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Educational potential of robotics in Greek school environment

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Abstract

In 2021 the segmental entry of robotics in the Greek school was lunched in the form of skills workshops. Robotics in the curricula of Greek schools is found as an independent course only in one specialty in the 3rd grade of vocational high school. As a separate subject, robotics is not found in any other grade or type of school in Greece. The University of the Aegean organizes robotics seminars as a reward for all participants in the Aegean Robotics Competition. Through these seminars, we have the opportunity to get in contact with students from all over the country. In this paper, the students' opinions regarding the introduction of ER in Greek education are reported. Through questionnaires at the start and the end of the seminars, pupils' opinion about robotics as a separate subject and as a means for teaching other subjects is revealed. In addition, reference is made to the attitude of students regarding the anthropomorphism of robots and whether this can affect the introduction of robots in education.

Keywords: Robotics, STEM, K-12 Education

Introduction

The student is no longer a passive receiver of what takes place in the classroom but becomes an active participant in the educational process. They act, create and build knowledge through collaborative learning processes. Therefore, educational robotics (ER) has come to change the traditional character of teaching by proposing the transition from teaching theory to practice.

The benefits that students gain from engaging in ER are not limited to the cognitive level and the enrichment of knowledge in STEM sciences (Benitti&Spolaôr, 2017; Faisal et al., 2012; Karim et al., 2015; Scaradozzi et al., 2015) but also have impact on their soft skills (Atmatzidou&Demetriadis, 2016; Eguchi& Almeida, 2013; Jung & Won, 2018; Nugent et al., 2010).ER can be integrated into the curricula of primary and secondary education moving on two axes:

- Educational robotics as a learning object, and
- Educational robotics as a means of learning

The separation is neither always clear and nor an easy task since robotics can provide a wealth of knowledge and be, at the same time, the vehicle and the destination (Alimisis, 2009). For years, robotics was banished from the school curriculum and constituted an extracurricular activity for students. Despite the benefits and outlets for expressing the particular inclinations of students, the integration of robotics into curricula occurred characteristically late in Greece and has not yet been completed to the extent and in the way imposed by modern technology and pedagogy.

In this paper, the students' opinions regarding the introduction of ER in Greek education are reported. The following section is a brief presentation of the seminars organized by the University of the Aegean and the profile of the pupils who participated them. Next, the students' opinions on the use of robotics in teaching courses (section 3) and on the

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introduction of robotics as an independent course (section 4) are recorded. Finally, section 5 refers to the pupils' views on the anthropomorphism of robots in education and the paper closes with the conclusions.

Robotics seminars

The Department of Information and Communication Systems of the University of the Aegean has been organizing the ER competition Aegean Robotics Competition since 2016. We are interested in ensuring that participation in the Competition is a fruitful process for students as well as a springboard for the digital world.

In this context, after the end of the Competition we organize free robotics training seminars for those of the participating students who wish to attend them. The seminars are addressed to pupils of the 5th & 6th of primary school and the three grades of Junior High School. They consist of 10 two-hour courses per week. At the beginning and end of the seminar, students fill in anonymous entry and exit questionnaires, the results some of which we present in this survey (Table 1).

Table 1. Participation in robotics seminar

	Questionnaire Entry	Questionnaire Exit
Boys	50	40
Girls	20	16
Total	**70**	**56**

Pupils' profile

The first finding was about the gender of the participants. The majority of the pupils in the seminars, just like the participants in the competitions, were boys. This has been reflected in other studies (Kucuk&Sisman, 2020; Latimer et al., 2019; Atmatzidou&Demetriadis, 2016; Beyer, 2014) and targeted actions of smaller (Screpanti et al., 2018) or greater range (Spreng et al., 2019) have been carried out to promote equal representation in STEM objects and robotics.

