# Teacher Views on Educational Robotics and Its Introduction to the Compulsory Curricula

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Abstract: Students' engagement with Educational Robotics (ER) has a positive impact on the development of their interdisciplinary knowledge and skills, however ER is not yet integrated into the school curriculum. The present study examines how teachers with prior experience in ER, view their students' learning through ER and how they perceive the potential integration of ER into the school curriculum. It is a qualitative study and the sample consists of teachers participating as coaches in the regional FIRST LEGO League Competition (FLL) of Tarragona-Reus, in the region of Catalonia in Spain. The results show that teachers in this specific context positively perceive their students' learning through ER as their students develop various 21st century skills and acquire programming knowledge. Teachers are also in favour of the ER integration into school curricula even at early educational levels. Our research results, although they cannot be generalized, are of use for educational institutions considering the integration of ER into the curriculum.

## 1 INTRODUCTION

The field of Educational Robotics (ER), as the name suggests itself, is related to both the discipline of robotics and education. In order to better understand the relation between robotics and education, and the learning taking place, definitions of the ER field present in current literature will be reviewed. According to Scaradozzi, Screpanti and Cesaretti (2019), the ER field and its identifying characteristics seem to not be clearly defined in current literature and to vary among research papers. When reviewing literature in ER, different definitions are encountered, among which, Denis and Hubert (2001) propose that "Educational robotics (ER) consists in building and programming small robots and conducting them with the help of computer programs that have to be built by the learners themselves". More recent research studies define the ER field by putting emphasis on its pedagogical perspective (Frangou and Papanikolaou, 2008; Mikropoulos and Bellou, 2013; Moro, Agatolio and Menegatti, 2018). Moro et al. (2018) highlight that "ER is not limited to the specific discipline of robotics, but it functions as a didactical method, based on constructivism and constructionism" while, Frangou and Papanikolaou (2008) define ER technology as an educational tool. Regarding the characteristics of the ER field, authors highlight its interdisciplinarity (Angel-Fernandez and Vincze, 2018; Scaradozzi, Screpanti and Cesaretti, 2019). More specifically, according to Angel-Fernandez and Vincze (2018) ER is a field of study that combines the areas of education, robotics and human-computer interface, whereas, Scaradozzi et al. (2019) point out that ER field merges the disciplines of robotics, pedagogy and psychology.

Based on the above, ER is considered a highly interdisciplinary area combining additional disciplines apart from education and robotics, and when students are engaged with ER activities, they acquire interdisciplinary knowledge and skills. According to Denis and Hubert (2001), ER may affect positively students' learning in STEM (Science, Technology, Engineering, and Mathematics) subjects. In addition, Denis and Hubert (2001) point out that students may develop skills as

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problem-solving strategies, the formalisation of thought, socialisation as well as the acquisition of various concepts. The research of Barker, Nuget, and Grandgenett (2008) confirms that engagement with ER brings positive learning outcomes in mathematics, programming and engineering. Furthermore, Di Lieto et al. (2017) highlight that through ER students improve their visuo-spatial working memory and inhibition skills and robot programming skills. Gains are also reported in students' 21st century skills as critical thinking, problem-solving, and collaboration skills, creativity and innovation (Eguchi, 2015). Students through ER also improve their attitudes towards STEM subjects (Sahin, Ayar and Adiguzel, 2014; Eguchi, 2016). More specifically, girls' involvement with robotics programs may have a positive effect on the perceptions of their abilities in STEM and career interests (Weinberg, Pettibone and Thomas, 2007).

