

# ANALYSIS OF ROBOTICS-BASED LEARNING INTERVENTIONS FOR PREVENTING SCHOOL FAILURE AND EARLY SCHOOL LEAVING IN GENDER CONTEXT

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## Abstract

Early school leaving (ESL) has become a problem plaguing many different countries around the world and several different solutions are being searched for. Gender, as a factor in early school leaving, has become a popular research topic among many researchers and has been displayed by recent OECD results that have shown that boys are dropping out of the education system more. Researchers are still debating whether or not the processes in school are inadequate for boys and so they're excluded out of the education system, the learning process is mostly organized according to the needs of the girls, not taking into account the boys' learning needs, and how the boys organize information and how do they find it easier to learn etc., or whether they are factors that are outside the school environment, which makes them leave the education system early. For example, the lack of support from parents, the desire to become independent and a desire for success, which they are unable to experience in school, a problem that is also related to motivation problems.

The idea behind the Erasmus+ project "Robotics-based learning interventions for preventing school failure and Early School Leaving" is to use robotics learning strategies to lessen the risks of early education leaving. Students from partnering schools in Greece, Italy and Latvia were chosen to participate in the project activities according to certain early school leaving criteria. Out of 101 students 77 were male and 24 were female students, making it clear already at this stage of the project that boys are more subject to risks of early school leaving, even in the partnering schools. The robotics activities were organized for everyone equally regardless of their gender. The main objective was to spark the students' interest in the learning process, promote their problem-solving skills, promote their motivation and lessen the risks that they face every day in schools. The robotics activities were aimed at students' getting actively involved in programming, testing their knowledge and constructing new knowledge. At the same time, mutual cooperation among the students was promoted, because they had to work in groups with one robotics set, thus promoting the ability to communicate, support each other, discuss the knowledge to be acquired and solve problems. Regardless of the fact that everyone involved enjoyed participating in the activities, more positive feedback was received from the girls involved in the project.

The aim of this paper is to analyse - are there gender based differences in how robotics-based learning activities tackle risks of ESL.

Keywords: Gender differences, robotics-based learning, early school leaving.

## 1 INTRODUCTION

The project intends to explore how innovative technology-enhanced learning and teaching can address low achievement in basic skills and support schools to tackle ESL (early school leaving) problem. Project partners' experience in the development of robotics-based projects in schools has shown that educational robotics (ER), if deployed in a constructivist/constructionist learning environment ([1]) and within a project-based learning methodology, can offer learning opportunities for children and support the development of basic and transversal skills such as creativity, teamwork, problem solving and more, and keep students interested and motivated with hands-on learning, learning by doing and other fun learning activities ([2]).

The main target group in the project are students who have a high ESL risk, the subordinate target group is also the teachers who, in the frame of the project, work with the developed materials during their training and later also other teachers who will be able to use the developed materials as open access resources, however the effect of projects' activities on the professional improvement of teachers will not be analysed.

Early school leaving is often related to social exclusion risks which, in its turn, can be both connected with the social economic situation of the student's family and the student's special needs as well as the problems in the educational process. When children and young people drop the education system early without obtaining the basic education or secondary education there exists a greater risk of not acquiring adequate education, profession, work, not earning enough means of subsistence which can lead to poverty, involvement into criminal groups and in general to social exclusion. The social exclusion is understood as a social multi-dimensional process of marginalization which possesses economic, social, cultural and political aspects and it is characterized by the inability of the individuals or the groups to join the society fully or partially, when they are denied the access or the access to such resources, services and activities that are vitally important for the person's development and that ensure a full-fledged functioning of the person in the society is encumbered ([3]). In education it is connected with insufficient possibilities to participate in the educational process, exclusion, unsatisfactory social integration and the inability to participate in the processes going on in the society in general. Social integration, in its turn, is defined as "a process in which everyone has the possibility to participate in the social, economic and political life based on the equality of rights, fairness and respect" ([4]).

