

Micro: bit in Science Education: A Systematic Review

(Received 21 March 2023; Revised 31 May 2023; Accepted 31 May 2023)

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DOI: 10.30870/jppi.v9i1.19491

Abstract

Micro: bit was officially released in 2016 and it was used by over one million students in the UK and its use in schools became a part of the curriculum. After being successfully deployed in the UK, Micro: bit was transferred and applied in many countries around the world. This article will present a systematic review on the use of Micro: bit in science education. Micro: bit is a small, programmable device that is gaining popularity in classrooms around the world due to its affordability, ease of use, and versatility. The systematic review aimed to identify the current state of the field, explored the ways in which Micro: bit is being used in science education and identified gaps in the literature. The systematic review included 37 studies that were published between 2012 and 2023. The results show that Micro: bit is being used in a variety of science education contexts, including physics, chemistry, biology, and environmental science. The studies identified several benefits of using Micro: bit in science education, such as improving students' programming and computational thinking skills, enhancing their understanding of scientific concepts, and increasing their motivation and engagement. Moreover, the systematic review also identified several challenges associated with using Micro: bit in science education, such as a lack of teacher training and support, limited access to technology, and the need for more research on its effectiveness. The systematic review concludes with recommendations for future research and implications for practice. Overall, this systematic review highlights the potential of Micro: bit to enhance science education and encourages further exploration of its use.

Keywords: Micro: bit, Science Education, Systematic Review, STEM Education

INTRODUCTION

The Micro: bit is a small, programmable device designed for use in education, particularly in teaching programming and electronics. It was developed by the British Broadcasting Corporation (BBC) and its partners in 2015 as part of a larger initiative to improve computer science education in the UK. Then, it has gained popularity and has been adopted in various parts of the world.

It is a computer that includes sensors for motion, compass, temperature, light, sound, a 5x5 LED matrix display, and Bluetooth to connect to computers, iPads, or smartphones. The programming environment for Micro: bit is modern and diverse, allowing students to program offline with the software on a computer and online or on mobile platforms like smartphones and tablets. Programming languages for Micro: bit range from basic drag-and-drop MakeCode to advanced languages like JavaScript, C, C++, or Python.

According to Dragana (2017), this device is designed to help students aged 8 to 13 become familiar with algorithmic thinking, science, especially coding, programming, games, and robots. Therefore, students can create their own specific content, stimulate creativity (Stanojević, 2017).

Following a year of implementation in the UK, (Gibson, 2017) conducted research to investigate the perceptions of students at two primary schools in Northern Ireland who used Micro: bit. The findings indicated that nearly all students found the Micro: bit easy, interesting, and useful for programming and problem-solving. Furthermore, students demonstrated great enthusiasm for using Micro: bit and expressed a desire to use it more frequently, both in and out of school.

After being implemented in the UK, Micro: bit has been adopted and utilized in many countries worldwide for educational purposes, helping in developing students' abilities in various subjects. However, as it is a new and highly integrated teaching tool, there are numerous challenges to its implementation process. Conducting an overall assessment of the use of Micro: bit in education could provide guidance for further research on its applications. This article aims to address the following research question: What is the current state of Micro: bit's use in science education?

METHOD

The research utilized a theoretical research method. A systematic review was conducted by using two databases: ERIC and Google Scholar. The databases were searched using three

different keyword combinations: "Micro:bit" + "science education" + "Students" or "pupils" for articles published within the last 10 years (2012-2023). A total of 521 articles appeared in journals, magazines, books, etc. were found, with 148 from ERIC and 373 from Google Scholar. The document screening process is depicted by the Prisma diagram in Figure 1.

