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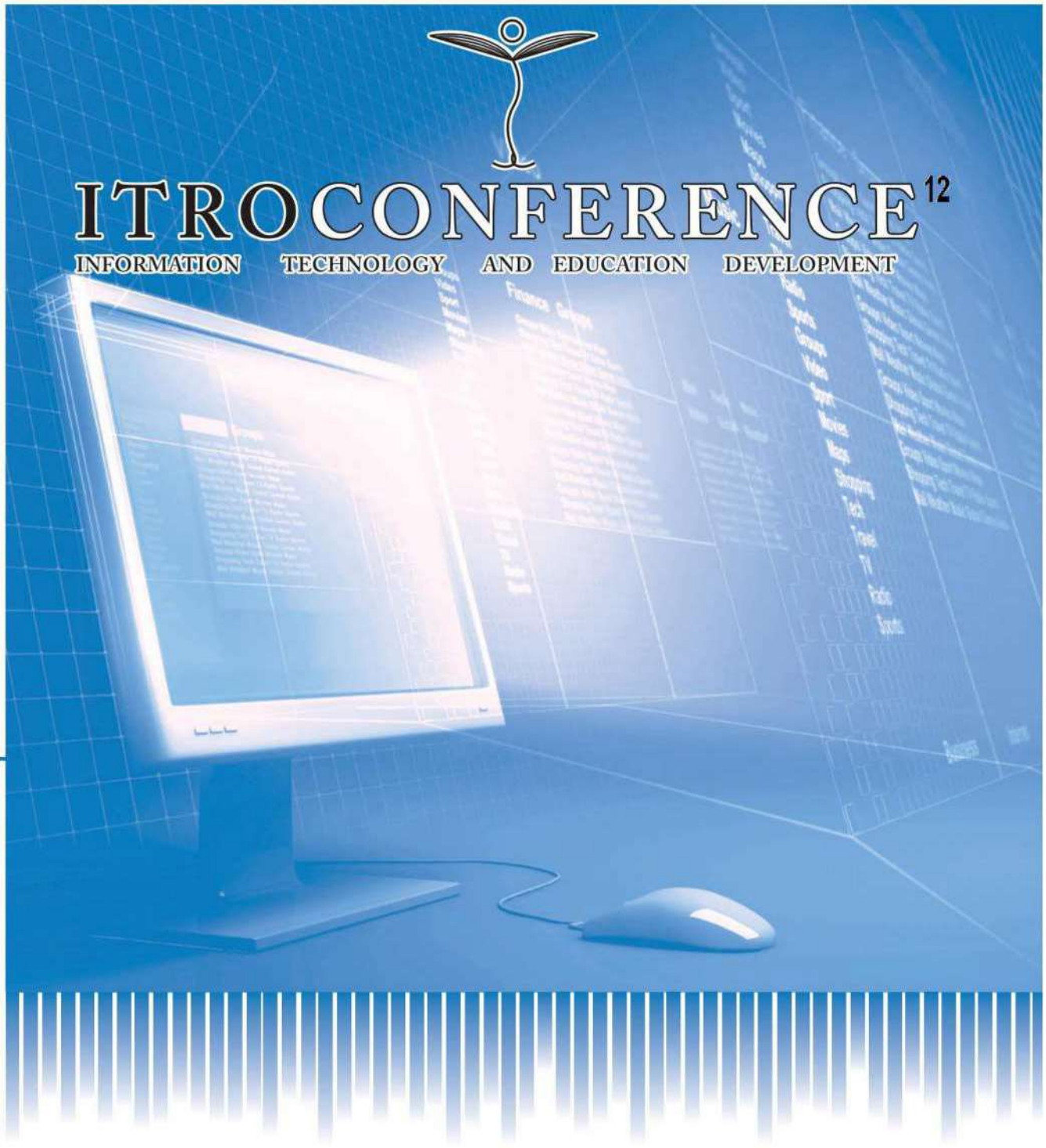
INFORMATION TECHNOLOGY AND EDUCATION DEVELOPMENT



PROCEEDINGS

ZRENJANIN, November 2021

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TECHNICAL FACULTY "MIHAJLO PUPIN"
ZRENJANIN
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PROCEEDINGS OF PAPERS

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With this publication, the CD with all papers from the International Conference on Information Technology and Development of Education, ITRO 2020 is also published.

