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Enhancing teachers' integrating micro:bit in their teaching through professional development program within the urban vegetable garden context

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Abstract

In this research, we proposed a professional development (PD) program on teaching micro:bit within the context of an urban vegetable garden. The study aimed to: (1) investigate teachers' confidence in integrating micro:bit in their teaching as the result of participating in the PD program; (2) investigate teachers' integrating micro:bit in their teaching; and (3) identify the factors that affected their application of micro:bit in their teaching. Thirty-three teachers, who teach in a school under the Bangkok metropolitan administration, participated in this study. Three of them were selected as case studies based on their confidence levels in applying micro:bit to their students i.e., high confidence, moderate confidence, and low confidence, respectively. Data were collected using questionnaires, semi-structured interviews, and classroom observations. For the quantitative data, the researchers employed means, standard deviation (*SD*), and dependent t-test. For the qualitative data, thematic analysis was used. The findings revealed that most teachers had confidence in integrating micro:bit into their teaching from low (M = 2.52, SD = 0.86) to high levels (M = 3.65, SD = 0.51) after participating in the PD program. For integrating micro:bit into their teaching, all cases challenged their students to create a project with the micro:bit to tackle issues in an urban vegetable garden. They promoted students to apply knowledge about micro:bit to new situations. Furthermore, three key factors affecting the teachers' use of micro:bit in their teaching were identified: teachers' background knowledge of micro:bit, school support, and students' awareness of the benefit of micro:bit.

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Introduction

Thailand has undergone a transition from an agriculture-based economy to an industrial one, with a primary focus on fostering creativity, innovation, and new technology through the implementation of the *"Thailand 4.0"* policy. Moreover, Thailand is reforming its education system by shifting from lecture-based to activity-based learning (Baxter, 2017).

As part of this transformation, the Thailand Ministry of Education has introduced computing science as a new subject in the National Standards, making it mandatory for all students to study from elementary to secondary school levels. The main objective is to equip students with computational thinking skills, thereby enhancing their problem-solving abilities in a systematic and step-by-step manner. Coding has become a crucial skill for the 21st-century generation, and one tool that has gained significant recognition for revolutionizing education is the micro:bit (Kanbul & Uzunboylu, 2017; Simović et al., 2022).

The micro:bit, a small programmable computer developed by the BBC, has been designed to support learning in the digital age and facilitate children's introduction to computers (Austin et al., 2020). Through sequencing command blocks and compiling via web browsers, students can code the micro:bit, exploring the world of coding, electronics, and digital creativity. Due to its user-friendly design, which includes embedded sensors and an LED display screen, the micro:bit is ideal for educational purposes. Employing the micro:bit, enhances students' computational thinking and problem-solving abilities (Sentence et al., 2017). Additionally, its compatibility with various platforms like Windows, Android, and iOS makes it even more versatile.

Several studies conducted in the Thai context have shown positive results, demonstrating the effectiveness of integrating micro:bit activities into education. For example, Amnouychokanant et al. (2021) implemented micro:bit project-based learning with first-year students in a bachelor of Education Program in educational technology and communications, leading to significant improvements in the students' computational thinking skills and programming creativity. Similarly, Thanyaphongphat et al. (2022) introduced micro:bit activities using project-based learning for secondary school students to enhance coding skills and foster computational thinking abilities. Their research findings indicated that these activities effectively improved students' overall computational thinking skills, along with their proficiency in specific skill areas. Furthermore, the students exhibited increased motivation for learning programming. Moreover, Pewkam and Chamrat (2022) developed computational thinking skills for Thai pre-service teachers through a two-day online STEM-based activity known as the computing science teacher training course. The study identified important factors that support learning through online channels for the teachers who participated in the training.

