strategy	Education content	Data Analysis
(Minić & Deretić, 2023)	Primary school	28 (students)	Not mentioned	Technique and Technology	Descriptive statistics
(Kalelioglu & Sentance, 2020)	Not mentioned	50 (teachers)	Not mentioned	Computing	Quantitative data using IBM SPSS Statistics 24 and quantitative data using coding
(Lu et al., 2022)	Primary school	3 (students)	PBL-oriented STEAM	STEAM Subjects	Not mentioned
(Cederqvist, 2022b)	Primary and high school	14 (students)	Paper tutorial	Programmed technological solutions (PTS)	Coding and analysis in a systematic way

Table 2 (Cont')

First Author	Education level	Sample	Instructional strategy	Education content	Data Analysis
(Cederqvist, 2022a)	Primary and high school	14 (students)	Paper tutorial	Programmed technological solutions (PTS)	Analysed by taking the phenomenographic approach
(Shahin et al., 2022)	Secondary school girls	203 (students), 31 (mentors)	Workshop	Women in STEM and Entrepreneurship (WISE) program	SPSS Statistics 26 software and coding by NVIVO
(Kvaššayová et al., 2022)	Informatics in-service teachers	388 students	Online webinar, Online course	Informatics	KMO and Bartlett's Test
(Kelly & Seeling, 2020)	High school	41 students	Hands-on exercises	STEM related disciplines, with Computer Science and Software Engineering	ANOVA
(Cheng et al., 2021)	Elementary school	22 students	Not mentioned	STEAM	Wilcoxon signed rank test and correlation test
(Fojtík et al., 2023)	Lower-secondary school	121 (students) & 2 (teachers)	Not mentioned	STEM Activities	Transcribed and analysed using grounded theory
(Campina López et al., 2024)	secondary school	26 (students)	A teaching-learning sequence based on inquiry, modelling, and computational thinking	STEM Context	Not mentioned
(Tan et al., 2021)	Secondary students	22 (students)	Not mentioned	Robotics, technology, science	Triangulation EDA (electrodermal activity) data analysis

Micro:bit-assisted STEM learning has been researched with various specific elements as shown in Table 1. Micro:bit has been applied at primary and secondary school levels with samples of 3 to 388 students. The micro:bit-assisted STEM studies involved students, teachers, and mentors. The learning strategies used include problem-based learning-oriented STEAM, paper tutorials, workshops, online webinars, online courses, hands-on exercises, and teaching-learning sequences based on inquiry, modeling, and computational thinking. Micro:bit-assisted STEM learning was implemented in the subjects of engineering and technology, computers, STEAM, STEM activities, programmed technological solutions (PTS), the Women in STEM and Entrepreneurship (WISE) program, Robotics, and informatics.

Data analysis is divided into two, namely qualitative data and quantitative data. Most quantitative data was analyzed using SPSS software, while qualitative data was analyzed using coding. More detailed characteristics of research in the STEM field using micro:bit can be found in Appendix 1.

Impact of Micro:bit on pupils

Previous research has examined the effect of micro: bits on learning, especially STEM-integrated science learning. The results showed an influence on students' knowledge, attitudes, and skills. The purpose of applying micro: bit in STEM learning is to increase students' knowledge and experience (Kelly & Seeling, 2020; Lu et al., 2022), for example, to encourage students' understanding of concepts (Campina López et al., 2024). Voštinár & Knežník (2020) found that students liked the lessons they worked on with BBC micro:bit and considered this work to be interesting and meaningful. Because the device promotes critical thinking and coding abilities among students by allowing them to program it themselves (Mersinllari & Papajorgji, 2022).

Micro:bit-assisted science learning has a positive impact on student performance in engineering and technology subjects (Minić & Deretić, 2023). The implementation of micro:bit-assisted STEAM curriculum improves disability creativity competence (Lu et al., 2022). In addition, the application of micro:bits is expected to assist students in solving real-world problems (Cederqvist, 2022a, 2022b; Shahin et al., 2022). STEM learning activities using micro:bit improve students' proportional reasoning, probabilistic reasoning, and ability to analyze a problem (Cheng et al., 2021). Micro:bit lessons with OGS significantly improve students' reasoning abilities. Because students are encouraged to solve problems by redesigning programming strategies or changing hardware when encountering difficulties (Cheng et al., 2021). It can be concluded that micro:bit can provide a complex science learning experience.

