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RESEARCH ARTICLE

Hands-On STEAM Programming: Microteaching with Micro:bit for Enhanced Learning

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ABSTRACT

This study explores the application of microteaching as an effective pedagogical strategy for teaching sequencing structures in programming through STEAM (Science, Technology, Engineering, Arts, and Mathematics) activities. Leveraging the Micro:bit platform, the research integrates hands-on learning with transdisciplinary problem-solving to enhance conceptual understanding among elementary students. The study involved an action research methodology, engaging two sixth-grade students in constructing and programming a Christmas tree model using LEDs and the Micro:bit environment. The findings highlight the significant role of microteaching in fostering engagement and comprehension, as students transitioned from foundational programming knowledge in Scratch to more advanced applications involving hardware. Despite challenges such as time constraints and difficulties in knowledge transfer, the approach demonstrated measurable improvements in students' understanding of sequencing. These results underscore the potential of combining microteaching and STEAM methodologies to make abstract programming concepts accessible, engaging, and practical for young learners. Recommendations for future implementations include enhanced scaffolding, iterative learning opportunities, and extended session durations to address identified challenges and optimize outcomes.

KEYWORDS

STEAM education; microteaching; hands-on learning; micro:bit; programming

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1. INTRODUCTION

STEAM education represents an evolution of the STEM framework, emphasizing the integration of the Arts (including Visual Arts, Music, Theater, Dance, and Language Arts) into the transdisciplinary domains of Science, Technology, Engineering, and Mathematics [1]. This approach seeks to enhance learning by fostering creativity, innovation, and critical inquiry, effectively bridging technical disciplines with artistic expression [2]. Through this synthesis, STEAM aims to develop holistic problem-solving abilities and multidimensional thinking, preparing learners for the complexities of modern challenges [3]. The inclusion of the Arts in STEAM is not merely an additive process but a transformative one, as it introduces new ways of understanding, exploring, and solving problems. Artistic disciplines encourage imaginative thinking and the development of unique perspectives, which complement the analytical and logical skills emphasized in STEM fields [4]. This transdisciplinary synergy cultivates a more inclusive and diverse learning environment, enabling students to approach real-world issues as interconnected systems rather than isolated domains [5]. The implementation of STEAM education requires careful attention to several critical factors. These include the balanced integration of all STEAM domains, the creation of an inclusive and engaging educational environment, and a focus on fostering both creative and social competencies through authentic, problem-based learning experiences [6]. Furthermore, the establishment of rigorous frameworks for assessing both learning outcomes and the overall effectiveness of the educational environment is essential for ensuring the success of STEAM initiatives [7], [8].

Programming emerges as a fundamental component within STEAM education, acting as a bridge between theoretical understanding and practical application [9]. By embedding programming into learning activities, students develop computational thinking, enhance their ability to model and simulate complex systems, and engage in innovative solution design across all STEAM fields [10]. This capacity to integrate technological tools with creative processes underscores the transformative potential of STEAM education in preparing learners for the demands of an increasingly interconnected and dynamic world [11].

Programming, inherently abstract, challenges elementary school students who are still developing the cognitive abilities needed for tasks like sequencing, variables, and algorithms [12]. These concepts require logical reasoning and higher-order thinking, which are often underdeveloped at this age [13]. The shift from hands-on, concrete activities to abstract programming tasks adds complexity, as students must connect theoretical constructs to real-world or digital applications [14]. Sequencing, a core programming concept, exemplifies these challenges. It requires students to understand the logical order of commands and the cause-and-effect relationships that ensure functionality [15]. When multiple sequences must be integrated, the cognitive demands increase significantly [16]. Sequencing involves not just basic understanding but also the application and analysis of knowledge, skills that many elementary students are still developing [17]. Traditional programming instruction, focused on lectures and isolated exercises, fails to effectively engage younger students. These methods rarely connect theoretical concepts to practical applications, making programming feel abstract and inaccessible [18]. In contrast, hands-on, experiential learning is more effective, as both plugged and unplugged activities enhance understanding in the learning of sequencing, reverse sequencing, and debugging [19].

Microteaching offers a key advantage in the teaching of programming by providing personalized attention to students. It enables educators to create a focused learning environment where abstract concepts, such as sequencing, algorithms, and variables, can be broken down into manageable steps [20]. In small-group settings, educators can monitor individual progress, identify misconceptions, and adjust their instruction to meet each student's needs [21]. The intimate nature of microteaching also enables immediate feedback from both students and observers, such as peers or mentors. This feedback loop is critical for reflection, allowing educators to evaluate their teaching methods and make informed improvements [22]. Additionally, the supportive context of microteaching encourages experimentation with new strategies or tools before applying them in larger classroom settings [23]. Microteaching is particularly effective for teaching complex programming concepts, such as sequencing structures, to young learners [24]. Programming requires abstract reasoning and problem-solving, which can be challenging for elementary students. Its iterative format mirrors the programming process of testing, debugging, and refining, helping students build both technical skills and the resilience needed for problem-solving in programming [25], [26].

The Micro:bit is a compact, user-friendly microcontroller designed to introduce young learners to programming and electronics [27]. Its block-based programming environment, MakeCode, resembles Scratch, making it easier for elementary students to transition into coding while exploring hardware applications [28]. The Micro:bit's capabilities, such as controlling LEDs, playing music, and interacting with sensors, make it an excellent tool for STEAM-based learning [29]. The built-in components, such as LEDs, buttons, and sensors like a temperature sensor and accelerometer, enable students to participate in a wide range of creative projects [30]. Additionally, the MakeCode platform streamlines coding through its drag-and-drop functionality, lowering cognitive barriers and fostering exploration for beginners [31]. The device also supports real-time feedback through its built-in simulator, enabling students to test and refine their code virtually before applying it to hardware [32]. This promotes experimentation and iterative learning, mirroring the problem-solving process in programming, while also supporting differentiated instruction and fostering collaboration among students in the context of STEAM education [33].

This study investigates the effectiveness of microteaching as a method for introducing sequencing structures in programming through STEAM activities. By leveraging the Micro:bit environment – a versatile, block-based programming platform integrated with physical hardware - this research aims to explore how focused instruction in a microteaching setting can enhance student understanding. The study also examines the potential of STEAM activities to make abstract programming concepts accessible and engaging for elementary school students. To guide the investigation, the following research questions were posed:

1) How does microteaching influence student understanding of sequencing structures in programming?
2) What challenges and opportunities arise from using STEAM activities in a microteaching setting?

Through these questions, the study seeks to uncover insights into the role of microteaching in STEAM education, identifying effective practices and areas for improvement in introducing programming concepts to young learners.

2. Methods

This action research examines the effectiveness of microteaching in introducing sequencing structures through STEAM activities, utilizing the Micro:bit programming environment. The methodology is grounded in the cyclical action research framework, encompassing the stages of planning, acting, observing, and reflecting. A single cycle was conducted, focusing on designing, executing, and reflecting on a microteaching session. The primary aim was to address challenges in teaching sequencing structures while evaluating student engagement and learning outcomes.