## **2 STUDENTS' INVOLVEMENT IN THE PROJECT**

In order to check the possibilities of applying the learning modules of robotics for reducing the early school leaving risk (ESL) a set of criteria for selecting students who are at risk of ESL was developed. Part of the criteria allowed receiving the assessment only in the form of YES or NO, where YES meant receiving one point while NO meant no points. The variation of several points from 1 to 4 was possible in the other part of the criteria where 1 meant that such a feature was not observed, 2 – the feature is rarely observed, 3 – the feature is sometimes observed and 4 – the feature is always observed ([5]). In cases if there were more students than it was possible to involve in the project activities teachers were advised to give priority to those students whose risks were more serious. Thus, it was ensured that students who had shown early school leaving risks would participate in the approbation of the developed materials. However, it was, to a certain extent, also the project risk because working with robotics activities in a group of students who are at risk of ESL has not been widely used and thus positive results are predictable but not guaranteed, especially in such a short period of time (approx. 3 months) because the impact of different programs is observed with time displacement, which means that positive results more frequently are observed after a longer period of time ([5]). Another risk factor was the time of lessons, because the robotics activities were organized after class, thus making the day longer for students involved in the project, which is a big challenge for students with low learning motivation, who experience trouble concentrating for learning and who prefer to spend their time outside of the school.

## **3 GENDER DIFFERENCES IN THE CONTEXT OF SOCIAL EXCLUSION**

It is clear that a low socio-economic status, low learning achievements, grade retention, low learning motivation are all contributing factors to the risks of ESL, however, research on school leaving indicates that gender is one of the risk factors ([6]). Among early school leavers, men outnumber women by three to two ([7]). This is not surprising, given, on the one hand, the disproportionate concentration of boys among low-achieving students ([7], [8]).

To alleviate the problem and determine the contributing factors in the context of gender differences and ESL, and to determine the factors contributing to different attitude towards learning, it is vital to understand and acknowledge the research done so far and their findings on the effect of gender differences on ESL. By analysing the main factors contributing to the attachment to school, thus alleviating the risks of ESL, Fredricks et al. (2004) has distinguished three dimensions – behavioural, emotional and cognitive, where behavioural involvement means involvement in learning and social activities; emotional involvement means relationships with the teachers, classmates and the school in general; cognitive involvement means the willingness and readiness to dedicate their energy in solving learning tasks of different difficulties ([9]). There are research papers showing that boys have weaker self-regulatory skills ([10], [11], [12]) and some papers proving that boys develop these skills at least one year later than girls do ([13]), proving that boys develop cooperation skills, which is one of essential aspects to sense an attachment to the school, later than girls. Research has proven that at a pre-school level boys have a lower level of attention, emotion and attention-cognitive regulation, than girls do ([14]). If these differences are not taken into consideration in the pedagogical process, it may

be an essential factor for boys slowly getting sifted through the educational system, because their needs are not being met and they start to sense a loss of self-efficiency, thus lessening their sense of attachment to the school ([15]). These results indicate another essential problem that needs to be analysed – it is the teachers' attitude towards various emotional expressions, which are different for boys than they are for girls, towards boys' different learning style, their involvement in learning activities etc. Teachers tend to characterize boys' behaviour as disciplinary problems, without trying to understand their emotional needs. During the educational process boys prefer to try everything out in practice, thus, achieving understanding, and if they are not allowed to fulfil their needs and utilize their strengths, they may slowly adapt a behaviour, which demands negative attention. Traditional learning methods are unsuitable for boys' learning style, their need to try everything out for themselves and "burn off" their energy, which is why boys do not think of them as exciting. In effect, when they are not getting involved in the learning process, disciplinary problems arise ([16]). There is research which has tackled the risks of ESL in a gender-context ([19]), proving that boys have more disruptive behavioural problems, which affect their attitude towards learning in class ([20]. [21]), however it could be explained by their differences in the development of emotional regulation skills ([14]). Girls have a more distinct need for learning achievements ([15]), which promotes a more positive attitude from the teachers, resulting in more favourable valuation of learning achievements, which in turn creates a stronger emotional bond between teachers and girls, but can be a contributing factor for exclusion for the boys.

However, a recent study on gender differences in developing programming thinking has shown, that girls take longer to learn programming ([17], [18]), which creates other problems, for example, choosing their future profession. There are several studies on gender differences in choosing to learn advanced computer skills and all of the studies have shown that there is a significant dominance of males in the field ([22], [23], [24]). There have even been studies that analyse gender differences in choosing specific courses, while studying computer sciences and these studies have shown that female students tend to choose more general courses, but male students tend to choose more specific courses, this research also shows that none of the female students chose to pursue robotics ([25]). It is important to note that this article perceives educational robotics activities by analysing them in the context of gender differences and ESL.

