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Factores que pueden influenciar la selección de una ingeniería como carrera dependiendo de las habilidades matemáticas de los estudiantes

Factors that influence students' decisions to pursue engineering as a major for students with different mathematics abilities

Fatores que podem influenciar a seleção de uma engenharia como carreira, dependendo das habilidades matemáticas dos alunos

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Resumen

Este estudio multimétodos busca lograr un mejor entendimiento de las razones que pueden motivar a un estudiante a seleccionar una carrera en ingeniería, poniendo énfasis en las diferencias que puedan existir entre alumnos con distintos niveles de habilidades matemáticas. Se recolectó información sobre las experiencias académicas y personales de 560 alumnos de una universidad pública de Estados Unidos mediante una encuesta. Esta información fue analizada por medio de pruebas estadísticas inferenciales, separando la muestra en grupos con habilidades matemáticas altas y bajas para comparar resultados y encontrar posibles diferencias entre estudiantes que seleccionaron una ingeniería como su carrera. Ser del género masculino mostró tener la influencia más significativa en la elección de ser ingeniero, seguido por tener una mejor preparación matemática; y estos resultados fueron más evidentes en el grupo de habilidades matemáticas bajas. Por otro lado, los participantes con habilidades matemáticas altas demostraron tener un interés genuino en las carreras de ingeniería y sus aplicaciones, mientras que los participantes con habilidades matemáticas bajas buscaban más el dinero y la posición social que les podía ofrecer un título de ingeniería.

Palabras clave: habilidades matemáticas, ingeniería, selección de carrera.

Abstract

This multimethod study explores the factors that affect college student motivation for selecting an engineering major, especially for students who have different levels of mathematics abilities and preparation in high school. Data from 560 students were collected at a U.S. public university, focusing on the personal high school academic experiences of those students during high school. This information was analyzed using inferential statistics where students were separated in two groups based on mathematics abilities (high and low) and compared in terms of their decision to pursue an engineering major. Being a male student was found to be the most influential factor for choosing an engineering major, followed by having a strong mathematics preparation in high school; these results were more pronounced for the low mathematics ability group. Findings also showed that participants in the high mathematics ability group were more motivated by interest in engineering and its applications, while participants in the low mathematics ability group were more motivated for the money and social status that getting an engineer career could bring them.

Keywords: mathematics abilities, engineering, major selection.

Resumo

Este estudo multi-método visa alcançar uma melhor compreensão das razões que podem motivar um aluno a selecionar uma carreira em engenharia, enfatizando as diferenças que podem existir entre os alunos com diferentes níveis de habilidades matemáticas. Foram coletadas informações sobre as experiências acadêmicas e pessoais de 560 estudantes de uma universidade pública dos Estados Unidos por meio de uma pesquisa. Essas informações foram analisadas através de testes estatísticos inferenciais, separando a amostra em grupos com alta e baixa habilidades matemáticas para comparar resultados e encontrar possíveis diferenças entre os alunos que selecionaram uma carreira de engenharia. Ser do sexo masculino mostrou ter a influência mais significativa na escolha de ser engenheiro, seguido por ter uma melhor preparação matemática; e estes resultados foram mais evidentes no baixo grupo de habilidades matemáticas. Por outro lado, os participantes com grande habilidade em matemática demonstraram ter um interesse genuíno nas carreiras de engenharia e suas aplicações, enquanto os participantes com baixas habilidades matemáticas buscavam mais dinheiro e a posição social que um diploma de engenharia poderia oferecer a eles.

Palavras-chave: habilidades matemáticas, engenharia, seleção de carreira.

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Introduction

The economic development of any country is largely related to its ability to educate and train new engineers with the skills to design and implement new technologies that provide solutions to the big problems that affect society: the lack of food, the lack of access to potable water, better telecommunications and health services, always taking into account the importance of protecting the environment (National Academy of Engineering, 2015). In the event that a country does not have the capacity to prepare enough engineers to find efficient solutions to these problems, it will face delays in its development, and will be unable to achieve well-being for its inhabitants (Committee on STEM Education, 2013).

