Developing Technical Skills of Pupils in Primary and Secondary Schools

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Abstract

The paper is aimed at the development of technical skills of pupils in primary and secondary schools. Technical courses are usually not popular among pupils. Therefore, within the scope of the "Windows of Science Wide Open" project, we prepared a number of activities, which should encourage pupils' interest in the technical courses and help develop their technical skills. During the academic year we held several workshops for primary and secondary school pupils. The workshops contained activities such as the programming of robotic kits, the use of electric microscope in education, the use of measuring systems and a computer for the measuring of quantities around us, or the use of modern technology when creating an audiovisual project. Approximately 150 primary and secondary school pupils participated in the workshops.

Introduction

In the majority of cases, primary and secondary school pupils do not find instruction of technical courses attractive. Pupils and students lack the motivation and dedication to learn algorithmization, programming, physics and chemistry. (Nagyová, 2014, Krpec, et al., 2011) Only avid and enthusiastic pupils find these courses attractive. As a result, the technically-oriented secondary schools and universities have fewer applicants than the humanities-oriented schools. The aim of the "Windows of Science Wide Open" project is to make the technical courses more attractive to pupils and spark their interest in further study of those.

The "Windows of Science Wide Open" project is financed from the "Education for Competitiveness" Operational Program. The University of Ostrava is both the applicant and recipient of the project. The Faculty of Science and the Pedagogical Faculty of the University of Ostrava participate in the project.

Within the scope of one of the key activities, the "Windows of Science Wide Open" project aims to introduce primary and secondary school pupils to the technical courses, spark their interest in them and thus deny the established notion that they are difficult to learn. In so doing, the project uses ICT and technical devices in the teaching of courses such as informatics, physics, chemistry or biology (Tvarůžka, 2015). Within the scope of the project, pupils visited a specialized laboratory at the Pedagogical Faculty of the University of Ostrava where they participated in a number of activities aimed at the use of ICT for the programming of robotic kits, the measuring of physical and chemical quantities, the examination of microscopic preparations or the creation of an audiovisual project.

Technical Resources

The LEGO Mindstorms robotic kits and the EdLab measuring system are the key elements of the activities for pupils.

Nowadays, the robotic kits (LEGO Mindstorms) are used more frequently in schools. A number of researches were conducted, which focused on the use of robots as an educational support. The study comes to a conclusion that robots help pupils develop their logical and creative thinking, the ability to solve problems and to learn programming, mathematics and science. (Scaradozzi et al., 2015, Veselovská, 2015) For instance, a study documenting that a robotic kit competition helps increase pupils' interest in ICT in their university studies was conducted at the Department of Computer Science at Qatar University. (Qidway et al., 2013)

Primary and secondary schools can use virtual laboratories to conduct various physical and chemical experiments. (Bílek et al., 2010) Some of the currently used measuring systems – EdLab, Vernier, Pasco – can be used for illustrative and real experiments. (Oujezdský et al., 2015) These measuring systems have measuring sensors, a measuring interface and a computer which is used for visualization, archiving and analysis of data. As a result, the computer-supported experiments are becoming more attractive for pupils. (Koníček, 2014)

Activities for Pupils

The courses "A Day with a Robot" and "Measurement around Us", which were realized during the course of the project, were attended by primary and secondary school pupils. From October 2014 to February 2015, five courses were held for the 5th, 6th and 7th grade primary school pupils and two courses for the secondary school pupils (the pupils from Secondary Grammar School of Prof. Otto Wichterle). During the courses, the following activities were prepared for pupils:

- Robotic kits Lego Mindstorms EV3,
- EdLab measuring system for the measuring of various quantities around us,
- Electric microscopes with preparations,
- Audiovisual technology for the creation of an audiovisual project.

Robotic Kits

The LEGO robot kits allow to build different types of robots and to solve tasks of various difficulty. The robot control is made possible through the programmable brick that controls engine (wheels, belts, robotic arm) and also can read and process the data measured by the robot's sensors such as distance, brightness, direction, etc. The orders for the robotic brick can be entered directly in the interface by assembling and setting of simple icons. The commands and programs for robot can be also inserted by the computer connected with the robotic brick, which allows solving even relatively difficult tasks.