2.1. Participants and Setting

The study involved two sixth-grade students, aged 12, selected based on their prior experience with Scratch programming and basic understanding of electrical circuits, as assessed during a preliminary session. The microteaching session utilized essential materials, including a laptop, Micro:bit device, LED lights, jumper wires, and cardboard. These resources were used to design and program a functional Christmas tree model.

2.2. Research Design and Procedure

In the Plan phase of the action research, instructional design focused on bridging students' prior programming experience with Scratch and their introduction to the Micro:bit platform. A hands-on task was developed, involving the construction and programming of a Christmas tree model, which incorporated elements of art, engineering, and technology. The key objectives were to facilitate the understanding of sequencing structures in programming and to create engaging, multidisciplinary learning experiences.

During the Act phase of the action research, the session was implemented and divided into four stages, each employing distinct educational techniques. The introduction, which lasted five minutes, familiarized students with sequencing in programming and fundamental principles of electrical circuits, contextualized through real-world applications. A fifteen-minute hands-on activity followed, comprising three steps. First, students engaged in investigation by constructing the Christmas tree model, attaching LEDs, and completing the electrical circuit. Next, during the guided programming step, they explored the Micro:bit MakeCode environment by running and analyzing pre-written programs. Finally, students participated in independent experimentation, modifying the code to create personalized sequencing programs that integrated LED patterns with sound playback. The activity concluded with a five-minute evaluation phase, where students answered targeted questions and completed a programming task to demonstrate their understanding of sequencing structures. A five-minute conclusion wrapped up the session with a discussion reviewing key concepts and reflecting on learning experiences and challenges.

As part of the Observe phase of the action research, data collection throughout the session focused on both qualitative and quantitative metrics. Real-time observations recorded student interactions and engagement, while verbal and written responses provided insights into their comprehension of programming concepts. Quantitative data on the functionality and accuracy of student-created programs further validated learning outcomes.

Within the Reflect phase of the action research, the focus was directed toward addressing the research questions by highlighting specific areas related to the microteaching session's impact on student understanding of sequencing structures and the challenges and opportunities presented by STEAM activities. In line with the first research question, the reflection prioritized understanding how microteaching influenced students' comprehension of sequencing structures in programming. Particular attention was given to how the personalized and focused nature of the microteaching setting supported students in developing logical thinking and applying programming concepts to practical tasks. Building on this, for the second research question, emphasis was placed on exploring the challenges faced in transitioning from Scratch to the Micro:bit platform and how these affected student learning. Additionally, the reflection examined how time constraints influenced the depth of experimentation and the overall learning process. Opportunities within the STEAM framework, such as its ability to integrate creativity with hands-on problem-solving, were also considered in detail as potential pathways to enhance student engagement and conceptual understandings.

2.3. Data Analysis

A mixed-methods approach was utilized to analyze the data, integrating qualitative and quantitative methodologies to provide a thorough examination of the subject matter. The qualitative analysis involved an examination of observation notes and student responses to identify recurring patterns in engagement, comprehension, and problem-solving strategies. Meanwhile, the quantitative analysis assessed the functionality and correctness of student-created programs, with particular attention to their effective application of sequencing commands. This comprehensive approach yielded a nuanced understanding of the role of microteaching in cultivating foundational programming skills and addressing cognitive challenges within the context of STEAM education.

2.4. Action Plan

The action plan for this research was carefully structured to integrate STEAM principles, combining programming concepts with a creative, hands-on task to create an engaging and multidisciplinary learning experience. The primary objective was to construct a functional Christmas tree model with LED lights and program their sequencing using the Micro:bit environment. This activity aimed to merge art, technology, and engineering, providing students with both theoretical and practical learning opportunities. During the planning phase, the session was designed to build on students' prior knowledge of Scratch programming and introduce them to the Micro:bit platform. By emphasizing the conceptual similarities between the two, the activity sought to ease the transition and enhance student familiarity with the new programming environment.

As outlined in Table 1, the session was divided into four phases, each employing specific educational techniques to facilitate learning progression. These phases included a brief introduction employing demonstrations, three steps within the implementation phase utilizing investigation, guided discovery learning, and experimentation, followed by an evaluation phase through formative assessment, and concluding with an interactive discussion to review key concepts.

Table 1. Teaching Phases

No.	Phase	Duration (min.)	Educational Technique
1	Introduction	5	Demonstration
2a	Implementation - Step 1	5	Investigation
2b	Implementation - Step 2	5	Guided Discovery Learning
2c	Implementation - Step 3	5	Experimentation
3	Evaluation	5	Formative Assessment
4	Conclusion	5	Interactive Discussion

Note: min. = minutes.

The implementation phase was divided into three distinct stages to ensure a systematic progression of learning. The session began with a brief introduction, during which students were taught the basics of electrical circuits, including their components and operation. This was followed by an explanation of sequencing in programming, with real-world examples like LED light control to highlight its applications. Additionally, the discovery learning approach was applied, where students were tasked with executing simple pre-written programs without prior knowledge of the code. After running the programs, they were guided through analyzing the code, answering targeted questions, and extracting insights about its structure and functionality. Connections were also drawn between the Scratch environment and Micro:bit programming to establish a conceptual bridge, making the new platform more accessible. The hands-on activity formed the core of the session, as students constructed a Christmas tree model using cardboard and attached LED lights to create a functional circuit. Under the guidance of the researcher, they connected the circuit to the Micro:bit device and tested its functionality. Students were introduced to the Micro:bit MakeCode environment, where simple programming commands were demonstrated. With this foundation, students wrote and executed their own programs to control the LED lights, fostering active learning and creativity.

2.4.1. Introduction

The lesson began with a general discussion aimed at introducing students to the content and goals of the activity. To establish a connection with their prior knowledge from physics lessons, the educator introduced the concept of electric circuits. As illustrated in Figure 1, students were shown how to create a simple circuit by connecting only one light bulb, highlighting the components of a closed circuit, such as the power source, conductors, and the light bulb itself. This demonstration set the stage for integrating the circuit with the Micro:bit programming environment later in the session.