While technology has the potential to greatly enhance education by facilitating efficient and advanced learning environments, its integration into education also faces several challenges, including infrastructure, funding, and individual experiences (Ruangsuwan, 2024). One significant obstacle is the level of teacher knowledge and confidence in using micro:bit in the classroom. The success of implementing micro:bit in teaching heavily relies on teachers, who play a critical role in the transformation process and must be well-versed in new classroom practices (Fraser & Tobin, 1998).

To address this issue, Professional Development (PD) programs are essential in effectively equipping teachers for this educational reform. Loucks-Horsley et al. (2003) identified the importance of providing necessary resources with good examples to make teachers aware of the integration of new teaching strategies in their classrooms, and the process of change can truly begin. To confirm this idea, Moomaw (2013) pointed out that outdoor contextualized learning is a pedagogical method of bridging the gap between difficult concepts and the world to make learning more meaningful because it can link real-life problems outside the classroom, allowing students to solve problems with teamwork. Especially in the context of urban gardens, teachers in PD could learn about smart farms and coding with micro:bit. This is related to the relationship between inputs and outputs. They can explore how coding works and test it to solve common agricultural problems (STEM Punks Education, 2023). Up to this point, the agricultural sector in Thailand has remained a significant source of livelihood, income, and raw materials. Meanwhile, smart farms contribute to various agricultural processes, such as harvesting and improving crop yields, as the automation of sensors and machinery has made the farming workforce more efficient (O'Grady & O'Hare, 2017). Moreover, the smart greenhouse has helped farmers automatically conduct farm work, without manual inspection, and protects the plants from hailstorms, winds, ultraviolet radiation, and insect and pest attacks (Kodali & Karagwal , 2016).

The micro:bit, a pocket-sized device designed to teach coding, electronics, and robotics, encourages students to learn basic coding through a smart farm scenario. Hence, researchers selected the smart farm, here referred to urban vegetable garden, as the context to develop PD programs. Consequently, utilizing these programs to enhance teachers' proficiency in using micro: bit for teaching poses significant challenges. In this study, we addressed the specific challenges faced in urban vegetable gardens in Bangkok, where concerns about irrigation, temperature, and humidity prevail. Teachers can guide students to create a smart device using micro:bit for effective solutions, advancing towards smart farming. Nonetheless, the findings of this study contribute to the growing knowledge about teachers integrating micro:bit in their teaching.

Research Objectives

The research aimed to accomplish three primary objectives: firstly, to investigate teachers' confidence in integrating micro:bit in their teaching as the result of participating in the PD program; secondly, to investigate teachers' integrating micro:bit in their teaching; and thirdly, to identify the factors influencing the integration of micro:bit in their teaching in an urban vegetable garden.

Literature Review

Learning with Micro:bit

The BBC micro:bit is a small, programmable computer measuring 4cm by 5cm, designed to encourage children's creativity with technology. It simplifies the creation of ubiquitous computing applications for students (Rogers et al., 2017). It operates on an ARM Cortex-M0 Processor with 256K of non-volatile flash memory for programs and static data, along with 16K of volatile RAM for stack and heap (Ball et al., 2016). Its affordability and compact size make it easily transportable and accessible. The micro:bit includes built-in sensors, buttons for input, and LEDs for output, making it a versatile tool for introducing primary school students to concepts like algorithmic thinking, coding, programming, game development, and robotics.

Teaching Practices

Teaching is a highly intricate process. Educators often acquire various teaching methods and strategies through professional development experiences, yet applying these effectively to everyday teaching situations can be challenging (Korthagen & Kessels, 1999). As a result, students' competencies may not improve unless teachers enhance their teaching practices (Loucks-Horsley et al., 2009). These teaching practices are influenced by the teachers' educational backgrounds (Thomas & Pedersen, 2003) and encompass a wide range of teacher knowledge (Even & Tirosh, 1995). Conversely, their teaching practices contribute to their understanding of the art of teaching (Guskey, 2002).

