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The BBC Micro:bit in the International Classroom: Learning Experiences and First Impressions

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***Abstract*—Introduction to computer science has been part in school curriculum for many years now. However, the way it has been performed traditionally poses motivational and collaboration challenges, thus having limited engagement from students. There is a renewed interest in enhancing learning with physical computing, owing to its positive impact on motivation and enhanced opportunities for collaboration and creativity. Recognizing this, a BBC-led consortium developed a portable and low-cost programmable device, the micro:bit. In this study, we report the impressions of students and teachers when they encountered it in the classroom for the first time. The device was presented to a group of 36 students and 5 teachers from 4 countries, and then after the brief tutorial, all of them familiarized with it by programming it themselves. We evaluate the ease of use and tangibility of the device, and analyze student quality of experience, that validate the aforementioned benefits of this approach for learning to code.**

***Index Terms*—BBC micro:bit, quality of experience, primary school computer science**

I. Introduction

The traditional based concepts on the knowledge acquisition and the repetition model has provided a lot of doubt about the quality of primary education [1]. There are many approaches that can be used to make education process more attractive to pupils and students.

The primary school education approach is shifting from teacher-lead and knowledge oriented towards students-engaged and skills development. In this manner, teacher role is more of a facilitator who encourages the class to think and question the world around students, than educator that leads the class from the classroom front [2]. The approach transforms the lesson plans by emphasizing the development of thinking skills, providing examples of applied thinking, and adapting to diverse student needs. Teachers help students to develop higher order learning skills through the scaffolding concept. The scaffolding approach is a dynamic intervention of teacher giving students support at the beginning of a lesson and gradually requiring students to practice the skills independently [3]. This way of learning changes students towards higher-order thinking abilities to work in teams or individually and become leaders while being accountable and adaptable, making them a socially responsible. Furthermore, the higher order thinking can be practiced by examples of open-ended questions that encourage students to analyze the known facts in order to make a concrete conclusion independently. This will support students when making choices, team brainstorming, finding solutions and practicing interpersonal and self-directed skills [4].

Different ways of thinking that include the skills for problem-solving; creativity and critical thinking have supported the development and increased children's interests in STEM subjects and careers [5]. Critical thinking and problem-solving approach within digital learning environments have an associated relationship in the learning process. Critical thinking is a meta-cognitive process that evaluates information through exploration of validity and produces logical conclusions to arguments or solutions and achieves resolutions [6]. This skill is becoming very important for education with the large quantity of information and resources made available with the Internet and connected society. Effective critical thinking skills within a digital learning environment will help students become more adaptable, flexible and better able to cope with the rapid development of ever-evolving information [6].

The ever-increasing range of technology tools available to support learning in the classroom enables students and teachers to use digital tools to personalize learning and promote creative thinking within a connected learning classroom [7]. The digital revolution brings many benefits for education and makes students be able to engage in fact-finding, understand bias and validity testing. Furthermore, most of the employers expect that today's graduate students are tech savvy and know how to use technology in their future careers. The digital literacy today means that a person understands computing technologies, programming, and computational concepts, which has become a core skill for an informed participant in modern society [8]. Therefore, it is very important to engage students with the computing concepts in the primary schools.

Today's tech-devices have extended student's opportunities for creative learning across time and space. For years, academic have tried to use virtual and augmented reality envi-

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ronments [9], or different resources within distance education systems [10] in order to increase both educational outcomes and quality of experience of the educational process [11]. All these approaches are really simulating hands on experience.

With the latest development in educational technology, the price of educational resources enable educators to change simulation environments based on e-learning paradigms with low cost resources that can be used directly in the classroom on a large scale [12].

The micro:bit is an ARM-based embedded system designed by the BBC for use in computer education [13]. The reason why it was developed was to address a trend that there were not enough students taking university computer science courses and not enough working people skilled in computer technologies [14]. This had happened because schools had stopped teaching children about computers and how to code them. It is an attempt to better educate people about computer science concepts, regardless of their (professional) goals in life [8].

The ultimate goal of micro:bit is to innovate the educational process of learning how to code by providing the easy to understand solution from Scratch inspired learning environment [15] to higher level languages programming environment, such as Python [16]. At the same time, it provides hands-on experiences on not only coding, but provides insights to basics of embedded programming.

The main goal of this paper is to illustrate how the micro:bit platform can be integrated in the classroom and evaluate how it will be accepted by students in terms of the achieved learning outcomes, and the obtained quality of experience.

Next Section II provides the background information on micro:bit platform. Next, Section III present the used methodological approach in our study. The results of the study are discussed in Section IV. Finally, Section V concludes the paper.

II. MICRO:BIT SPECIFICATIONS AND CODING ENVIRONMENT

The BBC micro:bit is a pocket-sized (4cm by 5cm), codable computer, designed to allow children to get creative with technology. It allows students to create ubiquitous computing applications in a simple way [17]. It is powered by an ARM Cortex-M0 Processor and has 256K non-volatile flash (for a program and static data) and 16K volatile RAM (for stack, heap) [13]. its production is low-cost, and because of the compact size, its transport is easy and it can easily become accessible. The chip is self-contained with sufficient on-board sensors and buttons for input, as well as LEDs acting as an output. This makes the BBC micro:bit a creative tool that can be used in order primary school students to become more familiar with concepts of algorithmic thinking, coding, programming, game development and robotics.