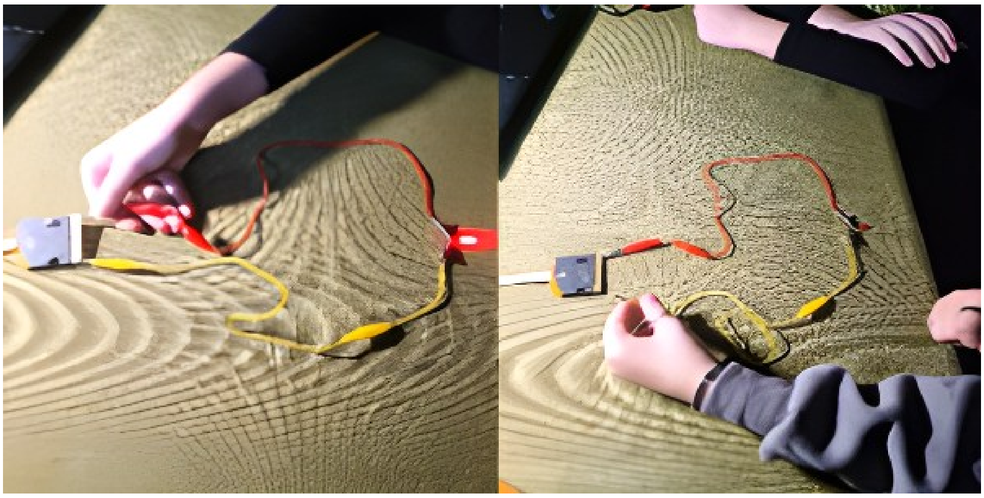

Figure 1. Demonstration of a simple electric circuit for STEAM learning.

2.4.2. Implementation

The next stage involved presenting a pre-written program on the Micro:bit that played Christmas music. The program was executed using the Micro:bit simulator, allowing students to observe its behavior before testing it on the physical device. The students were tasked with carefully analyzing the code, identifying its structure, and measuring the number of instructions required to produce the music. This activity emphasized the importance of sequencing and logic in programming while fostering critical observation skills.

To facilitate a deeper understanding of programming concepts, students first prepared the hardware setup by connecting multiple LED lights to a Micro:bit, forming a closed circuit that represented a Christmas tree model, as illustrated in Figure 2. This initial step allowed students to engage with the physical components of the project, establishing a concrete foundation for subsequent programming tasks. Once the setup was complete, students progressed to the hands-on task of executing predefined programs on the Micro:bit. By interacting with the device, they explored how pressing button A triggered a sequence that illuminated the LEDs in a specific pattern, while pressing button B activated an alternative sequence. This hands-on activity not only demonstrated the practical application of sequencing in programming but also highlighted the critical role of precise commands in controlling hardware behavior. This phase of the session reinforced their comprehension of how abstract programming instructions translate into tangible physical outputs, thereby bridging the gap between theoretical knowledge and practical implementation.

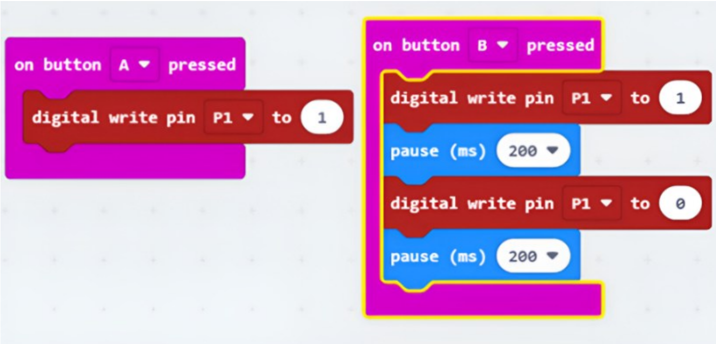

Figure 2. Demonstration of a simple electric circuit for STEAM learning

Building on previous activities, students faced a new challenge: modifying a program to synchronize the Christmas tree's lighting with music playback. As illustrated in Figure 3, the activity began with constructing the tree skeleton using colorful cardboard. Students then analyzed the existing code to understand its structure and functionality, emphasizing the value of reviewing pre-written solutions. Collaboratively, they experimented with adding new code blocks to combine lighting effects with musical tones, brainstorming creative modifications, and fostering critical thinking.

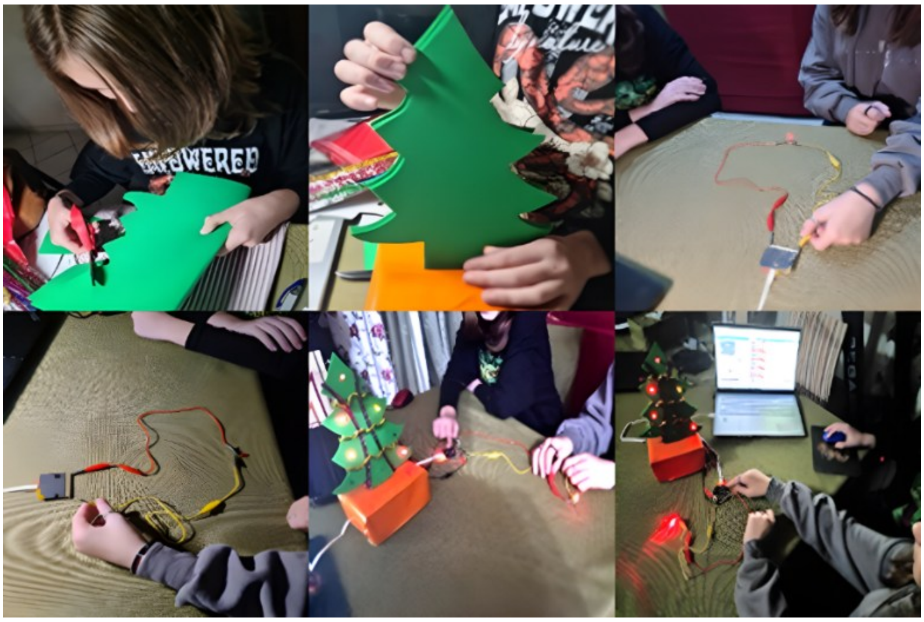

Figure 3. Stages of constructing the Christmas tree and connecting the LED lights.

Before deploying their modifications to the Micro:bit device, students tested their changes on a simulator, allowing them to identify and address any errors in a controlled environment. This iterative process, which involved cycles of testing, debugging, and refining, not only deepened their understanding of sequencing but also significantly strengthened their problem-solving and debugging skills. By encountering and resolving errors, students gained confidence in troubleshooting and adapting code to meet specific requirements.

Through this task, students not only reinforced their foundational programming knowledge but also acquired practical experience in adapting and refining code to achieve integrated, multi-faceted outputs. As illustrated in Figure 4, their successful implementation of synchronized lighting and music playback underscored their ability to apply abstract programming concepts in a tangible and meaningful way, preparing them for more advanced challenges in future learning activities.

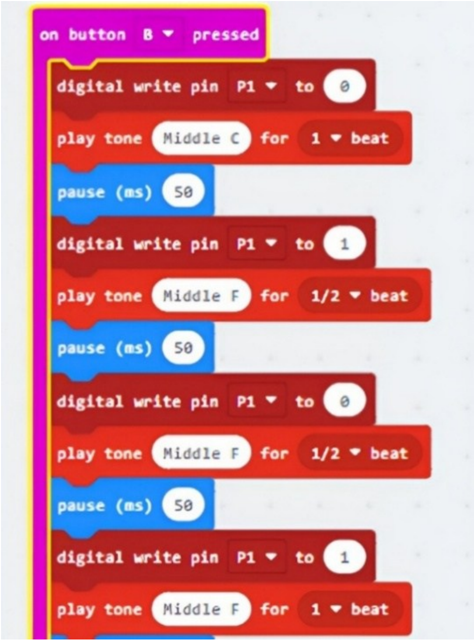

Figure 4. The students developed the code to synchronize the LED lights with sound.