The search results with duplicate articles were excluded, resulting in a

reduction of the dataset using three criteria. Firstly, all selected articles had to be journal articles, peer-reviewed conference proceedings, or book chapters written in English, which eliminated 94 articles written in other languages, as well as theses and dissertations. Secondly, the articles had to focus on the use of Micro: bit in teaching and learning. As the target population was elementary school students, middle school students, and

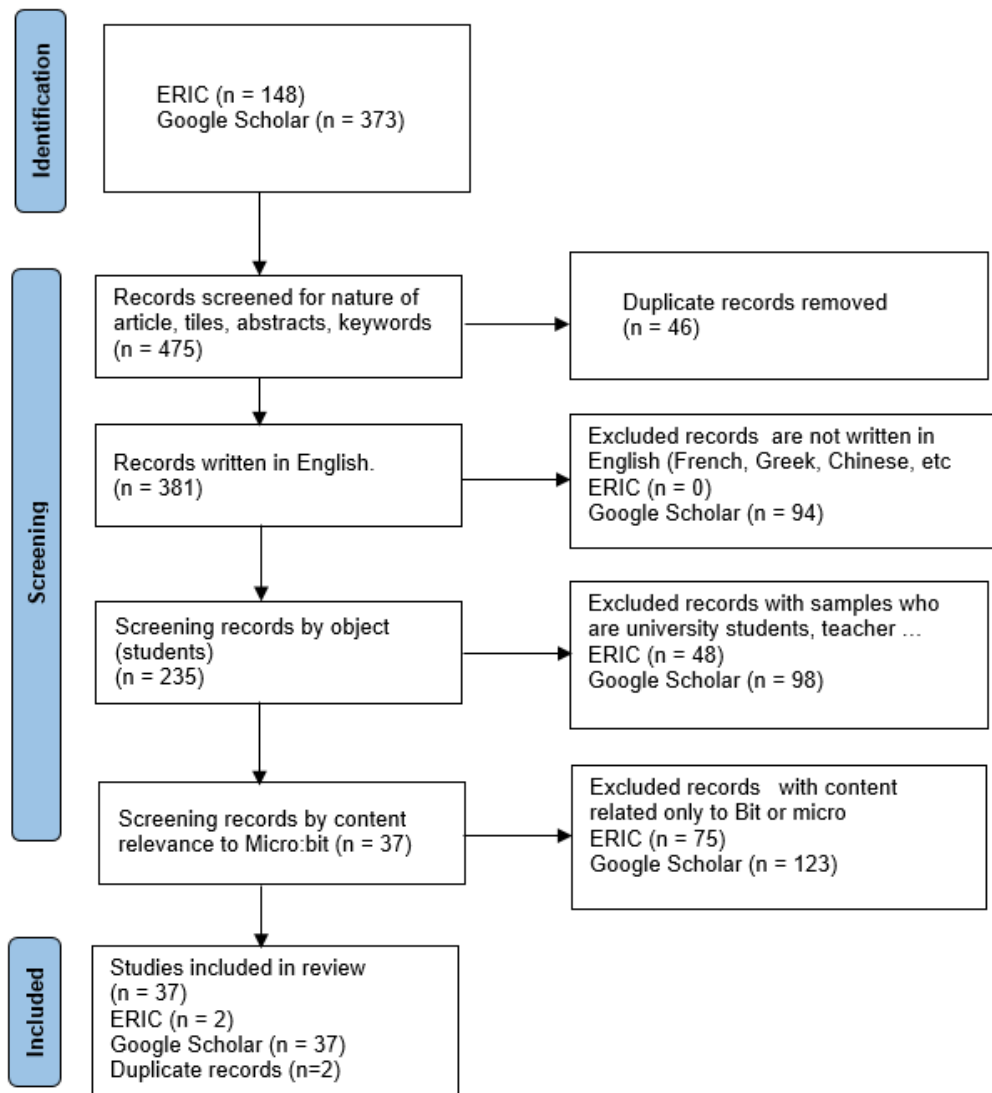


Figure 1. Prisma diagram for systematic review of studies on Micro: bit in education

high school students, 146 articles with target populations of university students, teachers, and administrators were excluded. Finally, 198 research articles on the use of Micro: bit in games, basic information technology (BIT), and education without the use of Micro: bit was excluded. One expert in science education checked whether the articles met the criteria, and in cases of doubt, the articles were discussed with another evaluator until a consensus was reached. After applying the criteria, only 37 articles met all the criteria.

RESULTS AND DISCUSSION

Micro: bit in teaching different subjects

The combined results of 37 studies mentioned above show that Micro: bit is mainly used in computer science accounting for 45% and STEM accounting for 20%. Some studies have also used Micro: bit in other subjects such as technology education, robotics, math, and physics (Figure 2).

