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Influence of Robotics Curriculum on Career Choices: An Exploratory Study with High School Students

Influencia del currículo de robótica a la hora de escoger la carrera: un estudio exploratorio en una escuela secundaria

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Abstract

Career choices of high school students can be affected by a multitude of factors. Discerning these factors may facilitate parents, educators, and industries to know where students place most of their trust, and what criteria influence the career selection process. The current study was mainly concerned on the impact that technical studies, offered in high school, had on the selection of engineering studies in a group of girls. An exploratory study was conducted using data obtained from senior female students at La Vall High School, using surveys and school records from a period of 10 years. We attempted to identify up to what extent Math level and robotics programme had an influence on career choice, especially on choosing engineering studies. Our findings suggest the following: (1) the percentage of choosing Engineering as a career has incremented drastically post robotics programme offered at the school; (2) students' interest in learning about the robotics programme positively influences choosing engineering as a career in spite of math level; (3) the study analyses the collected information and identifies existing trends in the career choice of engineering studies; (4) finally, the current exploratory study provides suggestions and explore implications and recommendations for future researchers and practitioners of institutions.

Key words: technology, robotics, engineering education, STEM, single-sex schooling, girls' education

Resumen

El presente estudio se centró en el impacto de los estudios técnicos ofrecidos en la escuela sobre la selección de estudios de ingeniería. Se realizó un estudio exploratorio utilizando los datos de secundaria de la Escuela La Vall. Este estudio tuvo como objetivo identificar si el nivel de matemáticas y el Programa de Robótica desempeñaron un papel en la elección de carrera de los estudios de ingeniería. Los objetivos del estudio fueron los siguientes: (1) la asociación entre el nivel de matemáticas y el Programa de Robótica en la elección de carreras de ingeniería; (2) demostración de la influencia del Programa de Robótica en elegir estudios de ingeniería como carrera pre y postintroducción del programa en la escuela. Nuestros hallazgos sugieren que las estudiantes del Programa de Robótica poseen una influencia positiva en la opción de la carrera en estudios de ingeniería a pesar del nivel de matemáticas. Finalmente, el estudio exploratorio actual proporciona sugerencias y explora las implicaciones y recomendaciones para futuros investigadores y practicantes de instituciones.

Palabras clave: tecnología, robótica, ingeniería, STEM, educación diferenciada, educación de chicas

School institutions have the main thrust of producing quality graduates who will play significant roles in the development of the community, society, and economy. One of the main choices students make in determining plans is career selection. This decision will have an important impact on their professional career and on their lives.

Selecting a career is considered as an immediate outcome after high school. The past literature on career choices identifies several factors as important influencers of career choices, such as role models of parents, teachers, personality, aptitude and academic ability, attitude of students, socio-economic status etc. (Creamer & Laughlin, 2005; Blum, 1995; Ferry, 2006; Gilroy, 2007; Mihyeon, 2009; Porter & Umbach, 2006; Wildman & Torres, 2002). Also, socio-emotional characteristics, environment, family background, and opportunities available are found to have an impact on students. Apart from these factors, the present study focuses on the importance of subjects chosen in high school education as an influence over career choice.

Subjects comprise of learning, knowledge, creativity, and techniques imparted from each unique structure (Adams, 2006). Technical studies like math and science drive students to tend to choose technology-oriented studies (Dick & Rallis, 1991). In today's technology driven world, educational institutions continuously adopt new technological studies to the needs of society. Along these lines, our current study is based on the impact that the robotics programming subject in high school made on students regarding their career selection.

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Furthermore, as part of technical studies, the mathematics subject emphasizes problem solving, communication, reasoning, and related mathematical connections to technological studies. Positive associations of mathematics on technology-related career choice have been found in past studies, especially mathematics subjects that focus on problem solving and conceptual understanding (Carpenter, Frank, Jacobs, Fennema, & Empson, 1998). Mathematics also provides reasoning and operational abilities for students learning other technical studies. In the same sense, robotics programming is a widely known recent development in academic institutions, which we consider an effective way of promoting

research readiness among engineering studies like computer science. The key characteristic of robotics is veracity and their hands-on application learning can be applied to a large variety of tasks without significant redesign, especially for engineering studies. «Robotics studies above all is a concrete and tangible way to build and strengthen cognitive development, as well as other academic areas such as mathematics» (Storming Robots, 2016).