## 4 METHODOLOGY

Data is collected by quantitative and qualitative research methods. The research tools make a mix method of investigation including mainly surveys before and after activities for students and teachers who were involved in activities, structured observation tool to collect results of activity observation. The SPSS software was used to process the data, and analyse them together with data from observations and discussions with teachers.

In order to verify whether the aim set in the project – to decrease the early school leaving risk has been reached, several research tools have been developed that were filled in both by the students and the teachers.

**Students** had to fill in the questionnaire before and after the participation in the project activities. Questions in both the surveys were formulated in a different way and it had several reasons – to avoid a situation that students give the same answers both before and after the project activities and the second reason was purely practical, for initially students participated without actual knowledge of robotics; they did not know how learning would take place and what activities would be included in the lessons therefore the questionnaire that had to be filled in before the participation in the activities asked for the students' attitude to learning, about their learning motivation and problems they faced in everyday learning process. After the participation in the project activities students again were asked to fill in the questionnaire in which some questions though formulated differently contained the same idea that was expressed in the initial questionnaire in order to compare whether there had been changes in the students' attitude while other questions were formulated so as to receive answers related to particular robotics activities and to find out how students assessed their progress. The statements included in the questionnaire had to be assessed using the Likert scale where 5 meant – fully agree and 1 – fully disagree.

101 students, who took part in robotics based activities and filled in surveys before starting robotics based activities, submitted their replies and all of the surveys were valid for result analysis. However, at the end of the study, 93 surveys were received out of which 80 were valid for result analysis. During the project, 8 students switched schools, thus terminating their participation in the project.

**Teachers** were asked to fill in several research instruments:

- The evaluation of student's ESL risks, in which teachers had to provide information about the level of student's academic achievement, the missed lessons, the special needs and the subjects in which the student had the highest and the lowest academic achievements.
- The evaluation of students' attitude to learning, motivation and problem solving strategies before and after the robotics activities. The statements included in the questionnaire had to be assessed applying the Likert scale where 5 meant – observable in all situations, and 1- not observable in any of the situations (in the questionnaire before students' involvement in the robotics activities) and 5 – considerable improvements are observed in all situations and 1 – no improvements are observed in any of the situations (in the questionnaire after students' participation in the robotics activities).

Only the teachers working with the students the compulsory educational process provided their opinion on the students' work, thus the results need to be regarded in the context of the whole educational process, rather than just the project. Altogether there were 242 teacher replies before the commencement of the project and 278 after the robotics based activities, all of the filled surveys were valid for result analysis.

- Structured observation in which teachers had to evaluate students' attitude to learning, motivation and problem solving strategies during the implementation of each particular teaching/learning module of robotics when teachers had to assess students' different actions on the Likert scale from 0 to 4, in which 4 meant – does more than it is expected from him/her and 0 meant – the activity is not observed. In this article results of observation will not be analysed.
- The assessment of the introduction process of the robotics activities in which teachers could freely express their thoughts about the whole process giving answers to 10 questions aimed at assessing teachers' opinion about the developed teaching/learning modules, the solutions that were used handling different challenges as well as the understanding if the developed teaching/learning modules corresponded to the students of the project target group. In this article assessment of the process will not be analysed.

## 5 RESULTS

The aim of this paper is to analyse gender differences in how robotics-based learning activities tackle risks of ESL therefore all the data was analysed from gender perspective.

By using the methodology of ESL risk assessment criteria, to choose students that could take part in the projects' activities, 101 students were chosen to participate in the project, and whose results were analysed. Data about the results of the project was acquired from the 80 student submitted surveys that were valid for analysis, out of which at the beginning 24 were girls and 77 boys, and at the end 19 were girls and 61 boys. Meaning that on average 52, 5% more male students were involved in the project. It confirms the fact that has been proven in several previous studies, that boys are more exposed to risks of social exclusion. It poses a topical question, one that should be analysed in a wider context, in order to evaluate educational processes and how well are they suited for each gender. This article contains a comparison of students involved in the projects' activities, by choosing a gender variable for the comparison. Out of the students' replies, all of the indicators showing their attitude towards learning, working with robots, ability to cooperate with classmates and teachers, were analysed. In the context of this article, out of the teachers' replies, indicators showing involvement of students in the educational process were chosen for further analysis because it is an essential aspect to provide students with a sense of attachment to the school, thus alleviating the ESL risks, which are sometimes called a "push" factor away from education ([19], [20]). Other ESL (socio-economic status, family situation, etc.) have not been analysed because the current situation can not be influenced with pedagogical methods.