INTRODUCTION

This Proceedings of papers consists from full papers from the International conference "Information technology and development of education" - ITRO 2021, that was held at the Technical Faculty "Mihajlo Pupin" in Zrenjanin on November 26th 2021.

The International conference on Information technology and development of education has had a goal to contribute to the development of education in Serbia and the Region, as well as, to gather experts from natural and technical sciences' teaching fields.

The expected scientific-skilled analysis of the accomplishment in the field of the contemporary information and communication technologies, as well as analysis of state, needs and tendencies in education all around the world and in our country has been realized.

The authors and the participants of the Conference have dealt with the following thematic areas:

- Education in crisis situations
- Educational challenges
- Theoretic and methodology questions of contemporary pedagogy
- Digital didactics of media
- Modern communication in teaching
- Curriculum of contemporary teaching
- E-learning
- Education management
- Methodic questions of natural and technical sciences subject teaching
- Information and communication technologies

All submitted papers have been reviewed by at least two independent members of the Science Committee. There were total of 94 authors that took part at the Conference from 12 countries, 3 continents: 52 from the Republic of Serbia and 42 from foreign countries such as: Macedonia, Bosnia and Herzegovina, Hungary, Slovakia, India, Bulgaria, Rumania, Albania, USA, Canada, Malaysia. They were presented 49 scientific papers.

The papers presented at the Conference and published in Proceedings can be useful for teachers while learning and teaching in the fields of informatics, technics and other teaching subjects and activities. Contribution to the science and teaching development in this Region and wider has been achieved in this way.

The ITRO Organizing Committee would like to thank the authors of papers, reviewers and participants in the Conference who have contributed to its tradition and successful realization.

Chairman of the Organizing Committee

Snežana Jokić, Ph.D, Ass. Professor

CONTENTS

INVITED LECTURE

SCIENTIFIC PAPERS

Use of Educational Hardware and Software to Encourage Children to Code

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Abstract – Primary and secondary computer education nowadays requires modern aids to be included throughout the educational process. The purpose of these aids is to encourage children to code, to be more interactive, and to express their creativity. A new class of computing devices, called Single Board Computers (SBC) are tools that can help achieve the modern educational requirements as critical thinking, problem solving, creativity, interaction etc. The main idea here is to present a short survey of educational programmable hardware systems. In our case study, we want to point out the benefits of SBC and their impact on the education process.

I. INTRODUCTION

Modern days require a modern educational approach. It is especially important to use modern educational tools in the computer educational process. These modern tools will ensure implementation of modern educational trends and practices. But it is more important that the use of modern practices is spread all over the educational process so that both children and teachers will have benefits from it.

There are many initiatives, projects, communities, and foundations which are committed on design and manufacturing of educational hardware and software. These educational computing platforms are intendent to encourage children to code with the use robots such as Lego Mindstorms, and other programmable hardware platforms such as Arduino [5], BBC Micro:bit, Calliope mini and etc. Most of these educational devices are described as half the size of a credit card and, depending on the hardware board they have a processor (ARM, AVR, etc.), several sensors, Bluetooth, USB connectivity and additional development tool kit sets with different modules and accessories. The educational software is intended to simplify programming concepts and make it easier for teachers and children to teach how to code. This means that the educational software is customized for children of different ages with or without technical pre-knowledge to programing. All educational computing platform can be used to code on one or more high level programming languages as C/C++, Python, Java, JavaScript, etc. or visual user-facing (drag and drop) block editors. There are various code editors, IDEs, interpreters, simulators, cloud-based programming environments and, etc. that are developed and intendent for coding the educational hardware.