As soon as Micro: bit was introduced in teaching computer science, Schmidt (2016) noted that computer science needed to be integrated into the curriculum, leading to an improvement in the ability to read and write computer concepts. Micro: bit increases computer literacy. Micro: bit encourages students to create their own products, something that has not been built before, to stimulate interest and attention (Schmidt, 2016). In

2022, Cederqvist's independent research tracked the development of Micro: bit in the UK during its early years of deployment and found that 85% of teachers using the device agreed that it made computer science more interesting for their students, and 90% of students reported that using it helped them see that anyone can do computer programming. Micro: bit provides an opportunity for students to develop their understanding of technological solutions and thus improve their design and programming skills (Cederqvist, 2022). Meulen also points out that Micro: bit is an effective assistive device for children with visual impairments to program (Meulen, 2022).

For technology education Cheng (2021) noted that integrating Micro: bit into science classes in middle schools attracted students better. Micro: bit is intended as a tool to engage all students in exploring computational science, undertaking interdisciplinary projects in science teaching and learning (Cheng, 2021). Some teachers in Serbia have had the opportunity to familiarize themselves with and incorporate Micro: bit into teaching, which has helped students try programming in Microsoft Block Editor.

Another benefit of this minicomputer is learning the basics of

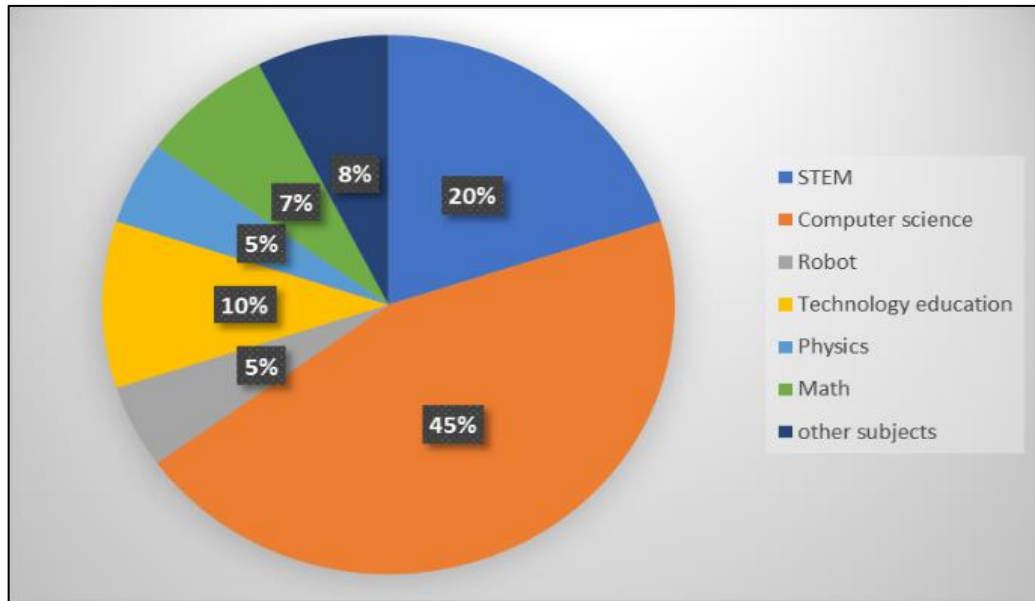


Figure 2. Micro: bit in teaching different subjects

robotics. Using Micro: bit and similar tools in working with students creates an atmosphere for new technologies. The simplicity of the minicomputer allows students to become familiar with various career challenges, which can help them choose future careers (Stanojević, 2017).

Micro: bit is suitable for integrated interdisciplinary teaching, especially with STEM subjects such as science, math, and technology. According to Milić (2018), even without owning a Micro: bit controller, the web browser is programmed with a Micro: bit emulator, so it can check your code at any time. Various peripheral sensors allow students and teachers to imagine and use them in many ways. Using Micro: bit makes it easy for every child to quickly learn basic programming skills, so that they can quickly create their own simple games, develop problem-solving skills,

and become interested in STEM (Milic, 2018).