The data acquired is analysed with an average (mean), because the split between genders was uneven in student groups.

**Table 1.** Students opinion about participation in Project activities.

	Gender of the student:	Learning process by using robots was exciting	I learned how to program the robots	I liked to work in groups during the robotic activities	Knowledge gained in the robotic activities can use in other subjects	Attitude to learning	Skills to Collaborate with classmates	Skills to collaborate with teachers'	
After robotic activities	Female	Mean	4,47	4,11	4,42	4,26	4,00	4,21	4,42
		Std. Deviation	,612	,567	1,261	,733	1,000	1,084	,692
		Variance	,374	,322	1,591	,538	1,000	1,175	,480
	Male	Mean	4,38	3,82	4,31	3,56	3,56	4,07	4,20
		Std. Deviation	,897	,904	,958	1,272	1,088	,964	,813
		Variance	,805	,817	,918	1,617	1,184	,929	,661

By analysing students' replies (see Table No 1), where they stated their opinion after their involvement in the projects' activities, it is evident that in all of the analysed parameters there are differences between male and female students answers. Regardless that the differences are minute, they attest that altogether female students' attitude towards learning is more positive than that of male students. The results approve that female students have a more positive attitude towards education. However let us not forget, that students involved in the activities are exposed to school leaving risk, which is why the lowest parameter for both genders was regarding the statement "Attitude to learning" (mean for girls 4, 00; boys 3, 56), which, in turn, can be explained by the fact that the activities were organized after compulsory classes, thus the students' attitude towards the learning process altogether is showing the least improvement. This comes to show that revision of compulsory learning is needed to make it more interactive and exploiting the possibilities of active learning approaches, for example, learning by doing. Early education leaving risks can be diminished by several aspects that were revealed in the course of this study. Risk group students often characterize the learning process as boring; on the other hand, they characterize learning by using robotics as exciting, which certainly can have a positive effect on students' willingness to continue their education. Another aspect that could promote the wish to continue learning is cooperation and sense of attachment, belonging. This statement is proved by the results as both boys and girls were positive about cooperation in group projects (mean for girls 4, 42; boys 4, 31) and improvement of cooperation skills among students (mean for girls 4, 21; boys 4, 07). Results of this study indicate that a positive and encouraging learning process improves the girls' attitude towards programming, which, in turn, can influence their will to pursue IT in their future, which still is a largely gender disproportionate field. One of the factors that could have influenced this result is the fact that the teachers who were trained to work with educational robotics in ESL risk groups were provided with specific knowledge regarding the rules of students' positive motivation. The most essential difference was shown at the statement "Knowledge gained in robotic activities can be used in other subjects" (mean for girls 4, 26, boys 3, 56), which attests to the concept stated in other studies, that boys have more difficulties to abstract the acquired knowledge in order to use it in a different context ([26]; [27]). The acquired results indicate a necessity for teachers to differentiate their learning methods, to utilize active learning approaches, to organize hands-on activities, in order to aid the boys to develop their ability to abstract and utilize the acquired knowledge in different learning situations, thus developing their meta-cognitive thinking.

**Table 2.** Teacher opinion about students before and after participation in Project activities

		Gender of the student:	Solves the learning problems by himself/herself	Asks for help from teachers	Cooperates with classmates during lessons in a positive way	Is ready for work in lessons	Is ready to join out of class/school activities together with other classmates	Is involved in sport/art activities not connected with learning at school	Average
<b>Before robotic activities</b>	<b>Female</b>	Mean	3,96	3,56	4,08	4,19	4,04	3,27	3.85
		Std. Deviation	1,110	,823	,647	,790	,824	1,216	
		Variance	1,232	,677	,418	,624	,679	1,478	
	<b>Male</b>	Mean	3,14	3,03	3,40	3,43	3,56	3,37	3.32
		Std. Deviation	1,095	1,053	1,059	1,062	,992	1,224	
		Variance	1,198	1,108	1,122	1,128	,984	1,497	
<b>After robotic activities</b>	<b>Female</b>	Mean	4,00	3,81	4,10	4,24	4,05	3,39	3.93
		Std. Deviation	,975	,846	,863	,900	,734	1,164	
		Variance	,951	,716	,745	,809	,539	1,356	
	<b>Male</b>	Mean	3,35	3,16	3,60	3,52	3,72	3,46	3.46
		Std. Deviation	1,148	1,031	1,095	1,153	,918	1,149	
		Variance	1,317	1,063	1,199	1,330	,843	1,320	