There is some interest among students who are of the age to select their university degree to become engineers due to the prestige that this professional area has. Similarly, the advances that can be achieved through the development of new technologies are a great motivation for many young people when considering an engineering (National Academy of Engineering, 2015). But, despite this interest in technological careers among young students, currently some countries such as the United States, England, Germany, France and the more developed countries of the European Union (Erdmann and Schumann, 2010) face problems to be able to occupy jobs necessary to meet their demands for technology creation.

In the case of Mexico, the differences in economic and technological development that this country has with respect to first world countries mean that the demand for new engineers is lower than in the developed countries mentioned above. However, like the more developed countries, Mexico has a great interest in the preparation of highly trained personnel in the areas of engineering to boost national development. This predilection in generating more engineers is clearly established in the bases of the third axis of the National Development Plan 2013-2018 of the Government of the Republic (Government of the Republic, 2013) and in the Special Program of Science, Technology and Innovation 2014-2018 (National Council of Science and Technology [Conacyt], 2014), which seeks to promote the interest of Mexican students in engineering careers, as well as offer better opportunities to students who experience problems to finish their engineering career due to deficiencies in his preparatory education. Regarding this last point, it is important to consider the high dropout rates in engineering careers in Mexico, since approximately 50% of students who entered these programs in the last decade dropped out or changed their careers (Secretaría de Educación Pública [SEP], 2007).

Purpose

If a better understanding of the experiences and reasons that can motivate a student to select a career in engineering is achieved, teachers and principals of basic education could be better prepared to promote greater interest in this professional field. Additionally, activities and strategies aimed at developing the necessary skills could be designed to face the challenges that arise in a career of this branch from the preparatory education.

The existing literature on the reasons that may influence the interest shown by students to select engineering as their professional career indicates that there are different factors that can affect this important decision. Among the most determining factors were the following: background and origin (Lent, Brown and Hackett, 1994), preparation and academic experiences, the influence of parents (Porter, 2011) and the skills and mathematical preparation of students (Lent, Lopez and Bieschke, 1991, Nicholls, Wolfe, Besterfield, Shuman and Larpkiattaworn, 2007). Some students even select the engineering degree with the desire to help society by designing and developing technological projects that can solve problems of daily life, even when they do not have a clear idea of the job opportunities that engineers have (Cunningham and Knight , 2004).

Although students may consider different reasons for selecting engineering as their career, it has been shown that the influence of mathematical skills and the way in which students think about the difficulty of mathematics courses is the most determining factor at his election (Betz and Hackett, 1983, Hackett, 1985, Lent et al., 1991). Current literature suggests that if a student feels that his math skills are good enough to pass the mathematics courses included in engineering careers without experiencing major problems, then he will be much more likely to select engineering as a career. In addition, relying on their math skills may be a determining factor in the decision of engineering students to stay in their careers if they encounter difficulties in crediting any of their mathematics courses (Brown and Burnham, 2012; Eris et al. , 2010, Kokkelenberg and Sinha, 2010, Levin and Wyckoff, 1988, Seymour and Hewitt, 1997).

Likewise, the existing literature on the students of this branch has shown significant statistical differences between the numbers of women and men who select an engineering as their career (Ohland et al., 2011). By having more men than women enrolled, it can be inferred that the former have more interest in these university programs, and in turn, better opportunities to achieve an engineering degree. This disparity between the numbers of women and men who select engineering can be caused by stereotypes that women may face if they show interest in these careers. For example, it has been shown that women are more likely to believe that their male partners can perform better in activities involving mathematics, and this happens even when women perform equally or better than their male counterparts in examinations and evaluations (Goetz, Bieg, Lüdtke, Pekrun and Hall, 2013). These negative stereotypes have been linked to high levels of mathematical anxiety and poor performance in activities of this field by female students, which has made them more likely to feel little confidence in their mathematical skills and consequently less interested in choosing careers of engineering (Aronson, Fried y Good, 2002; Hackett y Betz, 1989).

If it is possible to awaken a greater interest in the engineering careers of the middle and upper secondary students, there will be better bases to develop action plans aimed at meeting the training needs of highly qualified human capital in the established areas of technology. in the aforementioned National Development Plan 2013-2018 (Government of the Republic, 2013) and Special Program of Science, Technology and Innovation 2014 - 2018 (Conacyt, 2014). To collaborate with this goal, this research project was directed by the following research question:

What kind of experiences in high school education can influence students' decision to select engineering as their career depending on their math skills?