One example of implementing micro:bit to practice real-world problem solving skills is seen in Figure 3 and Figure 4 (Cederqvist, 2022b). A pair of students wanted to use a light sensor to detect differences in light levels if a cupboard door is open, which would activate a speaker to produce sound. To solve the problem, they discuss while arranging the appropriate blocks. With micro:bit, they can easily test whether the block works or not by connecting the micro:bit component to a computer/laptop. For example, students succeeded in uniting the IF/THEN block and connecting the other blocks with real world conditions. This learning is very interesting and challenging for students because what they have designed may have parts that need to be replaced or added. This really helps them in solving real world problems.

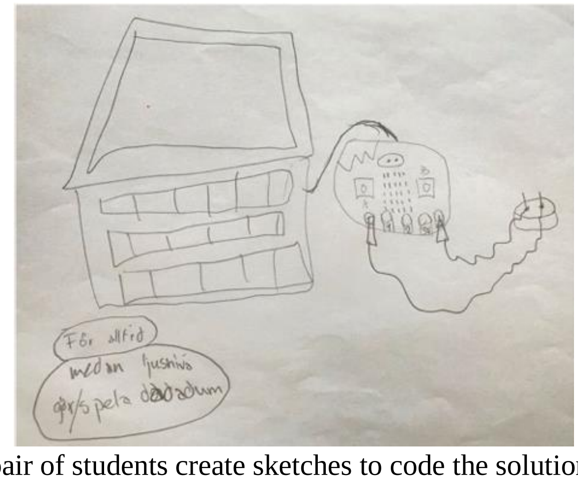

Figure 3. A pair of students create sketches to code the solution (Cederqvist, 2022b)

Figure 4. A pair of students start arranging blocks to find the right solution (Cederqvist, 2022b)

Micro:bit-assisted learning also influences students' positive attitudes. For example, research by Kvaššayová et al. (2022) revealed that the micro:bit has a positive impact on self-efficacy for instructional strategies. Science learning by applying micro:bit can increase positive attitudes toward computer science (Kelly & Seeling, 2020). Students become more sensitive to environmental problems and try to find solutions.

Future research opportunities

Research opportunities regarding micro:bit-based STEM learning are still quite extensive. Several recommendations presented by previous research to support the development of subsequent studies:

1. A comprehensive evaluation is warranted to assess the efficacy of integrating the micro:bit across educational levels, encompassing both teacher and student proficiency (Minić & Deretić, 2023).
2. Delve deeper into specific case studies to examine teachers' utilization of the micro:bit in teaching, analyzing their pedagogical approaches, and empirically studying its impact on programming comprehension. Additionally, investigate preferred learning modalities in physical programming (Kalelioglu & Sentance, 2020).
3. Explore the advantages and limitations of various programming materials for teaching content related to Programming, Technology, and Society (PTS) in design activities (Cederqvist, 2022b).
4. Investigate the procedural evolution of designing PTS using programming tools like the BBC Micro:bit, assessing its facilitative and constraining factors on digital and technological literacy (Cederqvist, 2022a).
5. Conduct similar research utilizing alternative technologies to the BBC Micro:bit within the same demographic, enriching insights with microteaching analysis of the teaching process (Kvaššayová et al., 2022).
6. Examine gender disparities in online STEM courses, given previous findings suggesting differing interests between male and female students. Notably, post-Micro:bit course, there appears to be an increased interest in coding among girls (Cheng et al., 2021; Berweger et al., 2014; Videnovik et al., 2018).

Micro:bit-supported STEM education presents significant opportunities, particularly in Asian contexts. Initiatives should prioritize training for STEM educators to effectively integrate the micro:bit into their teaching methodologies.

CONCLUSION AND IMPLICATIONS

This study reviews previous research on the influence of micro:bit in STEM learning. The number of articles that met the criteria was 12 articles, which generally came from Scopus-indexed journals. Over the last five years, micro:bit has been studied in 2022, with 4 papers. Most micro:bits are trained in STEM learning content including technology, informatics, and STEAM programs. Micro:bit has been widely used at secondary and primary school levels. STEM learning using micro:bit can significantly improve students' knowledge, attitude, and skills. Future research opportunities include a study of teachers' trends in designing STEM learning using micro:bit. In addition, future research can examine the differences in the performance of female and male students in micro:bit-assisted STEM learning.

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