2.4.3. Evaluation

To conclude the lesson, the educator used simple question-and-answer techniques to assess the students' understanding. Questions focused on determining whether the students grasped the concept of sequencing and its role in achieving desired outcomes. Students were asked to articulate how the commands they used influenced the program's behavior, providing insight into their level of comprehension. The evaluation phase assessed students' understanding of sequencing through targeted questions that probed their comprehension, such as the importance of command order and the consequences of incorrect sequencing. Students were also encouraged to reflect on their learning experience, articulate key takeaways, and identify challenges encountered during the activity.

2.4.4. Conclusion

The session ended with a review of the key concepts covered during the activity. The educator summarized the importance of executing instructions in a specific order and encouraged students to ask questions about any challenges they encountered. Following the session, the reflection phase focused on analyzing the effectiveness of the microteaching approach. Particular emphasis was placed on identifying successful elements, such as student engagement and reinforcement of sequencing concepts. Areas for improvement were also examined, including strategies for better time management and clearer guidance for integrating multiple programs. These insights provided a foundation for refining the approach in future implementations, ensuring a more impactful and streamlined learning experience.

3. RESULTS

3.1. The Impact of Microteaching on Understanding Sequencing Structures

The microteaching session effectively deepened students' understanding of sequencing structures in programming by integrating practical activities with a collaborative and reflective learning environment. The design of the session fostered engagement and comprehension, as evidenced by the positive feedback provided by the students and their active participation throughout the activity. The activity centered around constructing and programming a Christmas tree model with LEDs using the Micro:bit platform. This transdisciplinary task integrated elements of art, engineering, and technology, creating a balanced learning experience that appealed to diverse interests and learning styles. Students expressed high levels of enthusiasm for the hands-on nature of the task, which they found both enjoyable and helpful in understanding abstract programming concepts. Their feedback highlighted the value of seeing the immediate effects of their code, which made the importance of sequencing in programming more tangible and engaging. For example, the illuminated Christmas tree provided instant feedback that reinforced their understanding of cause-and-effect relationships within their code.

During the session, students demonstrated their ability to analyze and interpret pre-written programs, correctly identifying the sequence of commands needed to achieve specific LED patterns. This step-by-step breakdown not only solidified their grasp of sequential execution but also equipped them with the skills to troubleshoot and refine their work effectively. This foundational understanding was further strengthened as they moved on to create their own program to synchronize LED lighting with music playback. By organizing commands logically and observing their effects, students displayed a clear recognition of how the sequence influenced the functionality of their programs. Their reflections indicated that the hands-on and iterative nature of the tasks deepened their comprehension of programming structures.

The positive impact of the session was also evident in the collaborative atmosphere. Students actively engaged with the material, supported one another in problem-solving, and benefited from the structured guidance provided by the educator. Their feedback emphasized that the combination of clear instructions, real-time observations, and the opportunity to experiment helped them refine their understanding and build confidence in applying sequencing principles.

3.2. Student Performance in Practical Programming Tasks

The microteaching session revealed notable insights into student performance during practical programming tasks, highlighting their progress in foundational skills and the application of sequencing structures. Through hands-on activities with the Micro:bit platform, students demonstrated both their capabilities and areas requiring further support. Students successfully created programs to control LED lighting and synchronize it with music playback on the Micro:bit device. Their performance in analyzing pre-written programs was a key indicator of their growing competence. For instance, they accurately identified and described the sequence of commands that controlled the lighting patterns. This foundational understanding was evident as they transitioned from interpreting existing code to modifying it for personalized outputs.

While assembling a program to integrate LED control with music, students exhibited teamwork and iterative problem-solving skills. They began by testing individual segments of code on the simulator, identifying errors, and refining their approach collaboratively. Although they encountered difficulties, they ultimately succeeded in creating a cohesive program. This process reinforced their understanding of sequencing as they adapted the code to alternate between lighting and musical tones. One of the functional outputs involved programming the LEDs to blink in synchronization with each musical note. Initially, the lights illuminated sequentially and stopped before the music played. Through guided reflection and experimentation, students modified the code to include alternating open and close circuit commands for each note, achieving the desired synchronization. The students' performance demonstrated significant progress in applying programming concepts to practical tasks. Their ability to identify sequencing structures and make logical adjustments to achieve desired outputs reflected a deepening understanding of programming logic. However, their reliance on guidance during complex integrations indicated a need for further scaffolding and practice in combining multiple program components.

3.3. Challenges in Transitioning to STEAM Activities

One of the primary challenges identified during the microteaching session was the insufficiency of the planned timeline for exploration and experimentation. Although the structured activities aimed to balance theoretical understanding with practical application, the allocated time proved inadequate for students to fully engage with the programming tasks, particularly in the integration phase. This phase involved combining the LED control program with the music-playing program, a task that required iterative testing and refinement.

For example, students were tasked with integrating the code for lighting the LEDs and the code for playing music. While one student read commands from a provided sheet, the other assembled the program using the MakeCode platform. Despite their collaborative effort, significant time was spent locating commands within the interface due to their limited prior experience with the platform. After two minutes, the educator intervened to assist in finding the necessary commands, expediting the process. The completed program was then tested in the simulator, where it was observed that the LEDs on Pin 1 would light up once, followed by the music playback. This sequence, while functional, did not meet the students' expectations, as they preferred the LEDs to blink in synchronization with the music. To address this, the educator guided the students with targeted questions, such as how they might alternate the LED blinking and music playback. The students grasped that opening and closing the circuit multiple times within the code could achieve the desired effect. However, they struggled to organize the commands correctly. Through educator support, the program was adjusted to include alternating open and close circuit commands between each musical note. This iterative refinement process, while successfully enhancing the functionality of the program, consumed a substantial portion of the session, leaving limited time for further experimentation and reflection.

Another significant challenge arose from students' difficulty transitioning their programming knowledge from the Scratch environment to the Micro:bit platform. While both environments use block-based programming interfaces, the hardware interaction required by the Micro:bit added complexity. For example, students initially misinterpreted the relationship between the circuit's physical behavior and the sequence of commands in the program. However, through guided troubleshooting, they eventually understood that the circuit needed to alternate its state to synchronize with the music playback.

3.4. Opportunities within STEAM Activities for Enhanced Engagement

The microteaching session demonstrated the significant potential of STEAM activities to foster student engagement by integrating hands-on, transdisciplinary learning experiences. Through the construction and programming of a Christmas tree model with LEDs using the Micro:bit platform, students were immersed in a dynamic educational environment that blended creativity, engineering, and technology. One of the most engaging aspects of the activity was the construction phase, where students created the Christmas tree using cardboard and LED lights. This task appealed to their artistic sensibilities and introduced engineering concepts such as designing a functional electrical circuit. The physical assembly process enabled students to see their designs take shape, reinforcing their investment in the project.

