

# Expectancy-value, Stereotypes and Gender Role Beliefs in Engineering Students

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**Abstract**—Women continue to be underrepresented in STEM fields globally due to multiple reasons, including gender stereotypes, reduced women’s self-efficacy in math skills, and work-family balance preferences. This study gender stereotypes and gender role beliefs on engineering students, as well as their educational experiences and career expectations. The research was conducted at a private university in the Colombian Caribbean region, and 381 responses from engineering students were analyzed. The survey assessed students’ perceptions of STEM careers, their value in these fields, and their expectations for success in STEM careers. Results revealed that women generally exhibited more positive perceptions of STEM careers, valued STEM fields more highly, and anticipated more success than men. Additionally, the study identified prevalent gender stereotypes. It highlighted the need to address gender-specific factors to promote gender parity in STEM education.

**Keywords**—Women in STEM, expectancy-value theory, Gender role beliefs, Stereotypes.

## I. INTRODUCTION

According to the Global Gender Gap Report 2024 by the World Economic Forum, Latin America and the Caribbean have made significant progress towards gender parity since 2006, reducing the overall gap by 8.3%. This region registered the highest improvement in economic participation and opportunity indicators, advancing +9.8 percentage points in this period [1]. However, there is still a long way to go to achieve full gender parity. In 2023, it was estimated that at the current rate of progress, it would take up to 53 years to close the gender gap in this region [2]. Concerning education and the skills of the future, there are significant challenges to achieving gender parity, especially in STEM fields. Even for the countries with the highest equity levels, closing the gender gap in STEM has not been possible. For example, four countries in the top 5 of the global gender gap index (Finland, Norway, New Zealand, and Sweden) reported percentages of women between 27.4% and 35.48% in STEM graduates [1]. The data for Iceland, which is at the top of the ranking, is unavailable. In Colombia, the percentage of women was 33.41% in STEM graduates and 23.71% in information and communication technologies graduates [1].

The underrepresentation of women in STEM has several causes, including stereotypes and gender role beliefs, women’s inclinations towards care work and community service jobs, a gender gap in math self-efficacy, and work-family balance preferences, among others [3]. These causes are structural in

society, which makes it difficult to achieve steady and accelerated progress towards parity. STEM careers are often seen as male-dominated, incompatible with raising a family, and unrelated to society’s improvement [4], and these stereotypes are observed even in the most educated population. Previous works have studied gender stereotypes regarding STEM fields in college students. A study in northern California surveyed 199 women attending a public university and found that gender and nerd-genius stereotypes negatively affect women’s STEM identity and motivation [5]. Another study surveyed 499 students from two universities in the United States and found that women perceive traits like being analytical and logical more associated with males [4]. Notably, students with more educated mothers exhibited less traditional gender beliefs. Therefore, role models may help reduce gender stereotypes that prevent women from pursuing STEM careers [4].

The results presented in this paper are part of a more extensive study examining Latin American college students’ perspectives on themselves, their majors, and the STEM fields. In this part of the research, we focus on understanding the expectancy for STEM careers, the expectancy-value (perceived value of STEM fields and expectancy for success in STEM careers), and gender role beliefs and stereotypes in engineering students at Universidad Tecnológica de Bolívar (UTB), a private university in the Colombian Caribbean region. Previous studies identified a gender gap in UTB’s engineering programs, and several strategies have been implemented for the attraction, access, and guidance of women in these fields, such as attraction campaigns, scholarships, and mentoring programs with a gender perspective [6][7].

## II. METHODOLOGY

This study was conducted in the Colombian Caribbean region. It was developed at a private university with a Faculty of Engineering with more than 50 years of tradition.

We used a questionnaire with closed- and open-ended questions developed under the leadership of the Institute for the Future of Education (IFE) of TEC de Monterrey to collect the data. This instrument was validated by experts and by a small sample of students. In addition, it was adapted to the writing style of Colombian Spanish. To guarantee the confidentiality of the information, the data was anonymized, and each student was

assigned a participant code. The methodology and instrument were approved by the university's Ethics committee.

The questionnaire was administered to engineering students, and 554 responses were obtained. Participation in this study was voluntary.