Other advantages of these educational devices are the small size, affordability, ease of use with simple installation, they have many tutorials and examples, good documentation, and good auxiliary materials for beginners. These devices can bring different dimension in the approach to encourage children to code so that at the same time they can have fun and acquire and learn new programing skills.

By using computing educational aids through the educational process children can work together on many different and interesting problems and immediately feel the benefits from their work. In fact, such an approach can bring various benefits within the whole educational process and not only in computing education. One of the goals could be finding different applications across the different school subjects. With this approach it will increase the interest, curiosity, concentration, creativity, and many other crucial qualities which are critical for personal development.

Our focus with educational hardware will be on SBC [13] (microcontrollers and microcontroller kits) that are designed and built for educational use. The target group of our interest are primary school students.

The paper is organized as follows: General description of SBC with some representatives will be covered in Section 2. Section 3 will be devoted to the advantages and disadvantages analysis of all presented SBC in the previous section. Questionnaire in two primary schools in Berovo conducted over the teaching staff will be referred in Section 4. In the end there is a conclusion section.

II. SINGLE BOARD COMPUTERS

As the name itself tells us, SBC is a complete computer built on single circuit (printed) board, with

microprocessor(s) (MPU), memory, input/output (I/O) and other additional features required of a functional computer. On the other hand, a single-board microcontroller (MCU) is a microcontroller built onto a single circuit (printed) board. This board consists of all the circuitry necessary for a useful control task and is built with microprocessor, I/O circuits, a clock generator, RAM, stored program memory and any necessary support Integrated Circuit (IC).

The Central Processing Unit (CPU) is the logic electronic circuitry that control execution of the program instructions containing a computer program. Microprocessors consist of only a CPU, while the microcontrollers contain a CPU, Memory, I/O, all integrated into one chip. An MCU can be viewed as a single-chip computer, whereas an MPU has surrounding chips that support various functions like memory, interfaces, and I/O. One of the main differences between MCU and MPU is that a MPU will typically run an operating system.

In the next paragraph, we will briefly introduce the most popular and widespread educational hardware. Their basic characteristics and most important features will be included as well.

A. Arduino

Arduino (Fig. 1) is an open-source, easy-to-use hardware and software company, project, and user community that designs, develops and manufactures single-board microcontrollers and microcontroller kits [2]. Arduino boards can read inputs, light on a sensor, a finger on a button, etc. or can turn it into an output activating a motor, turning on an LED, etc. You can tell your board what to do by sending a set of instructions to the microcontroller on the board.

The Arduino hardware products are distributed under a CC-BY-SA license, while software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL). There various official Arduino boards are available from the official website or by the authorized distributers.

There are various microprocessors and controllers that are used to develop a range of Arduino boards. The boards are equipped with sets of digital and analog I/O pins that can be connect to various expansion boards, breadboards, modules, and other circuits. The boards contain serial communication interface and most of the model include Universal Serial Bus (USB) which, among the other things, are used for loading programs.

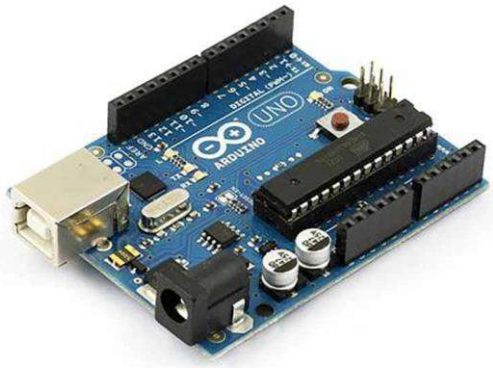

Figure 1. Arduino Uno SMD R3

The Arduino boards are based off an Atmel [3] 8-bit AVR, 32-bit ARM Cortex-M or Intel Quark (x86) microcontrollers with varying flash memory sizes, pins, and features. The microcontrollers can be programmed in any programming language with compiler that produces binary code for the target processor. Arduino can be programmed by C and C++ programming languages, using a standard API also known as “Arduino language”. Apart from traditional compiler toolchains, the Arduino provides open-source IDE and web editor.