The programming phase amplified their engagement further. Students used the Micro:bit platform to control the LEDs, experimenting with lighting sequences and integrating music playback. This tangible application of programming concepts transformed abstract ideas into real-world outcomes. For instance, students actively collaborated to combine pre-written code for LED control and music, testing their programs in a simulator before transferring them to the Micro:bit device. The ability to see their programming efforts manifest as synchronized lights and sounds provided immediate feedback, which heightened their motivation and sense of achievement. The session's success was also driven by its transdisciplinary approach. By blending familiar creative tasks with new technological challenges, the activity catered to diverse learning styles and interests. Students expressed enthusiasm for the opportunity to merge coding with artistic design, noting that the hands-on, collaborative nature of the task made learning more enjoyable and accessible.

3.5. Reflection on the Microteaching Approach

Microteaching's defining feature is its focus on small-group instruction, which creates a supportive and interactive environment for both educators and students. In this session, the hands-on activities were particularly effective, enabling students to actively engage with the material. By incorporating elements such as immediate feedback, guided discovery, and collaborative problem-solving, the session supported differentiated learning. The manageable group size allowed the educator to observe individual progress and address misconceptions in real-time, a hallmark of effective microteaching. The structured progression of the session, from introduction to guided tasks and independent experimentation, provided a clear framework for learning. Linking new content to students' prior knowledge, such as electrical circuits, facilitated their transition into the Micro:bit programming environment. Despite its strengths, the session revealed challenges that are instructive for refining the microteaching process. Time management emerged as a critical area for improvement. The educator's deviation from the planned timeline early in the session led to a sense of urgency, affecting both the delivery and the students' ability to fully process the material.

Reflecting on the microteaching session, several key guidelines for effective implementation were identified. Activities should be strategically designed to progress in complexity, enabling students to develop their confidence and competencies in a structured and manageable manner. Moreover, the integration of pre-configured resources, such as templates or partially completed tasks, serves to streamline instructional processes, thereby allowing greater emphasis on achieving essential learning objectives. Flexibility emerged as a critical component, requiring educators to adapt timelines and instructional goals responsively to accommodate student progress and engagement. Furthermore, the incorporation of immediate feedback mechanisms was also highlighted as pivotal, facilitating real-time refinement of students' understanding and fostering deeper cognitive engagement. Lastly, the iterative nature of microteaching underscores the importance of systematic reflection and revision. By analyzing each session's outcomes, educators can refine their instructional strategies and continuously enhance the efficacy of their pedagogical approaches, ensuring sustained improvements in student learning outcomes.

4. DISCUSSION

The findings of this study align with existing research emphasizing the effectiveness of microteaching as an educational strategy, particularly in small-group contexts [34], [35], [36], [37]. Prior studies have highlighted the importance of personalized instruction and immediate feedback in programming education, emphasizing their critical role in fostering student engagement and enhancing understanding [38], [39], [38], [40]. The microteaching approach in this study reaffirmed these benefits, as the small group setting enabled tailored support and real-time interventions to address misconceptions. This resonates with existing literature on the advantages of close teacher-student interactions in enhancing learning outcomes [41], [42], [43]. The integration of STEAM principles in the microteaching session builds on previous research that advocates for hands-on, transdisciplinary approaches in education [44], [45], [46], [47]. Prior work has also shown that combining physical construction with programming tasks enhances students' ability to apply theoretical knowledge in meaningful ways [48], [49], [50]. This dual engagement reflects the broader pedagogical trend of using project-based learning to improve understanding and retention of complex concepts [51], [52].

The findings also contribute to the growing body of literature supporting STEAM education as a means of integrating technology and engineering concepts into elementary curricula [53], [54], [55]. The transdisciplinary nature of the activity aligns with research that advocates for creative problem-solving as a fundamental component of STEAM education [56], [57], [58]. The Christmas tree project illustrated how blending artistic elements with technical challenges fosters creativity while equipping students with practical skills. The study also reinforces findings from prior evaluations of the Micro:bit platform, which has been recognized for its user-friendly interface and compatibility with physical components [59], [60]. As noted in previous research, tools like Micro:bit provide an accessible entry point for introducing programming and engineering concepts to elementary students [61], [62]. This study further substantiates the platform's efficacy, particularly in contexts where hands-on learning is a focal point. However, the challenges identified in this study also echo limitations noted in prior research. Issues such as time constraints, platform transitions, and the need for enhanced scaffolding are common in project-based and transdisciplinary educational approaches [63], [64], [65].

One significant limitation of this study was the prior familiarity of students with programming environments like Scratch, which may have influenced their ability to transition to the Micro:bit platform more easily than complete beginners. This preexisting knowledge could have enhanced their comprehension and engagement. Additionally, the study was conducted in a non-formal educational setting, where the teacher had full control over the available time. This level of flexibility is not typically feasible in standard classroom environments, limiting the generalizability of the findings to traditional educational contexts. Another limitation was the small sample size, involving only two students. While the microteaching setting allowed for personalized instruction and immediate feedback, the limited number of participants restricts the ability to generalize the results to a broader population.

Despite these limitations, the study highlights important implications for integrating microteaching with STEAM education. The results suggest that incorporating hands-on, multidisciplinary activities in microteaching settings can significantly enhance student engagement and understanding of abstract programming concepts. Educators can leverage tools like the Micro:bit to provide a tangible connection between theory and practice, fostering deeper learning and creativity. The findings also underscore the importance of scaffolding and iterative learning to address transitions between programming platforms. Instructors should consider incorporating additional support materials and phased activities to ease students' progression from one environment to another. Future research could expand on these findings by exploring the effectiveness of microteaching in more varied and formal educational contexts, with larger and more diverse student groups. Iterative cycles of action research could provide deeper insights into refining and optimizing the teaching approach.

5. Conclusion

This study demonstrates that microteaching is an effective approach for introducing programming concepts, such as sequencing structures, within a STEAM framework. The hands-on, transdisciplinary methodology fostered engagement and connected abstract programming ideas with tangible applications. Using art, technology, and engineering to create a functional Christmas tree model showed how STEAM activities enhance understanding and motivation. The Micro:bit platform was particularly effective in bridging theory and practice, though challenges in transitioning from Scratch highlighted the need for improved scaffolding and pre-configured tasks. The study also emphasized the benefits of small-group microteaching, such as personalized instruction and immediate feedback, which supported individual learning. The structured session phases provided a solid foundation for both conceptual and practical learning. However, limitations included insufficient time and difficulty transferring programming knowledge. Future improvements could include longer sessions, simpler initial tasks, and iterative learning, ensuring better alignment with students' needs and enabling them to tackle more complex programming scenarios.