It is important to understand the reasons why someone decides to select a career in the area of engineering and how their mathematical skills can influence this decision. In this way, actions can be designed and implemented to awaken the interest of young people in these careers since high school and high school. The mathematical preparation of people of age to choose their professional career can be a determining factor in this important decision (Sadler, Sonnert, Hazari and Tai, 2012). This takes great relevance since the Mexican students show a considerable lag in their mathematical preparation from their basic education. According to data from the Organization for Economic Cooperation and Development (OECD), in its studies of international evaluation of students in 2014, Mexico has almost 60% of its students in levels 1, 2 and 3 (of a maximum of 6) in mathematics education: in general a low and insufficient level to participate in the development of a modern society (OECD, 2014). This lag in mathematics education may be negatively affecting the possible interest of Mexican students for engineering careers and causing some to decide to avoid a program in this area because their skills are not good enough to accredit courses of study. mathematics that it includes in its reticle.

Theoretical framework

The present study is based on the cognitive social theory of career development (SCCT, for its acronym in English) raised by Lent et al. (1994). This theory identifies three relevant cognitive social mechanisms for career selection: a) feelings of self-efficacy, b) expectations of results and c) selected objectives. The theoretical framework of the SCCT was developed based on three models that place these constructs as factors that can have a great influence on the academic decisions of a student, especially if the way in which the student reacts to possible barriers and supports is analyzed. they can affect their interest and performance in activities related to a specific career. The constructs and models specified by the SCCT were used in the present work to determine what reasons have a greater impact on the decision of a student to select a career in the area of engineering, with emphasis on whether they come to perceive the mathematics courses as a barrier due to poor mathematical performance and understanding.

Additionally, the social learning theory of Bandura (1986) was used to achieve a better understanding of the relationship between academic experiences and the decisions of students' daily life, and how this relationship can influence their interest in seeking a Engineers title According to Bandura (1986), the experiences that individuals experience in upper secondary education can be a determining factor in the selection of school activities and professional career, especially if they feel that their skills are good enough to finish a particular university study.

Method

This research followed a multi-method design since the information collected contained answers that could be better analyzed using quantitative methods, while responses to open questions should be analyzed qualitatively (Creswell and Clark, 2011). In the end, the results of the qualitative and quantitative analyzes were used independently to facilitate and present the answer to the research question in a more detailed way, but not enough connections were found between these two methods to be able to establish a mixed design of research (Creswell and Clark, 2011).

The High School Activities, Characteristics, and Influences Survey developed by Porter (2011) was used. This consists of 64 items that ask students about their academic preparation and the courses they took in high school (example: please indicate all the math courses you took in high school.), Their level of confidence doing academic activities with standard questions Likert (example: indicates your level of confidence in your abilities to solve complex math problems.), Your socio-economic situation (example: what is the highest academic level obtained by your parents?) And some open questions to gather information about aspects family and personal (example: what was the biggest influence you had to choose the career you wanted to study?). And it was developed following the guide for the development of online surveys of Dillman (2007). In addition, it has proven to be able to collect information for similar successful investigations, as well as being statistically proven to validate its reliability in previous studies (Porter, 2011).

It should be noted that, in addition to the aforementioned, this survey was selected for this study due to the relationship that was found between the design of some of its questions and the theories established by Lent et al. (1994) and by Bandura (1986). This allowed us to select the most relevant and appropriate questions of the survey in order to better answer the research question proposed by the statistical analysis, and discard the questions that did not contribute anything to the analysis due to its lack of relationship with the theories established as a framework. theoretical of this investigation. In the end, 26 questions were eliminated that were not related to the preparatory training activities that could influence the decision of the students to enroll in a specific career according to the theoretical framework that guided this investigation (example: what type of TV shows you watched while you studied high school?).

The survey was distributed online at a public university in the southeastern United States: 560 participants answered it voluntarily. These participants were enrolled in the first year of various careers related to science, technology, engineering and mathematics. Regarding gender issues, the sample consisted of 322 men and 238 women. However, the majority of the participants were Caucasians, with 86% of the sample belonging to this ethnic group and the remaining 14% was composed of African-Americans, Latinos and Asians. It should be noted that this ethnic and gender distribution represented the correct demographic characteristics of the entire university at the time of collecting the information, since the majority of the university's total population was composed of Caucasian students, and there was a majority of men in the races. This marked difference in the gender of students in the careers of science, technology, engineering and mathematics is documented in the literature (Nicholls et al., 2007, Ohland et al., 2011) and, therefore, was an expected difference in the sample for this study.

