Engagement in Physical Computing for the Primary Classroom: the BBC Micro:bit Experience

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Abstract: Computational thinking is an essential skill for 21st century learners. Many efforts have been made to support and enhance computer science instruction in formal and informal educational settings. However, it remains a challenge to engage students in algorithmic design and computer programming. Physical computing, the approach of computer-human interaction design that links computer programming with the physical world, promises to increase student motivation and engagement. However, the nature of student engagement in physical computing activities has not been extensively studied. The main aim of this study is to investigate the nature of primary school students engagement in physical computing activities through a popular single-board physical computing device, the BBC Micro:bit. The study uses the constructionism as its theoretical framework and implements a series of project-based physical computing activities with primary school students. Mixed methods design have been employed. Study findings highlight the cognitive, behavioural, emotional and social dimensions of student engagement in physical computing activities using the BBC Micro:bit. High engagement levels in all four dimensions were revealed with the emotional dimension to prevail. The study findings can inform future physical coding activities and pedagogical approaches that foster pupils' engagement.

Keywords

BBC micro:bit, physical computing, K-12 computer science, engagement

1. Introduction

Computational thinking, based on its operational definition by the International Society of Technology in Education and the Computer Science Teachers Association (2011), is the process of developing solutions that can be carried out by computers and incorporates logical organisation and analysis of data, abstraction, pattern recognition and algorithmic thinking. Computational thinking, beyond problem solving skills, involves critical thinking and creativity (Wing, 2006). Therefore, it is essential for the 21st century learners. In recent years, there has been a growing interest in developing computational thinking and integrating computer science in school curricula (Hubwieser, Armoni, Giannakos & Mittermeir, 2014). Moreover, there is a growing need for evidence on designing engaging and effective computer programming activities for children (Lye & Koh, 2014).

In this context, physical computing has been employed as a means of supporting student motivation and engagement in project-based activities. Physical computing can extend computer science instruction through programmable sensors and actuators that interact with the real world. However, despite the affordances that physical computing can offer, barriers involving teacher knowledge and experience, student overload or poor teaching design may discourage student engagement (Katterfeldt, Cukurova, Spikol & Cuartielles, 2018). Previous studies on student experiences in physical computing activities have been focused on student attitudes (Videnovik, Zdravevski, Lameski, & Trajkovik, 2018; Sentance, et al., 2017) or motivation and engagement (Papavlasopoulou, Giannakos & Jaccheri, 2019; Cápay & Klimová, 2019). However, to the best of our knowledge, no study exists to investigate the nature of student engagement in physical computing activities. The current study aims to investigate student engagement in physical computing activities (BBC Micro:bit) in the context of primary education.

2. Background

2.1 Physical Computing and the BBC Micro:bit

In recent years, there has been a significant effort from different educational systems worldwide to introduce computer science into school curricula. However, despite the growing interest in computational thinking, its successful integration in school curricula is still facing several challenges and barriers (Bocconi, et al., 2016).

One of the promising approaches to increase student interest towards coding is the introduction of physical computing. Physical computing are hardware and software systems that interact with the real world by sensing and responding to changes in environmental variables. Physical computing has been used in educational contexts to extend computer science curriculum by introducing programming concepts in a more meaningful way (Przybylla & Romeike, 2014). Among the benefits of physical computing are opportunities for collaboration, creativity, ease of use and tangibility that supports learning algorithmic thinking and programming (Sentance et al., 2017).

The BBC micro:bit (Ball et al., 2016) is small physical computing device that aims to support the creative use of digital technologies in schools and "inspire every child to create their best digital future".

2.2 Engagement in BBC Micro:bit classroom activities

Engagement in learning is the student's active involvement in a learning activity and it has four dimensions: behavioral, emotional, cognitive and social (Fredricks, Blumenfeld, & Paris 2004). Behavioral engagement is the participation in class-based activities. Emotional engagement is the interest and enjoyment during the learning process. Cognitive engagement is about deeper learning strategies and self-regulation. Social engagement refers to social interactions during the learning process.

While previous studies have highlighted the impact of the BBC Micro:bit physical computing platform on student engagement, to the best of our knowledge, no study exists on the nature of the engagement that students exhibit while participating in BBC Micro:bit activities. The current study aims to fill this gap by answering the following research question: What is the nature of engagement that primary school students exhibit while participating in physical computing activities using BBC Micro:bit?