Declarations

Author Contributions

Margarita Rafti: Resources, Methodology, Investigation, Writing – Original Draft. **Emmanouil D. Milakis:** Methodology, Writing – Original Draft, Supervision. **Constantina Corazon Argyrakou:** Formal Analysis, Data Curation. **Dimitra G. Vangeli:** Writing – Review & Editing, Validation. **Maria Christina Katsarou:** Writing – Review & Editing, Validation. All authors have read and approved the final version of this manuscript.

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Ethical Approval

All participants in this study provided informed consent prior to their involvement, ensuring that they were fully aware of the research objectives, procedures, and their rights as participants. Given that the study involved educational activities with minimal risk, explicit parental consent was obtained for all student participants. The research was conducted in strict compliance with the General Data Protection Regulation (GDPR, Regulation (EU) 2016/679), a European Union regulation that governs data protection and privacy for all individuals within the EU and the European Economic Area. This regulation sets high standards for the processing of personal data, ensuring confidentiality, anonymity, and secure data handling. No personally identifiable information was recorded, and all data were securely stored and used solely for research purposes. As this study was conducted independently, without direct involvement of a medical or psychological intervention, and within the framework of standard educational practices, no additional ethical approval from a university ethics committee was required. However, all ethical considerations, including voluntary participation and the right to withdraw at any time, were strictly adhered to throughout the study.

Data Availability Statement

The data supporting the findings of this study are available upon reasonable request from the corresponding author. Due to privacy restrictions, the data are not publicly available.

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Competing Interests

The authors declare that they have no competing interests.

Generative AI and AI-Assisted Technologies Statement

During the preparation of this work, the authors used ChatGPT4o to assist in improving the readability, language, and overall structure of the manuscript. Following the use of this tool, the authors thoroughly reviewed and edited the content, ensuring its accuracy and integrity. The authors take full responsibility for the content and conclusions presented in the published article.

REFERENCES

[1] G. Yakman, "STEAM education: An overview of creating a model of integrative education," in *Pupils' Attitudes Towards Technology (PATT-19) Conference: Research on Technology, Innovation, Design & Engineering Teaching*, Salt Lake City, Utah, USA, 2008. [Online]. Available: http://www.steamedu.com/2088_PATT_Publication.pdf

[2] J. Bazler and M. Van Sickle, Eds., *Cases on STEAM Education in Practice*. IGI Global, 2017, doi: 10.4018/978-1-5225-2334-5.

[3] T. Costantino, "STEAM by another name: Transdisciplinary practice in art and design education," *Arts Education Policy Review*, vol. 119, no. 2, pp. 100–106, 2018, doi: 10.1080/10632913.2017.1292973.

[4] V. A. Segarra, B. Natalizio, C. V. Falkenberg, S. Pulford, and R. M. Holmes, "STEAM: Using the arts to train well-rounded and creative scientists," *Journal of Microbiology & Biology Education*, vol. 19, no. 1, pp. 19-1, 2018, doi: 10.1128/jmbe.v19i1.1360.

[5] C. F. Quigley, D. Herro, and F. M. Jamil, "Developing a conceptual model of STEAM teaching practices," *School Science and Mathematics*, vol. 117, no. 1-2, pp. 1–12, 2017, doi: 10.1111/ssm.12201.

[6] D. Herro, C. Quigley, and H. Cian, "The challenges of STEAM instruction: Lessons from the field," *Action in Teacher Education*, vol. 41, no. 2, pp. 172–190, 2019, doi: 10.1080/01626620.2018.1551159.

[7] D. Herro, C. Quigley, J. Andrews, and G. Delacruz, "Co-Measure: Developing an assessment for student collaboration in STEAM activities," *International Journal of STEM Education*, vol. 4, pp. 1–12, 2017, doi: 10.1186/s40594-017-0094-z.

[8] E. D. Milakis, C. C. Argyrakou, T. Loukisas, D. G. Vangeli, M. C. Katsarou, and A. Lalou,

"Comparative analysis of large language models as AI assistants for educational assessment: A case study in STEAM education," *International Journal of Computing and Artificial Intelligence*, vol. 5, no. 2, pp. 51–55, 2024, doi: 10.33545/27076571.2024.v5.i2a.97.

[9] N. Park and Y. Ko, "Computer education's teaching-learning methods using educational programming language based on STEAM education," in *IFIP International Conference on Network and Parallel Computing*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2012, pp. 320–327, doi: 10.1007/978-3-642-35606-3_38.

[10] S. W. Kim and Y. Lee, "The analysis on research trends in programming based STEAM education in Korea," *Indian Journal of Science and Technology*, vol. 9, no. 24, pp. 1–11, 2016, doi: 10.1007/978-3-642-35606-3_38.

[11] M. Yee-King, M. Grierson, and M. d'Inverno, "STEAM WORKS: Student coders experiment more and experimenters gain higher grades," in *2017 IEEE Global Engineering Education Conference (EDUCON)*, 2017, pp. 359–366, doi: 10.1109/EDUCON.2017.7942873.

[12] S. S. Hudin, "A Systematic Review of the Challenges in Teaching Programming for Primary Schools' Students," *Online Journal for TVET Practitioners*, vol. 8, no. 1, pp. 75–88, 2023, doi: 10.30880/ojtp.2023.08.01.008.

[13] C. Williams, E. Alafghani, A. Daley, K. Gregory, and M. Rydzewski, "Teaching programming concepts to elementary students," in *2015 IEEE Frontiers in Education Conference (FIE)*, 2015, pp. 1–9, doi: 10.1109/FIE.2015.7344134.

[14] S. L. Mason and P. J. Rich, "Preparing elementary school teachers to teach computing, coding, and computational thinking," *Contemporary Issues in Technology and Teacher Education*, vol. 19, no. 4, pp. 790–824, 2019. [Online]. Available: https://www.learntechlib.org/primary/p/184723/

[15] J. Waite and S. Sentance, *Teaching programming in schools: A review of approaches and strategies*. Raspberry Pi Foundation, 2021. [Online]. Available: https://www.raspberrypi.org/app/uploads/2021/11/Teaching-programming-in-schools-pedagogy-review-Raspberry-Pi-Foundation.pdf

[16] O. M. Nche, R. Boulware, S. M. Che, E. T. Kraemer, M. Sitaraman, and V. B. Zordan, "Basic code understanding challenges for elementary school children," in *2020 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, vol. 1, 2020, pp. 1–2, doi: 10.1109/RESPECT49803.2020.9272421.

[17] K. M. Tank et al., "Investigating Sequencing as a Means to Computational Thinking in Young Children," *International Journal of Computer Science Education in Schools*, vol. 6, no. 3, pp. 67–77, 2024, doi: 10.21585/ijcses.v6i3.192.

[18] B. Xie et al., "A theory of instruction for introductory programming skills," *Computer Science Education*, vol. 29, no. 2–3, pp. 205–253, 2019, doi: 10.1080/08993408.2019.1565235.