For a better analysis that would allow a clear answer to the research question, the information collected was classified into different groups according to the different levels of mathematical abilities of the participants (see table 1). These groups allowed to find the differences between participants with low and high math skills, and facilitated the analysis of the information and the comparison of the results. In addition, the Clemson Mathematics Placement Test (CMPT) was used to estimate the math skills of the participants: the participants with a score lower than 80 were placed in the group of low math skills and those who scored 80 or higher in the group of high math skills.

The CMPT is a mandatory diagnostic test that places incoming students in the most appropriate math course according to the level of their math skills upon entering college. The test is taken online and evaluates students' math skills on a scale of 1 to 100 with increments of one point. Additionally, the participants were separated into two groups depending on their gender to perform a more in-depth analysis of the differences that may exist between women and men when selecting an engineering as their professional career (see table 1).

Tabla 1. Clasificación de los participantes según sus habilidades matemáticas y género

	N	Ingenierías	Otras carreras
Total de participantes	560	295	265
Habilidades matemáticas bajas	300	93	207
Habilidades matemáticas altas	260	202	58
Hombre	322	216	106
Mujeres	238	79	159

Fuente: Elaboración propia

We used the software R (R Development Core Team, 2012) to run statistical tests with the data obtained through the survey, using a multiple binomial logistic regression model to determine which type of variables had a significant impact on the decision of the participants of choose to be engineers. It is not unnecessary to specify that a binomial logistic regression model was used because the dependent variable (being enrolled in a career in the engineering area, or not) is a binary variable (Collett, 1991). The analysis of the information followed a multiple regression model to be able to work with several independent variables, which could have some relation with the selection of a career in the engineering area by the participants (Hayes, 2013).

It is also important to mention that only part of the information collected through the survey was used in the quantitative analysis by means of regression, since 26 questions were previously eliminated, and another 8 were separated to be used in the qualitative analysis. that they were open questions that could not be categorized for their quantitative analysis. This left a total of 30 items for statistical analysis through regression. The variables that were considered for this model contained questions about the mathematics courses taken in high school (algebra, geometry, trigonometry, precalculus and calculus), science courses taken in high school (chemistry, biology, physics and physical education), extracurricular activities taken in high school (languages, academic visits, advanced classes and computers), high school average, college entrance exam scores (ACTm), standardized knowledge test to be accepted in the United States university similar to the National Center exam of Evaluation for Higher Education [Ceneval]), results of the CMPT, participation in research projects or science camps, mathematical self-efficacy and solving problems and family members in some engineering.

After running the multiple binomial logistic regression model with 30 independent variables, it was decided to eliminate those variables that turned out not to have a significant correlation with the independent variable (example: how many times did you visit a science or engineering museum while studying high school?). In this way, it was decided to run a model that had only the six significant variables that could be related to the decision to select an engineering career to analyze its level of correlation in a more precise way. The six independent variables that were used in this last regression model were the following: 1) take calculation classes (X1), 2) student gender (X2), 3) results of the CMPT (X3), 4) qualification of the ACTm (X4), 5) take biology classes (X5) and 6) take science classes in general (X6). And the model followed for the regression was presented as follows:

$$\hat{Y} = -5.810 + 0.739X_1 + 1.194X_2 + 0.050X_3 + 0.055X_4 - 0.539X_5 - 0.597X_6$$

In addition to selecting these variables following the results of the statistical analysis, this specific model was used following the SCCT and social learning theory to strengthen the results with the qualitative analysis in an appropriate manner (Creswell and Clark, 2011), as already mentioned above.

For a more detailed analysis of the information collected with the survey, three different statistical tests were run to analyze the groups established by the participants' mathematical level, using the low and high math skills groups separately, and an additional test with the total sample (n = 560). This analysis by groups allowed to find the most significant factors when selecting an engineering as a career depending on the mathematical skills of the participants.