#### A. Data Preparation

A data cleaning process was implemented to ensure the quality and consistency of the data. This process included eliminating records without consent, those from minors, tests, incomplete responses, and duplicates. In duplicates, the most complete record was selected, or open-ended responses were combined to create a more robust record. As a result of this process, 381 valid and complete records were obtained. 62% of the subjects identified as male, 37% as female, and 1% preferred not to answer. Subsequently, a demographic analysis was performed considering 379 records (excluding those that selected "prefer not to answer" in the sex question).

#### B. Expectancy for a STEM career and Expectancy-value

The analysis of the responses was carried out using a 5-point Likert scale in closed-ended questions, where the response options ranged from "Strongly disagree" (1 value) to "Strongly agree" (5 value). This approach allowed us to quantify the responses and gain an in-depth understanding of students' beliefs and values related to their gender and expectations in engineering careers. The weighted mean of the responses was calculated for both males and females to obtain a representative measure of perceived value for each question. This calculation was made by multiplying the percentage of responses in each Likert category by the corresponding value for that category and then summing these products. The weighted mean provides an average of participants' level of agreement or disagreement, providing a direct comparison between genders regarding perceived value in STEM areas.

In addition, a t-test was conducted to determine if the difference between the mean results for each question is statistically significant. A total of 19 questions were analyzed to evaluate the expectancy-value and expectancy for a STEM career as follows.

The questions regarding the perceived value of STEM fields are given next.

- 1) I find STEM-related jobs very interesting.
- 2) I would take a course in STEM, even if it were not required.
- 3) STEM is an important area for me.
- 4) I like STEM courses.
- 5) My program in STEM areas is good for me.
- 6) I believe that working in STEM areas would help me achieve my career aspirations.
- 7) I feel I would have something to be proud of by pursuing a career in STEM areas.
- 8) Working in STEM areas would not be a waste of my time.

The questions regarding the expectancy for success in a STEM career are given next.

- 1) I believe I will be successful in STEM areas.
- 2) I believe I can make an impact if I take a job related to STEM areas.
- 3) I would definitely feel useful in a job related to STEM areas.
- 4) I feel I have what it takes to be successful in a STEM-related job.
- 5) I would be able to achieve success in STEM areas like most of my peers in the program.
- 6) I believe I can achieve something meaningful as a professional in STEM areas.
- 7) I feel I have some good qualities to be successful in STEM areas.

The questions regarding the expectancy for a STEM career are given next.

- 1) "I would enjoy a job in STEM,"
- 2) "I have good feelings about a job in STEM,"
- 3) "Having a job in STEM would be interesting,"
- 4) "I would like to have a job in STEM."

#### C. Gender stereotypes and gender role beliefs

This section results from the analysis of open-ended questions. A non-experimental, descriptive study was conducted. In this type of study, phenomena are described, understood, and interpreted through the perceptions and meanings produced by the participants' experiences [8]. We adopted a qualitative approach based on a grounded theory with an emergent constructivist design [8], focusing "on the meanings provided by the study participants. It is more interested in considering people's visions, beliefs, values, feelings, and ideologies. The results should be presented through narratives; that is, it supports foreground, open coding, and subsequent grouping."

The researchers cleaned the dataset using the Excel spreadsheet (this exercise included removing adjectives such as super, very, too much, and quite a lot for responses that sought to identify specific characteristics). An additional column was added for each open-ended question, converting the answer into a numerical code. The results are described in a summary table, which were analyzed quantitatively and qualitatively. Code 0 was chosen for empty answers or answers that denoted ignorance. Code 5 was chosen for responses identified as generated using Artificial Intelligence and eliminated.

The open questions to identify gender stereotypes and role beliefs are given next:

- 1) What are the adjectives or traits that describe women in STEM fields? That is, women in STEM fields are...
- 2) What are the adjectives or traits that describe men in STEM areas? I.e., men in STEM fields are...
- 3) What are the characteristics (social, psychological, physical, etc.) of a person who studies in STEM fields?

4) What areas of study, programs and/or professions do you consider “male-only”, “female-only” and/or “mixed-gender”? Why?

5) What is your perception about the rights and opportunities for women and men in STEM-related studies and/or work? Why?