Therefore, the present study focused on the students' math level and robotics programming subjects imparted in high school among seniors and the subject's relationship on predicting the students' career choices related to engineering. We presume the following hypotheses:

- Hypothesis 1: Robotics programming subject will be significantly positively associated with choosing an engineering career.

- Hypothesis 2: Math high level scores will be significantly positively associated with choosing an engineering career.

Furthermore, the present study was aimed to be carried out specifically on the female population based on the importance of single sex education shown in past empirical studies. According to Calvo (2011, 2013), differentiated education guarantees equality of opportunity because it addresses the specific problems of each sex. Various scientific studies show the existence of differences between the sexes, both in the way of learning, and in the way of reacting and working, and that these differences are not only the result of roles traditionally attributed to one sex or another (Calvo, 2009; Gurian, Henley, & Trueman, 2001).

Moreover, the differences between boys and girls have a neuropsychological basis as shown by some of the past research studies: Differences in the developmental sequence of various cognitive regions (Cahill, 2006; De Bellys et al., 2001); different rhythm in the evolution of cognitive areas involved in language, motor coordination and social development (Halpern, 2000;) distinct rhythm in hippocampal development, brain structure involved in memory (Frings et al., 2006;) differences between girls and boys in the areas of the brain that are used when processing and storing the information (Andreano & Cahill, 2009; Frings et al., 2006).

Furthermore, the results of some of the recent Meta-analyses (Riordan 2008 et al;) on the comparisons of mixed and differentiated schools have shown that in secondary education, empirical support exists to affirm that differentiated

schools can increase the positive academic results, especially for girls (Glazer, 2011; Moore et al., 1993; Mullins, 2005). There is no compelling research against this hypothesis, so there seems to be no basis for rejecting an educational model when there are numerous studies that have found positive findings. Therefore, the choice of differentiated education has, in short, has based on a strictly scientific and empirical basis. Understanding and accepting the existence of these differences between the sexes will allow us to accept the existence of different ways of understanding and learning in students, and take advantage of them from the pedagogical point of view. For this reason, the study was aimed to be carried out only with a female population: to show, after the exploratory study, that differentiated education favours the empowerment of women by breaking stereotypes in the field, such as, the choice of careers in science and technology. Moreover, in the literature there is sparse evidence specifically on the relationship between math level and robotics programmes in the career choice of female high school students.

Research Methodology

Data Collection

The study employed quantitative data collected from a survey. The participants of the study were seniors from La Vall girls' high school. La Vall School is located approximately 25 kilometres north from Barcelona. The high school is comprised of approximately 1600 students, mostly from middle-class families, and medium to higher education levels, 60 of which are seniors. The staff at the high school is comprised of one principal, two assistant principals, advisors, a librarian, counsellors, and a multitude of academic support staff personnel (Gilroy, 2007).

The data were collected from school records that covered a 10-year span (from academic year 2005-2006[1] to academic year 2015-2016) of 600 students. The entire senior class of La Vall High School was chosen for this study based on the belief that they should have the greatest reason to be interested in career choice. The La Vall School comprised of students from several areas of the district of Barcelona.

1 In Spain, the academic year runs from September to July of the chronological year.

Instruments.

Data were collected using a descriptive survey questionnaire regarding career choices (see Appendix) from 600 students using a stratified random sampling technique. The questionnaire was designed based on the standard structure adopted from the other career choice studies. The survey was first carried out on a pilot study based on the verbal changes were made by technicians of linguistics and psychology to attain contain validity. The survey was designed and administered in Spanish. The 600 students who participated in the study were finally told to answer without verbal instructions. It was understood and distinctly directed that this was an elective and voluntary survey on the part of the students. Apart from the survey, with the students' parents' consent, the school records for the ten-year span were chosen based of the grades attained. The survey was sent to alumni students who had finished school and had already chosen their career, and from the current academic year students on their possible choice of career.