According to Sentance (2017), some schools not only use Micro: bit in the STEM field but also in other subjects such as textiles and art. In the field of textiles, Micro: bit is programmed to light up and then sewn onto clothing. Research conducted by Sentance et al (2017) showed that Micro: bit is very easy for children to use and learn about STEAM (a comprehensive educational program developed based on a combination of science, technology, engineering, art, and math). As an example, the project-based learning initiative titled "Chinese Paper-Cutting Art Combined with Micro: bit" for elementary students focuses on developing students' creative thinking through the use of interactive lights with Micro: bit in paper cutting products.

According to (Lu, 2021), the experimental results demonstrated that project-based learning combined with STEAM activities had a significant positive impact on the development of students' creative recognition skills.

Therefore, Micro: bit is an exciting new teaching tool that has been successful in engaging and motivating students. Currently, it is mainly used in computer science and information technology subjects to help students learn and apply programming concepts. However, recent research has also shown promising results in using Micro: bit for teaching STEM and STEAM-related subjects. This indicates that integrating Micro: bit in other subjects such as natural sciences, math, physics, and more could also be effective in enhancing students' learning outcomes.

Impact on student learning

Some studies on Micro: bit devices have focused on promoting learners' enthusiasm and interest in computing and programming (Videnovik, 2018; Fessard, 2019; Schmid, 2022; etc). Sentence et al (2017) also noted that children enjoy using Micro: bit, often with a high level of enthusiasm or excitement, and emphasized that this device has been well-received even by students who are weaker, academically (Sentence, 2017). In Seanpaul Gibson's (2017) survey into Micro: bit use in Northern Ireland

primary schools, students cited several reasons why they wanted to use Micro: bit again, which is that Micro: bit is very interesting, challenging, and easy to program (Gibson, 2017).

Sentence et al (2017) interviewed students in the UK high school about their experiences with Micro: bit, and the results showed that not only were students very excited about the potential of Micro: bit, but also that the use of the device had created a creative environment for students. With the open nature of the device, programming can be done according to one's wishes, and it can be connected to external devices. Students can follow the teacher's or website's instructions step by step, and they can propose better activities. In case those student proposals are not accurate, students can try and make mistakes and come up with results for themselves, then they will propose new alternatives. It is an important creative thinking benefit that they have learned from their experience with Micro: bit. Also, in this study, Sentence affirmed that the emergence of Micro: bit has brought opportunities for teaching for teachers and learning for students. There are new and interesting activities to do in lessons, creating opportunities for teachers and students to be creative. Teachers can experience new ways of working that

they could not do before (Sentance, 2017).

In Cederqvist's (2022) study on Micro: bit usage by 4th and 8th grade students in Sweden, students were assigned a task to use Micro: bit to design and program a theft alert device. Students worked in pairs to analyze and sketch a design. To support programming, students had a website displaying different blocks that could be used in the Micro: bit editor. Furthermore, the students had to implement their design using code, test it, and present it to the class. The results showed that this activity provided an opportunity for students to develop skills in programming, problem-solving, and communication (Cederqvist, 2022).

Dermaku (2020) conducted research on the use of Micro: bit in three middle schools in the city of Kamenica in Kosovo. The results showed that using Micro: bit had a positive impact on students' critical thinking, creativity, and collaboration between students and teachers. Developing critical thinking and problem-solving skills requires the flexibility of teachers and a safe learning environment where students feel free to think, ask questions, explore, and work in groups without fear of making mistakes (Dermaku, 2020).

According to Lang (2021), for female students, stereotypes and cultural

factors have reduced enthusiasm and ability for women in computational thinking. Recently, computational thinking education programs have been designed to enhance women's interest, involvement, and participation in computer and technology fields (Lang, 2020). Shahin et al (2021) designed and implemented a computational thinking program specifically for female students (OzGirlsCT program), with one of the purposes being to explore the impact of the OzGirlsCT program on high school female students' computational thinking practice when they use Micro: bit. Feedback received from participating female students showed that OzGirlsCT was an inspiring, engaging, and helps reduce coding errors for female students (Shahin, 2021).