There is a belief that robotics and computer science are subjects that are more suitable for boys. Contrary to what is believed, Sun L. and his colleagues showed that girls have higher skills in Computational Thinking (C.T.) than boys, but their negative attitude towards programming can affect the development of their skills in this field (Sun et al., 2020). Dealing with robotics and computer science is not related to gender, but rather to the interests and stimuli that a person has.

Of the children who participated in the seminar, 71.4% were boys and the rest 28,6% girls. Although there were drop outs during the seminar, the boy-girl ratio remained unchanged. This means that in absolute numbers, more boys than girls dropped out before the end of the course.

The introduction of robotics into the school environment

One of the elements and indeed the most basic, that compose the edifice of education, is the students, as they are the recipient of the entire educational process and contribute with their evaluation to the system's feedback. Consequently, their point of view is of great importance. So, what is the students' perception of robotics in school?

When asked if they would like to use robotic constructions in their school for educational reasons, which could be the creation of a robotic project that would be presented at the end of the school year or the participation in a competition, the vast majority (88.6%) answered positively. Regarding the use of robotics as part of the teaching aids or as a tool for teaching specific subjects, eight out of ten replied that they could be taught a scientific subject at school with the use of robots, as the lesson would be easier and understandable if the teacher used applications with robots in the classroom.

ER is a useful tool for teachers, a tool which cultivates knowledge fields of interdisciplinary areas, along with soft skills. However, in order for its introduction into the educational process to be effective, it should fulfill certain conditions. According to M. Moro and his colleagues, there are three conditions that must be met (Moro et al., 2018):

- Accessibility, the robotic tools should not be complicated to use or expensive to acquire.
- The pedagogical foundation of the activities should be clear, as the teacher should know exactly the objectives they hope to achieve and the methodology to be implemented to do so, and
- Inclusiveness, so that the activities include all students even those with special needs regardless of their cognitive background.

The combination of learning with play, especially at younger ages, is not prohibitive, but instead should be pursued as long as the teacher does not lose their focus on the intended learning outcomes. This concludes that the role of the teacher in the educational process with the use of robotic devices, is not degraded but, on the contrary, strengthened.

On the other hand, the generation to which ER is addressed has been born into the digital revolution and is growing alongside with technological leaps. As Prensky describes it, they are natives and not immigrants in the digital world (Prensky, 2001). Users of digital applications or gamers from an early age, they seem ready to experiment with the new teaching approaches brought by the entrance of robotics into the school environment.

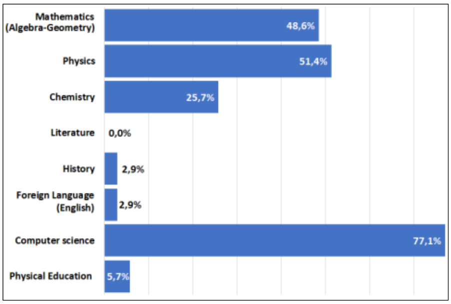

Figure 1. Teaching lessons with the use of robots

Robotics in teaching

The students were asked which subjects they would like to be taught with the help of robotics (Fig.1). The first choice is the computer science course with 77.1%. This proves how closely related the computer science and robotics are in students' mind. It is followed by Physics with 51.4% and Mathematics with 48.6%. Then Chemistry with 25.7% and Physical Education (P.E.) with 5.7% which students particularly relate to robotics. Students have exercise intertwined with physical activity, failing to imagine a robot as an assistant in it.Finally, the students dismissed the teaching of the humanities courses with the use of robotics. Thus, History and

Foreign Language gathered a percentage of 2.9%, while literature did not receive any preference for the teaching with the assistance of robotics.

From the figure above, it appears that the students have combined robotics with STEM subjects, wishing these lessons to be carried out using robotic devices or the teacher giving the robot the role of a monitoring tool. Obviously, these results are very encouraging. They do, however, show a one-dimensional use of robotics impressed not only on the students.