Professional Development

In developing PD, the PD program should be designed regarding the aspects of effective PD, such as using various methods and strategies for promoting teachers' teaching practice (Loucks-Horsley et al., 2009), offering ongoing professional support (Thammaprateep & Chartisathian, 2007), continually reflecting and evaluating their working tasks (Guskey, 2002), providing good examples for application in their own teaching (Avery & Reeve, 2013; Pitiporntapin et al., 2023; Thammaprateep & Chartisathian, 2007), and enhancing inspiration for teaching (Chamrat et al., 2018; Thammaprateep & Chartisathian, 2007).

Methodology

The methodological perspective of this research is an interpretive paradigm, which is often used to understand how teachers make sense of their practices in order to improve their teaching (Gallagher, 1991). In this study, the researchers attempt to understand and explain teachers' using of micro:bit in their teaching as a result of their participating in the PD program. Additionally, the study investigates the factors influencing the adoption of micro:bit in their teaching. There were two phases of this study. The first phase attempted to investigate teachers' confidence in integrating micro:bit in their teaching as the result of participating in the PD program. The second phase is providing deeper understanding and uncovering meaning by investigating three case teachers integrating micro:bit in their teaching and identifying the factors that affected their application of micro:bit in their teaching in an urban vegetable garden.

Participants

In the initial phase of this study, 33 teachers voluntarily participated in the PD program. They comprised 4 male and 29 female teachers. The average age of all the teachers was 41.82 years. The average teaching experience of all the teachers was 16.29 years, encompassing various subjects, including Science and Technology, and Mathematics (9 teachers), and other subjects such as Thai language, English, Health and Physical education, Art , Music, and Home economic (24 teachers).

For the subsequent phase, three specific cases were selected to take part in this segment. These three cases were chosen based on three criteria: (1) their voluntary engagement in all PD program activities; (2) their different levels of confidence in teaching with integrating micro:bit; and (3) their intention to integrate micro:bit in their outdoor activities. To protect their identities, pseudonyms were assigned to these three teachers: Mary, Jenny, and Kevin. Mary, a 40-year-old woman, possessed 13 years of experience teaching Art at the elementary level. She had low confidence in using micro:bit in the classroom and did not believe that she would gain any benefit from it. Jenny, a 41-year-old woman with 16 years of experience as an English teacher, demonstrated moderate confidence in employing micro:bit in the classroom. Her intention to integrate micro: bit into her teaching practices was also moderate. Kevin, a 46-year-old man, had been responsible for teaching computer subjects to grade 1–6 students for 20 years. His participation in the PD program stemmed from the desire to enhance his teaching abilities and facilitate improved learning outcomes for his students.

Data Collection

In this study, the researchers collected data using multiple methods from the participants before, during, and after their participation in the PD program. Prior to enrolling in the PD program, the 33 teachers completed a questionnaire and were interviewed to assess their confidence in integrating micro:bit levels in their teaching in the urban vegetable garden context. The questionnaire comprised five items, each rated on a 5-point scale. Subsequently, the teachers engaged in the PD program, which was divided into three distinct parts. During Part I, teachers were introduced to micro:bit technology and the design thinking process (Emphasize, define, ideate, prototype, and test) for learning in an urban vegetable garden context. This one-day session (6 hrs.) took place at a Bangkok Metropolitan school in Bangkok.

Moving on to Part II, they participated in a one-day camp (6 hrs.) at an urban vegetable farm in Bangkok with a practical demonstration of outdoor learning activities that utilized micro:bit to create a workpiece according to design thinking process. After the second day of training ended, the teachers were then asked to completed a questionnaire and were interviewed again about their confidence in integrating micro:bit in their teaching. These two-day activities were led by a team of researchers serving as instructors.