3. Methodology

The study aims to investigate the different dimensions of student engagement in physical computing activities using the BBC Micro:bit. The study is based on the theoretical framework of constructionism (Papert, 1980). According to this approach, learning happens in real context with the learner actively constructing their own knowledge by building on top of what they already know and by producing real artefacts. Meaningful construction of knowledge through engagement in creating artefacts in a social context.

3.1 Participants

Participants in the study were twelve Primary 6 pupils from an urban area school in Scotland. Participation in the study was voluntary; participating students and their parents were informed in advance and written consent forms that gave permission for data collection were obtained, in accordance to the ethics standards of the researchers' University.

3.2 Procedure

The study was implemented during a three-week period in the context of a six-week program on integrating digital fabrication in the primary curriculum. The students participated in three 2-hours sessions. Students worked in groups of 2 to 3. They used the BBC Micro:bit with electronic circuits in small projects.

3.3 Data collection and analysis

The study follows a mixed methods design. Quantitative data about student engagement were obtained through the questionnaire that students were asked to fill in after the last session. Questionnaire items were based on the well-validated multidimensional engagement questionnaire developed by Wang et al. (2016).

In order to gain more insight into the student views, qualitative data were also obtained through classroom observations and two focus group meetings. For the qualitative analysis, thematic analysis was used (Saldaña, 2015).

4. Results

The analysis of the results is ongoing. Internal consistency was verified for the four dimensions of the engagement questionnaire. All dimensions of engagement were reported high (their mean values correspond to the Likert response options above "agree" and "strongly" agree). The emotional dimension was the higher (mean value = 4.42). Table 1 shows the descriptive statistics of the study.

Variable	N	Mean	SD	Median	Min	Max
Cognitive Engagement	12	4.04	0.37	4	3.63	4.88
Behavioural Engagement	12	4.00	0.41	4	3.50	4.63
Emotional Engagement	12	4.42	0.43	5	3.60	4.90
Social Engagement	12	3.89	0.44	4	3.38	4.50

Table 1. Descriptive statistics

From the two focus groups in the study and the classroom observations, five main themes were emerged: programming is/can be fun, programming is/can be easy, programing is creative, programming can be collaborative, programming skills are useful. All themes are related to the engagement dimensions revealed from the quantitative analysis and are relevant to our research question.

In all interviews, students expressed that they really enjoyed the BBC micro:bit physical computing activities. Most students agreed that "programming with Micro:bit is really good" and "learning with Micro:bit is fun". The majority of the students found the activities easy to do, "programming can be easier than I thought". Students found that "BBC micro:bit activities gave the opportunity to collaborate with classmates". Almost all students expressed the views that "Micro:bit helped them to learn many useful things" and "programming is really useful".

5. Discussions and Conclusions

The paper contributes to the current debates about how to improve student motivation and engagement in computational thinking through physical computing innovative practices. It informs education practitioners about the opportunities that tangible computing has to offer in order to design more engaging computer science instruction in primary and/or secondary education.

The study is in line with findings from previous studies on the opportunities offered by physical computing: computational thinking support (Sentence, Waite, Yeomans & MacLeod, 2017), creativity (Videnovik, 2018), collaborative learning (Horn, Crouser & Bers, 2012) and engagement (Sharma, Papavlasopoulou, & Giannakos 2019; Cápay & Klimová, 2019). The highly engaging nature of the physical computing can help to overcome other barriers to its adoption such as, lack of teacher experience, overload due to hardware assembly arrangements or timing constraints.

Moreover, the study makes a contribution in the general context of the Maker Movement initiative. Maker Movement refers to activities ranging from the re-creation and assembly of products by using low-cost materials (including electronics) to the employment of new technologies such as 3D printing and laser cutting for the prototype stages. It is as an important and promising development in educational technology (Becker, et al., 2018).

The current study raises the importance of computational thinking in the physical representations of the Maker Movement, the Fabrication Laboratories (FabLabs).

The BBC Micro:bit offers opportunities to overcome the challenges of teaching and learning algorithmic thinking and computer programming and to place pervasive computing at the center of Computer Science education. Student engagement with Computer Science is of great importance for pursuing successful careers in science and engineering. One of the limitations of the study is its small sample size. Future studies will employ larger samples from more diverse educational contexts.

Acknowledgements

The authors would like to thank the University of Strathclyde Vertically Integrated Projects (VIP) for Sustainable Development, the University of Strathclyde Fab Lab, and the Head Teacher, Principal Teacher and all pupils of the participating Primary School.

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