The different activities were prepared for both groups of students (elementary and high school) with the robotic LEGO Mindstorms EV3 set, mainly with regard to the different difficulty of the tasks. Elementary school pupils had the possibility to develop mainly technical skills by building blocks and constructing the robot itself. The high school students were focusing on the robot controlling, work with engines and sensors of the already assembled robot and they also focused on the creation of programs for robotic brick in the environment of LabView programming language.

Fig. 1: The construction of a robot

Within the scope of "A Day with a Robot" the primary school pupils spent three hours with the robot. They were divided into groups of four to five pupils; each group worked with one robotic kit. Following the introduction and concise guidance, the pupils constructed the first robot according to the instructional manual in which the basic programs for the robotic brick are listed (see fig. 1). After the pupils constructed one part of the robot, they tested the possibilities of a given program and then, according to further instructions, modified and expanded the basic program. There are interesting extensions in the form of small programs created in the environment of robotic brick like:

- Advanced robot motion – forward, backward, turning, etc.

- The move by regular geometric patterns (triangular, square, circle) with the possibility to repeat parts of the movement sequences.

- An ultrasonic sensor usage to detect obstacles complemented with move backwards from the obstacle. If the robot turns for 180° while detecting the obstacle, it can

endlessly move between two opposing obstacles. If the robot goes backward and right while detecting the obstacle, it creates a game for pupils in the form of circle: the robot detects a pupil, then goes backwards and goes towards another pupil, who will be again recorded.

- The robot rotation using gyroscope, which allows to move on eight-pointed star.

- The detection of dark line using a light sensor and robot movement in the space defined by a dark line on the mat.

- The movement of robotic arm – the fun part is to oscillate repeatedly with robotic arm.

On "A Day with Robot" the pupils' work was not limited. Some were attracted by the work and they created fairly complex program structures or built all sorts of mazes. They tried to lead the robot through the maze afterwards. Other pupils were rather intrigued by the building and they enhanced the basic form of robot with extensions – wings, shovels, moving trucks, etc.

After a short break, students had the opportunity to create simple programs directly in the computer. Then there are far greater possibilities; the robot activities are more accurate and fine. The program templates were prepared for the pupils, who modified and edited them. The program environment has an integrated editor for working with sound and black and white pictures. Pupils were able e.g. to design and record the cry which was played on the robot's movement. They set a sound to play in the template and edited and complemented its movement. They could draw a logo too, which was drawn on a robotic brick display. The linking with yelling and robot's movement allowed all sorts of work.
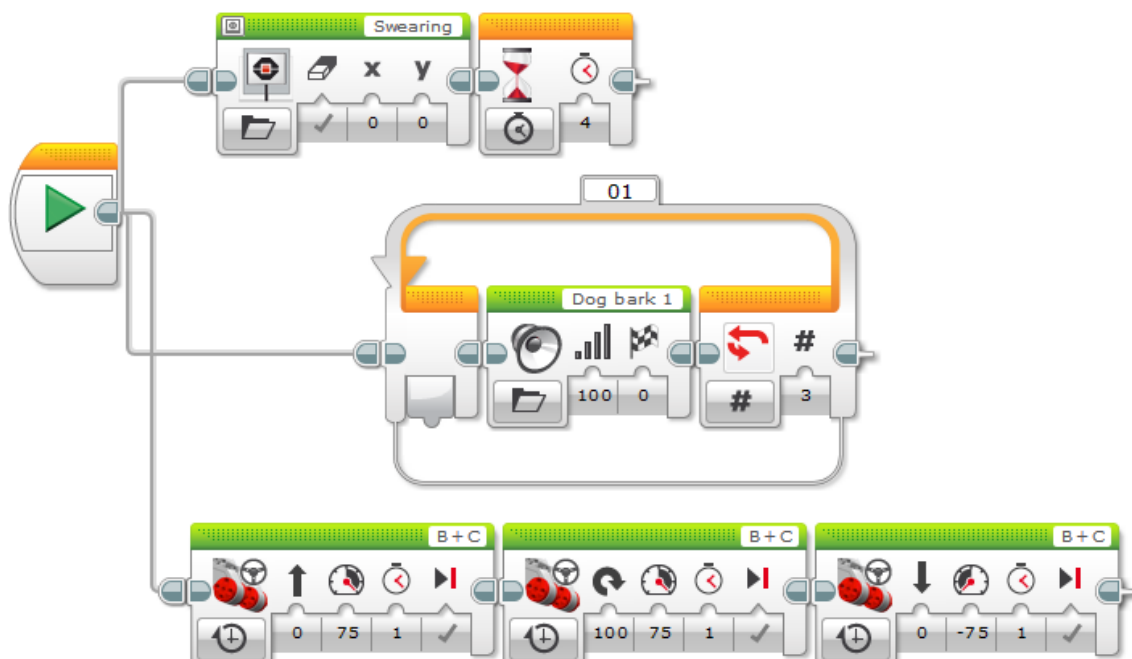

