ISSN:0975-3583,0976-2833 VOL08,ISSUE04,2017

A Pilot Study Using the H&S Electronic Systems Platform for Educational Robotics and STEM Education in Primary Schools

B.TIRUPATHI REDDY, U.SASHICAHNDAR,
Assistant Professor, Assistant Professor,
Department of Humanities and Science,
Samskruti College of Engineering and Technology, Ghatkesar.

ABSTRACT

Teaching the basics of A.C.S. (Automated Control Systems) and programming through educational robotics applications is the focus of this study. The H&S Electronic Systems robotics package was employed in the STEM teaching method for this objective. Last, but not least, the interconnectedness of STEM (Science, Technology, Engineering, and Mathematics) is a priority (STEM). As a means of accomplishing these objectives while also encouraging students to take an active role in their education, educational robots may be a valuable resource. Students must work in groups to create, develop, and implement programmes to govern the behaviour of their robotic constructs, using worksheets that have been specifically prepared for the purpose of this assignment.. A final goal of this research is to examine and emphasise the positive effects of data analysis on students' education.

The following terms and concepts are often used in conjunction with educational robotics: STEM education, programming basics, and H&S electronic systems.

INTRODUCTION

robotics is the study of robots that can take the place of people in a variety of activities, including physical work and decision-making [1]. Even outside of Greece, educational institutions have been using robots since the late 1980s, both as a teaching topic and as an adjunct tool for teaching different ideas in fields such as mathematics, physics, engineering, and computer science.

Automation is also utilised to improve cognitive abilities such as problem solving, specific and abstract reasoning, critical thinking, and effective teamwork [3]. The programming and manufacturing of a robotic system are two separate processes. Learning to solve real-world issues in the classroom as well as in the real world is made easier when students learn how to use computational thinking and other cognitive processes to aid their learning [2, 4]. In order to come up with and answer an issue, a student is required to use logic, semantics, and sometimes even abstract thinking. Furthermore, the creation of the robot and its programming help to the student's socialising via the execution of the activities.

An effort was made in this research to employ instructional robots in primary school based on the STEM education theoretical framework. H & S Electronic Systems' Basic Robotic System platform's hardware and software environment was used to this end. As a result, a variety of group-based learning activities were developed to help instructors teach the foundational concepts and structures of programming and automatic control systems.

Educational Robotics and STEM Education

Educational Robotics

Students who have access to miniature robotic systems are tasked with putting them together and programming them to carry out a certain task for instructional reasons. Since educational robotics is founded on constructivism, particularly constructionism, from a pedagogical perspective [5, 6], it is considered a branch of classic constructivism. Thus, learners gain more effective knowledge as they actively participate in the design and production (manual and digital) of actual items that have significance to them in a more natural manner via the use of the learning environment.

The use of educational robots turns learning into a game that is more enjoyable, simpler, and more effective [7]. Individual activity and motivation may be positively influenced by the game-like feature of robotic structures in primary education [8].

Children are also given the opportunity to become scientists-inventors who find their own unique ideas and solutions, thereby increasing their sense of self-efficacy [9]. Students are more likely to pursue a career in science and technology if they are actively engaged in addressing real-world challenges.

ISSN:0975-3583,0976-2833 VOL08,ISSUE04,2017

As a result, students have the chance to establish a solid conceptual foundation for the reconstruction of their knowledge at a later time by engaging in circumstances that demand them to utilise and apply their knowledge from mathematics, science, technology, and engineering.

The use of educational robots encourages students to think creatively and imaginatively about what they will build and how they will accomplish their goals via the programming of their machines [11]. Construction of their robots is also a problem-solving scenario that supports a multidisciplinary and interdiscipline approach [12].

Furthermore, educational robotics activities are built on collaboration and inter-action of people and groups, fostering thinking through conflicts in cognitive and social level as students are asked to explain ideas, views and thoughts and defend their replies [13]. Moreover, High-level mental abilities such as analysis, planning, and implementation are also required of pupils. Because they are still in the Concrete Operational Stage and are about to enter the Formal Operational Stage, activities with children this young (in primary school) have a higher failure rate (11, 12 years old). However, when youngsters are given real issues to solve, they are better prepared for the next cognitive stage because they have a greater understanding of abstract ideas (e.g. speed, time, variable) [14].

