Robotics based learning activities in vocational education for combating Early School Leaving (RoboEsl)

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Abstract. The school evidently plays a crucial role in the life of a student. Many researchers claim that school and family context constitute the most influential parameters that contribute towards the growth and development of children. The educational process is very important to all students, not only for expanding their knowledge, but also for developing their critical thinking as well as their cognitive and social skills. However, Early School Leaving (ESL) has a negative influence in the European educational systems. This paper presents an alternative educational approach, which aims to reduce the effect of ESL and has been designed, developed and implemented by the RobosESL project (Erasmus+) and uses Robotics as a teaching tool in order to regain the students' interest in school. This paper demonstrates the main features of the RoboESL educational approach and the learning practices which were implemented from the perspective of the 6th Lab Center of Piraeus teachers.

Keywords: Robotics education, Early School Leaving, RoboESL, 6th Lab Center of Piraeus, vocational education.

1 Introduction

The problem of school failure and early school leaving (ESL) challenges European education systems and economies by influencing negatively personal, professional and economic growth. According to Eurostat [1], in 2013, approximately five and a half million young people in Europe did not complete upper secondary education and did not participate in any training program. Among the headline targets set in the Europe 2020 strategy is the reduction of the EU average rate of early school leaving to less than 10% by 2020. Early school leaving is a long process of school disengagement that culminates the first years of secondary school. Research studies show that drop-outs are students with low achievements or failure in one or more school subjects, very often in science, technology and maths. However, many students failed in school or early school leavers identify the curriculum as discouraging factor towards staying at school. Educational content is boring or hard to grasp, activities are not related to real life, practical tasks are missing, and opportunities for hands-on activities are not given [2]. Teaching practices are indicated as dry and far beyond students' needs. There have been voices in education world-wide arguing that there is a gap between the current educational practices in schools and the modern societal needs calling for an education that will foster creativity and inventiveness [3]. Students claim they are rarely offered with opportunities to develop their creativity, to work on hands-on activities and to learn practical skills useful in their life; they often feel disappointed when their school reality lacks practical tasks that might connect learning to real life and the needs of the job market.

During last decade studies assure that educational robotics (ER) can provide learning experiences that promote children's creative thinking, teamwork, and problem solving skills – the essential skills necessary in the workplace of the 21st century [4.]. ER toolkits i.e. Lego NXT have prepared the ground for the popularity of robotics in young generation. However, there is no systematic introduction of robotics in school curricula in European school systems. In addition to this, very often robotics is introduced as suitable only for talented science and technology majors.

RoboEsl project aims to exploiting the potential of ER in order to tackle the ESL problem improving the attainment and fostering the above mentioned creativity skills for students with low basic skills and being at risk to drop out from school.

The paper is organized as follows: Section 2 presents the Roboesl educational approach. Section 3 describes how the proposed educational activities were implemented in the 6th Lab Center of Piraeus. Section 4 provides statistical results, regarding students' behavior and attitude towards school. Finally, Section 5 concludes the paper and presents the general outcomes.

2 RoboESL approach

Robotics-based learning interventions for preventing school failure and Early School Leaving (RoboEsl) is an Erasmus+ project that started in October 2015 and will last for 2 years [5]. RoboEsl aims to support schools to tackle Early School Leaving (ESL) by developing basic and transversal skills using innovative methods such as teaching robotics and developing a series of extra-curricular constructivist learning activities in schools that will engage students being at risk of failure and ESL. These activities aim to foster students' creativity skills, to motivate their interest in schooling, and to encourage them towards staying at school.

Educational robotics (ER) is often introduced in school projects according to a narrow perception as suitable only for science and technology majors or for talented students [6]. However, this project is innovative as it introduces ER as a learning tool for students at risk of school failure and early school leaving (ESL). The project suggests innovative teaching approaches and novel technologies (robotics) to exploit students' excitement with robotics.

The contribution of robotic-based projects is based on creative and innovative use of technology in order to engage students that are at risk of school failure/ESL. Its purpose is to provide an attractive extra-curricular learning environment free of any sense of fear for failure, to rebuild their confidence, self-esteem, social skills and finally to provide a bespoke pathway into further education.

Existing ESL projects took into consideration social-emotional factors, socioeconomic problems in families, school violence and bullying, personal factors such as students' self–esteem and confidence. The RoboEsl project, without neglecting the importance of the above factors, is based on the premise that the weaknesses and deficiencies of the existing educational system, as it is operated, has the largest share of responsibility in the creation and preservation of the conditions that lead a lot of youths to school failure and to their exclusion from further education. For example in the project "Reducing Early School Leaving in the EU (RESL.eu)" [7], the rationale behind this approach is the belief that the high rate of ESL in the EU is a symptom of the traditional education system's inability to adapt to new educational realities. In line with this belief, our project focuses on the core problem of schooling, which is the quality of the education offered.