Through ER, students can acquire cross-curricular knowledge, develop interdisciplinary skills and get engaged in STEM disciplines and careers, however, the question that arises here is whether teachers are aware of the benefits students gain through their involvement with ER. Based on previous literature, students positively perceive their learning with ER when carrying out ER activities in either formal or informal contexts. Regarding informal contexts, students consider FIRST LEGO League robotics competition as a great opportunity for learning about real word problems and for the acquisition of skills in STEM areas of studies and at the same time they view that they acquire social, collaborative and communication skills (Schina, Usart and Esteve, 2020). Regarding, students' engagement with ER in formal contexts, students positively perceive ER as a plaything, as a source of employment, and as a way to high technology (Liu, 2010). Students' perceptions of their learning throughout ER activities are positive, however, teachers' perceptions of ER are not sufficiently studied in current literature, despite the fact that teachers play a crucial role in the implementation of ER in the educational institutions. The aim of the present study is to further examine how teachers perceive ER in the context of the region of Catalonia in Spain. This paper will particularly focus on the effects of robotics on students' skills and learning of programming and engineering concepts, as perceived by teachers, and will examine teacher views on the potential ER integration into the formal school curriculum.

# 2 THEORETICAL BACKGROUND

## 2.1 Teachers and ER

The implementation of ER activities in the framework of school subjects requires teachers to play a new role in the teaching and learning process (Alimisis et al., 2007). Addressing this need for change in the role of teachers, Alimisis et al. (2007) suggested that teachers need to receive specialized training in ER technologies and its use in the school classroom. More specifically, the TERECop project (Alimisis et al., 2007), was launched aiming at enabling teachers to implement the robotics-enhanced constructivist learning in school and reflecting on their classroom experience with robotics. According to Chambers and Carbonaro (2003), introducing ER activities in the school classroom is a demanding task for teachers. Sisman, Kucuk, and An (2019) underline that there are still teachers who are unfamiliar with the positive effects of ER on students' learning, while the teachers who are indeed aware of the ER advantages, are not adequately prepared to apply ER in their teaching.

When it comes to teachers' perceptions of ER, a research implemented in Canada demonstrates that ER is perceived by teachers as to impact positively students' lifelong learning skills (Khanlari, 2015). This study highlights that teachers perceive ER as a useful tool facilitating the learning of science and technology related topics. However, teachers in this study, do not view ER as a useful learning tool for improving the learning of mathematics, although some of them provided examples of mathematics topics that can be taught using ER (Khanlari and Kiaie, 2015). Despite the fact that teachers acknowledge the benefits of ER for students' learning, they mention a number of barriers that impede the integration of ER into their teaching (Khanlari and Kiaie, 2015). For example, they feel that they need to receive further support regarding the ER implementation in their teaching (Khanlari and Kiaie, 2015). Taking everything into consideration, based on the limited research on teacher views on ER, it is observed that teachers acknowledge the benefits of ER in teaching, however, they remain hesitant in the integration of ER in their teaching.

## 2.2 ER Integration in the Curriculum

After reviewing the positive perceptions of students and teachers of ER, a question that undoubtedly comes up concerns the necessity of its integration in

the school curriculum. Scaradozzi et al., (2019) vividly support that ER should be part of the school curriculum; ER should be a distinct school subject within the school's regular hours, with its own lesson and evaluation plan. However, obstacles to implementing robotics as part of the regular school curriculum appear to be the fact that ER activities tend to be time consuming, the cost of the equipment high, while the effort required from teachers to arrange the equipment quite demanding (Alimisis, 2013). Scaradozzi et al. (2019) underline that ER should be integrated in the educational institutions at an early stage either as a whole curriculum-based education or as a regular activity inside another broader subject. Kubilinskiene et al. (2017) suggest integrating ER activities in the following areas of the curriculum that extend further than STEM; languages, development of general competencies (in the subject "human safety" of primary and secondary school), cognition of the world (in the subject "world's knowledge" in primary school) and in the general education for the deaf and hard of hearing in primary school.

