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PLAY TO LEARN: USING DRONE-AIRCRAFTS AND BLOCK-BASED PROGRAMMING FOR IMPROVING LEARNING SUCCESS RATES

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Abstract: *This paper provides a discussion on the development of attractive and innovative STEAM-based educational courses for school and university students. The paper specifically presents the methods for block-based programming that are implemented or developed by the University of Ruse and that are used for the improvement of the educational processes in the university and as extra-curricular classes in other educational institutions. The courses are strongly focused on the practical implementation of the STEAM paradigm. The students that participate in the educational activities are provided with small-scale educational drones, which can be programmed to implement specific tasks and missions.*

The benefits of using drones in the education processes are numerous. They include the possibility for customization of the educational materials, as well as the establishment of clear links between the programming environments and the actual devices. In this way, the students learn how to develop programming codes for control of the drones, while at the same time they entertain themselves. The presented learning process also improves the logical thinking of the students and helps them develop additional technical skills. The courses that are presented in the paper are developed using the content-based approach and require from the learners to develop solutions to specific problems. Additionally, to strengthen the level of penetration of the educational materials, the developed courses conclude with mini-competitions between the students, which pushes their capabilities to the maximum and helps them develop competitiveness and teamwork skills.

Keywords: *Block-based programming, unmanned aerial vehicles, drones, Airblock, Tello*
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INTRODUCTION

The block-based programming paradigm was initially developed in the second half of the 20th century. Its main purpose was to present the theoretical aspects of the programming languages, as well as to be an alternative to the text-based programming approaches. In the block-based programming, all procedures and instructions are represented as graphical blocks. In this way, complex codes can be developed without the use of specific programming languages, commands or instructions. This makes the use of the block-based programming much more appropriate for schools students and novice programmers.

UNMANNED AERIAL VEHICLES FOR BLOCK-BASED PROGRAMMING

Many block-based programming environments, like Scratch [1] and Tynker [2], are now widely accepted and are used as primary or alternative means for teaching programming related subjects. Nevertheless, the inclusion of an underlying hardware platform, which is to be directly used for demonstration of the developed programming codes, enhances significantly the educational processes and opens many new possibilities by making the teaching and learning more entertaining and by this - more efficient. Examples of good practices in this area are the Arduino line of platforms, the Raspberry Pi microcomputers and other similar platforms [3].

Following the recent advancements in the micro and nano-technologies, cheaper and more powerful processing units and small-scale computers became available. This made possible the construction of a new generation of unmanned aerial vehicles (UAVs), which nowadays are used in many different areas, including for education and research activities [4]. While the drones were initially used as tools for acquisition of data and images, which were then processed, analysed, and presented in the educational processes, the true potential of UAVs as standalone educational platforms was only recently discovered [5]. This led to the development of small-scale drones for educational purposes, like the Airblock (Fig. 1) and the DJI Tello (Fig. 2).

The Airblock is a unique modular platform that allows the students to create their own drone designs by connecting hexagonal modules with different capabilities [6]. All configurations require the use of a master module, also known as the main brick, which houses the computational unit, the remote wireless connection interface, several multi-colour diodes and the power supply unit. This module has several magnetic connection pins on each of its sides, which allow the linking of up to six propulsion blocks with clockwise and anti-clockwise spinning motors. In this way, the students can create tricopters, quadrocopters and hexacopters. Other combinations are also possible, as the platform allows the horizontal and vertical alignment of the motor modules and the use of additional components for the creation of other types of vehicles, like for example a hovercraft (Fig. 1). The body of the Airblock is made of soft expanded polypropylene foam, which makes it durable and resistant to potential crashes. While the platform has many advantages, it also suffers from several disadvantages. The Airblock has no camera, which limits the possible educational activities that involve visual navigation, photography and first person view operations.