Attempting a literature review, one could discover in numerous studies and in a large amount research the use of robotics in the teaching of STEM (Zhong & Xia, 2020; Faisal et al., 2012; Karim et al., 2015; Benitti&Spolaôr, 2017), but only few references to theoretical subjects, mainly in the form of teaching proposals.

This particular situation is probably related to the fact that teachers who have a theoretical background in robotics do not possess the knowledge base of humanities courses and vice versa. So, it is much easier for a computer science teacher to incorporate robotic applications into their course in order to explain programming concepts than a language teacher who wants to use robotic devices to integrate them into the historical narrative.

This conclusion should not be confused with the digital aids, platforms and tools of the humanities, which thrive and constitute popular research fields, but is limited to the use of robotics in literature courses.

Asking the students to indicate to what extent the teaching of each subject could be carried out with the help of robotics, the results are more or less expected, as shown in figure 2. The course of computing is completely identified to teaching through robotics at a rate of 62.9%.

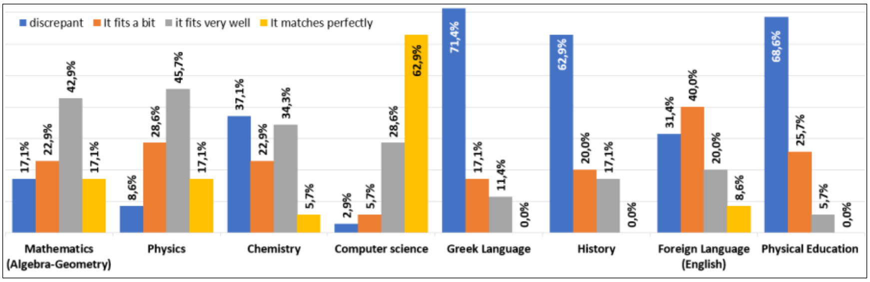

Figure 2. Estimations of the use of robotics in STEM, Humanities and P.E. courses.

Physics and Mathematics follow in order of courses that can be carried out using robots, with a percentage of positive evaluations of 62.8% and 60.0% respectively. Of the science courses, last in the ranking of ease of use of robotics for the needs of teaching comes Chemistry with the percentage of positive evaluations reaching 40.0%.

At the opposite end of the estimations of the use of robotics in STEM courses, are those of the humanities. For Greek language, P.E. and History the students surveyed did not find any correlation with robotics and claimed an inability to use robotic technology in the teaching of courses at a rate of 71.4%, 68.6% and 62.9% respectively. The situation is a little better for the teaching of the foreign language (English), where 60.0% believe that robotic devices can somehow be integrated to assist the foreign language lesson.

Robotics as an independent course

Robotics in the curricula of Greek schools is found as a separate course in only one specialty of Vocational high school. Specifically, it is taught in the laboratory for three (3) hours weekly in the 3rd grade specialty "Electronics Technician".

As a self-contained course, robotics is not found in any other level of education or type of school, neither in elementary school, nor in Junior high school or general high school. It is noteworthy that it is not taught in any class and in any specialty of the IT sector of vocational high school either.

In 2020, the teaching of skills workshops in Kindergarten, Elementary and Junior High School was established and implemented the following school year (2021-22). One of the modules is "STEM-Educational Robotics" which teachers can choose for implementation in kindergarten, 1st, 4th & 5th Primary and 1st & 2nd junior High School.The introduction of the institution of skills workshops is clearly a positive development, but the fact still remains that robotics is just a part of a module.

We asked the students of the seminar their opinion on the possibility of robotics being an autonomous subject, different from computer studies in schools. We were also interested to know which level they considered suitable for the entry of the course into the educational process (Fig. 3).

Before the start of the seminars, the vast majority of students (91.4%) responded positively to the prospect of robotics being an autonomous subject within the school curriculum. Half of them (48.6%) considered junior high school as an appropriate level of introduction of robotics into school reality. On the contrary, Elementary School was suggested by 28.6% as the starting level. Of these, the majority (22.9%) believe that students in the last two grades are able to cope with the teaching of robotics, while 5.7% believe that robotics lessons can also start in younger elementary grades. A percentage of 11.4% postponed robotics courses until high school, showing rather a lack of self-confidence or perhaps overestimating the difficulties of the course. Finally, only 2.9% believe that robotics could start being taught since kindergarten.