### 2.3 ER Integration in Spain

Nowadays, the educational community in Spain as in the rest of Europe, shows increasing interest in ER. However, back in 2007, Alimisis et al. (2007) pointed out that the use of robotics in primary and secondary education in Spain was very limited and not official at all. At the same time Alimisis et al. (2007) remarked that the activities in the field of Robotics in Spain mainly were in research or industry while there were also a few robot competitions organized for secondary level students. The authors pointed out that it was not common to encounter ER well-thought and well-structured activities applied in the field of education.

Nevertheless, since these observations in 2007 (Alimisis et al., 2007), ER field has developed and expanded substantially across all educational fields and levels in Spain. According to a research carried out in Spain and in Latin American countries, the use of robotics as a learning tool is significantly growing in Spain and Latin America (Pittí et al., 2013). This growth refers to ER extracurricular activities that take place as after school programs and are most commonly implemented by private enterprises (Pittí et al., 2013).

Regarding the ER curricular implementation, Pittí et al. (2013) report that the use of ER in the classroom occurs in subjects closely related to robotics. Interestingly, only 12% of the teachers requested report to apply ER in Science, while even less teachers, around 5% of them state that they applied ER in Mathematics and Physics. In a subsequent research carried out exclusively in Spain (Pina and Rubio, 2017) it is reported that teachers delivered classes through ER that are linked to several fields, not limited to Computer Science. To be more precise, according to Pina and Rubio (2017), the teachers view that through ER, they could implement activities beyond Computer Science, linked to different areas of the curriculum (Mathematics, Social Sciences, Arts, Language etc.) and they would facilitate their students' development of transversal and social skills.

## 3 METHODOLOGY

The general objective of the present study is to further examine how teachers perceive ER and the benefits it offers when students are engaged with this field of studies. The study is oriented towards two main domains; (1) teacher views on the development of students' skills/ learning (2) teacher views on the integration of ER in the school curriculum. It is a qualitative study that aims to explore how teachers with prior experience in ER, perceive the development of their students' learning of programming and engineering basic concepts through ER and their views on ER integration in the curriculum. The variables of the study are the following: teacher views on students' skills, teacher views on students' learning of programming and engineering, teacher views on ER integration into the formal school curriculum. Based on these, the research questions are formulated accordingly:

### 3.1 Research Questions

RQ1: How do teachers with prior experience in ER perceive students' learning with ER?

RQ2: How do teachers with prior experience in ER view the potential integration of ER in the Spanish compulsory curricula?

### 3.2 Research Context

The research took place in the province of Tarragona in the region of Catalonia in Spain within the regional FIRST LEGO League Competition (FLL) Tarragona-Reus in 2019. The FIRST LEGO League Competition is an international competition that is addressed to students from 9 to 16 years old, while its Junior

edition is addressed to younger primary school students (FIRST LEGO League, 2020). FLL Competition has a theme, in 2019 season the competition was called "INTO ORBIT" referring to the space theme (FIRST LEGO League, 2020). In the FIRST LEGO League Competition teams compete in 4 categories, Robot Design, Core Values, Project and Robot Game, while in the Junior Edition teams present to a panel of judges what they learned and created, without formally competing. The competition is international and the participants are assessed by the same evaluation rubrics across countries, while the winners of the national competitions participate in subsequent international competitions. Based on previous research, (Usart et al., 2019) the FLL competition, evaluates 21st century skills through the evaluation rubrics for each category (Robot Design, Core Values and Project). The 21st century skills evaluated in the competition are communication, collaboration, social/ cultural skills, ICT literacy, creativity, critical thinking, problem solving, developing quality products (Usart et al., 2019). In this research paper, the teachers/coaches accompanying the students at the FLL Competition and FLL Competition Junior are requested to provide their views on their students' learning with ER and on the potential integration of ER into the school curriculum.