Research Design.

The control group consisted of students from five academic years before the robotics programme was introduced, and five academic years after it was introduced, which included up to the 2015-2016 academic year students intending to graduate soon. Internal validity was not guaranteed; however, the subjects surveyed were unaffected by environmental qualities that may skew results.

Measures.

The choice of engineering career was the dependent variable. It was a categorical variable assigned as yes/no to engineering.

The variables used to predict the behaviour of the dependent variable were math level and robotics programme. Math level was a continuous variable which distinguished from grade scores of 5 to 7 as low level of math and a grade score of 8 to 10 as high level of math.[2] Robotics programme was a categorical variable which was coded Yes/No.

2 Grades in Spain range from 0 to 10.

Statistical analyses.

The information collected in this survey contains ordinal and continuous data. Descriptive statistics were used as a measure of analyses for the pre-robotics period of a total of five academic years (i.e., 2005 to 2010). The trend of the impact of math level on engineering studies was computed. From the descriptive analyses of the post robotics period (i.e, academic years 2010 to 2015) and correlational analyses, the association between the dependent variable and predictors were computed. Based on the results from the correlational analyses, additional analyses on the strength and significance of the relationship were explored. Since the dependent variable is a dichotomous variable, logistic regression analyses were conducted. Separate models were conducted for each academic year from 2010 to 2015.

Results

In relation to the study on the influence of robotics in career choice, the findings (see Figure 1) suggest that the percentage of engineering as a career has increased (26 %) with the introduction of robotics programme in the academic year 2010-2011 offered at the School. It should be noted that, the following academic year 2012-2013 show a decrease in the percentage of engineering as a choice (14 %), which could be due to the reason of the major economic crisis in Spain.

In the survey of factors affecting career choices after and before the introduction of robotic programmes in the school, various factors were found to be affecting career choices depending on the students' exposure to robotics programmes. It was found that, after the robotics study programme, among the three criteria of influences described in the survey[3] (i.e., high achievement in math level, passion for math at school, and school opportunities), on an average, appropriate programming and ICT is shown to have higher influence (60 %), followed by teachers imparting knowledge (56 %), and awareness creation on technology oriented studies (55 %). On the other hand, before the introduction of robotics study programme, students believed that teachers' imparting knowledge (79 %), followed by willingness to develop self-competencies (62 %) and passion for math level (57 %) had a higher influence on engineering as career choice comparatively.

3 See Appendix.

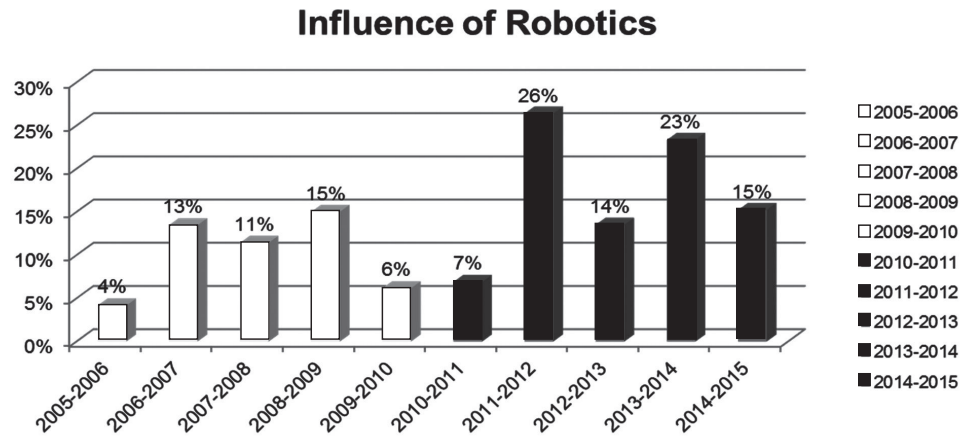

Figure 1. Influence of robotics programme (2008-2009) on engineering career choice.