Educational robotics also helps students learn programming and get acquainted with its fundamental ideas [15]. A novel learning environment that is extremely stimulating, encourages the test-and-error process, which is known to Primary school kids, and emphasises approved approaches and solutions, because a behaviour may be described in many ways [3] is created by programming robotic constructs. As a bonus, it encourages pupils to engage in metacognitive processes by encouraging reflection on their own actions and thoughts [16].

STEM Education

In the United States, the phrase STEM Education was coined and the necessity for such a programme was first recognised. Because of the poor performance of American students in core topics including math, engineering, science, and technology, a reorganisation of classroom instruction is necessary. [17] The acronym STEM (science, technology, engineering and mathematics) education was coined by the National Science Foundation (NSF) in 2001.

STEM education aims to cultivate a child's enthusiasm in science as well as their aptitude to tackle real-world challenges. All of the world's functioning will be revealed by connecting the four fields as these talents are honed. There are specific goals in mind, such as better comprehending the natural environment and making choices that will have an impact on it. The ability to employ new technical tools and an understanding of how technology affects and modifies the surrounding environment are both important goals for technology education. Since technology is the mechanism by which it comes to "life," students should have a firm grasp of the real-world significance of engineering [18]. It is also hoped that mathematics skills like as analysis, documentation, and problem solving would be enhanced so that students may better deal with the challenges they face in their everyday life [19].

An integrated and scientific approach to STEM education, the four fields create a unified and indivisible whole where each part interacts and influences the other. This approach necessitates the employment of alternate teaching methods because of its unique characteristics. Traditional teaching approaches, such as instructor leadership, the project method, laboratory practises, and technology instruments [20] are all examples of this kind of instruction.

In environments that emphasise on STEM education, strong leadership, professionalism of instructors, strong ties between society and parents, student-oriented techniques, and the utilisation of instructional situations for teaching [21] are all characteristics. In addition, there is a lot of cooperation.

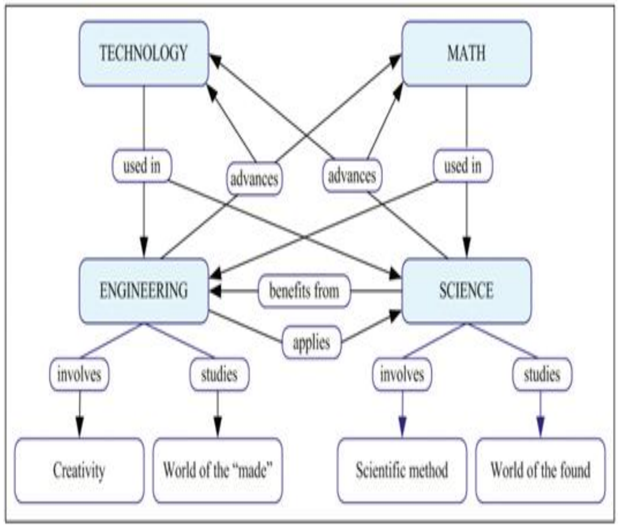

Fig. 1. An Interdisciplinary Approach. (Source: The Thornburg Center for Space Exploration[17])

STEM (science, technology, engineering, and math) education emphasises problem solving, critical thinking, and acceptance of failure as a necessary part of the learning process (Fig. 1).

However, there are some characteristics that must be taken into consideration for the effectiveness of STEM education programmes. In addition to having a challenging curriculum and a research-based learning environment, these conditions must also exist in order for an education to be successful [22].

Robotics and STEM Education

Today, robots have the potential to transform education. Children are more responsive to learning stimuli because of their inventive nature, hands-on experience and enthusiasm. Robots, on the other hand, have a lot to offer and are becoming an important instructional tool in the STEM approach [9].

Robotics and Technology and Engineering seem to have a direct connection, however the connection to Science and Mathematical Science may not be as clear-cut as the connection to Robotics and Engineering.