The BBC micro:bit device has a possibility to connect with other devices, sensors, kits and objects, and is intended as a companion rather than a competitor to other devices (Arduino, Raspberry Pi and etc.) acting as a springboard for more complex learning [13].

Each micro:bit device has the following physical features, and their layout is shown in Figure 1.

- 25 individually-programmable LEDs
- 2 programmable buttons
- Physical connection pins
- Light and temperature sensors
- Motion sensors (accelerometer and compass)
- Wireless Communication, via Radio and Bluetooth
- USB interface

Figure 2 shows the interactive web-based editor where all code is written through dragging and dropping components in a logical order.

Creating programs is through drag and drop of various components, and the experience resembles to playing with LEGO. Underneath this, however, each component corresponds to a code-block from a programming language. In Figure 3, an exemplary block of commands is shown as blocks in the editor, but also the corresponding Python code. The similarity is obvious, and the idea is that this will simplify the transition from programming micro:bit to programming real software. The same paradigm is used in the Scratch environment for learning to code.

III. STUDY

In this study, we report the impressions of students and teachers when they encountered the micro:bit in the classroom for the first time. The device was presented to a group of 36 students of age 12 and 13, and 5 teachers from 4 countries. Then after the brief tutorial, all students familiarized with it by programming it themselves.

The first goal the experiment was to identify different features that influence on qualitative integration of tools that incorporate digital learning in the classroom and investigate their value in the educational process. The parameters refer to students' attitudes, opinions and interactions while using educational tool. Ease of use is a factor that determines students' motivation for using the tool for learning. We also took into account the use of a tool for achieving educational goals (not only as an assessment method). In that way, we tried to make a correlation between motivational and educational value of a tool. The second goal of the experiment was to investigate whether there is a need to deploy different educational tolls regarding the gender of the students.

The major challenge that we have faced in this class was the lack of time to deliver thorough and practical training. We wanted to promote a creative and simple approach to coding, and application of digital technologies. Our tool was a very simple computer (Micro:bit) that accepts input instructions, processes it according to the previously inputed instructions, and then generates an appropriate output. In general, our focus was to draw attention to digital creativity.

During the training, we have organized students and teachers to work in international teams. The class engaged all teachers because they were required to describe Micro: bit features

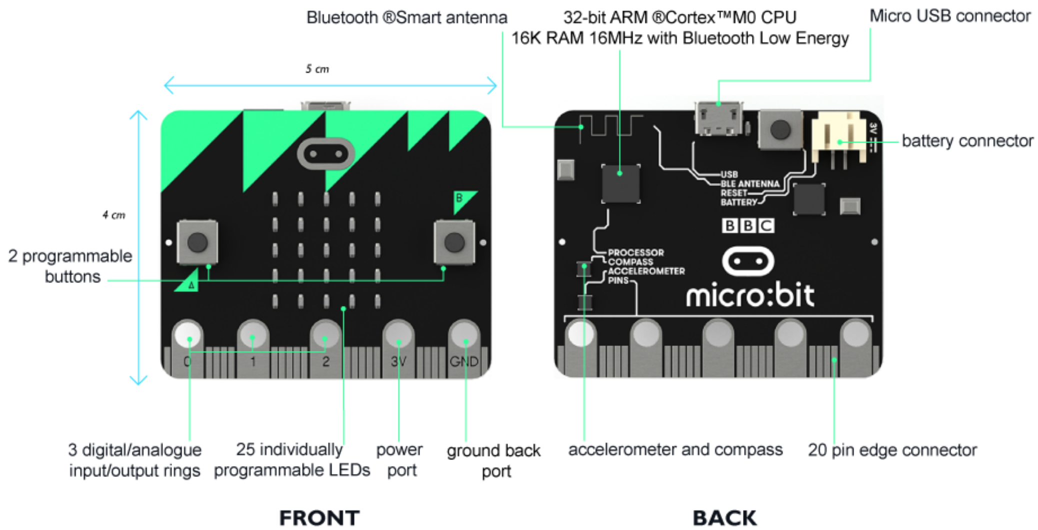

Fig. 1: Physical layout of hardware sensors on the micro:bit board

and to support students with their practice. The teachers were instructed to use open questions, and to encourage competition with other teams. The goal was to create "most fun" solution within the group. Students were free to check all the other groups at any time, and to discuss among students from others groups at all the time.

After the classes, which lasted about 4 hours, each student was given a questionnaire with the following questions:

1) Age
2) Gender
3) City
4) Country
5) What did you learn about programming micro:bit?
6) I had fun programming micro:bit?
7) It was hard to program micro:bit?
8) I liked coding before?
9) I like coding now?
10) I would like to learn more about micro:bit?