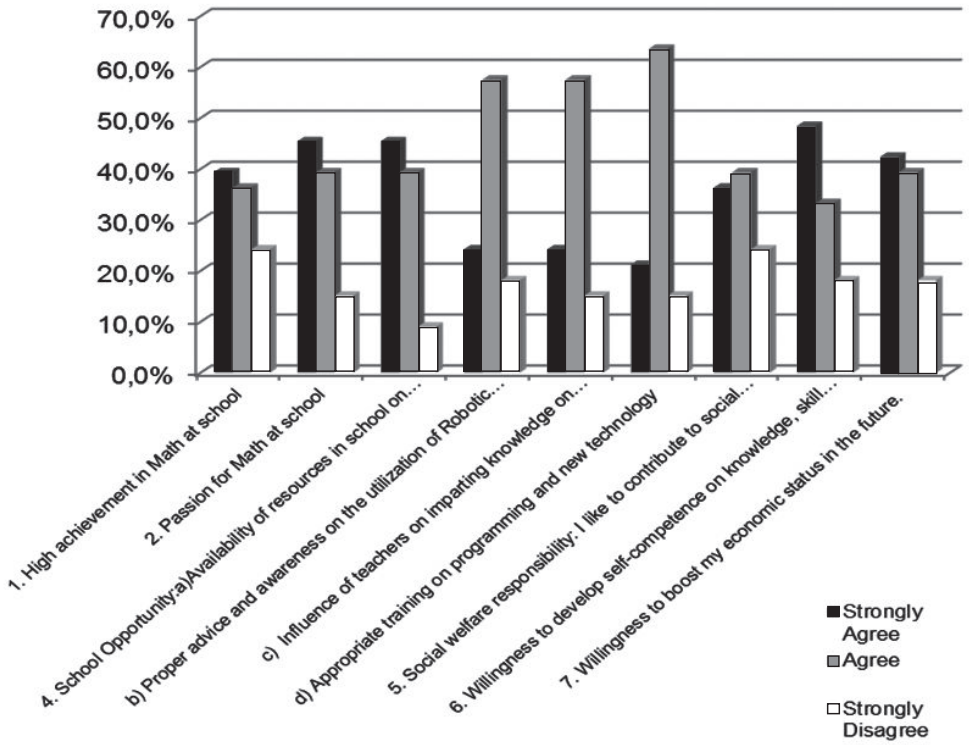

Figure 2. Students' opinions on choosing the engineering career after attending a robotics programme.