Fig. 2: Program template for working with sound and robot motion in the LabView

The robotic brick can be controlled through applications in the touch mobile devices, which are connected to it via Bluetooth and this allows to control the assembled robot remotely.

A competition for pupils, where the main goal was to go in a defined path in the shortest possible time, was appreciated mostly by the boys.

"A Day with Robot" was unusually challenging for elementary school pupils. The lessons lasted ninety minutes which is unusual length in Czech grammar schools. Nevertheless, the pupils managed to work and were often so impressed that they might be able to work even longer. On the other hand, there was always a little group of three to five kids, who were not interested at all and who would prefer some activities from different areas.

High school students completed "A Day with Robot" in the subject Informatics. The basics of programming was introduced to them in the school already, they learned basic programming constructs – sorting of instructions, repetition and branching. Working with robots thus required a different concept. Students did not build a robot, they only programmed it. They worked in pairs on the computer. The programs were created according to a task, which included about twenty concept ideas. Each group addressed a task according to its interests. Some devoted themselves to work with a light sensor and tried to control the movement of the robot by colors on the mat. Other were more focused on ultrasonic sensor and tried to park robot in a certain place. The girls were interested in the ability to write music tracks using notes and to adjust the movement of the robot according to played melody. In all groups, the created programs had the relatively high levels. The prior knowledge of basic programming structures was evident. At the end each group showed the work they created.

Experience and comparison of the work with both elementary and high school confirmed the assumptions in the area of interests and motivation, but also in the area of algorithms and programming. Working with the robot was most appreciated by the pupils of the sixth and seventh grade, who assembled the robot with genuine enthusiasm and passion. Younger pupils of fifth and sixth grade worked also with great passion, but the work itself was significantly slower and often required more explanation and support from teachers. The younger kids were unable to edit and create programs for the robot independently. This work did not catch their interest much and the possibility to program-control the robot was hard to understand for them, they often did not get the meaning.

On the other hand, the high school students, even though they had the opportunity to build the robot, did not use that option much. They were intrigued by the possibility to create their own programs and to control the movement of the robot from the beginning. They solved many of the tasks quickly and even implemented another variants and extensions of program sequences by themselves. Especially the boys oriented in the issue quickly and were able to solve the tasks with ease. The girls were more reasonable and precise in the work. Their progress was slower, but systematic approach and ambition led them to the solution even in the most difficult and time-consuming tasks. The boys did not show such persistence.

EdLab Measuring System

The EdLab measuring system is a special device that is used as an educational support in the natural history and technical courses in primary and secondary schools. It is used mainly in physics and chemistry classes where it helps conduct a number of experiments. The system consists of a measuring interface, which is connected to a computer through USB. Sensors for

the measuring of electric and non-electric quantities are connected to the interface. The six analog and two digital sensors can be connected to the EdLab system.

Within the scope of the "Measurement around Us" day, a number of tasks with the EdLab system were prepared for the pupils. The pupils could measure quantities such as air temperature, humidity, static pressure, lighting in the room, noise in the room, but also the concentration of oxygen and carbon dioxide in the air. The EdLab measuring interface and several sensors were used for each task. The measured quantities were displayed on mobile computers.

The secondary school pupils were more inventive and creative. Not only were they interested in a particular task, but also in how the individual sensors worked. They tried to realize their own ideas such as the measuring of the telephone temperature by the infrared thermometer, depending on the CPU load. Another idea was to use the spirometer for the measuring of the volume of inhaled air of a smoker and nonsmoker.