Robots have been shown to have a significant impact on students' math abilities, as well as their ability to learn numbers and ratios in a fun and engaging way. It has been shown that problem solving abilities and the ability to recognise quantities and amounts have improved as a result of a large-scale research in Peru.

Students benefited from science exercises that used robots and were grounded in classical physics ideas, such as those using LEGO robots. It is said to have been used to explore and debate the link between distance, time, and speed via the building, programming, and design of robot motion [23]. They indicated that student motivation had increased significantly [24], as had their outlook on learning and their level of involvement.

Student understanding of fundamental Newtonian concepts, such as friction, forces, weight, and the diameter of the wheels was also significantly improved by robotic construction-based activities [23]. Other examples include a solar automobile, a rubber catapult, and a wind-turbine, all of which helped to teach the fundamentals of energy and energy conversion.

Platform of H&S Electronic Systems

Description

Czech academics Ji Hrbásek and Jan Skora (from Brno University – Czech Republic) created and built the H&S Electronic Systems platform. The systems may be used in a variety of settings, including classrooms and recreational centres for students from kindergarten through high school, as well as in the workplace. In addition to

ISSN:0975-3583,0976-2833 VOL08,ISSUE04,2017

electronic systems, the company's goods include components, automated systems, digital technology, and a range of electronic and electrical engineering for use in robotics [26].

Short-range infrared sensors consist of two reflective plates, whereas long-range sensors comprise of two reflective plates. Additionally, it contains a board with switches for the robot's manual control, a twin H-bridge (bridge plate), four and eight LED modules, and the main processor board PICAXE20M2 with a USB host connector. There are also two wheels, two motors, a reduction gear and rubber ring, as well as a series of wires and plastic clips. It's now time to put the system together, and the battery box (for four AA batteries), a computer cable (for connecting the computer), bolts, nuts, a tiny wrench, and a screwdriver are included.

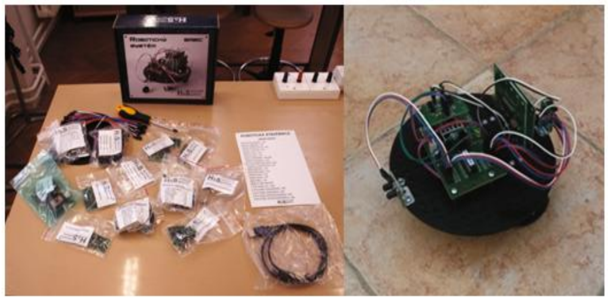

Fig. 2. Basic Kit

Main Advantages

Robotic packages such as Lego Mindstorms, Boe-Bot, ActivityBot, and other platforms like Arduino are frequently used in educational institutions of all levels to teach basic concepts of automated control and programming. Because of its many benefits, this robotic system was selected for our project.

First and foremost, it's a brand-new idea and a brand-new teaching resource. Lego Mindstorms and Arduino are well-known platforms in most educational institutions, with predetermined curricula and ways of delivery. Using a new tool, it is possible to determine whether or not there is a true grasp of robotic systems and their programming, as well as the potential inaccuracies that may come from standardised measurements [27]. First and foremost, the platform concentrates on low-level accomplishments and on introducing newbies to programming environments via the use of easy-to-learn approaches. The platform may be programmed in one of two ways. The first is to draw a flowchart. Designed for elementary school students, it is easy to use and maintain. The second method is to write a programme in a programming language that is based on BASIC, the most popular programming language for beginners [27]. (Fig. 3).