The results observed in table 2 are only of the variables that showed a significance level of p <0.05, using the estimation coefficient B to determine a possible correlation between the independent variables and the dependent variable (Falk and Well, 1997). It is considered that a positive value of the estimation coefficient suggests a higher probability that a student will select a career in the area of engineering. On the other hand, a variable with a negative estimation coefficient indicates a lower probability that a student will select an engineering. In addition, the manual calculation of the strength of the relationship of all the factors that showed to have a significant influence on the selection of engineering by the participants was made. For this, the formula of f (x) = ex was followed, where the variable x took the value of the coefficient of estimation B. It is considered that a level of strength of the correlation> 1 establishes that the factor that is being analyzed increases the possibilities for a student to select an engineering career, and these possibilities rise as this level of strength increases. On the other hand, a strength level of the correlation <1 decreases the student's chances of selecting an engineering (Falk y Well, 1997).

The information collected through the eight open questions was analyzed using codes based on the SCCT. These previously established codes helped to connect the answers of the participants with the existing theory about the factors that can affect the selection of professional career (Saldaña, 2009). Special attention was paid to the following question: what was the greatest influence you had in choosing the career you wanted to study? This was selected because it was directly related to the research question, and the information gathered from this open questioning facilitated researchers to establish meaningful units of text that could be compared with previously established codes (Creswell, 2009). By coding the qualitative information using the SCCT as a previously established basis, the interpretation of the most determining and common factors in the selection of engineering as a professional career was facilitated, which helped to complement the statistical analysis in order to adequately answer the question of investigation.

Five codes were used for the qualitative analysis of the information collected with the open questions, which are described below: 1) Interest (personal interest or satisfaction when carrying out activities related to engineering); 2) Mathematical self-efficacy (confidence in their abilities to solve mathematical problems); 3) Expectations of results (types of work,

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remuneration or any type of reward that students expect to obtain by becoming engineers); 4) Close social supports (relatives, close friends or former teachers), and 5) Other supports (experiences in extracurricular activities or taking certain courses).

For the analysis of the open questions, only the information collected from the participants who were studying some engineering was used (N = 295). To facilitate comparison between participants studying engineering with low and high math skills, these participants were separated into two groups using the same criteria as in the quantitative analysis. This distributed the qualitative analysis participants in 93 participants in the group of low math skills (CMPT <80) and 202 in the group of high math skills (CMPT ≥ 80). The qualitative information was presented in a quantified form by using a table (Sandelowski, Voils and Knafl, 2009). This way of presenting the qualitative information helped to analyze the codes and reach a conclusion that could answer the research question in a more complete way (see table 4).

Results

The only variable that showed to be a significant influence in the selection of engineering as a professional career in all the groups that were analyzed quantitatively was the gender of the participants (see table 2). According to the results of the binomial logistic regression, men are 3.3 times more likely to select an engineering career than women based only on the gender of the people. This gap at the time of selecting some engineering was more evident in the results obtained by the binomial logistic regression of the group with low mathematical skills (see table 2), where the men were 4.6 times more likely to select an engineering program compared to the women. Although this gender margin was lower when analyzing the group with high math skills, men continued to select engineering as their professional career more frequently: twice as likely to select this career as the women in this group.

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Tabla 2. Resultados de la regresión logística binomial para determinar las probabilidades de seleccionar ingeniería separados por habilidades matemáticas

	Todos los participantes				**Habilidades matemáticas bajas**				**Habilidades matemáticas altas**			
	B	**SE**	**P**	**RP**	**B**	**SE**	**P**	**RP**	**B**	**SE**	**P**	**RP**
Cálculo	0.73	0.21	***	2.09	0.19	0.36	NS	1.21	0.45	0.31	NS	1.56
Género	1.19	0.20	***	3.30	1.53	0.29	***	4.61	0.70	0.31	*	2.03
CMPT	0.05	0.01	***	1.05	0.01	0.01	NS	1.01	0.04	0.01	*	1.04
Biología	-0.53	0.22	*	0.58	-0.56	0.33	NS	0.56	-0.54	0.34	NS	0.57
Otras ciencias	-0.59	0.23	*	0.55	-0.29	0.31	NS	0.74	-0.59	0.42	NS	0.55

***: P < 0.001; **: P < 0.01; *: P < 0.05; NS: No significativo; RP: Radio de probabilidad.

Fuente: Elaboración propia

Although there was no other variable, besides gender, that was significant for selecting an engineering in all the groups analyzed with binomial logistic regression, the analysis of all the participants showed that having a high score in the CMPT and having taken a course of calculation in high school were significant factors (see table 2). These results suggest that, in general, the mathematical preparation of the students is a determining factor in the selection of a university program of the branch in question. In addition, the CMPT score also proved to be a significant factor in the group of high mathematical skills, which shows that having a good mathematical knowledge is a point to consider when selecting an engineering even among the participants with the best mathematical preparation. According to the results obtained by the binomial logistic regression analyzing all the participants, the qualification obtained in the CMPT makes a student 0.05 times more likely to select an engineering for each point that increases in its qualification in this exam.