RoboESL's suggestion for extra-curricular learning activities is complementary to the implementation of a flexible learning zone as it is operated in some European education systems (e.g. in Greece). Our approach for flexible learning pathways, innovative and learner-centric pedagogical approaches, taking into consideration individual needs, is also in line with the different applications of learning by doing and the well known UK inclusion policy "Every child matters".

Finally, the innovation we have in mind in this project is to broaden students' thinking about what is learning and to motivate another kind of exploratory learning that can be promising to make it plausible in school curriculum to support learning as a way of fostering self-confidence and promoting a sense of well-being.

3 RoboESL educational activities

The 6th Lab Center of Piraeus participated in the implementation phase of RoboESL project by running three educational activities in its facilities. The implementation period lasted a total of 6 weeks (1/3 – 15/4/2016) and it included three educational activities for 3 hours per week, as an extracurricular program. All related workshops took place in an Electrical Automation Lab which provided all the necessary equipment in order to complete the experiments.

Ten teachers with minor or no previous experience in robotics were trained to run the project in three, five-day long seminars that took place in Genoa (Italy), Athens (Greece) and Riga (Latvia).

A total of thirty-two students voluntarily participated in the program, thirty of which were boys and were recruited from Information Technology, Mechanic and Electricity educational sections.

Table 1. Students and Teachers of the 6th Lab Center of Piraeus

Educational Section	Students	Teachers
Electrical	11	3
Mechanical	9	3
Information Tech	12	4

As already stated the RoboESL program aims to investigate the effect of robotics instruction in students with learning difficulties. Students with low performance and lots of absences are at high risk of Early School Leaving. Thus, the group was formatted by students with this profile. The group's GPA (grade point average) varied from 9.5 to 16 (20 point scale). Furthermore, most students had a high number of unexcused absences varying from 21 to 87 hours (not cause by sickness), in a five-month period.

3.1 Activities

The first year workshops were based on the Lego MINDSTORMS EV3 [8] educational platform. Each activity has been designed taking into account two primary guidelines. Firstly, the fact that no prior knowledge in robotics was required from the students in order to successfully complete it and secondly, the activities were designed on hands-on learning. The main goal was for students to come up with solutions in simple math and physics problems.

These were key features of the RoboESL educational approach in order to achieve one of the primary goals, which was to trigger students' interest in the learning process. Students who drop out of school complain that they have difficulties overcoming their lack of knowledge from previous years. This kind of difficulty stands as a barrier to their future academic success and leads to high numbers of ESL.

The following subsections provide a short description of the three robotic activities that were implemented in 6th Lab Center of Piraeus.

3.1.1 Robo Rail

This first experiment is designed to be useful to introduce some important basic commands of EV3-G and some relevant concepts like time and speed control, proportionality and others.

The activity illustrates a monorail, placed in a big amusement park. It has a number of stations, including the one at the beginning and one at the end of the line, connected by a straight rail, see fig. 1. The distance between two successive stations is constant. A robot runs over this rail, travelling at constant speed on the track between two stations, and stops for some time at each station before leaving again. When it reaches the end of the line, it waits a bit longer and then it comes back in reverse way towards the starting station.

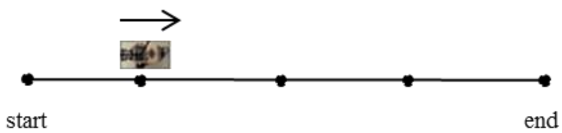

Fig. 1. Robo-rail activity.

At the end of this activity students will be able to build the robot and program it to execute basic movements, read values from sensors and produce sound notifications.

3.1.2 Desert Scout

Autonomous robots are used in very different environments, particularly when these environments are dangerous or hard for humans.

This activity emulates an extractor robot which has to visit relatively distant stations, situated first on the vertices of a quadrangle and next on a N-sided regular polygon and eventually come back to the 'docking station' to report measurements taken at each station. The robot must perform a coring and measure a factor of quality of the natural gas in the ground. In addition, it has to identify the position of the maximum quantity among these measures. The coring measurement is emulated by a reading of a color value using the color sensor at each station (the starting one excluded), see fig. 2.

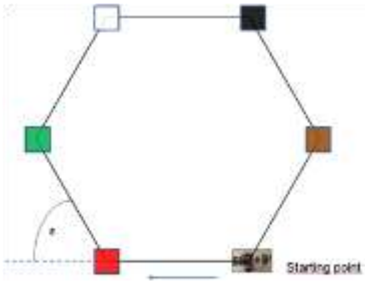

Fig. 2. Desert Scout activity.