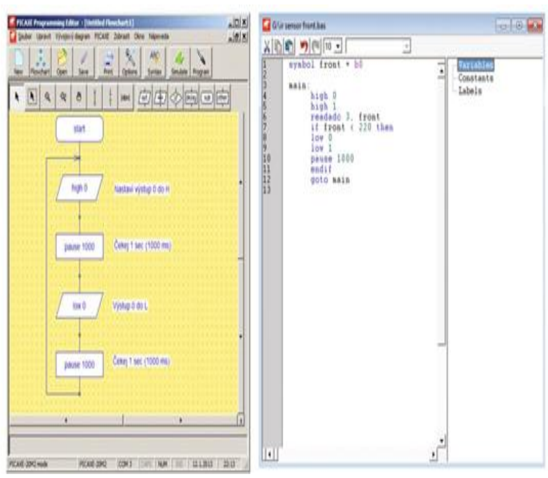

Fig. 3. Program as a flowchart (left) and program in code (right) in Picaxe Programming Editor

ISSN:0975-3583,0976-2833 VOL08,ISSUE04,2017

In addition to this, it is a very inexpensive platform. The PICAXE processor may be employed as a structural component and is deemed more cost-effective than others [26, 27]. Although this robotic system has its advantages, it has a few downsides as well. The chassis is the foundation upon which the rest of the components are installed, as stated before in the description. In contrast to Lego Mindstorms, the finished robot does not resemble a humanoid machine, and the cables attached to it can be seen. However, this disadvantage may readily be turned into an advantage when it comes to student innovation.

Methodology

Two public elementary schools in Patras, Greece, hosted the instructional activity in question. There were twelve (12) sixth grade pupils that agreed to participate in the research. There were eight females and four males among the group. This age range was selected since students in this group have already dealt with a broad variety of topics and have been taught the principles essential to complete the activities outlined in this article. Two two-hour sessions in the school's computer lab were scheduled for the pupils, who were randomly assigned into four groups of three students each.

It began with the delivery of a diagnostic questionnaire to the pupils and a talk on robotic systems. Students were then handed the first and second worksheets to complete. Third and fourth worksheets were completed and assessment questionnaires were answered during the second two-hour session. Students progressed through four worksheets that increased in difficulty as they built and developed increasingly complicated programmes and structures.

The Educational Activity

Using a robotics build and ideas, principles, and structures from programming, the educational activity was designed to provide students an introduction to the fundamentals of automatic control systems and programming while also drawing on their prior understanding of science and mathematics. Students were expected to leave the course with a basic understanding of electronic circuits, a programme written in a programming language (in our case, Picaxe Programing Editor), a grasp of the connections between engineering, science, mathematics, and technology, and an understanding that a robotic system must be assembled (hardware) and programmed (software), as well as the ability to describe the structure and function of a robotic system in detail.

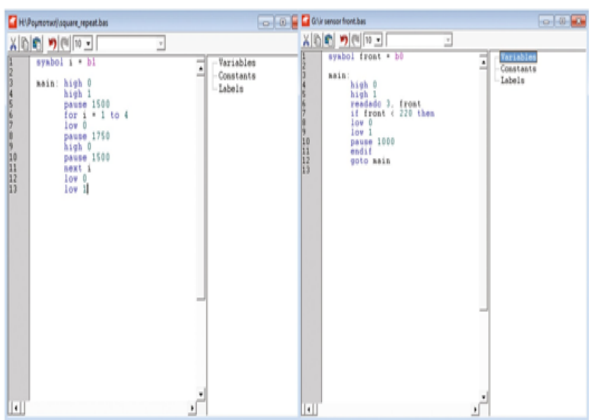

Fig. 4. Program of the 3rd (left) and one of the programs of the 4th (right) worksheet in code

Each of the four worksheets had progressively more difficult exercises that required the students to think about the issue, devise a solution (creating an algorithm), work with programmes, and alter them appropriately, gradually exposing them to more complicated structures each time.

Because it was regarded simple to learn and use by the students, we chose the PICAXE programming environment's code mode for our projects. Additionally, the use of basic instructions in short programmes was thought to be more efficient in terms of saving time.

ISSN:0975-3583,0976-2833 VOL08,ISSUE04,2017

Findings

Students' work during the educational activity and their answers to the distributed ques- tionnaires offered important educational information. Regarding the Diagnostic Ques- tionnaire, the majority of the students had "much" to "very much" previously used thecomputer (12/12), most of them found it quite easy to use (6/12) and all of them would be interested to learn programming (12/12) (Table 1).