When analyzing the relevance that taking a high school course of calculation can have, it was found that having taken this preparation makes a student 2.1 times more likely to select any engineering. However, taking a high school calculus course lost its significance when participants separated into groups based on their math skills, which suggests that the experience participants had in taking this course and their final grade may be an extra factor. to consider when these young people make the decision to seek to become engineers.

On the other hand, having taken courses in biology or other sciences in high school showed to be a significant negative factor when selecting an engineering career (see table 2). This means that the participants who took these courses are less likely to select an engineering as their career; shows twice the probability of selecting any other different race.

When running the binomial logistic regression with the groups separated by the gender of the participants, some differences were found between the most significant factors for selecting engineering. The result obtained in the mathematical part of the university admission test (ACTm) turned out to be a significant factor for women when selecting an engineering. However, this data was not a significant factor for the test with all the participants and neither did it prove to be relevant for the male gender group (see table 3). On the other hand, the results obtained in the CMPT and the experience of having taken a course of calculation in the high school proved to be significant factors for both men and women when selecting an engineering (see table 3).

Some differences between men and women were also found in the analysis of the factors that proved to have a negative significance when selecting an engineering. The results of the binomial logistic regression showed that the group of men was less likely to select an engineering if they had taken a biology course in high school. On the other hand, it was found that women who had taken another science course other than biology in high school were less likely to select a college degree as engineers.

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Tabla 3. Resultados de la regresión logística binomial para determinar las probabilidades de seleccionar ingeniería separados por género

	Todos los participantes				Mujeres				Hombres			
	B	**SE**	**P**	**RP**	**B**	**SE**	**P**	**RP**	**B**	**SE**	**P**	**RP**
Cálculo	0.73	0.21	***	2.09	0.88	0.33	**	2.42	0.62	0.27	*	1.86
ACTm	0.05	0.03	NS	1.05	0.15	0.05	**	1.16	-0.01	0.04	NS	0.99
CMPT	0.05	0.01	***	1.05	0.05	0.01	**	1.06	0.04	0.01	***	1.04
Biología	-0.53	0.22	*	0.58	-0.39	0.33	NS	0.67	-0.65	0.31	*	0.51
Otras ciencias	-0.59	0.23	*	0.55	-0.80	0.37	*	0.44	-0.47	0.32	NS	0.62

***: P < 0.001; **: P < 0.01; *: P < 0.05; NS: No significativo; RP: Radio de probabilidad.

Fuente: Elaboración propia

The qualitative analysis of the information gathered with the question: what was the biggest influence you had to choose the professional career you wanted to study ?, showed that the most common factor that could influence a student to select an engineering career was the nearby social supports (see table 4). These close social supports refer to the possible influences that family members, close friends or former teachers may have on the preferences of young students when determining what they want for their future as professionals. Among the responses of the participants were comments such as: "My dad is an industrial engineer, and I always wanted to design things like the ones they do in your company." This tendency to consider the social media nearby as the biggest influence to select an engineering like The professional career was the same in the high and low math skills groups, with a slightly higher percentage for the latter (see table 4).

The most interesting result of this qualitative analysis was the difference found in the second most frequent response for each group, since in the case of high mathematical skills the most frequent influence after close social supports was personal interest in related activities to engineering. On the other hand, the most common influence after the close social supports in the group of low math skills were the expectations of results, which may be looking for a job with a good social status or having a good salary.

Tabla 4. Influencias más comunes para seleccionar ingeniería como carrera profesional según la pregunta: ¿cuál fue la influencia más grande que tuviste para escoger la carrera profesional que deseabas estudiar?