Finally, in Part III, each teacher was tasked with designing and implementing micro:bit activities to their students during a two-day meeting at their own school. Moreover, Mary, Jenny, and Kevin were chosen as case study teachers to gather in-depth data based on their confidence levels obtained through interviews before commencing the program. While engaged in the PD program, the researchers gathered data from all teachers through video recordings, discussions, and presentations of participants' artifacts. Specifically for Mary, Jenny, and Kevin, they were requested to complete a questionnaire aimed at assessing their integration of micro:bit into their teaching. The questionnaire comprised four questions regarding their preparation of learning activities involving micro:bit for their students, the teaching techniques employed to instruct micro:bit concepts, the ways they integrated micro:bit into their teaching, and the factors influencing the integration of micro:bit in their teaching. Additionally, their teaching during the activities was observed for two days, with six hours each day, to identify their integration of micro:bit into their teachings. Following the completion of the PD program, all the teachers completed the questionnaires once more. Furthermore, Mary, Jenny, and Kevin were interviewed again after finishing their teaching activities.

Before data collection, all research instruments were validated by three experts with at least ten years of experience in science and technology education. The experts assessed each item based on the item-objective correlation (IOC). Therefore, the questionnaire and the semi-structured interview items were determined to have an Index of Item-Objective Congruence greater than 0.8, signifying a strong correlation (Rovinelli & Hambleton, 1976). The reliability coefficient (Cronbach's alpha) of the questionnaire was 0.95, indicating that the items were favorable and valid for implementation (Bland & Altman, 1997; Tavakol & Dennick, 2011).

Data Analysis

Regarding data analysis, the researchers processed information obtained from a 5-item, 5-scale rating questionnaire assessing teachers' confidence in integrating micro:bit levels in their teaching in the urban vegetable garden context by calculating the means, standard deviations, and a dependent t-test. For the quality levels, the data were categorized based on the following criteria: 1.00–1.80 score = lowest, 1.81–2.60 score = low, 2.61–3.40 score = moderate, 3.41–4.20 score = high, 4.21–5.00 score = highest (Sözen & Güven, 2019). Additionally, the collected data from the three case studies underwent thematic analyses which include familiarizing with the data, generating initial codes, searching for internally consistent themes, reviewing themes, and defining and naming themes. Ultimately, three themes emerged for teachers' integrating micro:bit into their teaching activities: (1) Challenging students to create a project with the micro:bit to tackle issues in an urban vegetable garden; (2) Linking micro:bit activities to the expertise area of teaching under an urban vegetable garden context; and (3) Promoting students to apply their knowledge about micro:bit to new situation. In addition, three themes emerged for factors influencing teachers' use of micro:bit in the classroom: (1) Teachers' background knowledge in micro:bit, (2) School support, and (3) Students' awareness of the benefit of micro:bit.

Results

Teachers' confidence in integrate micro:bit in their teaching in the urban vegetable garden context

The questionnaire data revealed a significant improvement in teachers' confidence in integrating micro:bit in their teaching in the urban vegetable garden context. Initially, teaching levels were low (M = 2.52, SD = 0.86) and increased significantly to high levels (M = 3.65, SD = 0.51) with a statistical significance of 0.05, demonstrating the effectiveness of the PD program in enhancing teachers' in micro:bit integration as shown in Table 1.

Teachers' integrating micro:bit in their teaching in the urban vegetable garden context

Regarding the qualitative data obtained from the case study, it was evident that the teachers experienced a positive and noteworthy enhancement in their integrating micro:bit into their teaching activities. The observed changes in teaching were consistently positive and beneficial, as demonstrated in the following findings.