### III. EXPECTANCY-VALUE AND EXPECTANCY FOR A STEM CAREER

The results from the analysis of closed-ended questions in expectancy-value (perceived value and expectancy of success in STEM fields) and the expectancy of having a career in STEM reveal differences between male and female students. Overall, women exhibited slightly more positive perceptions across all areas evaluated.

#### A. Perceived Value of STEM Fields

Regarding the perceived value of STEM fields, women had higher results in all questions, suggesting they place more value on careers related to STEM. The smallest differences were found in perceptions of the importance of STEM and the adequacy of the programs. In contrast, the largest differences were observed in the perceived value of working in STEM and the pride associated with these careers. The largest gender differences were found in questions 8 and 7. In question 8, which assesses whether working in STEM areas would be a waste of time, women scored higher (4.19) than men (3.98), reflecting a more positive perception of the value of these careers among women. Similarly, in question 7, which explores the pride associated with pursuing a career in STEM, women also scored higher (4.13) than men (3.82), highlighting a stronger appreciation for these fields among female students.

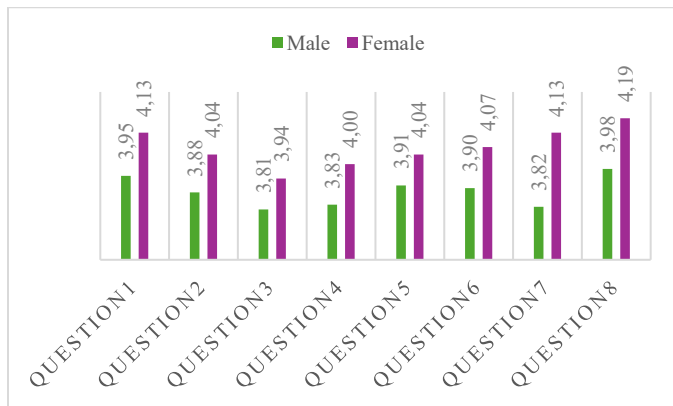


Fig. 1 Perceived value of STEM fields

The t-test results reveal significant gender differences in the perceived value of STEM fields. Women generally rated the value of STEM areas higher than men, especially in aspects such as pride in working in STEM and not considering it a waste of time. The p-values for these questions were below the 0.05 threshold, further supporting that women place a higher value on STEM careers than men. These findings suggest that gender

plays a role in how the value of STEM fields is perceived, with women exhibiting a more favorable view.

#### B. Expectancy for Success in STEM.

The expectations of success in STEM also showed slightly more positive perceptions among women, with the greatest difference in their self-assessment of qualities needed for success in STEM. The largest gender difference was observed in question 7: “I feel I have some good qualities to be successful in STEM areas.” Women averaged 4.13, while men scored 3.82.

The statistical analysis of these questions presents a mixed pattern. While some questions, like the belief in being useful in a STEM job and possessing qualities to succeed, show significant gender differences, others do not. Specifically, women rated themselves higher on attributes like the ability to be successful and impactful in STEM, reflected in lower p-values ( $< 0.05$ ) for these questions. However, the overall perception of success in STEM did not differ significantly between genders for most questions, indicating a shared confidence in achieving success in STEM fields.