	Todos los ingenieros	**Ingenieros con habilidades matemáticas bajas**	**Ingenieros con habilidades matemáticas altas**
Soportes sociales cercanos	105 (36.7%)	35 (40.1%)	70 (35.8%)
Interés	68 (23.9%)	15 (16.5%)	53 (27.2%)
Expectativas de resultados	51 (18%)	20 (22.3%)	31 (15.9%)
Otros soportes	32 (11.3%)	10 (11.1%)	22 (11.3%)
Autoeficacia matemática	28 (10.1%)	9 (10.1%)	19 (9.8%)

Los participantes con respuestas que no se podían analizar con estos códigos fueron eliminados de esta parte del estudio.

Fuente: Elaboración propia

Discussion

The differences that were found between the factors that can be significant to predict the probability of a student selecting an engineering as their professional career suggest that young people may have different reasons and influences that lead them to be interested in an educational program of this branch. According to the results of the different groups that were analyzed, the reasons that students have to select an engineering can vary depending on the level of mathematical preparation they have when making this important decision. Understanding the differences that exist between students with different mathematical skills when choosing an engineering can be of great help to improve the chances that young people can be interested in these careers without feeling intimidated by its strong mathematical content.

The only factor that proved to be significant in selecting an engineering as a professional career for all the groups that were analyzed was the gender of the participants. This result was somewhat expected, since, as mentioned above, current literature suggests that men are more likely to select engineering than their female colleagues (Hackett and Betz, 1989, Ohland et al., 2011, Paderewski et al. , 2017). This marked difference between men's and women's interest in training as engineers may be related to negative stereotypes and environments that affect women trying to get involved in careers and activities related to mathematics (Aronson et al., 2002). The negative stereotypes that women face when carrying out mathematical activities can generate little confidence in their numerical abilities, stress and little interest in continuing a path that leads them to select a professional career related to mathematics (Goetz et al., 2013).

The gender of the participants was a factor that stood out for its great impact on the decision of the participants to select an engineering in the group of low math skills: women are 4.6 times less likely to select an engineering than their male colleagues. This result was the most significant and evident of all the regression models that were run, and suggests that women are less likely to select engineering if they think their mathematical skills are not good enough to help them get a degree. This theory can be supported with the results of the regressions using the groups separated by gender, where the women showed to give more relevance to have good results in the mathematical part of their ACTm when considering an engineering. These data also suggest that women can be more cautious in the process of selecting a professional career, which leads them to analyze their level of mathematical skills in a more detailed way than their male colleagues to determine if they have the adequate preparation to finish satisfactorily an engineering before trying to enroll in one.

Although having experience taking a course of calculation proved to be a significant factor in predicting the probabilities of selecting an engineering when the results of the regression were analyzed with all the participants, this factor lost relevance when analyzing the groups separated by the level of their mathematical abilities . Since having taken a course in calculus ceased to be a significant factor in selecting engineering in the results obtained with low and high math skills groups, it can be interpreted that students give great importance to the type of experiences they had when carrying this course and how was their final performance to consider the possibility of selecting to be engineers.

On the other hand, the high school courses that showed to be significant negative factors were always related to the sciences. The only difference that was found is that taking a course in biology makes it less likely that men will select engineering, while taking any other course related to science makes women move away from the possibility of selecting an engineering career. These results can be further explored to determine if there really are certain courses or experiences that cause a young student to lose interest in engineering careers since their high school education, which can help generate better opportunities for the number of students of engineering in groups that are currently a minority in these professions as women increase (Ohland et al., 2011).

When analyzing the information gathered with the question: what was the biggest influence you had to choose the professional career you wanted to study ?, the importance of having a role model, or a close person that could arouse the interest of the students, was established. students looking for an engineering degree. This was demonstrated by finding that the most common influence in the decision to start a career related to this field was to have close social supports such as family members, friends or teachers who will talk to students about the activities that different engineers can perform in their work. . Having a close relationship with a person who could connect the student with some experience in the field of engineering was a determining reason for students who chose to prepare themselves as engineers regardless of their level of mathematical skills; but some differences were found in the influence that students mentioned as second most frequent in high and low math skills groups.