Because of the simplicity and the accessible user experience, this platform takes part in thousands of different projects and applications. The software is easy to use for beginners and advanced users alike. Anyone, including children can start by following the step-by-step instructions of the kit or sharing the ideas online with the Arduino community.

Arduino simplifies the process of working with microcontrollers, and some advantages are low cost, Cross-platform (run on Mac, Windows, and Linux), simple, clear programming environment, open source, extensible hardware, and software

B. Micro:bit

The Micro:bit [8] (Fig. 2) is open source educational hardware originally created by the BBC [4] and collaborators for use in computer education in the UK. This device is with half size of credit card, and the boards are based on ARM Cortex-M microcontroller, flash memory, static RAM memory, require 3V power supply, it has two embedded accelerometer and magnetometer sensors, there are also two connecting interfaces Bluetooth and USB, two programmable buttons, a display that consists of 25 LEDs, and five ring I/O pins connectors. The device can be powered by either USB or an external battery pack.

Figure 2. Micro:bit

The second nearly identical Micro:bit board has been released in October 2020. This board is identified as v2. Mainly the differences between the boards are in the hardware configuration. Naturally, newer boards have better hardware such as microprocessor, more memory, and other new features.

There are two official code editors: Microsoft MakeCode [10] and MicroPython [9] for Micro:bit board that can run as a web application in the browser. These code editors are available on their foundation web site [8]. There are other non-official editors for programing on Micro:bit. Except the text-based programming, some of the editors provide programming of Micro:bit by visual block-based languages. There is a possibility to switch to the text-based code which is behind blocks. The programing languages that can be used for programming the Micro:bit are Python, JavaScript, C++, Pascal, etc.

This device is particularly designed with purpose to encourage children to code and build new things. It is designed to work alongside other systems to improve computing education. Alongside this board there is are different development kit sets with different modules and accessories that enriches board functionalities and applications.

C. *Calliope mini*

Calliope mini (Fig. 3) is a tiny SBC developed for educational usage at German primary schools [6]. This initiative was been inspired by the BBC Micro:bit. The Calliope mini is in the shape of a star (Fig. 3) that prevents short circuits which is more secure for the children. It can be said that it's based on Micro:bit with ARM Cortex-M0 microcontroller, flash memory, RAM memory. This device has additional components such as a loudspeaker, microphone and RGB light-emitting diode, two Grove connectors, extended input and output options.

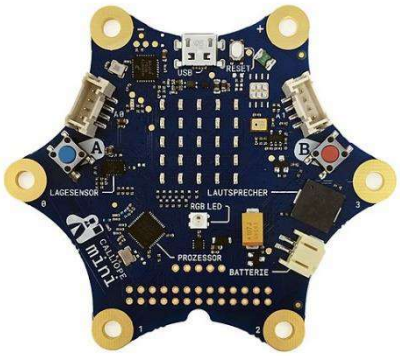

Figure 3. Calliope mini

The Calliope mini can be programmed in C++, JavaScript, Python programing languages. There are several editors that can run as web applications in the browser or as offline desktop editors. The visual development software that can be used to program Calliope mini includes Scratch [15] the Microsoft MakeCode based editor, Open Roberta Lab (NEPO) [12] and the Calliope mini Swift Playground (Apple App) [16]. There is also MicroPython support for the Calliope mini. Calliope mini kit set with accessories enriches board functionalities and applications.

D. *Additional remarks*

There are other SBC that can be used in computing education but from various reasons that are not mentioned here. The Raspberry Pi, Banana Pi, GoWarrior, Omega2, etc. can be included to the category of educational hardware but because of their characteristics, software, and programing user interface, required level of knowledge of programming languages, their purpose is not very appropriate for our target group of users.

III. ANALYSIS ON SINGLE BOARD COMPUTERS

The devices mentioned in the previous section are chosen for analysis because of their predefined purpose. These devices are specially designed computing educational platforms which are intended for the youngest population.