### 3.3 Research Sample

The initial sample consists of 10 coaches whose teams participated in the FIRST LEGO League and FIRST LEGO League Junior Competition of Tarragona-Reus in 2019. As main aim of this research paper is to explore teacher views on robotics, two questionnaires completed by coaches that are not school teachers are not taken into consideration. As a result, the sample studied for the purpose of this paper is limited to 8 school teachers. The sample is comprised of both primary and secondary school teachers (5 out of 8 are primary school teachers, while 3 are secondary school teachers). The sample has extensive teaching experience (2 out of 8 have been working as teachers for over 15 years, 5 of them from 5 to 10 years and only one of them from 1 to 5 years), is very familiar with Educational Robotics and carries out ER activities on a regular basis, as they took over the team preparation for the FIRST LEGO League Competition and the FIRST LEGO League Junior Edition.

### 3.4 Research Instrument

The research instrument is based on the questionnaire of Theodoropoulos, Antoniou and Lepouras (2017). It was translated from Greek into Spanish and it was adapted to the research context. Initially, the questionnaire was addressed to teachers whose students were participating in the 7th PanHellenic ER competition and for the purpose of this research was adapted to the context of FIRST LEGO League Competition. The adapted version of the questionnaire can be found in the following link[5]. The questionnaire was forwarded to coaches of the FIRST LEGO League Competition by the organization committee right after the completion of the regional competition Tarragona-Reus. The questionnaire collects the following data; coaches' demographic data, coaches' competition participation data, coaches' views on students' acquisition of skills/ learning of programming and engineering with ER and coaches' views on ER integration into the formal school curriculum.

## 4 RESULTS

### 4.1 Students' Learning with ER

RQ1: How do teachers with prior experience in ER perceive students' learning with ER?

The participants of our study report that students through their involvement with Educational Robotics gain important skills as problem-solving, collaboration, creativity, discipline and presentation skills (Figure 1). All teachers in our sample underline that their students definitely develop problem-solving skills and their creativity through ER. Regarding collaboration skills, 7 out of 8 teachers support that through ER students definitely develop collaboration skills while one teacher is more hesitant, stating that ER probably encourages students' development of collaboration skills. Teachers seem to be also positive about students' development of discipline and presentation skills through ER. To be more precise, 5 teachers report that students definitely develop their discipline and presentation skills through ER while 2 teachers are positive but hesitant stating that probably students do develop these skills and one teacher stays neutral.

[5] Link for the questionnaire; https://forms.gle/6EFotK6SSSxFfQHz6

When teachers are asked to specify the benefits of students' involvement with ER both at short-term and long-term, they make reference to the previously-mentioned skills (e.g. collaboration skills, problem-solving skills etc.) and remark some additional ones. For example, as presented in Table 1, teachers consider that students through ER may gain interest in technology and robotics, they may have the chance to put in practice previously acquired knowledge and overcome themselves when dealing with challenges. It is also pointed out that through ER students may feel more motivated to learn and that through ER students may broaden their horizons.

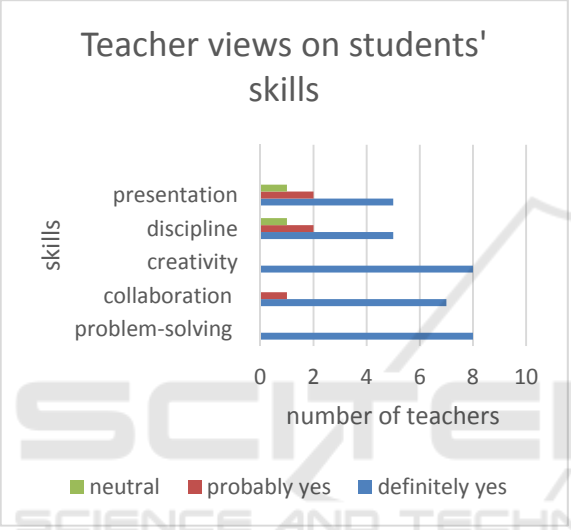


Figure 1: Teacher views on students' skills acquired from ER.