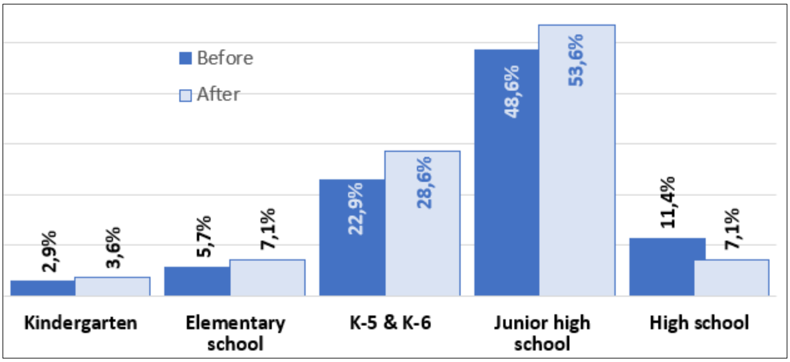

Figure 3.Appropriate level of introduction of robotics into school

Two and a half months and ten weekly robotics lessons later, we had a small change. From the students' responses in the exit questionnaire, there was a slight strengthening of the view that robotics can stand alone as a subject in the curricula of different school types. The positive response rate reached 92.9%.

More interesting, however, was the fact that the students' opinion about the age they now considered suitable for the introduction of robotics into school changed. The ranking based on the percentages did not change, however, we had a shift towards the younger ages manifested by an increase in their percentages and a parallel decrease in those of high school. The first introduction of the robotics course at the Lyceum level is supported by 7.1% in comparison to 11.4% 2.5 months ago. Middle school is still seen by students as the ideal age to start robotics at school with 53.6%, strengthened by 5% compared to the Entry questionnaire. The primary school solution is proposed by 35.7% of the students. It is the largest percentage increase and shows that students are oriented towards the last grades of Primary school considering them as optimal to include robotics as a separate subject. Finally, even in kindergarten rates there is an increase of 3.6%.

This image is confirmed by the Greek institute of educational policy, which proposed the gradual entry of robotics, even in this fragmentary form, into as early as kindergarten, with the implementation of skills workshops. It is no coincidence that the whole effort of educational robotics started at these ages with Papert's programmable LOGO turtles and took off from the MIT MediaLab group with the presentation of the intelligent brick, a result of the cooperation of the Lifelong Kindergarten group with LEGO and forerunner of the LEGO Mindstorms RIS. At the same time, in scientific literature there are programs (Scaradozzi et al., 2015) and methods (Atmatzidou&Demetriadis, 2016) of integrating robotics into the Primary school curriculum that highlight its undoubted contribution to the cognitive level (Lathifah et al., 2019) and soft skills (Jung et al., 2018).

Anthropomorphism in education

Finally, we asked to explore the attitude of students regarding the anthropomorphism of robots and whether this can affect the introduction of robotic mechanisms in education. Human Robot Interaction (HRI) is a large field of research for many scientists from different disciplines. However, the introduction of robots into the educational process should not only be considered by technological and pedagogical criteria but also by psychological ones, especially for the younger ages.

Robots can take many forms, depending on the work they perform. Some people are of the opinion that robots that are very similar to humans are unnatural and scary, while others argue that in order to overcome our fears they should be as similar to us as possible. The attitude of people towards robots is directly affected depending on the appearance and interaction that robotic machines have (Marchesi et al., 2022). Marchesi and her colleagues demonstrated through experiments the positive attitude that individuals adopt when interacting with humanoid robots. At the same time, however, kinesiology is equally important. When a robot's behavior is perceived as more mechanistic in a common task, participants reduce the likelihood of adopting a positive attitude towards the robotic device (Ciardo et al., 2021).