[19] Z. Wafula et al., "Assessing Computational Thinking Skills in Early Elementary Students: A Focus on Sequencing Tasks," in *Society for Information Technology & Teacher Education International Conference*, 2024, pp. 400–405. Association for the Advancement of Computing in Education (AACE). [Online]. Available: https://www.learntechlib.org/primary/p/223964/

[20] S. A. Kalaian and R. M. Kasim, "Small-group vs. competitive learning in computer science classrooms: A meta-analytic review," in *Innovative Teaching Strategies and New Learning Paradigms in Computer Programming*, IGI Global, 2015, pp. 46–64, doi: 10.4018/978-1-4666-7304-5.ch003.

[21] L. Springer, M. E. Stanne, and S. S. Donovan, "Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis," *Review of Educational Research*, vol. 69, no. 1, pp. 21–51, 1999, doi: 10.3102/00346543069001021.

[22] D. A. Trytten, "Progressing from small group work to cooperative learning: A case study from computer science," *Journal of Engineering Education*, vol. 90, no. 1, pp. 85–91, 2001, doi: 10.1002/j.2168-9830.2001.tb00572.x.

[23] A. Remesh, "Microteaching, an efficient technique for learning effective teaching," *Journal of Research in Medical Sciences: The Official Journal of Isfahan University of Medical Sciences*, vol. 18, no. 2, p. 158, 2013. [Online]. Available: https://pmc.ncbi.nlm.nih.gov/articles/PMC3724377/

[24] Y. Lou, P. C. Abrami, and S. d'Apollonia, "Small group and individual learning with technology: A meta-analysis," *Review of Educational Research*, vol. 71, no. 3, pp. 449–521, 2001, doi: 10.3102/00346543071003449.

[25] S. Grover and R. Pea, "Computational thinking in K–12: A review of the state of the field," *Educational Researcher*, vol. 42, no. 1, pp. 38–43, 2013, doi: 10.3102/0013189X12463051.

[26] S. Y. Lye and J. H. L. Koh, "Review on teaching and learning of computational thinking through programming: What is next for K-12?," *Computers in Human Behavior*, vol. 41, pp. 51–61, 2014, doi: 10.1016/j.chb.2014.09.012.

[27] M. Kalogiannakis, E. Tzagaraki, and S. Papadakis, "A systematic review of the use of BBC micro:bit in primary school," in *Conference Proceedings. New Perspectives in Science Education 2021*, Mar. 2021. [Online]. Available: https://conference.pixel-online.net/library_scheda.php?id_abs=5036

[28] C. A. Philbin, "Beyond Apps: Tablet and Micro: bit Devices as Tools for Creative Computing in Primary Schools," in *Proceedings of the 8th Conference on Computing Education Practice*, Jan. 2024, pp. 25–28, doi: 10.1145/3633053.3633054.

[29] P. Vostinar, "Micro: bit for STEAM Education," in *2024 47th MIPRO ICT and Electronics Convention (MIPRO)*, May 2024, pp. 490–495, doi: 10.1109/MIPRO60963.2024.10569427.

[30] R. Krnasc, M. Capay, and S. Koprda, "Education with physical device BBC micro: bit," in *2020 18th International Conference on Emerging eLearning Technologies and Applications (ICETA)*, Nov. 2020, pp. 352–357, doi: 10.1109/ICETA51985.2020.9379166.

[31] M. Ellis, G. Thompson, and P. Haskell-Dowland, "Building a better micro: Bit IDE–teaching computer science," in *INTED2020 Proceedings*, 2020, pp. 8425–8433, doi: 10.21125/inted.2020.2290.

[32] S. Papadakis, E. Tzagkaraki, and M. Kalogiannakis, "Teaching Electricity Topics with Project-Based Learning and Physical Computing to Enhance Primary School Students in Science Education. An Educational Experiment with BBC Micro: bit Board," in *International Conference on Interactive Collaborative Learning*, Cham: Springer Nature Switzerland, Sep. 2023, pp. 320–330, doi: 10.1007/978-3-031-52667-1_31.

[33] S. Y. Lu, C. L. Wu, and Y. M. Huang, "Evaluation of disabled STEAM-students' education learning outcomes and creativity under the UN sustainable development goal: project-based learning oriented STEAM curriculum with micro: bit," *Sustainability*, vol. 14, no. 2, p. 679, 2022, doi: 10.3390/su14020679.

[34] I. N. A. Saidah and N. Ngazizah, "Analysis of small group and individual teaching skills students of microteaching learning," *Islamic Journal of Integrated Science Education (IJISE)*, vol. 1, no. 3, pp. 143–151, 2022, doi: 10.30762/ijise.v1i3.357.

[35] F. Evangelou, "The contribution of microteaching in teaching practice: A research approach to Greek students, prospective teachers," *International Journal of Education and Research*, vol. 10, no. 12, pp. 53–68, 2022. [Online]. Available: https://www.ijern.com/journal/2022/December-2022/05.pdf

[36] D. Liu and P. Bhotisarn, "Influence of micro-teaching mode on students' performance of Datong

Primary School in Sichuan province, China," *Procedia of Multidisciplinary Research*, vol. 2, no. 10, pp. 73–73, 2024. [Online]. Available: https://so09.tci-thaijo.org/index.php/PMR/article/view/5371

[37] A. Ilya, "A Comparative Analysis of Classroom Discourse in Microteaching and Practice School Contexts," *Sakarya Üniversitesi Eğitim Fakültesi Dergisi*, vol. 22, no. 2, pp. 111–127, 2022, doi: 10.53629/sakaefd.1140040.

[38] A. Rojas-Lopez and F. J. Garcia-Penalvo, "Personalized education for a programming course in higher education," in *Research Anthology on Computational Thinking, Programming, and Robotics in the Classroom*, IGI Global, 2022, pp. 344–367, doi: 10.4018/978-1-6684-2411-7.ch017.

[39] Y. Chen et al., "Edcode: Towards personalized support at scale for remote assistance in CS education," in *2020 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*, Aug. 2020, pp. 1–5, doi: 10.1109/VL.

[40] Y. Deng, D. Lu, C. J. Chung, D. Huang, and Z. Zeng, "Personalized learning in a virtual hands-on lab platform for computer science education," in *2018 IEEE Frontiers in Education Conference (FIE)*, Oct. 2018, pp. 1–8, doi: 10.1109/FIE.2018.8659291.

[41] C. Piech et al., "Co-teaching computer science across borders: Human-centric learning at scale," in *Proceedings of the Seventh ACM Conference on Learning*, Aug. 2020, pp. 103–113, doi: 10.1145/3386527.340591.

[42] M. Y. L. Yeung, H. H. M. Cheng, P. T. W. Chan, and D. W. Y. Kwok, "Communication technology and teacher–student relationship in the tertiary ESL classroom during the pandemic: A case study," *SN Computer Science*, vol. 4, no. 2, p. 202, 2023, doi: 10.1007/s42979-023-01667-7.