At the end of this activity students will be able to use light sensors and experiment on light reflection in order to recognize different colors and perform movement in a square track.

3.1.3 Go to Park

Modern cars are equipped with a system based on ultra sound sensors to help the driver park more easily and safely, particularly when the overall visibility is limited.

This activity emulates the behavior of such systems with a simplified experience, in which the robot explores a sequence of parking slots, turning 90 degrees in front of each of them, and using an ultrasonic sensor to check whether the slot is empty or not.

The task is to park the vehicle in the first free spot of a sequence of parking slots of the same size. When it is in the middle point of the current slot, it turns 90 degrees and checks with the ultrasonic sensor if it is free or not. In the first case it moves inside the slot and produces a final sound; otherwise it turns back 90 degrees to move to the next slot, see fig. 3. If no slot is found free, the vehicle stops and produces a 'complaint' sound.

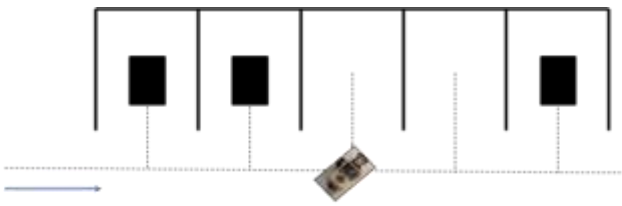

Fig. 3. Go to Park activity.

At the end of this activity students will be able to use infrared and ultra sound sensors and perform accurate turning movements.

4 RoboESL statistic results

Students' progress was quantified through questioners, provided by University of Latvia, were filled in from the teachers at the end of each session. The questions were regarding the behavior and the progress of each student participating in the project. This method provided a tool to track each student's progress throughout the program, in specific areas, such as their ability to successfully work in small groups, overcome problems and difficulties that might have risen and following classroom instruction and rules, etc.

In the following figures we can see diagrams, presenting statistical results based on the questioners provided by the teachers. All diagrams show the frequency of the observed behavior and the number of students presenting the particular behavior.

In fig. 4. we observe that there was a high level of collaboration within the groups in all three robotic activities. It is worth to notice that in the "Go To Park" activity students showed even greater involvement, engagement and cooperation in the group-work. We should we take into consideration that the groups were randomly formed and in some cases, group members had never worked together in the past.

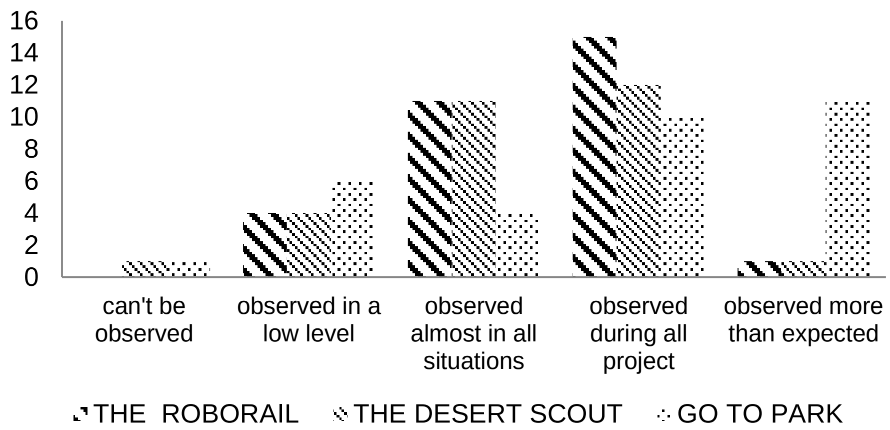

Fig. 4. Participation in groups.

Another issue that was interesting to investigate was the influence of the proposed activities on student's problem solving approaches. Despite the fact that students participating in the program have many gaps in basic subject matters and as a result they usually do not put the effort in problem solving, fig. 5 shows that the students presented great interest in overcoming problems, in all activities. This is due to the fact the learning activities are designed to encourage students to solve basic mathematical problems based on hands-on experiments. As a result, students showed improvement in their self-esteem and self- confidence, which made them invest time and effort in problem solving procedures.