Each of the representatives have their strengths and specific characteristic. For analysis purposes, several will be considered as different categories to evaluate and compare. Apart from this, some of the categories will have greater weight during evaluation from the obvious reasons. For example, easy comprehensibility, simplicity will have greater value during the evaluation. Simplicity is it important for our target group.

To have a more general and efficient analysis there will be considered several main categories as software, safety use, range of applications, development tool kit sets, study documentation as

guides, books, tutorials, or videos. The comparation will be made upon the officially available hardware,

TABLE I. TABULAR SBC ANALYSIS

SBC / Categories	Arduino	Micro:bit	Calliope
Software	Intended for students (basic knowledge)	Intended for children (beginners)	Intended for children (beginners)
Compactness and safety use	Various board with different shape and sizes	Credit card size	Shape of a star for safer use
Tool kit sets	Wide range of different tool kit sets	Starter set with additional accessories	Starter set with additional accessories
Range of applications	Wide range of education, home and cheap industrial - scientific application	Wide range of educational application	Wide range of educational application
Study documents	Various study materials intended for students	Various study materials intended for children	Various study materials intended for children
Simplicity of use and understend	Requires certain knowledge	Easy to use and comprehend	Easy to use and comprehend

software tools and documentation. Depending on the situation, we will mention important information from nonofficial sources. The intention here is not to make strict conclusion for the best educational SBC but rather to present general conclusions. This analysis can make it easier for teachers to choose educational hardware according to their personal preferences.

The analysis done in Table I only confirms the general conclusions so far. It is important to note that according to the analysis Arduino boards are for more advanced applications. These boards are intended for users with prior knowledge about programing languages and hardware. The main disadvantage concerning the software can be overcome by using nonofficial drag-and-drop Arduino friendly block coding editors as ArduBlock [1], EduKits [7], Open Roberta Lab (NEPO) [12], etc.

The general conclusion about the other two SBCs is mostly the same. Both are designed and developed for use in computer education, and they are intended for primary school students. Because Calliope mini was inspired by the Micro:bit, it can be said that in some way, it is his extended and improved version. It's needed to be mentioned that the shape of Calliope mini is safer for use. There is not an absolute winner between the two of them. The choice between them may depend on their own preference and their availability.

IV. TEASHING STAFF QUESTIONNAIRE

During the summer period primary and secondary high school teaching staff in Macedonia have a variety of activities including various trainings. With the support of British Council under the program "21st Century Schools" [14] there was an online course, Micro:bit Basics for Teachers [11]. Apart of this, there was an internal training for the teaching staff in secondary schools OOU "Dedo Iljo Maleshevski" and OOU "Nikola Petrov Rusinski" in Berovo. This was a good reason to carry out a questionnaire for the teaching staff that attended the training. The main aim of the results of this questionnaire is to obtain an assessment of the Micro:bit for their possible use in the educational process. It should be noted that the assessment is according to the teacher's opinion and convictions.

The questionnaire contained fifteen questions with multiple possible answers. This questionnaire is about the educational process and use of additional aids as Micro:bit. Teachers from various age groups and with different professional profiles participate in the questionnaire. The number of teachers that participate in this questionnaire are 24. More general questions concerning the educational processes with the results are given in Table II. In Table III, questions are given with the results relating opinion about possibly use of the Micro:bit in the educational process. The results are presented with number and percentage.

TABLE II. MICRO:BIT QUESTIONNAIRE FOR TEACHERS, PART I

1. Do you think that students are interested to embrace new innovative learning methods that include modern aids?			
Answers	Yes, the most of them	Yes, but only a few in a class	No, they are not interested
Results	11 (45.83%)	12 (50%)	1 (4.16%)
2. Do you think that the way in which you are teaching influences on students' motivation?			
Answers	Yes, it is crucial	Yes, but not always	No, the method is not important
Results	9 (37.5%)	14 (58.33%)	1 (4.16%)
3. How often do you use different teaching methods that include modern aids?			
Answers	Very often	Not very often	Never, I prefer traditional teaching
Results	5 (20.83%)	16 (66.66%)	3 (12.5%)