Unlike the Airblock, the DJI Tello (Fig. 2) has no detachable components and is not reconfigurable. Instead, this drone relies on the proven quadrocopter configuration, which is typical for many professional or industrial unmanned aerial vehicles. The Tello is available in several configurations, which differ in the used hardware components and the general looks of the drone. The Tello is also equipped with an on-board HD camera, capable of making up to 5MP photos, which makes the drone suitable for a wider range of applications and educational activities [7]. The Iron Man (Fig. 2) and the EDU versions of the Tello drone are equipped with hardware, which can be used for computer vision, AI and cooperative robotics related applications.

Fig. 1. The Airblock modular platform

Fig. 2. DJI Tello Iron Man edition

DEVELOPMENT OF EDUCATIONAL STEAM COURSES FOR BLOCK-BASED PROGRAMMING WITH DRONES

In the recent years, the University of Ruse has been actively involved in the development of out-of-the-classroom educational courses for school and university students. The majority of these courses were STEAM related and involved the use of 3D printers, 3D scanners, robotics platforms, specialized software products and most recently drones.

In the first half of 2018, representatives of the Telecommunications Department of the University of Ruse developed a course for block-based programing with drones, which was focused on the Airblock platform. The course was held for four weeks and was attended by 12 school students from the Mathematical High-school “Baba Tonka” in Ruse. The course included six primary topics and two additional topics and concluded with a standalone competition between the students. The topics of the classes are listed in more details in the table below (Table 1.).

Table 1. Topics of the course for block-based programing with the Airblock platform

№	Topic description
Topic 1.	Introduction to Airblock – Hardware components and software environment
Topic 2.	Colour Carousel – Development of a basic RGB diode configuration app
Topic 3.	Bi-car – Development of a remotely operated dual motor ground vehicle
Topic 4.	Colour lamp – Development of a multi-colour night lamp
Topic 5.	Spinning hexacopter – Development of a spinning colour-changing hexacopter
Topic 6.	Dancing hovercraft – Hovercraft that dances using predefined moves/actions
Topic 7.	Flipping game – Programming the main brick as heads/tails coin flipper
Topic 8.	GyroHover – Controlling the Airblock using the mobile device gyroscope
Competition	All students develop programmes and compete to finish in an obstacle course

As seen from the table, the course contents were not strictly focused on the functionality of the Airblock platform as a drone. However, the few exercises where the platform was used as UAV or as hovercraft were evaluated by the students as the most interesting.

In order to enhance the experience of the students, all exercises included the development of a graphical user interface for control of the Airblock platform (Fig. 3). The functionality of the different GUI elements was then provided by block-based code segments (Fig. 4). The delivery of the course contents was made using presentations (Fig. 5) and actual demonstrations of the code development process.

In general, the developed course was met with great interest by all participants. The students overall satisfaction was caused by the possibility to use their own mobile devices for the development of the programming codes (Fig. 6), as well as by the fact that they were able to install and run the developed programmes on the Airblock platform and then experience the results of their programming activities.