Table 1 The teachers' confidence in integrating micro:bit in their teaching in the urban vegetable garden context before and after participating in the PD program

(N = 33)

Items	Topic		Mean	*SD*	Interpretation	*t*	*df*	Sig
1	Teaching students to write computer program related to micro:bit	Pre-test	2.30	0.91	Low	6.39	32	0.00**
		Post-test	3.45	0.44	High			
2	Teaching students to think critically for problem solving using micro:bit	Pre-test	2.58	1.06	Low	6.61	32	0.00**
		Post-test	3.79	0.48	High			
3	Teaching students to develop workpiece from micro:bit	Pre-test	2.52	0.70	Low	5.58	32	0.00**
		Post-test	3.48	0.57	High			
4	Teaching students to use design thinking for solving problem by using micro:bit	Pre-test	2.58	0.88	Low	8.12	32	0.00**
		Post-test	3.79	0.55	High			
5	Teaching students to use design thinking for developing workpiece from micro:bit	Pre-test	2.64	0.74	Moderate	7.40	32	0.00**
		Post-test	3.76	0.50	High			
Average		Pre-test	2.52	0.86	Low			
		Post-test	3.65	0.51	High			

Note: ** Significance at 0.05

Challenging students to create a project with the micro:bit to tackle issues in an urban vegetable garden

Before enrolling in the PD program, all case teachers did not provide any chances for their students to apply their knowledge of micro:bit to create innovations. For example, Mary revealed that "*I don't believe that my students will be able to use micro:bit to develop a project because they don't have any previous experiences*." Upon completion of the PD program, all case teachers designed hands-on activities for students using micro:bit to create various projects to solve problems in the garden. Mary challenged her students to create insect detectors as part of their project (Figure 1a). For example, Mary said that *"My students did well more than my expectation ... They do hands on activities to use micro:bit to create insect detector involving using sensors to detect the presence of insects and programming the micro:bit to provide alerts".* In Jenny's case, she asked her students to create the air quality in a garden (Figure 1b). As she reflected: "*I tried to help my students apply their knowledge and experience about coding to create a simple air quality monitoring system in the garden".* Regarding Kevin, he facilitated his students to complete their projects related to create watering systems (Figure 1c) as he revealed: "*My students work in groups and help together to create watering systems based on the moisture data collected automate watering systems for maintaining a soil moisture level for plant growth*". These challenges had a positive impact on the students in working with micro:bit and contributed to solving problems in an urban vegetable garden. Examples of students' workpiece are shown in Figure 1.

Linking micro:bit activities to the expertise area of teaching under an urban vegetable garden context

Prior to engaging in the PD program, Mary and Jenny held the belief that they could not effectively apply their background knowledge in conjunction with micro:bit. Mary, who taught art, initially perceived micro:bit as being related solely to Science, Technology, and Mathematics. Likewise, Jenny, who taught English, had not considered how she could integrate her knowledge of the subject with teaching micro:bit to her students. In the case of Kevin, he was a computer teacher, but he lacked confidence in using micro:bit due to the unavailability of equipment. In the PD program, they acquired hands-on experience with micro:bit equipment, simulating the same learning process as their students. All participants had a positive and enjoyable experience utilizing micro:bit as a teaching tool. Upon implementation, all case teachers applied the micro:bit they learned during the PD program in their expertise areas of teaching.

In Mary's case, she utilized her expertise in art to teach her students drawing, painting, and designing, as she expressed "*I can facilitate my students to sketch design the prototype of insect detector, and give some advice about drawing and painting."* Similarly, Jenny employed her English skills to enrich her students' reading instruction, as she revealed "*All I can help with is teaching my students vocabulary related to instruction set and teach them how to translate instruction set or give the name to the air quality monitoring system in English such as Lovely dust car*." In the case of Kevin, he instructed his students to utilize their prior knowledge of "Scratch" and apply that knowledge to create their projects. He mentioned that "*At first, I didn't think that I would have much experience about micro:bit to teach my students, but now I have applied coding in Scratch to micro:bit for students to create watering systems in the garden*." These findings showed that they emphasized the connection of their micro:bit activities with their expertise area of teaching in a garden context.