Table 1: Teacher views on the benefits from students' ER involvement.

| Teacher views on benefits on students | Number of cases |
|---|---|
| Interest in technology and robotics | 1 |
| Overcoming themselves | 2 |
| Putting in practice knowledge previously acquired | 1 |
| Broadening their horizons | 1 |
| Motivation for learning | 1 |
| Acquisition of collaboration skills | 3 |
| Acquisition of problem-solving skills | 3 |
| Fostering creativity | 2 |
| Becoming more disciplined | 1 |

Regarding students' learning of programming and engineering through ER, teachers seem to be positive regarding programming basic principles while a bit unsure as far as engineering basic principles are concerned. When it comes to engineering, as displayed in Figure 2, 3 out of 8 teachers point out that ER definitely fosters or somewhat fosters students' learning of basic engineering principles while, 4 of the teachers remain neutral and one teacher negative about students' learning of engineering through ER. As far as basic programming skills are concerned, 5 out of 8 teachers (62.5%) report that through ER students definitely develop or somewhat develop their basic programming skills. In this case, 2 teachers remain neutral and one teacher is negative regarding the benefits in students' learning of programming. When teachers are asked to specify the programming and engineering concepts that are developed through ER they report a series of learning outcomes that are displayed on Table 2. When it comes to students' learning of programming, teachers make reference to the acquisition of basic programming concepts as loops and conditions, they state that their students learnt a visual programming language, realized the importance of sensors and learnt how to program. Interestingly teachers underline that their students learnt how to optimize a program referring to reducing the blocks required for a specific program. As far as engineering principles are concerned, teachers report that students get familiar with mechanical movement, engineering design and physics/mathematics knowledge in the context of engineering.

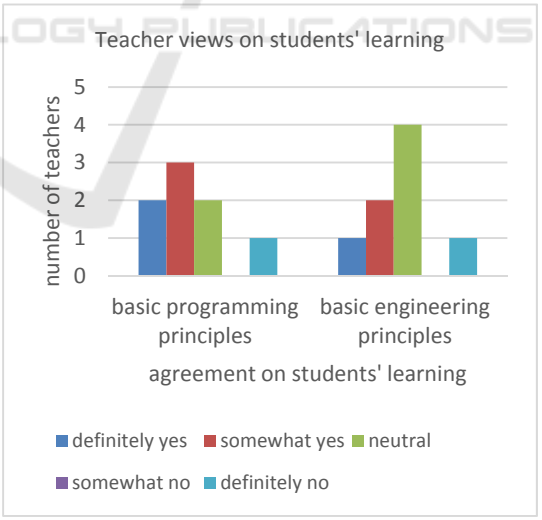


Figure 2: Teacher views on students' learning of programming and engineering basic principles.

Taking everything into consideration, teachers report that their students may acquire a number of skills as problem-solving, collaboration, creativity, discipline, presentation skills and other skills (see

Table 1), while at the same time they may acquire knowledge related to programming and engineering. Teachers seem to perceive their students' learning of programming more likely than their learning of basic engineering principles.

Table 2: Teacher views on students' learning of programming and engineering.

| Students' learning of Programming | Students' learning of Engineering |
|---|---|
| Basic programming concepts (e.g. loops, conditions etc.) | Mechanical movement (e.g. speed, angles, forces etc.) |
| Familiarization with Visual Programming | Engineering design |
| Program optimization (reducing blocks, improving robot behavior) | Physics and mathematics concepts applied in engineering |
| Use and usefulness of sensors | |

## 4.2 Integration of ER in the Curriculum

RQ2: How do teachers with prior experience in ER view the potential integration of ER in the Spanish compulsory curricula?

The majority of the teachers participating in this research report that they are in favour of the integration of ER into the school curriculum; 7 out of 8 teachers report that they agree with the ER integration into the school curriculum. In addition, when they are requested about the appropriate school level of the integration, 3 teachers report that ER should be integrated across all educational levels, while 2 teachers specify that ER should be integrated into primary school curriculum, only one teacher supports that ER should be integrated into secondary school Education, and another teacher points out that it should be integrated even in pre-school education (see Table 3).