Students could write free-text answers on the first 5 questions. On questions 6-10, they could choose an answer from 1 to 5, 1 meaning strongly disagree and 5 meaning strongly agree. The results from the questionnaire are presented in Table I.

IV. Results and Discussion

Given that there were only five teachers, each responsible for up to 8 students, the time dedicated to each student was limited, so the students needed to explore the possibilities on their own. Students managed to find already functional code and transfer it to the device using on-line tutorials with no, or very little support from the teachers. Once they understood which part of the code is responsible for which input (with a teachers' support), they were able to modify it and produce new alternatives to the existing solutions.

Working in teams encouraged them to compete to create more appealing solutions than the other teams, which resulted in more efficient way of learning the basic coding concepts. The learning was based on student inquires, and the teachers only helped students teams to realize their ideas, The gamification of the process proved to increase the efficiency of the learning process.

Working in international teams in the environment that requires collaboration in order to achieve better results (due to the gamification based competing element encouraged during the class) increased both the communication skills of all students and the self detected leadership skills of some of the students.

There were no significant difference in answers or results from students from different countries or age. This is due to the fact that they work collaboratively and in mixed teams. This helped in sharing of the obtained knowledge.

More extrovert students asked questions and things were clarified to them. Therefore, it is understandable that there were positive comments, reported in the questionnaire, and some of them are listed below:

- 'I learned to program rock paper scissors.'
- 'I learned how to make a dice out of it and how to make a program that would count your jumps.'
- 'That by shaking the device the number can change.'
- 'It is not very hard and its fun.'
- 'It was very easy to program.'

However, there were comments which illustrated the lack of time, such are:

- 'Nothing really; I didn't see anything. I just know how to program text.'
- 'It was so hard, I learned that micro:bit is difficult to program.'
- 'I don't know', reported by few students.

Fig. 2: Interactive web-based editor

TABLE I: Gender distribution of average answers of grading questions (1-strongly disagree, 5-strongly agree).

Gender	Fun programming micro:bit	Hard to program micro:bit	Liked coding before	Like coding now	Like to learn more about micro:bit
Boy	4.0	3.4	3.7	3.7	4.1
Girl	4.1	3.8	3.5	3.6	4.1
Total	4.1	3.6	3.6	3.7	4.1

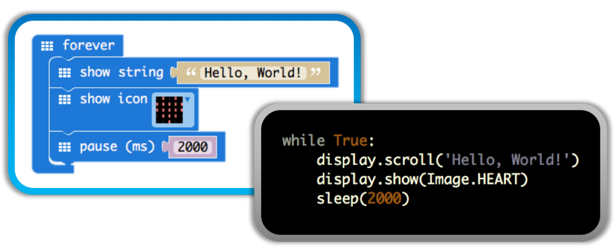

Fig. 3: Comparison of editor blocks and corresponding Python code

The possibility to be connected to devices and sensors is lowering the barrier to entry into programming due to the fact that students can see and touch the results of their work. In the same time, they can independently create notions in benefit of computational concepts and become familiar with the basics of programming. Its low-cost price, easy and simple web-based interface and variety of sensors increases students' interest to continue developing computational thinking skills independently. We believe that these factors increase students' quality of experience (fun) while learning. This reflects with the interest in more detailed knowledge about the tool used for learning to code that is bigger than the general interest in learning how to code. At the same time, we think, that increase in the value of "like to code" variable from 3.6 to 3.7 in only few hours is also due to the high quality of experience obtained using the tool.

The students that have more fun have increased interest in learning how to code. The students that declared lower quality of experience (fun), show no increase of interest about learning to code. In matter of fact, two students with low level of quality of experience, decreased their interest in learning to code.

Different studies show that there is still gender imbalance in learning computer science [18]. To see how this is reflected when learning the micro:bit, we paid special attention to this aspect. The average results from the questionnaire grouped using gender data are given in Table I.

During the tutorials, there was an initial gender preference regarding which students were prone to try to program the devices first. Boys were more forthcoming and girls were more reserved. However, after properly explaining the functionalities and encouraging girls to participate more, this initial interest seemed to change. This was achieved by explicitly instructing girls to lead the programing, as opposed to picking a volunteer, which was in more cases a boy. Then the same girls, which were initially reluctant to lead the development, paid more attention, were intrigued by the programming, and then they were able to do the practical tasks correctly. On ambiguous questions, or when some things could be done in multiple ways, girls picked the right way to do some task more frequently and answered the questions more accurately than boys. This reinforces the thesis that the preferences for learning programming and computer science in general is not about gender specifics and usage of learning tools, but rather about learning opportunities.

V. Conclusion

In this paper we described the first impressions of students when they had the first encounter with BBC micro:bit. We conducted an experiment in order to investigate different features that influence on qualitative integration of digital educational tools in the classroom. The presented results show clear relation between quality of experience obtained by using tool for learning and educational value of a tool.

We also analyzed how the experience is affected by gender and learning opportunities. Interestingly, after the course girls liked coding more than they did before, which we attribute to opportunities provided to them during the class.

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