Promoting students to apply their knowledge about micro:bit to new situation

Before participating in the PD program, all case teachers had no idea how to link micro:bit activities to real life situation limited to using micro:bit solely

Figure 1 Examples of students' micro:bit workpieces applied in an urban vegetable garden context. (A) insect detector, (B) air quality monitoring car, and (C) watering systems in the garden.

as a learning context for their students. For example, Kevin utilized micro:bit for students' learning concept of coding, as he reflected. *"My students have learned about coding so that they can practice it in the context of micro:bit."*

Nevertheless, all the individuals appeared to have a change of their teaching practices after they discussed about the application of using micro:bit to solve problems not only in an urban vegetable garden context but also in the various contexts. As a result, they were able to design activities for students to connect between micro:bit activities and real-life situations. Mary associated the micro:bit with her students to do further projects about light sensor. She mentioned, *"I let my students think about the need of users. Finally, they got an idea to create a light sensor with a micro:bit to automatically turn on a light when the ambient light level falls"* Likewise, Jenny chose the issue of dust pollution as the topic for her students to create a project using micro:bit. She stated, "*Micro:bit can be used for my students to solve the problem about PM 2.5 pollution … they will be good innovators in the future*." For Kevin, he instructed his students to work in groups and apply micro:bit to solve a problem in the animal farm. He reflected that, "*My students can apply the knowledge about coding to other situations such as creating the food giver machine for animals*". The findings indicated that teachers aimed to encourage their students to apply their knowledge of micro:bit to new situations.

Factors influencing teachers' use of micro:bit in teaching

The use of micro:bit in Mary, Jenny, and Kevin's teaching was influenced by three factors: teachers' knowledge in micro:bit, school supports, and students' awareness of the benefit of micro:bit.

Teachers' background knowledge in micro:bit

All case teachers pointed out that teachers' knowledge in using micro:bit influences their use of micro:bit in the classroom. Mary, Jenny, and Kevin accepted that if they did not participate in the PD program, they would not have used micro:bit in their classroom as Jenny revealed that *"I had limited knowledge of micro:bit before participating in the PD program. During the program, I learned various functions of micro:bit from experts. I could design my lesson to link with micro:bit and facilitate my students while they did the project related to the vegetable garden."* Kevin pointed out that he had basic knowledge about coding to adapt more quickly to incorporating micro:bit to his lessons as he stated that *"I am a computer teacher, so I have basic knowledge about coding, that makes me feel comfortable to apply micro:bit to my teaching."* Therefore, teachers who have background knowledge in micro:bit are likely to use of micro:bit in their teaching.

School support

All case teachers needed school support for using micro:bit in their teaching. Mary raised concerns about the school support related to technical support system to assist teachers with any issues related to micro:bit as she stated that: *"I need school support IT staff, providing troubleshooting support, sharing experiences, ideas, and resources related to micro:bit. This support can be included"*. Jenny needed school to support learning communities where teachers can share experiences, ideas, and resources related to micro:bit as she said *"If school provided learning community about using micro:bit in teaching, it would encourage peer learning and problem-solving about micro:bit. I would be more confident to use micro:bit in my teaching"*. Moreover, Kevin revealed that he required budget support from the school administrators after participating in the PD program. This suggests that the cost of acquiring micro:bit equipment was a barrier for him as well. *"We need budget support from school administrators for enough devices and resources. Anyway, the device is breakable and expensive, so teachers must watch students practice carefully"*. Such school support can create an environment where teachers feel empowered to effectively integrate micro:bit into their teaching,

Students' awareness of the benefit of micro:bit

All case teachers revealed that students' awareness of the benefit of micro:bit make their students more engaged in learning activities. Mary and Jenny reflected that their students' awareness of how micro:bit projects connect to real-world applications can impact their students to more engage in working with micro:bit, as she expressed. "*Students in this generation learn so fast. Someone who is aware of the advantages of micro:bit and has an interest in it will exhibit greater enthusiasm when engaging in activities* ". Kevin pointed out that his students were aware of the future career related to micro:bit. They displayed intelligence and creativity in creating workpieces using micro:bit that can link to career as he reflected. *"My students had more enthusiasm; they were proud of their developed artifacts from micro:bit. Consequently, they can link their knowledge and skills to other situations such as creating lie detector machine for police"*. This awareness may inspire students to recognize the real-world applications of their education outside the classroom, encouraging them to contemplate pursuing careers associated with micro:bit.