Table 1. Results of the Diagnostic Questionnaire (closed-type questions)

	Not at all	Little	Quite	Much	Very much	Sum
Previous use of the computer	0	0	0	4	8	12
Ease of use	0	0	6	1	5	12
Programming experience	0	3	5	2	2	12
Difficulty of programming	0	4	6	0	1	11
Future interest in programming	0	0	0	5	7	12

As a result, just two out of four groups' replies concerning the robot's turn instructions were correct, and they were based on the Scratch environment, rather than the Picaxe Program ming Editor. Despite this, the pupils were able to put into practise the new ideas and structures for the square shape fairly well. As a result, students were acquainted with the FOR loop structure and the idea of VARIABLE, as well as the repeat structure (loop).

Third, they were required to change the software so that when the robot detects an obstruction in front of it, it turns instead of being immobilised. Worksheet No. 4 was regarded as the most difficult. Despite the difficulties, they seemed to follow the reasoning correctly, identifying and appropriately using the command "IF...THEN..." to accomplish the worksheet's objectives (Table 2).

Table 2. Results of the Assessment Questionnaire (closed-type questions)

Questions	1ª	2ª	3ª	4ª	5ª	Sum
Did you enjoy the activities?	0	0	1	2	9	12
How easy were they?	0	0	7	4	1	12
Would you like to concern yourself with such activities in the future?	0	1	1	1	8	11
Was Picaxe Programing Editor understandable?	0	0	2	5	5	12
Are you more interested in programing now?	0	0	1	4	6	11
Would you like to make your own programs with Picaxe Programming Editor?	0	0	1	7	4	12
Did your knowledge from Science and Mathematics help you do the activities?	0	0	0	6	6	12
Did technology (the robotic system) help you understand concepts of Science and Mathematics?	0	0	3	8	1	12

Discussion and Conclusions

Students were introduced to the foundations of programming and the fundamentals of automatic control systems as part of an educational project designed to see whether they could make connections across STEM subjects (Science, Technology, Engineering, and Mathematics).

ISSN:0975-3583,0976-2833 VOL08,ISSUE04,2017

Personal notes by researchers as well as completed questionnaires provided valuable information on how the study objectives were met.

To guarantee that the educational activity complied with the STEM approach's pedagogical recommendations, a lot of effort was put into it. Activities with graduated difficulty were employed, indicating that each activity contributed something more or needed the combining of individual pieces and, therefore, was classified as more difficult than the preceding activity. It was possible for students to engage in hands-on programming activities in a laboratory experimental learning setting, which required them to solve issues within a constructionism framework.

This activity helped most children learn to identify key components of the circuit (e.g. LEDs, wires, sensors) and to effectively describe their function based on knowledge from Physics, as well as to use mathematical knowledge and combine it with algorithmic thinking in order to create a programme for the effective control of their robotic construction.

Basic programming principles such as the VARIABLE (sequence, repetition, selection) and the VARIABLE were employed in the design and development of a programme.