Table 3- Teacher views on the age and school level of ER integration into the curriculum.

| Teacher views on the age and school level of ER integration into the curriculum | Number of cases |
|---|---|
| Secondary school. | 1 |
| Primary school | 2 |
| All levels | 3 |
| All levels, pre-school included. | 1 |

When teachers are asked about how would parents view the curriculum integration of ER, most of them (7 teachers in total) view that parents would definitely or somewhat agree with this integration while one teacher view that this integration would be negatively perceived by parents.

Taking everything into consideration, the majority of the teachers participating in the research at the local context of Tarragona-Reus positively perceive a potential integration of ER into the formal school curriculum even from early educational levels.

# 5 DISCUSSION

The results of this study are in line with previous research results on teacher views of their students' learning: it is observed that teachers positively perceive their students' involvement with ER as they develop 21st century skills as problem-solving, collaboration, creative thinking and presentation skills. These results are in line with Khanlari, (2015) who support that teachers view that ER may boost students' lifelong learning skills. In addition, the research results of the present study are in line with Theodoropoulos et al., (2017) who point out that teachers consider that most students improve important skills such as: problem-solving, collaboration and creativity through ER. Positive outcomes regarding collaboration and creativity are also observed in the research of Pina and Rubio (2017) who point out that teachers/coaches of the FIRST LEGO League Competition observe important learning outcomes primarily at teamwork and secondly at creativity and innovation.

As far as programming and engineering skills are concerned, the findings of this research demonstrate that the teachers seem to positively perceive their students' learning outcomes in the area of programming while they seem to perceive less positively the learning outcomes in the area of engineering. As displayed in Figure 2, the majority of teachers view that their students acquire programming skills through ER while, a minority perceive students' learning of engineering equally positive. Our findings are in line with Theodoropoulos et al. (2017) who point out that most teachers believe that their students can learn programming and engineering through ER. However, as also observed in our study, these authors underline that the results are not promising regarding engineering. Consequently, the teachers view more positively the development of students' programming

knowledge rather than their knowledge of engineering through ER.

Regarding the integration of ER into the school curriculum, the results are very promising as teachers suggest the integration of ER even at early educational levels. Teachers also view that parents would be in favor of such a change in the school curriculum. Based on our findings, the ER integration into the school curriculum is desirable, however, it would raise additional challenges for the educational community. For instance, among the challenges would be the kind of the ER integration into the curriculum referring to whether it would be introduced as an independent subject or as a sub-discipline in other subjects. Additionally, the integration of ER into the curriculum would require dealing with two main barriers: the high cost of the ER equipment and the teachers' unfamiliarity with ER technologies.

# 6 CONCLUSIONS

The results of this study confirm that ER is positively viewed by teachers with prior experience in the field of ER, in the local context of Tarragona-Reus in Spain. Teachers value positively the learning outcomes that students acquire through ER and support its integration into the school curriculum. The limitations of this study are related to the context of the researchers. First, the limited sample size and the teachers' experience with robotics (all participants are coaches of FLL and therefore very familiar with ER), may impair us from generalizing our results to other contexts. Therefore, next steps in this research would be to implement a subsequent study at a regional or national level with a more representative and broader sample. The sample would be school teachers coming from different disciplines and with different degrees of knowledge and involvement with ER activities. Provided teachers' perceptions would remain positive towards an ER curriculum integration, the authorities, the research community and educational institutions would need to further study the integration of ER into the school curriculum, to ensure the smooth implementation of this curricular change. The first step to the ER integration would be to determine whether ER would be an independent subject in the curriculum or a sub-discipline in certain subjects. After dealing with the kind of the ER implementation and the educational levels in which it would be applied to, in-service teachers would need to receive specialized training in ER, while pre-service teachers would need to receive ER training throughout their teacher specialization degree.

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