Trends in Educational Robotics

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Abstract. The present paper tries to emphasize the importance of STEM education in the primary and secondary school, as well as the use of educational software in robotics taught in high schools and universities. Several European and wide world current trends in educational robotics are reviewed.

Keywords: Education in robotics · STEM education · Educational software

1 Introduction

Educational Robotics is a branch of Educational Technology that offers vocational skills for future science, technology, engineering and mathematics (STEM) workers towards robotic technology literacy.

Educational Robotics should be seen as a tool to encourage cognitive and personal development and team work, through which young people can develop their potential to use their imagination or their creativity skills in order to express themselves [1]. Educational Robotics creates a learning environment in which students can interact with real-world problems.

Educational Robotics has a huge impact on young people's personal development including cognitive, meta-cognitive and social skills, research skills, creative thinking, decision making, problem solving, communication and team work.

To practice robotics at an affordable price, dedicated software is used to simulate the actions of robots. In universities, educational software makes easy to understand how to control and program robots.

Educational software is a complex computer program, especially designed to be used in the teaching process. It can also be considered as a manual, not in the form of a simple document, but with a friendly interface to allow user interaction.

The performance of the educational software should be drawn from the quality of the presentation that ensures the information requirements for a specific topic and the interaction between the computer and student or professor. The software should be able to adapt itself to the characteristics of the user (for example, programs should submit several levels of difficulty, a transition to a higher level assuming browsing through the previous levels etc.).

There are many educational software classifications, but making a summary thereof, we can consider the following:

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- *Interactive learning software* - which facilitates the transmission or the interactive presentation of knowledge;
- *Simulation software* - simulation of real situations on which the student may make a study or analysis in order to draw conclusions;
- *Training software* - for the development of the specific skills;
- *Soft of investigation* - is an environment from which the student may retrieve information on his own;
- *Thematic presentation* - addresses topics from various areas of school curricula, providing opportunities for widening the horizon of knowledge;
- *Software assessment* – for administration of the evaluation tests;
- *Software Utilities* – provides tools like dictionaries, tables, formulas etc.
- *Educational games* - in which, under the form of a game, teaching purposes are achieved;
- *Administration and management of education* - product for supporting the school activities or training in general.

The efficiency of educational software can be established according to several criteria: the degree of difficulty, the area of coverage, the internal structure and vulnerability, the way of operating from the point of view of the user.

The educational software must allow browsing through the stages of a completely learning act: the first contact with new knowledge, the application of knowledge recently acquired, and the updating of knowledge after a certain period of time. Modular platforms are designed for education and training programs.

Featuring standard industrial-grade components and comprehensive academic tools, Educational Robotics Platforms can be customized to fit curriculum layout. They offer intelligent virtual environments or friendly interfaces which pupils can easily use to learn robots controlling and programming.

The rest of the paper is organized as it follows: the STEM concept and some implementing difficulties in schools are presented in the second section. The third section describes some examples of STEM programs implemented in Europe and world-wide. Some Romanian projects and initiatives in the field of educational robotics are presented in the fourth section.

2 Robotics in Schools: The STEM Concept

Nowadays pupils and students live in a different world from their parents and grandparents. New technologies are reinforcing old ways of teaching and learning. As the twenty century was the time of microelectronics, computers and internet, the twenty-first century is that of robots and artificial intelligence.

The educational concept called STEM (Science, Technology, Engineering and Mathematics) implies an interdisciplinary and applied approach. The objective of STEM education is to teach pupils how to put in practice their knowledge in these four fields.

Teachers must use different strategies and concepts to provide students multiple pathways into robotics and to engage young people with diverse interests and learning

styles [2]. Different strategies and methodologies for the implementation of the robotics curricula are applied in practice, followed by testing and continuous improvements.

Unfortunately, the way of introducing this discipline in curricula is not systematic, especially in European schools.

Researches accomplished by legislative organizations as the International Federation of Robotics, the United Nations Economic Commission for Europe, or the Japan Robotics Association, indicate that the demand for entertainment and educational robots is growing and this trend may continue in future [3].

In Europe, most national education authorities are encouraging the development of projects on educational robotics in schools. However, educational robotics has not been introduced in the European school curricula yet. Most of the experiments involving robotics research and conception activities take place in after-school programs, in week-ends or in summer camps [4].

Obstacles in implementing robotics as part of the regular curriculum in schools appear to be linked to the duration of the robotic activities, the cost of the equipment and the practical work required from teachers to cope to arrange all the pieces in the right place. Other problems in implementing robotics curriculum are the lack of teachers in this field and the inappropriate laboratories existing in schools.

However, robotics has a huge potential to offer in education so it is obvious that we have to rethink our approaches in Educational Robotics. Robotics develops students' motivation to learn mathematics, electronics, mechanics, physics, it develops competences and practical skills and encourages team work and collaboration.