Conclusion and Discussion

The results of this research showed a very interesting outcome that depicts the impact of micro:bit and PD program to the education domain. Thirty-three teachers participated in the PD program. Three teachers were selected as case studies, applying experiences from the PD program to their teaching by allowing students to create their own projects using micro:bit, with the teachers acting as facilitators of learning. This was an effective by-product of the PD program that provided examples for teachers to apply the knowledge gained from the program to their own teaching (Avery & Reeve, 2013; Thammaprateep & Chartisathian, 2007).

As a result, they had more confidence and teaching efficacy. Consistent with various research studies, including Rich et al. (2021) and Kaya et al. (2019), they found that teachers' knowledge, as well as their teaching efficacy in coding and computational thinking, increased after engaging in a coding PD program. In order to effectively teach coding and computational thinking, teachers require positive self-efficacy in both their ability to grasp the subject matter and their ability to impart it to their students. Efficacy beliefs have consistently been associated with educational success (Bandura, 2006; Tschannen-Moran & Hoy, 2001). Thus, teachers with higher self-efficacy are more likely to invest greater effort in learning and teaching coding compared to those with lower self-efficacy (Eells, 2011). In addition, the teachers who participated in the PD program of this current study better linked micro:bit activities to their expertise area of teaching such as Art, English, under the garden context. As Voštinár and Knežník (2020) found, teachers could link micro:bit activities in primary and secondary schools with STEAM education to create smart home. Moreover, the students' awareness of the benefit of micro:bit were positive as their generation forces them learn to quickly. Yalçın-İncik and İncik (2022) mentioned that the use of technology increases students' interest in the lesson, enables them to learn easily, increases their technology use skills, and provides easier and faster access to more information.

Furthermore, the teachers of various subjects in this study accepted that micro:bit could be linked with real-life situation more than concept of coding. Stanojević et al., (2021) mentioned that micro:bit pervades our overall living and working space to the extent that digital illiteracy dramatically handicaps and marginalizes an individual; therefore, possible use of micro:bit in teaching its impact on the development of the use of technology in all lessons.

However, the factors that constrain or facilitate their using of micro:bit in their classrooms are their knowledge in micro:bit, and financial support. Similarly, Ruangsuwan (2004) indicated that there were many problems in using technology in education such as infrastructure, funding and personal experience. In addition, limitations of software (e.g., updating the value of variables) should be of concern to develop micro:bit in the classroom (Bernad et al., 2021). The teachers in this study also pointed out about that students' interest in using micro:bit was the main factor that they encountered when they implemented micro:bit in their classrooms. Hence, teachers should encourage all students to use micro:bit, in not only the computer technology subject, but also to integrate it into another subject area. Due to this, students will have a great opportunity to gain an experience that will benefit them in many situations.

Recommendations

The observed transformations among teachers in this study offer compelling evidence that the activities devised and implemented within this professional development (PD) program, situated in the context of an urban vegetable garden, effectively prepare educators to integrate the micro:bit into their instructional methods. Nevertheless, additional research is imperative to substantiate the PD program's effectiveness on a larger scale. To foster the ongoing integration of the micro:bit in teaching, it is vital to establish professional learning communities that can offer teachers guidance in their utilization of the micro:bit. Given that this study focused solely on a Bangkok Metropolitan school, future research should encompass teachers in diverse school contexts to compare factors and changes in micro:bit utilization resulting from the PD program.

Furthermore, researchers should pay attention to the formulation of policies and support mechanisms for the sustained use of the micro:bit over the long term. Lastly, it is essential to address both hardware and software limitations when developing the micro:bit activity for classroom use.

Conflict of Interest

The authors declare that there is no conflict of interest.

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