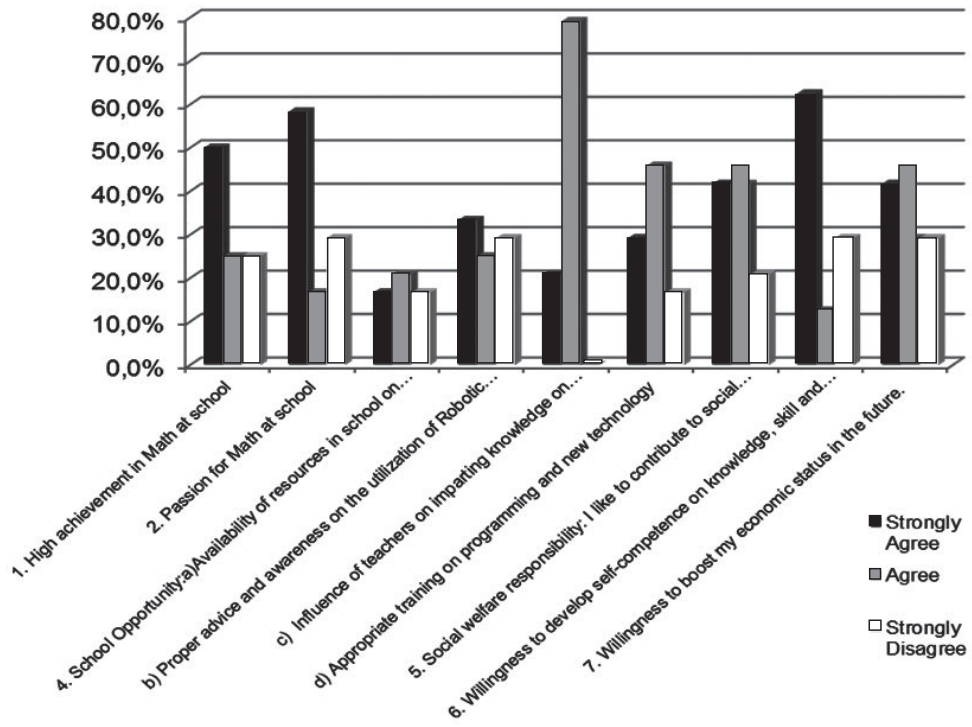

Figure 3. Students' opinions on choosing the engineering career before attending a robotics programme.

Table 1 shows the percentage of increments of students choosing their career choice of engineering career from the academic years 2005 to 2010. The engineering choice of career varies from 6 % to 23 % through that time span. The explained percentages of students' choice of career choices do not clearly show the existence of relationship between math level and engineering choice. Therefore, in order to see the direction of their association, descriptive studies and correlational analyses were used for the post robotics period, which is from the academic year 2010-2015. Table 2 demonstrates the relationship between math level, robotics programming, and engineering choice from the period 2010-2015. High level in Math is not significantly linked to engineering choice as predicted except for the academic year 2014-2015. Low level math is significantly negatively related to engineering choice except for academic years 2011-2012 and 2013-2014. As predicted, enrolling in a robotics programme is positively related to engineering career choice.

Table 1

Percentage of students scoring math level grades and the corresponding students choosing engineering as their career

Academic Years	% of students scoring high/ low in Math		% of students choosing engineering career
2005-2006	Math high level	44 %	6 %
	Math low level	56 %	
2006-2007	Math high level	38 %	16 %
	Math low level	62 %	
2007-2008	Math high level	42 %	23 %
	Math low level	58 %	
2008-2009	Math high level	45 %	12 %
	Math low level	55 %	
2009-2010	Math high level	48 %	8 %
	Math low level	52 %	

Table 2

Descriptive statistics and correlational analysis from 2010-2015 of post-robotics

Variables	Mean	SD	N	HM	LM	Robotics
2010-2011						
HM (a)	.27	.44	59	—		
LM (b)	.67	.47	59	-.88**	—	
Robotics (c)	.18	.39	59	-.09	.05	—
Engineering (d)	.10	.30	59	.05	-.36**	.27*
2011-2012						
HM (a)	.42	.49	73	—		
LM (b)	.41	.49	73	.71**	—	
Robotics (c)	.35	.48	73	-.02	-.09	—
Engineering (d)	.21	.41	73	.01	-.16	.39**
2012-2013						
HM (a)	.50	.50	74	—		
LM (b)	.39	.36	74	-.65**	—	
Robotics (c)	.29	.46	74	-.06	-.35**	—
Engineering (d)	.12	.32	74	.19	-.24*	.48**
2013-2014						
HM (a)	.47	.50	90	—		
LM (b)	.30	.46	90	-.62**	—	
Robotics (c)	.37	.48	90	.31**	-.06	—
Engineering (d)	.24	.43	90	.12	-.13	.62**
2014-2015						
HM (a)	.56	.49	91	—		
LM (b)	.27	.44	91	-.65**	—	
Robotics (c)	.20	.40	91	.34**	-.19	—
Engineering (d)	.17	.38	91	.35**	-.22*	.33**

Note: significance levels *p > .05, **p > .01. HL = High level Math; LM = Low level Math

Table 3 shows the regression models results for each of the post robotic academic years. The significantly related variables predicting engineering choice is highlighted in bold. The results clearly demonstrate, as predicted, the robotics programming to be significantly related to the choice of engineering career. That is, as robotics programming subject adoption increases, the student's choice to take engineering career increases. Finally, math level does not predict significantly choice of engineering career.