Some important objectives have to be taken in account so as the implementation of robotics in schools being successful:

- Promoting communication and networking between researchers, teachers, and learners in view of sharing experiences, products and expertise
- Supporting teacher education
- Encouraging implementation of educational robotics in schools curricula
- Validating new methodologies in teacher education
- Forming groups interested to study specific issues in the domain of Educational Robotics
- Providing reports on the latest developments in the domain of educational robotics to authorities, parents or teachers.

3 Worldwide Landmarks

Nowadays, there are calls in education in Europe and worldwide for educational approaches that will encourage student creativity and inventiveness. Appropriate learning methodologies such as constructionism and constructivism lead to the development of creativity, systematization, critical observation, collaboration and communication.

There are many sites and companies that provide STEM resources like [9, 10], or [11]. Among science resources we find lab-aids kits in physics, chemistry or electricity. Examples of technological resources: drones, robots, flight simulators, 3D printers.

Engineering kits are provided by grades: for elementary school, middle and high schools. Mathematical tools are also classified by type, grade and subject.

LEGO Mindstorm, VEX Robotics, and Fischertechnik are the most widely used robotic kits. They are composed of libraries of prefabricated parts. Alternatives to these popular kits are highly modular (e.g., Kondo, Bioloid, Cubelets, K-Junior V2, and Kephera) expensive and unaffordable for the majority of schools, or single-configuration robots (e.g., AERObot, iRobot, and Boe-Bot) with a restricted number of possible actions [19].

In the United States, National Science Foundation (NSF) is an American agency which ensures support for all fields of fundamental science and engineering. NSF has several programs in STEM education, which implements higher cognitive skills for students and enables them to inquire and use techniques used by professionals in the STEM fields. There is also STEM Academy which is a national nonprofit organization dedicated to improving STEM literacy for all students. It developed 5,200 programs in over 4,700 schools in all 50 states [5].

Canada is on the 12th place out of 16 peer countries in respect of the percentage of graduates in STEM programs [5]. The country with the greatest proportion of graduates in STEM programs is Finland, which has over 30% of their university graduates coming from science, mathematics, computer science, and engineering programs [6].

Many Super Science High Schools emphasize the importance of education of mathematics and science. However, few high schools emphasize that of technology and engineering. This is because of the lack of facilities of making things by using 3D printers and laser cutters. That is why the STEM Education is not popular in Japan yet [7].

In December 2015, the Australian Federal Government announced a National Innovation and Science Agenda. The program was given almost $65 million for the professional development of teachers and as grants for specialized STEM programs in classrooms. As a result, university curricula were changed. For example, science has become a pre-requisite to enter a Bachelor of Education primary course at some universities. In addition, coding is now being taught from the primary school to the 10th grade [8]. Microbric, an Australian company based in South Australia, launched EDISON, an educational robot, in 2014. Edison is a programmable robot designed to be a complete STEM teaching resource for coding and robotics education for students from 4 to 16 years of age [15].

In Turkey, there is an association of teachers and academicians who make a huge effort to increase the quality of education in STEM fields rather than focusing on increasing the number of STEM graduates.

In Germany, on the initiative of the University of Education Freiburg and the DZLM (German Centre for Mathematics Education), was founded The European STEM Professional Development Centre Network (STEM PD Net), today comprising 30 institutions from all Europe.

This program objective is to ensure that all pupils are provided with the best STEM education by supporting international exchange of students and the continuous professional development of STEM teachers.

For example, there are dedicated programs that prepare teachers to efficiently implement STEM education. ABB's SMART Certification Program[1] (Software, Maintenance and Robotics Training) certifies teachers in STEM methodologies to teach the curriculum to their students.

In the Netherlands, RoboMind software is specifically developed to support technology education. By programming a robot, students learn about logic, computer science and robotics.

In many EU member states, due to demographic developments there are less and less young people. However, the proportion of young people with STEM competences should increase to meet the various technological challenges. At the same time there are more vacancies for STEM jobs as well as high youth unemployment. There is a need for one million additional researchers by 2020 in order to keep Europe growing.

The EU STEM Coalition – launched in October 2015 – is helping to develop and implement national strategies to promote STEM subjects across Europe. The EU STEM Coalition focuses on the development and improvement of national STEM strategies that increase impact of STEM related activities on the national level, through the active exchange of best practices between the existing STEM platforms.

Resources are available on the internet for teachers, for example, robot kits such as Lego Mindstorms and Vex Robotics, simple programmable robots such as Sphero balls, and lesson plans. At present, the educational methodology based on LEGO® MINDSTORMS® kit is used successfully in more than 25000 of schools from all around the world from primary schools to universities.