[43] K. Aldrup, B. Carstensen, and U. Klusmann, "Is empathy the key to effective teaching? A systematic review of its association with teacher-student interactions and student outcomes," *Educational Psychology Review*, vol. 34, no. 3, pp. 1177–1216, 2022, doi: 10.1007/s10648-021-09649-y.

[44] J. C. Hong, J. H. Ye, Y. J. Ho, and H. Y. Ho, "Developing an Inquiry and Hands-On Teaching Model to Guide STEAM Lesson Planning for Kindergarten Children," *Journal of Baltic Science Education*, vol. 19, no. 6, pp. 908–922, 2020. [Online]. Available: https://www.ceeol.com/search/article-detail?id=944945

[45] H. M. Thuneberg, H. S. Salmi, and F. X. Bogner, "How creativity, autonomy and visual reasoning contribute to cognitive learning in a STEAM hands-on inquiry-based math module," *Thinking Skills and Creativity*, vol. 29, pp. 153–160, 2018, doi: 10.1016/j.tsc.2018.07.003.

[46] C. Bartlett and L. Bos, "STEAM around the world: Successfully incorporating hands-on learning and diversity into children's programming," *Journal of Library Administration*, vol. 58, no. 2, pp. 174–182, 2018, doi: 10.1080/01930826.2017.1392223.

[47] A. Sullivan and A. Strawhacker, "Screen-free STEAM: Low-cost and hands-on approaches to teaching coding and engineering to young children," in *Embedding STEAM in Early Childhood Education and Care*, Cham: Springer International Publishing, 2021, pp. 87–113, doi: 10.1007/978-3-030-65624-9_5.

[48] T. Sapounidis, S. Tselegkaridis, and D. Stamovlasis, "Educational robotics and STEM in primary education: A review and a meta-analysis," *Journal of Research on Technology in Education*, vol. 56, no. 4, pp. 462–476, 2024, doi: 10.1080/15391523.2022.2160394.

[49] Y. Zhang, R. Luo, Y. Zhu, and Y. Yin, "Educational robots improve K-12 students' computational thinking and STEM attitudes: Systematic review," *Journal of Educational Computing Research*, vol. 59, no. 7, pp. 1450–1481, 2021, doi: 10.1177/0735633121994070.

[50] M. Cetin and H. O. Demircan, "Empowering technology and engineering for STEM education through programming robots: A systematic literature review," *Early Child Development and Care*, vol. 190, no. 9, pp. 1323–1335, 2020, doi: 10.1080/03004430.2018.1534844.

[51] D. Darmawansah, G. J. Hwang, M. R. A. Chen, and J. C. Liang, "Trends and research foci of robotics-based STEM education: A systematic review from diverse angles based on the technology-based learning model," *International Journal of STEM Education*, vol. 10, no. 1, p. 12, 2023, doi: 10.1186/s40594-023-00400-3.

[52] A. M. Simamora, "A Decade of Science Technology, Engineering, and Mathematics (STEM) Project-Based Learning (PjBL): A Systematic Literature Review," *Journal of Computers for Science and Mathematics Learning*, vol. 1, no. 1, pp. 58–78, 2024, doi: 10.70232/pn3nek61.

[53] A. Leavy, L. Dick, M. Meletiou-Mavrotheris, E. Paparistodemou, and E. Stylianou, "The prevalence and use of emerging technologies in STEAM education: A systematic review of the literature," *Journal of Computer Assisted Learning*, vol. 39, no. 4, pp. 1061–1082, 2023, doi: 10.1111/jcal.12806.

[54] E. D. Milakis, "Designing an online community of practice: The STEAM-Robots educational community," *Neos Paidagogos*, vol. 17, pp. 361–369, 2020, doi: 10.5281/zenodo.6465023.

[55] R. Kwan and B. T. M. Wong, "Latest advances in STEAM education research and practice: A review of the literature," *International Journal of Innovation and Learning*, vol. 29, no. 3, pp. 323–339, 2021, doi: 10.1504/IJIL.2021.114528.

[56] J. Holbrook, M. Rannikmäe, and R. Soobard, "STEAM Education—A transdisciplinary teaching and learning approach," in *Science Education in Theory and Practice: An Introductory Guide to Learning Theory*, Cham: Springer, 2020, pp. 465–477, doi: 10.1007/978-3-030-43620-9_31.

[57] A. K. Segarra-Morales and M. Juca-Aulestia, "Strategies and Skills in STEAM Education Systematic Review of the Literature," in *International Conference on Information Technology & Systems*, Cham: Springer Nature Switzerland, Jan. 2024, pp. 398–411, doi: 10.1007/978-3-031-54235-0_36.

[58] R. Singha and S. Singha, "Application of Experiential, Inquiry-Based, Problem-Based, and Project-Based Learning in Sustainable Education," in *Teaching and Learning for a Sustainable Future: Innovative Strategies and Best Practices*, IGI Global, 2024, pp. 109–128, doi: 10.4018/978-1-6684-9859-0.ch006.

[59] K. T. Quyen, N. Van Bien, and N. A. Thuan, "Micro: bit in Science Education: A systematic review," *Jurnal Penelitian dan Pembelajaran IPA*, vol. 9, no. 1, pp. 1–14, 2023, doi: 10.30870/jppi.v9i1.19491.

[60] R. Cabrera, A. Carrion, and M. Huerta, "A Scoping Review and Bibliometric Analysis of BBC Micro: Bit Research," in *2024 IEEE World Engineering Education Conference (EDUNINE)*, Mar. 2024, pp. 1–6, doi: 10.1109/EDUNINE60625.2024.10500601.

[61] A. M. Cederqvist, "Designing and coding with BBC micro: bit to solve a real-world task–a challenging movement between contexts," *Education and Information Technologies*, pp. 1–35, 2022, doi: 10.1007/s10639-021-10865-w.

[62] V. Mardian and W. Azzahra, "A Review: The Impact of Micro: Bit-Assisted STEM Education," *International Journal of Science Education and Teaching*, vol. 3, no. 1, pp. 30–37, 2024, doi: 10.14456/ijset.2024.3.

[63] T. C. Hsu, S. C. Chang, and Y. T. Hung, "How to learn and how to teach computational thinking: Suggestions based on a review of the literature," *Computers & Education*, vol. 126, pp. 296–310, 2018, doi: 10.1016/j.compedu.2018.07.004.

[64] L. Thibaut et al., "Integrated STEM education: A systematic review of instructional practices in

secondary education," *European Journal of STEM Education*, vol. 3, no. 1, p. 2, 2018, doi: 10.20897/ejsteme.

[65] M. A. Almulla, "The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning," *Sage Open*, vol. 10, no. 3, p. 2158244020938702, 2020, doi: 10.1177/2158244020938702.

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