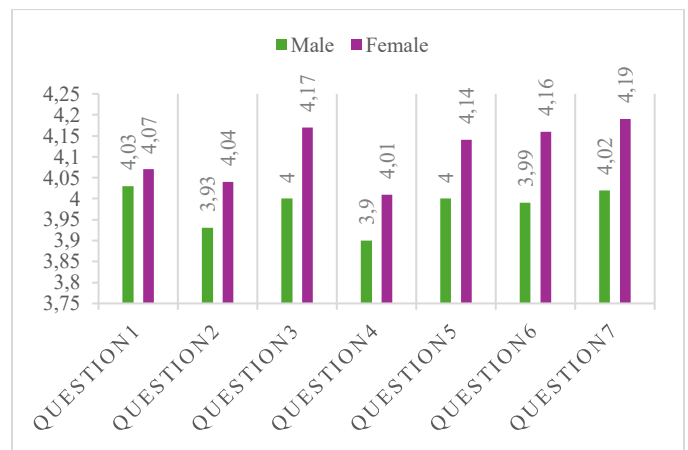


Fig. 2 Expectancy of Success in STEM

#### C. Expectancy for a STEM career.

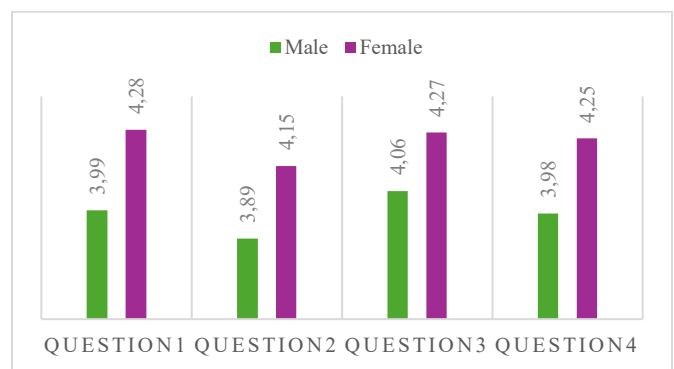


Fig. 3 Expectancy of having a career in STEM

Finally, expectations of having a career in STEM revealed that women anticipate greater enjoyment in a STEM-related job, with a larger difference in enthusiasm for these careers. The largest difference between men and women was observed in question 1 ("I would enjoy a job in STEM"), with a difference of 0.29 points. Women averaged 4.28, while men scored 3.99.

The t-test results show significant differences between male and female students' expectations of pursuing a career in STEM. The negative t-statistic values across all four questions suggest that women, on average, have higher expectations for a STEM career than men. The questions explored aspects such as the enjoyment of a STEM career, positive feelings towards a STEM job, perceived interest, and the desire to pursue a career in STEM. The significant p-values (< 0.05) confirm these disparities, highlighting a stronger inclination among women towards STEM careers. Table I shows the outputs of the t-test for all closed-ended questions.

TABLE I  
RESULTS OF THE T-TEST

Construct	Question	Male vs Female t-stat	Male vs Female p-val
Perceived Value of STEM Fields	1	-1,944	0,054
	2	-1,950	0,053
	3	-1,192	0,235
	4	-2,274	<b>0,025</b>
	5	-1,948	0,054
	6	-1,949	0,053
	7	-3,466	<b>0,001</b>
	8	-2,068	<b>0,040</b>
Expectancy for Success in STEM	1	-0,468	0,641
	2	-0,915	0,362
	3	-2,256	<b>0,026</b>
	4	-0,570	0,570
	5	-1,968	0,051
	6	-1,687	0,094
	7	-2,120	<b>0,036</b>
Expectancy for a STEM career	1	-3,063	<b>0,002</b>
	2	-2,713	<b>0,007</b>
	3	-2,315	<b>0,021</b>
	4	-2,778	<b>0,006</b>

#### IV. GENDER STEREOTYPES AND GENDER ROLE BELIEFS

The analysis of open-ended questions revealed significant insights into students' perceptions regarding the characteristics of women, men, and individuals in STEM areas.

##### A. Characteristics of Women in STEM fields.

Table II shows the codification of the answers to this question.

Code 1 was chosen for the answers of students who found no differences between women and men. Some answers obtained were "like any other person in that area" (participant 2) "the same as men, if they are good" (participant 187), "the adjectives for men and women who belong to STEM are exactly the same, gender does not determine the skills and/or abilities of a person in STEM" (participant 118). Surprisingly, 100% of these responses were from men and different engineering firms.

These results confirm previous studies that show a worrying lack of awareness about the gender gap among engineering students [2] since the proportion of responses under this code would be expected to be higher.

TABLE II  
CODIFICATION OF THE ANSWERS RELATED TO WOMEN IN STEM

Code	What are the adjectives or terms that describe women in STEM areas? In other words, women in STEM areas are..	Count	%
0	They didn't answer (blank), they answered ignorance (I don't know, I don't know)	94	25%
1	They responded that there is no difference between women and men	9	2%
2	Specific characteristics answered	261	69%
3	Sexist responses	5	1%
4	Other responses	8	2%
5	Removed for being GPT	4	1%
	Total	381	100%

Code 3, chosen for sexist responses, was interpreted as jokes such as: "black sheep" (participant 317), "I have the right to remain silent and anything I say can be used against me" (participant 49) "some interested, others disinterested or difficult to understand" (participant 236) or interpreted as beliefs that continue to enhance gender stereotypes such as: "necessary companions and support" (participant 18) "I think they can help" (participant 322). This code was also used for questions 2 and 3 with similar answers.