4. How often do you use a computer or other educational electronic device in a classroom when you are teaching a new unit?				
Answers	Always, when the unit allows	Not very often	Not very often, due to limited aids disposal	Never
Results	9 (37.5%)	8 (33.33%)	6 (25%)	1 (4.16%)

TABLE III. MICRO:BIT QUESTIONNAIRE FOR TEACHERS, PART II

5. Are you willing to embrace the use of education aids such as Micro:bit in your classes?			
Answers	Yes, always when the aids are suitable	Yes, but rarely	No, there is no use of this types of aids
Results	14 (58.33%)	6 (25%)	4 (16.66%)
6. Do you think that use of Micro:bit will encourage/motivate students to code?			
Answers	Yes, all will be encourage/ motivate	Yes, but only few of them	No, it will not make the difference
Results	9 (37.5%)	13 (54.16%)	2 (8.33%)
7. Will you motivate students to use Micro:bit?			
Answers	Yes, very often	Yes, but rarely	No
Results	11 (45.83%)	11 (45.83%)	2 (8.33%)
8. Do you think that Micro:bit is simple for using and coding?			
Answers	Yes, it is simple	Yes, but for a certain group	No, it is complicated
Results	9 (37.5%)	13 (54.2%)	2 (8.3%)
9. Do you think that Micro:bit can helps you to improve and enrich the teaching plan?			
Answers	Yes, it will improve and enrich the teaching plan	Yes, but will takes me a long time than the usual planning	No, will not improve the process of planning
Results	5 (20.83%)	14 (58.33%)	5 (20.83%)
10. Do you think that with Micro:bit will be increase communication between students and increase your cooperation with students?			
Answers	Yes, will able to increase communication and cooperation	Yes, but will depends from the personal characteristic	No, doesn't increase communication
Results	8 (33.3%)	13 (54.2%)	3 (12.5%)
11. Do you think that use of this type of educational aids as Micro:bit can increase building and improve personal characteristics and skills as curiosity, concentration, creativity, communication, teamwork, etc.?			
Answers	Yes, I agree	Yes, partially agree	No. I disagree
Results	10 (41.66%)	13 (54.16%)	1 (4.16%)
12. Do you think that students who are usually passive on classes can be encouraged to be more active with additional aids as micro:biit?			
Answers	Yes, always	Yes, depends on the type of the unit, or the given task	No, the passive students are passive
Results	6 (25%)	15 (62.5%)	3 (12.5%)
13. Do you think that you will need more time for preparation if you want to use the Micro:bit in your class?			
Answers	Yes, always independently of the lesson	Yes, but depends on the lesson	No
Results	10 (41.7%)	14 (58.3%)	/
14. Do you think that in general there will be benefits from using Micro:bit as additional aids in the educational process			
Answers	Yes	Yes, but not particularly	No
Results	10 (41.66%)	10 (41.66%)	4 (16.66%)
15. Would you like to recommend the Micro:bit to your colleagues?			
Answers	Yes, very often	Yes, sometime	No
Results	8 (33.33%)	15 (62.5%)	1 (4.16%)

According to the results from Table II, there is mostly a positive opinion for the need of innovative approach, but availability of the computers or educational aids leads to limitations. As it can be seen from the results in Table III there is a divided opinion which goes in favor of Micro:bit and its benefits. The results lead to the general conclusion that use of such educational aids has a great potential to improve the educational process.

V. CONCLUSIONS

In this paper, a general description is given of educational hardware aids as SBC. An analysis has been made on the advantages and disadvantages of all mentioned SBCs. We discussed the benefits from it and the improvements that it can apply on the educational process.

A questionnaire was carried out to assess teachers' opinion concerning the possible use of Micro:bit in the education process. The questionnaire results give a general picture of the opinion of the teachers concerning the benefits and positive practices of the use of educational aids like Micro:bit.

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