For the group of low math skills, the expectations of results were a common reason for selecting an engineering as a professional career. This suggests that these students may think that obtaining an engineering degree is a good way to have a better lifestyle and a good economic remuneration, without seeing engineering as a profession that really interests them. On the other hand, students with high mathematical abilities mentioned having a genuine interest in the concepts of the branch in question; They mentioned, for example, that they would like to design and build technological devices as part of their work in the future. These results can be a good beginning to look for some relation between the experiences and results that the students can have in their mathematics courses in high school and the interest that these can develop in programs and activities related to engineering.

Conclusions

Students who proved to have good mathematical preparation through high marks in the tests of mathematical knowledge (CMPT and ACTm) and the testimony of having taken courses of calculation in high school showed more interest in selecting an engineering career than those with deficiencies in their preparation mathematics. If it is desired to increase the student body in the engineering careers it is necessary that these results are taken into account. To this end, teachers and principals in charge of upper secondary and higher education should emphasize the design of activities and programs that motivate high school students to become involved in activities and courses that can help them improve their math skills. If it is possible to awaken a greater interest in these courses and activities from the preparatory education of the students, not only could the enrollment rates in the engineering programs be improved, they would also be offering better tools to the students who are studying some engineering so that they successfully complete their careers, in addition to fostering the development of a real interest in the design and innovation activities related to these careers.

Another relevant result of this research was the marked difference between male students and female students who enroll in engineering careers. This result is consistent with the current global literature, which makes it a problem of global interest. For this reason, it is important that professors and executives in charge of upper secondary education design and propose conferences and workshops that seek to alert teachers and students of their age of career selection to this reality. In this way we can start to raise awareness in society that we are leaving technological development in the hands of a male majority, which causes the lack of different points of view and solutions to problems that meet the needs of men and women alike. In addition, women who are prepared and successful in the areas of engineering should be looked for so that they can serve as role models for young women in their academic formation. If female students could have easy access to talks and events led by successful women in the area of engineering, they could get a better idea of how they can help society by developing technological solutions to common problems. This can have a great impact on the interest of young students in activities related to mathematics and engineering, since it is considered that women are interested in careers related to the social sciences due to their desire to help other people from a direct way. Although it is recognized that reducing the gender gap in the areas of engineering is a complicated job, we must begin to work on strategies to tackle this problem from high school education, since most students decide what kind of professional career interest depending on the activities and experiences they have during their training at this level.

Future work and limitations

For future studies related to the level of mathematical skills of students in other countries such as Mexico, it is recommended that standardized knowledge tests be used to determine the mathematical preparation of students, for example, diagnostic tests designed by the National Center for the Evaluation (National Assessment Center for Higher Education, 2017). The results obtained in these exams can serve as a more approximate estimate of the math skills of the students, and thus it could be determined if there is a relationship between the qualification in the mathematical part of the Ceneval exam (standardized knowledge test for admission to the university in Mexico) and the chances of selecting an engineering by Mexican students. No doubt this could be of great help to develop plans to improve technology education in our country.

In addition, it is recommended to conduct a more detailed investigation on the gender gap that currently exists between professionals and students in the areas of engineering in countries such as Mexico. Future studies that seek to clarify this gender disparity should pay special attention to the influence of the courses taken in high school, whether in mathematics or science, in this way you can identify what kind of activities and courses can encourage the students to become interested in engineering careers. In Mexico, compulsory calculation courses are taken as part of the high school academic program, while in other countries such as the United States, the calculation classes are optional at this level. These differences can help us compare what kind of effect it can have to offer courses of calculation in an optional or mandatory way in the interest of high school students to become engineers, especially in groups affected by negative stereotypes related to mathematics such as women.

The results and conclusions of this research should be interpreted with knowledge of the limitations generated by the limited size and diversity of the sample. The reader should review similarities among the populations he wishes to analyze in order to apply the concepts and ideas presented in this research paper. More information should be collected in different contexts and countries in order to generalize these results, especially if you wish to continue this line of research with Mexican students. In addition to the lack of suitable conditions to generalize the conclusions of this work, the way in which the sample was selected for the quantitative analysis represents a limitation for the external validity of the results due to the fact that it is not a random probabilistic sample. On the other hand, it should be considered that the results of this research are based on regressions, and this limits the possibility of determining the direction of the correlation reported in this paper (Rovine and Von Eye, 1997). To determine the possible causality of these results, qualitative research is needed to determine the reasons why a high school student may become interested in a career in engineering.

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