Therefore, the benefits of using Micro: bit in education are very clear. With the use of Micro: bit, students can enhance their computational thinking, learn more deeply, and develop problem-solving skills and collaboration (Milic, 2018). In addition, using Micro: bit in teaching has a positive impact on creativity, critical thinking, and the development of digital skills.

Although as indicated in the preceding sections of this paper, Micro: bit tends to yield positive outcomes and has had a profoundly positive impact on education in general and STEM

education in particular, numerous studies highlight various challenges associated with this program. According to Sentence (2017), the implementation of Micro: bit in the classroom, to some extent, depends on the teacher's knowledge and expertise. The exercises provided on the official website (<https://makecode.microbit.org>) at the time of related research provide detailed and accurate guidance. In addition to not allowing any independent learning activities, such activities can increase cognitive load because they require reading and processing instructions. In addition, students may not be able to explain their learning when they follow instructions that are too detailed (Sentence, 2017). A study on primary school students in Northern Ireland showed that students were overwhelmed by the amount of written information and found it difficult to follow instructions. Although the source material was quite difficult to understand due to the amount of information provided, students, mainly through their own efforts, did not take much time to understand how to program Micro: bit (Gibson, 2017).

Cederqvist's study found that for students, the most difficult part of using Micro: bit is creating code for control functions. In the study, students planned to design a theft alarm using feedback control based on analyzing conditions in

the real world by using changes in light levels or changes in motion. Therefore, they had to combine blocks to create a code that uses conditional statements to control how components interact and thus respond to the technological solution's function. Therefore, teachers need to help their students understand the physical structure and function of the technological solution, as well as the advantages of Micro: bit (Cederqvist, 2022). Nowadays, in problem-solving activities, including programming, students often use block programming to make the syntax easier. However, block programming still shows difficulties in understanding the concepts related to what blocks represent and how to use them when building code that includes variables, conditions, and loops (Grover, 2017).

Cheng et al (2021) identified a problem with integrating Micro: bit into a formal curriculum. Teachers may not have enough time to cover Micro: bit-related content as it may be a side topic in the curriculum. Besides, teachers may not have enough skills and knowledge to use Micro: bit effectively, leading to limited student engagement and low learning outcomes. Therefore, there is a need for teacher training programs to help teachers incorporate Micro: bit into the curriculum more efficiently (Cheng, 2021).

To successfully teach with Micro: bit, according to Milić (2018), some improvements need to be made, including: Designing and building a good project; Providing specific technical support; Providing support for teachers; Monitoring projects at all stages; A repository of supporting materials at all stages. When starting future projects, Milić suggests creating limited inputs and project tracking documents. In addition, teachers need to pay attention to managing students' time to complete tasks (Milic, 2018).

The aim of this paper was to assess the status of using Micro: bit in general education. Accordingly, as elaborated in this text, Micro: bit is a necessary educational tool in general education. Micro: bit has been proven to be an excellent motivational tool (Milic, 2018). It can be used in various subjects related to technology, computers, and science and in integrated lessons or clubs. The use of Micro: bit not only creates interest for students but also helps to develop computational skills, problem-solving abilities, creativity, numerical competence, critical thinking, and more.

CONCLUSION

Furthermore, the implementation of Micro: bit requires improvements such as good project design and construction, specific technical support, teacher support, project monitoring, and

supportive documentation at all stages. When starting future projects, it is recommended to create limited input and project tracking documents. Additionally, teachers need to pay attention to managing students' task completion time. In conclusion, Micro: bit is a powerful educational tool that can enhance students' learning outcomes and create a dynamic learning environment.

Considering the importance of Micro: Bit programme as articulated above, more research is needed in this under researched but very significance area of education. Accordingly, further research could explore the effectiveness of Micro:bit in different educational settings, such as in online learning or in classrooms with diverse student populations. It would also be interesting to investigate the long-term impact of using Micro:bit on students' interest and engagement in STEM fields, as well as their academic achievements. Additionally, future studies could explore the potential of integrating Micro:bit with other emerging technologies, such as virtual and augmented reality, to enhance students' learning experiences. Finally, more research could be conducted on how to effectively train and support teachers in implementing Micro: bit in their classrooms.

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