From a young age robots have been given a stereotypical image through cartoons and illustrations. Perhaps at this point lies the fear of the total acceptance of a completely anthropomorphic robot in education. Through their answers, the students show that they waver. They show acceptance of anthropomorphism, but at the same time they distance themselves from it. The fact is most likely due to the lack of representations and experiences in anthropomorphic interaction systems. After all, even the representations they have through the cinema are most often not flattering to androids and their pursuits.

More than half of the students (54,3%) replied that, depending on the occasion, the robot may or may not look like a human, while a significant percentage (40.0%) took a clearer position, stating that they should have human characteristics but differ from people significantly.

The pupils were then given a series of photos of humanoids to evaluate, based on appearance alone, the attitude they could have towards them in a possible teaching process. The results confirmed to a certain extent, what is known as the uncanny valley effect, which was proposed by Masahiro Mori in 1970 (Fig.4).

According to this, as robots become more and more human in their appearance, they become more acceptable and seem more familiar until they reach a point at which subtle imperfections of their appearance now make them look eerie and repulsive. Although this particular view of the Mori has received a lot of criticism as to its scientific basis and proof, nevertheless our results show that similarity to humans does not necessarily produce intimacy. This fact has been observed not only in android robots but much more in the digital world and the avatars that dominate there and they are now part of online education as well (Hepperle et al., 2022).

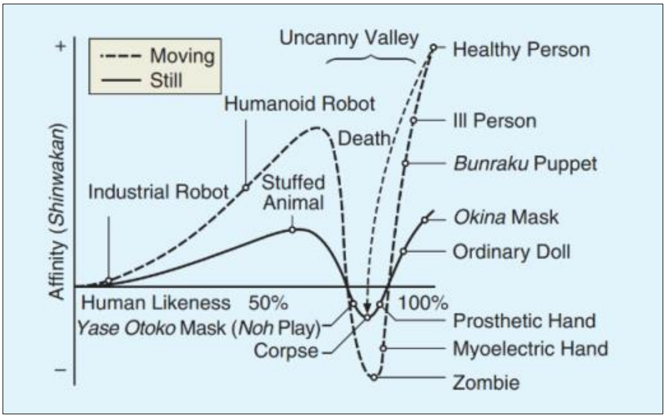

Figure 4.The uncanny valley effect. Image source: Mori et al. 2012

From the above it can be deduced that a critical distinction must be made between anthropomorphic beliefs and anthropomorphic interactions. Anthropomorphism is not based on specific belief systems but rather on a specific way of interacting, being a means of establishing a relationship (Airenti, 2018). Besides, at younger ages it is very common to anthropomorphize animals or objects in order to explain concepts or situations. The percentage of anthropomorphism of robots that will be called upon to serve in education matters very little in view of the possibilities of interaction that these robots must have with students and their environment.

Conclusions

The majority of the pupils who participated in the robotics seminars wish for the introduction of robotics as an autonomous course, distinct from IT. Half of them propose the introduction of the robotics course in junior High School. Their second preference is during the last two grades of Primary School. Students seem familiar with robotics and want to use it in school for educational purposes. Furthermore, they indicate that robotics is a motivation for teaching other subjects, which are made easier and more understandable with robotic applications in the classroom.

Regarding the subjects that students would like to be taught with the use of robots, we can distinguish a stereotypical perception that robotic technology is suitable for science courses, excluding the language courses from their involvement in the process. The same result is obtained from the answers to the question regarding the extent to which the various courses could be conducted with the help of robotics.

Finally, regarding the anthropomorphism of robots that could be used in schools during the integration of robotics in the educational process, the results show that the familiarity with humans does not necessarily produce intimacy. The value of the involvement of robotics is assessed by students at the interaction degree with these devices rather than proximity to appearance.

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