Table 3

Logistic regression model for 5 consecutive academic years predicting choice of engineering career for high school students by math level and robotics programme

Academic Years	Predictors	Choice of Engineering		
		B	*Sig.*	*S. E*
2010-2011	Math high level	-23.46	.99	21930.42
	Math low level	-25.95	.99	21930.42
	Robotics	3.09*	.04	1.51
2011-2012	Math high level	19.64	.998	10251.95
	Math low level	19.97	.998	10251.95
	Robotics	20.38**	.01	7483.89
2012-2013	Math high level	19.17	.998	9766.17
	Math low level	.447	1.000	12820.19
	Robotics	2.5*	.02*	1.12
2013-2014	Math high level	19.01	.998	8022.11
	Math low level	20.40	.998	8022.11
	Robotics	3.94***	.000	.96
2014-2015	Math high level	19.88	.998	10377.78
	Math low level	17.87	.999	10377.78
	Robotics	1.14*	.04	.62

Discussion

The main objective of the present study is to analyse the importance of the development of mathematics and technology subjects in high schools over students' career choices. The current study focused on predictions of students from Barcelona, Spain predicting students from Barcelona, Spain choosing engineering as a career (La Vall-girls higher secondary school). The findings suggest that introducing the robotics programme to the school predicts a significant positive relationship for the choice of engineering career among senior female students in high school.

Our findings suggest some important conclusions and implications for future research. First, that technology oriented studies like robotics programming would positively influence engineering studies. Therefore, institutions may be encouraged to implement more programming studies to promote engineering and research-based further studies. Second, although math level has been claimed to be highly related to engineering and scientific studies in the literature, our results for the ten-year span do not show any significant outcomes. This may suggest that there are other external influences like socio-emotional characteristics and other attributes related to learning changes that may affect their choosing engineering as a career. Therefore, we propose further empirical studies on math level and other personality attributes of students to be correlated in relating their choice of career studies.

In regard to the limitations of the study, firstly, the sample is restrictive to a certain city alone in the geographical grounds of Spain. A larger, varied sample (i.e., urban students, varied socio-economic status etc.) would be more appropriate for reliable results. Secondly, there can be moderating effects from other factors, such as pay level influences among participants, parents' influence etc., affecting the engineering career choices. Also, gender differences have not been analysed in the present research work, which is out of scope of the study. It would be interesting to demonstrate gender differentiation in factors affecting engineering as career choices. Finally, the results are based on single-sex education school and as an interesting fact, future studies can analyse on the differences in findings over career choices on engineering in comparison to schools of coeducation.

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Appendix

1. The influence of these variables in your career choice

Hello, Alumni!
La Vall is now preparing a workshop and we are collecting data about women's reasons for their career choice (Engineering).

Rate from 1 (Strongly agree) to 7 (Strongly disagree)

1. School Opportunity:

a) Availability of resources in school on robot programming (since year 2009-10)

1 2 3 4 5 6 7

2. Willingness to boost my economic status in the future.

1 2 3 4 5 6 7

3. Willingness to develop self-competence on knowledge, skill and expertise

1 2 3 4 5 6 7

b) Proper advice and awareness on the utilization of Robotic programming in the real world or future scientific research

1 2 3 4 5 6 7

c) Influence of teachers on imparting knowledge on Technology & Math curriculum

1 2 3 4 5 6 7

4. Passion for Math at school

1 2 3 4 5 6 7

d) Appropriate training on programming and new technology

1 2 3 4 5 6 7

5. Social welfare responsibility: I like to contribute to social welfareness in a technological field

1 2 3 4 5 6 7

Name and Surname

Age

6. Has your father and/or mother studied or work in a field related to Technology, Mathemathics, Engineering?

o YES

o NO

7. High achievement in Math at school

1 2 3 4 5 6 7