Code 4 was chosen for responses that did not mention specific characteristics of women in STEM areas but a general perception, such as "normally, there are not many women who decide to choose this area of knowledge as the aspect they want to focus on for the rest of their lives in a professional career, But those who do want to make the most of everything they can get out of it and be professionals who can apply what they know to problems that need a solution" (Participant 111) "A gender struggle" (Participant 100) "It depends on the situation" (Participant 182) "They achieve their purposes" (Participant 37) "The best decision-makers (Participant 48)

Code 2 was chosen for responses that mentioned specific characteristics of women in STEM areas, equivalent to approximately 70% of the sample. The Top 14 words that were repeated the most (the frequency was a minimum of 10 and a maximum of 127) in descending order were: "Intelligent," "Capable," "Innovative," "Creative," "Dedicated," "Talented," "Courageous," "Passionate," "Empowered," "Leaders," "Persevering," "Strong," "Determined," "Disciplined."

##### B. Characteristics of Men in STEM fields.

Table III shows the codification of the answers to this question.

Code 1 was chosen for the answers of students who found no differences between women and men. Some answers obtained were "competitive and equally capable of others" (participant 1) "as any other person in that area (participant 2),

"there is no difference in whether the person who is in STEM is male or female, since everyone has the same abilities" (participant 285), "I would not qualify it with a different adjective" (participant 242). Surprisingly, 85% of these responses were from men and from different engineering degrees.

TABLE III  
CODIFICATION OF THE ANSWERS RELATED TO MEN IN STEM

Code	What are the adjectives or terms that describe men in STEM areas? In other words, men in STEM areas are..	Count	%
0	They didn't answer (blank), they answered ignorance (I don't know, I don't know)	95	25%
1	They responded that there is no difference between women and men	8	2%
2	Specific characteristics answered	265	70%
3	Sexist responses	2	1%
4	Other responses	6	2%
5	Removed for being GPT	5	1%
	Total	381	100

Code 4 was chosen for responses that did not mention specific characteristics of men in STEM areas, but a general perception, such as "they are the majority" (participants 312 and 323) or more information was sought to be able to answer, such as "I want context" (participant 182) or "it depends on the professional" (participant 187)

Code 2 was chosen for responses that mentioned specific characteristics of men in STEM areas, which is equivalent to approximately 70% of the sample. The Top 14 words that were repeated the most (the frequency was a minimum of 10 and a maximum of 101) in descending order were "Intelligent," "Capable," "Creative," "Innovative," "Dedicated," "Passionate," "Collaborators," "Ingenious," "Persevering," "Determined," "Responsible," "Hardworking," "Visionaries," "Analytical".

### C. Characteristics of People in STEM fields.

In this case, two codes were used. Code 1 was chosen for the answers of students who did not find differences between the disciplines, as they responded that the area of study does not define a person's characteristics. Some answers were, "We are all capable or have any characteristic to be or study STEM areas; it is to have the vocation and the desire to love" (participant 54). Unlike the previous questions, a higher proportion of this type of answer was from women.

Code 2 was chosen for responses that mentioned specific characteristics of people in STEM areas, equivalent to approximately 65% of the sample. The Top 11 words that were repeated the most (the frequency was a minimum of 10 and a maximum of 37) in descending order were "Intelligent," "Curiosity," "Creative," "Problem Solving," "Responsible," "Teamwork," "Critical Thinking," "Friendly," "Communication," "Sociable," "Capable," "Mathematical Skills."

These results show that the characteristics associated with STEM women and men are very similar. However, some characteristics were mostly assigned to women, such as "talented," "brave," "empowered," "leaders," "strong," and "disciplined" in the case of men, such as "resourceful," "responsible," "hardworking," "visionary" and "analytical." In the case of the question aimed at people in STEM areas, the characteristics were associated with competencies such as curiosity, problem-solving, teamwork, critical thinking, communication, social influence, and mathematical skills. These results coincide with the 2023 Future of Employment Report [11], which shows the top basic skills that workers need today, which are shown in a taxonomy of competencies being classified in a first level in socio-emotional attitudes and competencies, skills, and knowledge.