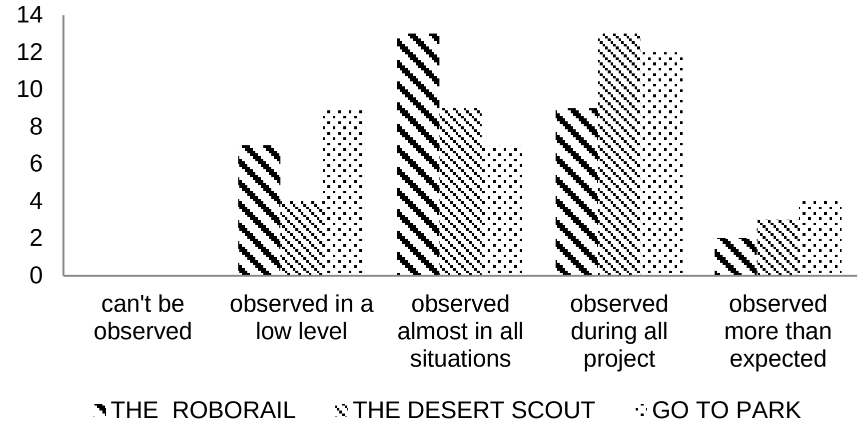

Fig. 5. Problem resolution.

As stated above, the profile of students with learning difficulties participating in this project, also face behavioral problems affecting their overall presence in the classroom. Their difficulty to follow classroom instruction affected negatively their classroom behavior. Fig. 6. presents the results regarding the students' adaptation to the accepted behavioral rules. It is noticed that in all cases students showed positive behavior and followed their teacher's directions and the classroom rules. The positive behavior is due to the fact that they realized they are capable of overcoming difficulties and completing activities successfully.

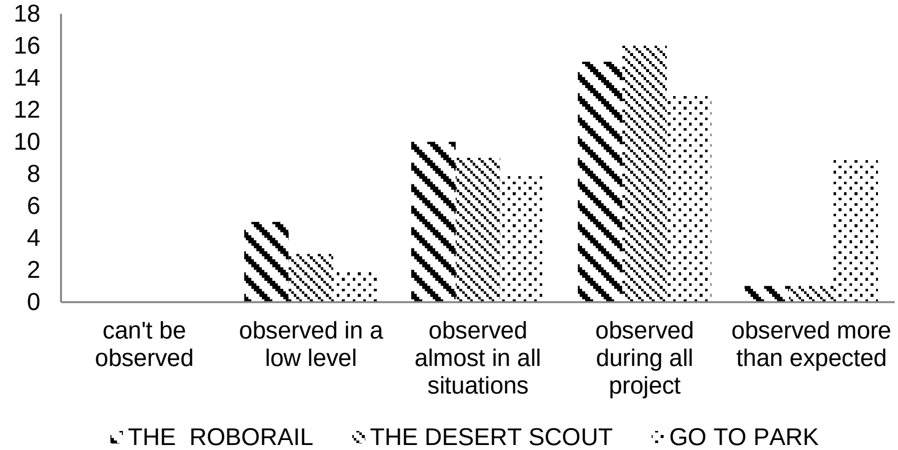

Fig. 6. Adaptation to behavioral rules.

5 Conclusion

After six weeks of the students' involvement in the RoboESL Project, we can conclude that they experienced high enthusiasm, high participation and a real sense of achievement. In general, they achieved successfully working in groups and cooperating with their peers, helping or assisting each other in difficulties, advising their classmates to solve and overcome problems. They, also, discovered the importance and the power of "learning how to learn", which will motivate them in the future to discover and explore.

The teachers also reported positive feedback from the project. They had the opportunity to work exclusively with students who have learning difficulties, outside the regular school hours. Furthermore, they were trained to teach a new subject that was not included in their regular syllabus and were not familiar with it beforehand. It was very fulfilling for the educators, to see the positive effects this teaching approach had on their students.

We can conclude that the first year outcomes were very promising and both the students and the teachers are looking forward to the second year of the program.

References

1. Eurostat, http://ec.europa.eu/eurostat/statistics-explained/index.php/Quality_of_life_indicators_-_education
2. European Parliament, http://www.europarl.europa.eu/RegData/etudes/etudes/join/2011/460048/IPOL-CULT_ET(2011)460048(SUM01)_EN.pdf
3. D. Alimisis, "Robotics in Education & education in robotics: Shifting focus from technology to pedagogy", Proceedings of the 3rd International Conference on Robotics in Education, 7--14 (2012)
4. D. Alimisis, "Educational robotics: Open questions and new challenges," Themes in Science & Technology Education, vol. 6, no. 1, pp. 67–71, 2013.
5. RoboESL, http://roboesl.eu/
6. Alimisis, D. and C. Kynigos, Constructionism and Robotics in Education, in Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods, School of Pedagogical and Technological Education: Athens, Greece.
7. Resl.eu, http://www.fpce.up.pt/ciie/?q=en/content/projeto-resleu-%E2%80%93-reducing-early-school-leaving-eu-0
8. Lego Mindstorms, http://www.lego.com/en-us/mindstorms/