Most of them being relatively affordable, they are also used in the laboratories of the universities in lab support. In the developed countries, there are special educational centers, in the US and UK it is implemented in the form of the optional method or as a support for the creation camps during the holidays. Sophisticated, engaging robots such as the NAO robot are also available. For example, ASK NAO is a suite of games that have been developed for the NAO robots to teach autistic children.

There is even a worldwide competition, the World Robot Olympiad, which meets annually to the representative of the member affiliated teams, for a wager of intelligence, creativity and at the same time promoting innovative education concept based on NXT set. In the same category of large-scale competitions is the First Lego League, the world organization purpose being to maintain the interests of the young generation in science and technology, and to provide memorable experiences in the organized competitions.

4 Romanian Landmarks

In Romania, there are several projects and initiatives, but most of them are condemned to remain only on paper because teachers did not find the necessary financial resources. There is also an acute lack of teachers with training in the field of IT and robotics.

[1] ABB is a pioneering technology leader that works closely with utility, industry, transportation and infrastructure customers to write the future of industrial digitalization.

Moreover, at the ministry level, there is no coherent strategy for the promotion of educational robotics in the school curricula, the teaching staff having the possibility to decide on the content of curricula.

The alternative is aimed at determining the child to learn doing what he likes most, which is playing. The child is challenged to "play smart". He no longer receives a simple toy of which most of the times he bores quickly, he now receives "ingredients" – as the LEGO® kit and guidance.

From the most simple to the most sophisticated robots able to perform complex tasks, from the simple programming language based on the intuitive graphical blocks to the advanced programming language as well as C and Java, students are trained in an adventure of knowledge based also on solid theoretical foundations, but also on the game, imagination and heuristics methods. For many, this "play" gave birth to passions that will last a lifetime and it will be a real support in choosing the path to be followed in carrier.

However, in Romania there are clubs, groups, camps and organizations that promote robotics and educational software so as pupils that are passionate in this field could apply their abilities in construction and programming a robot. There are dedicated teachers that work with students after the school program and participate together to thematic courses and contests. There are also dedicated platforms that ensure free support and materials for education in robotic field [12].

Some free courses are taught by Bosch in the program Kids in Tech. From the autumn of the school year 2017–2018, Romanian students in secondary and upper-cycle enrolled in the Kids in Tech clubs from all over the country will receive one Arduino kit per club and Robotic courses for free, sponsored by the BOSCH, a global leader in providing innovative technologies and services. This initiative aims to encourage and support passionate students about technology and programming to accomplish projects in robotics.

Running as a private initiative - organizing courses for groups of 8–12 and 12–16 years age, the project SmartClass is based on solid foundations, a curriculum correlated with the level of knowledge of students and a solid partnership with the Carnegie Mellon Robotics Academy department of robotics, who developed the language ROBOTC®, a simplified version, dedicated robotics MINDSTORMS®, a popular programming environment in Visual C, promoted by Microsoft® [13].

Another example is the BRD FIRST Tech Challenge Romania that invests in future tech leaders. It empowers Romanian students in their educational journey as we aim to bring "learning by doing" and "having fun" while creating a robot from scratch.

They started in the first season with 54 high schools, over 800 students from 33 cities who had the challenge to take part in the biggest Robotics Championship in Romania.

The contest has reached season two with plans of reaching around 90 teams, over 1200 students, 330 mentors and 300 volunteers. The grand finale of Championship will take place in Bucharest in March 2018 [14].

At the academic level, students use educational software to create and simulate robot actions. They also use computer applications for controlling and programming different kind of robots. For example, they use ARIA to dynamically control robot's velocity,

heading, or other motion parameters, to receive estimate positions, to read sonar and other current data sent by the robot platform [16].

Different software is used to conceive and simulate robots actions (3dsMAX software®, Alice 3D, MobileSim or ARENA). Students animate applications using Java or C++ programming. As they put passion in their work, they are formed to follow a research career in the field of robotics.

5 Conclusions

Educational Robotics should be seen as a tool to enhance personal skills through which students can develop their practical potential, to use their imagination, to apply their technical abilities, to collaborate and to communicate each other, to work in teams and to value their professional knowledge.

Different strategies for introducing students to robotics technologies and concepts should be employed by teachers to provide multiple pathways into robotics and to ensure that there are premises to engage young people in this field. Education must not remain behind technology. That's why, Robotics curricula must suffer continuous improvements that keep up with new technologies.

STEM learning is a vision for an innovative future that must be promoted in schools at a large scale [17, 18].

The open-source robotics role has increased lately and it allows the use of free software platforms and hardware devices. Open-source systems are guaranteed to have their designs available for ever so communities of users can continue support after the manufacturer has disappeared [20].

More European projects in educational robotics will enhance knowledge, expertise and further networking of researchers in the field.

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