Fig. 2: Measuring of noise by the sound level meter and the EdLab measuring interface

Electric Microscopes

For examining biological preparations, the primary school pupils used electric microscopes equipped with a video camera that were connected to a computer. The pupils examined approximately 50 different biological preparations. The main advantage was that the preparations were displayed on a computer monitor so more pupils could see it. The pupils mastered the operation of both the microscopes and the software application for the displaying of the preparations. As a result, the microscopes and the biological preparations enabled them to visit the micro world. In one case, a biology teacher who accompanied the pupils was glad to join them in the process because their school did not have as many preparations.

Fig. 3: Examining a preparation by an electric microscope

Audiovisual Technology

The secondary school pupils expressed their interest in modern audiovisual technology and wanted to create an audiovisual project. Using a HD video camera, a studio microphone and a green screen they made a video clip to a song which one of them sang. The entire project was realized according to a short script, which was prepared by the pupils themselves. First they shot a dance performance (choreography by the pupils themselves) and then recorded the singing part using a prepared audio device. Using the chromatic key, they added the singer to the dance scene. The professional editing software application Adobe Premiere CS6 was used for the creation of the project. The pupils were creative and modern audiovisual technology enabled them to realize their ideas.

Educational movies

In the project called "Windows of Science Wide Open" were also created educational movies whose content are robotic LEGO Mindstorm kits and measuring system EdLab. The half-professional Canon Legria HF G30 cameras were used to capture the film. An audio commentary was recorded by a studio microphone RODE. (Bijnens et al., 2006)

Robotic Kits

The educational movie about robotic LEGO Mindstorm kits originated as a live recording of several events called "A Day with Robot." It is a compilation of more days of recording. The movie was divided into two parts in post-production. The first part contains the building the robot and its programming directly on the control brick, the second part focuses on the programming of the robot by a computer.

Shooting took place in the classroom with the kids and there was no possibility to prepare a script in advance and deploy cameras in the room. The whole shooting was dynamic and with regard to the development of the situation and activity of children. Because the final movie was created as a compilation of several events filmed on different days, it was necessary to cut the individual images in chronological order and to select from the several possible scenes. Movies were also complemented by audio commentary.

Fig. 4: The video of event "A Day with Robot"

The final movie about working with robotic kits can be used as an inspiration for teachers how to implement teaching with robots.

EdLab Measuring System

Educational movie about working with measuring EdLab system was captured as live shooting. There was always a scene prepared according to a scenario. Recording was captured on more than one camera and multi-camera cut was used in the post-production. Movie was complemented by audio commentary too. (Dancyger,2007)

Filming took place in a small classroom where was prepared a notebook, the measuring system EdLab and sensors to be used. The filming tasks were divide on the measurement of variables around us (such as temperature, pressure, humidity, etc.) and electrical values (voltage, current, electrical resistance).

Fig. 5: Recording an education movie about the measuring system EdLab

The movies were exported to modern multimedia MP4 container, where H.264 video codec for compression was chosen. The movies are captured in high definition resolution called Full HD (1080p).

Conclusion

Within the scope of the "Windows of Science Wide Open" project the courses "A Day with a Robot" and "Measurement around Us" for the primary and secondary school pupils were realized. The aim of the courses was to motivate the pupils to use ICT in class and thus make the natural history and technical courses such as algorithmization, programming, physics or chemistry more attractive to them.

During the courses, more than 150 primary and secondary school pupils visited a specialized laboratory at the Pedagogical faculty of the University of Ostrava where they were engaged in a number of activities such as the programming of the LEGO Mindstorms EV3 robotic kits, the use of the EdLab measuring system for measuring quantities around us, the use of electric microscopes with a computer for examining biological preparations or the use of modern audiovisual technology for creating an audiovisual project.

Students showed great interest when working with ICT. Younger pupils built a robot from bricks, invented yells for the robot and drew pictures. Older students especially appreciated the opportunity to create their own programs and ability to control the robot through the environment LabView. They were all highly motivated using the robotic LEGO set and they competed with each other. The more creative high school students invented their own tasks and they also created their own audiovisual project.

There were also filmed the educational movies, which cover the topic how to work with robotic LEGO Mindstorms EV3 and the work with measuring system EdLab too. A movie about robotic kits emerged as a montage of live shooting of events called "The day with robot." A movie about measuring system EdLab was created as a live performance where several electrical and non-electrical tasks were recorded. Both movies were given a narrative commentary in the postproduction.

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