### D. Gender roles.

As can be seen in Table IV, participants identified a more significant number of professions for men; in fact, engineering continues to be associated to a greater extent with men (six engineering majors were reported as male jobs; two engineering majors as female jobs, and three engineering majors were reported for both sexes). These results reinforce what has been reported in the literature as horizontal segregation [10], and care-related professions continue to be associated with women. Notably, 42% of the responses mentioned that there was no difference between women and men in the case of professions, and that is progress.

TABLE IV  
PROFESSIONS CONSIDERED FOR WOMEN, MEN, AND BOTH

Women	Men	Both
<ul style="list-style-type: none"> <li>• Biomedical engineering</li> <li>• Cosmetology</li> <li>• Stewardess</li> <li>• Environmental engineering</li> <li>• Social communication</li> <li>• Infirmery</li> <li>• Psychology</li> <li>• Humanities</li> <li>• Customer support</li> <li>• Medicine</li> <li>• Children's pedagogy</li> <li>• Social work</li> <li>• Psychotherapist</li> <li>• Fashion design</li> <li>• Secretary</li> <li>• Arts</li> <li>• Ethics</li> </ul>	<ul style="list-style-type: none"> <li>• Mechatronic engineering</li> <li>• Mason</li> <li>• Mechanical engineering</li> <li>• Space engineering</li> <li>• Computer science and engineering</li> <li>• Naval engineering</li> <li>• Physical education</li> <li>• Architecture</li> <li>• Business administration</li> <li>• Civil engineering</li> <li>• Police, army</li> <li>• Plumbing, woodworking</li> <li>• Nuclear physics</li> <li>• Related to calculus</li> <li>• Law</li> <li>• Accounting</li> <li>• Finance</li> <li>• Business</li> </ul>	<ul style="list-style-type: none"> <li>• Industrial engineering</li> <li>• Environmental engineering</li> <li>• Finance</li> <li>• Civil engineering</li> <li>• Business administration</li> <li>• Accounting</li> <li>• Law</li> <li>• Social sciences</li> <li>• Engineering</li> <li>• Business</li> <li>• Medicine</li> <li>• Arts</li> <li>• Architecture</li> <li>• Economy</li> <li>• Psychology</li> </ul>

### E. Rights and opportunities for women and men in STEM areas.

The answers obtained were analyzed and classified into codes as in the previous questions. Most participants answered

that there was no difference between women and men, and some answered that "they should have the same opportunities" (participant 4, 20, 22). It is followed by those who did not answer (blank) and answered ignorance (I don't know, I have no knowledge). These two codes represent the perception of almost 70% of the responses obtained.

However, it was attractive to group some responses from participants into the following codes, which are presented descendingly: Women continue to have barriers and inequalities in STEM areas, and Men are stronger in STEM areas. In a deficient proportion, it was found that women have preferences and more significant opportunities than men in several fields or that women have greater visibility in STEM areas.

#### IV. CONCLUSIONS

This study aimed to analyze the expectancy-value, stereotypes, and gender role beliefs in engineering students. The results show significant differences between male and female engineering students regarding their expectations of success in STEM, having a career in STEM, and their perceived value of STEM fields. Women showed more positive perceptions of STEM careers, valued STEM fields more highly, and anticipated more success than men. The university has several programs to promote the participation of women in STEM; these activities may have contributed to empowering women toward STEM fields.

Regarding the traits of women and men in STEM, most of the participants mentioned "intelligent," "capable," "creative," and "innovative" for both genders. A small percentage of responses included sexist remarks, indicating the persistence of gender stereotypes. It is interesting that even engineering students still have stereotypical views of gender roles. Only two engineering programs were mentioned in the professions for women: healthcare (biomedical engineering) and sustainability (environmental engineering). In contrast, six engineering programs were mentioned in the male professions.

This study highlights the importance of continuing to develop strategies to reduce gender stereotypes and occupational segregation that limit women's participation in STEM. Gender-related issues in STEM education and career development should be addressed to ensure that both men and women can equally benefit from opportunities in these fields.

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