The teachers' answers were also compared using a gender variable and the stages before and after students' involvement in the projects' activities were also compared. Analysing the compiled results (see Table No 2) it is evident that there is no significant positive improvement in the parameters, however, as stated previously, the measurements were performed after only a 3 month interval, which is a brief period of time to detect any significant improvements in attitude towards learning of students exposed to ESL risk groups. Altogether a positive shift can be traced within 0, 1 point limits. A longitudinal research should be carried out to be able to detect changes and analyse whether there are differences in gender aspect of involvement in the learning process, using robotics activities working with students exposed to ESL risks. Such a research was not feasible in this project on account of limited time for the project.

The only parameter where girls show a lower result than boys, both before and after involvement in the projects' activities is "Is involved in sport/art activities not connected with learning in school", which altogether proves that boys wish for more activities where it is possible to get involved not only mentally, but physically as well. This aspect, regardless that it is not analysed in depth in the article, is highly informative. It enables us to pose a conclusion that the traditional learning process where the teacher is the main actor and the students are merely a passive audience is less suitable for male students.

During the first stage the average female student advantage (in teachers' assessment) is in five out of six parameters chosen for analysis, where female students' grades were 0, 64 points higher. During the second stage, after involvement in the project, the difference had reduced to 0, 57 points; however it cannot be regarded as a significant difference to pose assumptions regarding gender differences in the learning process using robotics activities working with ESL risk group students.

## 6 CONCLUSIONS

Students' answers illustrate gender differences in evaluating their attitude towards learning, working with robots, learning motivation and cooperation, because the results attest that male students tend to evaluate themselves more negatively than female students, which corresponds with evaluations done by teachers analysing them in a gender context.

The acquired data indicates that teachers tend to value female students' involvement in learning activities more positively, in problem solving, in cooperation with other students and teachers by asking them for help if it is needed, in willingness to get involved in learning. Regardless that there are no significant changes in students' average results, the fact, that in both the students' self-assessment and the teachers' opinions there is a difference between parameters characterizing the involvement of male and female students in the learning process, indicates a significance to devote special attention to this problem. It allows for an assumption to be made that girls are able to have a positive communication with the teachers, in turn, they get more positive feedback and/or grades and *vice versa*, teachers having a more positive attitude towards female students enables them to have a more positive self-assessment, which in turn diminishes the risks of ESL. To some extent, this proves the assumption that teachers and their attitude can serve as a "push" factor and slowly repel male students from the educational system ([28]; [19]), especially male students exposed to risks of ESL.

Considering that male students are more exposed to risks of ESL, it is plausible that their risks were more evident or there was a combination of several risks that accumulated mutually, which is why it takes longer to overcome these risks than it does for the female students. Even though the results were acquired during a brief period of time and should be verified by carrying out a longitudinal research, they indicate to several potential problems, such as:

- It is plausible that there are significant problems in the pedagogical process – teachers have a gender-differentiated attitude towards students, which may be caused both by a lack of understanding of children and teenager development differences in gender context, or by problems in organization of the learning process, which is more suitable for female cognitive process organization peculiarities. The validity of the statement is proved by the fact that male students have a higher parameter of "is involved in sport/art activities not connected with learning in school", which indicates that male students have a need for active involvement, hands-on activities, which should be taken into consideration organizing the compulsory learning process.
- Teachers have no grasp of ESL risks and their impact on learning, in turn, they are unable to distinguish the, firstly minute, changes in the students' attitude and motivation. If students were positively encouraged for their efforts during compulsory learning activities, it would promote the development of their achievement motivation, thus diminishing the role of ESL risks ([29]).
- An assumption can be made, based on the results, that by utilizing positive motivation strategies in the robot programming process, girls also illustrate an attitude improvement towards programming.

Another aspect worthy of additional attention in future studies is social stereotypes, which may be one of the factors when evaluating students with a low socio-economic status, with special needs and/or with behavioural problems.

It should be emphasized that students involved in the project were chosen based on ESL risks, it means that the results could have been different if students, who are motivated to acquire new knowledge, with no learning problems and with a positive attitude towards the learning process, would have been involved in robotics activities. Taking this aspect into consideration the authors wish to emphasize that these results cannot be generalized and attributed to all students. To comprehend the special needs of ESL risk groups and how to differentiate the pedagogical process to diminish these risks, further, thorough studies must be carried out.

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