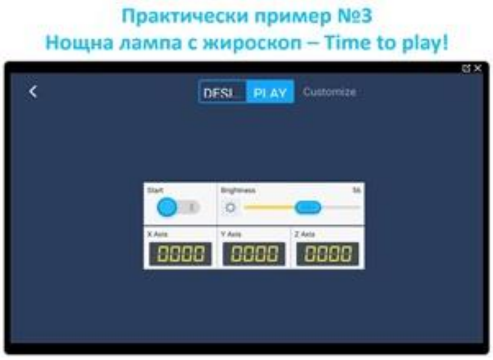

Fig. 3. The environment for development of the GUI for the Airblock apps

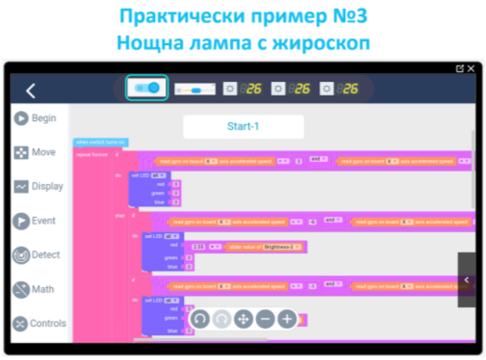

Fig. 4. An example of a block-based code for control of the Airblock platform

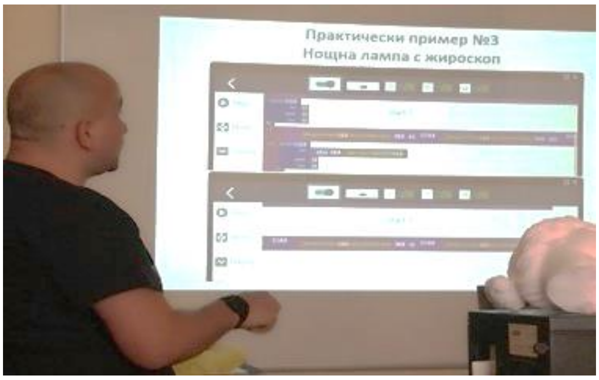

Fig. 5. Moment from one of the lectures about the Airblock programming environment

Fig. 6. A school student while developing and testing a programme for the Airblock

Apart from being actively involved as beneficiaries in the course activities, the students also provided feedback on the exercises and the capabilities of the Airblock. The main disadvantage of the platform, namely the lack of camera, was easily evaluated by the students as its weakest point. The superficial use of the platform as UAV was also evaluated as drawback of the course. Despite all of this, the students also expressed their overall satisfaction from the practical block-based programming exercises and indicated their readiness to participate in further out-of-the-classroom courses that involved similar activities.

To answer this demand, representatives of the Telecommunications Department decided to develop another block-based programming course, but this time with better focus on the needs of the school students. To accomplish this, another platform was selected – the DJI Tello. Initially designed and developed as a low cost drone, the Tello quickly became market sensation due to its value-for-money ratio. The course contents were also revised and the number of practical exercises was increased to twelve. The focus of the exercises was further entangled with the solving of different mathematical problems. The exercises required the students to develop programmes for “drawing” of different basic geometrical figures with the drones, including triangles, rectangles and squares, as well more complex figures, like pentagons (Fig. 7) and hexagons (Fig. 10). The more complex tasks required the students to program the drone to follow paths that reassemble alphabetic letters, squared spirals, inverted pyramids, complex routes (Fig. 8), etc.

The course was planned for delivery to small groups of ten to twelve schools students, which are enrolled in the sixth to eight grade. Due to popular demand, the initial delivery of the course was made to more than 70 students from the Mathematical High-school “Baba Tonka” and from the “Vasil Levski” school in Ruse (Fig. 9 and Fig. 10).

The course was evaluated highly by the school students and they were especially intrigued by the fact that the creation of the programming codes for the practical exercises actually involved the solving of embedded mathematical problems.

Fig. 7. The development of the block-based codes for control of the drones required the solving of different mathematical problems

Fig. 8. The most difficult missions involved the use of different programming elements - variables, conditional operators and cycles

Fig. 9. The students were very satisfied form the possibility to use their own mobile devices to program and control the drones

Fig. 10. An DJI Tello drone flying in front of the block-based instructions for implementation of a hexagon mission

CONCLUSIONS

The block-based programming paradigm represents an alternative approach for teaching different subjects in the area of the information and communication technologies. With the technological advancements of the last three decades, this method for teaching programming concepts became very popular. However, the widespread of the block-based programming is partially caused by the cheap hardware solutions for practical testing of the developed codes, which are now widely available and are more and more intensively used in the educational processes. The combination of the block-based programming approach and the possibility to test the developed codes directly on hardware platforms makes this education method highly preferable by the school students.

In this paper, we have presented the contents and the results from two interactive STEAM courses, which are involving the use of the block-based teaching approach in combination with educational drones that are acting as underlying hardware platform for testing of the programming codes. The students that were involved in the courses have acquired new knowledge by setting up the drones to implement different tasks and missions on demand and at the same time, they had fun participating in the classes, which made the educational process more efficient.

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