References

1. Doulgeri, Z.: Robotics: Kinematics, dynamics and control of articulated arms. Kritiki, Athens (2007). (In Greek)
2. Karatrantou, A., Panagiotakopoulos, T.C.: Educational robotics and teaching introductory programming within an interdisciplinary framework. In: Jimoyiannis, A. (ed.) Research on e-Learning and ICT in Education. Springer, New York (2011)
3. Alimisis, D. (ed.): Teacher Education on Robotics-Enhanced Constructivist Pedagogical
4. Methods, School of Pedagogical and Technological Education (2009)
5. Karatrantou, A., Panagiotakopoulos, T.C.: Algorithm, pseudo-code and Lego Mindstorms programming. In: Proceedings of International Conference on Simulation and Programming for Autonomous Robots/Teaching with Robotics: Didactic Approaches and Experiences, Venice, Italy, pp. 70–79 (2008)
6. Piaget, J.: The Principles of Genetic Epistemology. Basic Books, New York (1972)
7. Papert, S.: The Children's Machine. Basic Books, New York (1993)
8. Eguchi, A.: Proceedings of 4th International Workshop Teaching Robotics, Teaching with Robotics & 5th International Conference Robotics in Education, Padova, Italy, 18 July 2014,pp. 27–34 (2014)
9. Panagiotakopoulos, T.C.: Applying a conceptual mini game for supporting simple mathematical calculation skills: students' perceptions and considerations. World J. Educ. **1**, 3–14 (2011)
10. Barker, S.B., Nugent, G., Grandgenett, N., Adamchuk, I.V.: Robots in K-12 Education: A New Technology for Learning. Information Science Reference. IGI Global, United States of America (2012)
11. Alimisis, D., Karatrantou, A., Tachos, N.: Technical school students design and develop robotic gear-based constructions for the transmission of motion. In: Eurologo Conference "Digital Tools for Life Long Learning", Warsaw 27-31/08/2005
12. Mubin, O., Stevens, J.C., Shahid, S., Mahmud, A., Dong, J.: A review of the applicability of
13. robots in education. Technol. Educ. Learn. (2013). doi:10.2316/Journal.209.2013.1.209 0015
14. Arlegui, J., Menegatti, E., Moro, M., Pina, A.: Robotics, Computer Science curricula and Interdisciplinary activities. In: Workshop Proceedings of SIMPAR International Conference on Simulation, Modeling and Programming for Autonomous Robots, Venice, Italy, pp. 10–21 (2008)
15. Kiriakidi, F., Taraperas, C., Karatrantou, A., Panagiotakopoulos, T.C.: Educational robotics in support of teamwork activities in primary education. In: 6th National Congress of Computer Science (2012) (In Greek)
16. Feldman, R.S.: Developmental Psychology, Development Across the Life Span, vol. 1. Gutenberg, Athens (2009) (In Greek)
17. Papadanelis, G., Karatrantou, A., Panagiotakopoulos, T.C.: Utilization of lego mindstorms NXT for teaching programming: the concept of the variable. In: Proceedings of the 6th Panhellenic Conference "Didactics of Computer Science" (2012) (In Greek)
18. Alimisis, D., Arlegui, J., Fava, N., Frangou, S., Ionita, S., Menegatti, E., Monfalcon, S., Moro, M., Papanikolaou, K., Pina, A.: Introducing robotics to teachers and schools: experiences from the TERECop project, Constructionism 2010, Paris, France, 16–20 August 2010
19. Hanover Research: Best Practices in Elementary STEM Programs, March 2012. http://

ISSN:0975-3583,0976-2833 VOL08,ISSUE04,2017

school.elps.k12.mi.us/ad_hoc_mms/committee_recommendation/4.pdf. Accessed
20. Thornburg, D.D.: Why STEM Topics are Interrelated: The Importance of Interdisciplinary Studies in K-12 Education. p. 3. Thornburg Center for Space Exploration (2008)
21. National Governors Association Center for Best Practices: Building a Science, Technology, Engineering and Math Agenda (2007).
22. B., Confrey, J., House, A., Bhanot, R.: STEM High schools: specialized science technology engineering and mathematics secondary schools in the U.S. Bill and Melinda Gates Foundation Report. SRI International. (2008)
23. National Research Council: Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics. Committee on Highly Successful Science Programs for K-12 Science Education. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education. The National Academies Press, Washington, DC (2011)
24. Bayer Corporation: Planting the Seeds for a Diverse U.S. STEM Pipeline: A Compendium of Best Practice K-12 STEM Education Programs (2010)
25. Karim, M., Lemaignan, S., Mondada, F.: A review: can robots reshape K-12 STEM education?
26. In: Proceedings of the 2015 IEEE International Workshop on Advanced Robotics and its Social impacts (2015)
27. Robinson, M.: Robotics-driven activities: Can they improve middle school science learning?
28. Bull. Sci. Technol. Soc. **25**(1), 73–84 (2005)
29. Saygin, C., Yuen, T., Shipley, H., Wan, H., Akopian, D.: Design, development, and implementation of educational robotics activities for k-12 students. In: Proceedings of American Society for Engineering Education Annual Conference & Exposition (2012) H&S Electronic Systems. http://www.hses.cz