

# Impacts of mentoring and support networks on the self-efficacy and self-regulation of women engineering students

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## I. INTRODUCTION

Self-efficacy and self-regulation are two fundamental learning skills, especially in STEM (Science, Technology, Engineering, and Mathematics) fields [4,5,6]. Individuals with high self-efficacy are confident that their efforts can result in positive outcomes, and individuals with high self-regulation can successfully manage their learning process by planning, monitoring, and adjusting behaviours to reach their goals [18]. During the transition from high school to university, students gain autonomy and must identify, develop, and adapt their learning strategies. Academic success depends on their ability to self-regulate and effectively calibrate their self-efficacy [19].

A study developed in Germany found that self-efficacy for motivational regulation is fundamental for the motivational regulation process and contributes to academic satisfaction [20]. Another study developed in the United States investigated the effect of self-regulation on STEM persistence and found that cognitive-emotional self-regulation skills were a stronger predictor of persistence intentions in minority students, compared to non-minority students [21].

Women continue to be underrepresented in STEM fields, which poses challenges that can affect their self-efficacy and

self-regulation. Previous studies have identified three factors that affect these skills in women in STEM.

1) *Gender stereotypes*. The belief that STEM fields are not for women can decrease female students' self-efficacy [9], and social and cultural beliefs about what is expected of each gender can directly affect how women see themselves in relation to these disciplines [10].

2) *Lack of representation*. Representation has a key impact on the sense of belonging. When women don't see other women in their academic or professional environment, they may feel isolated or like they're fighting against a system that doesn't support them. This isolation can generate emotions of insecurity and the feeling of being an exception, which also affects their confidence and desire to persist in STEM [11, 12].

3) *High expectations*. Women in STEM often feel like they must prove they belong in the field, which can lead to psychological pressure and anxiety. This constant need to validate their presence and ability can become a source of stress, hindering their ability to self-regulate emotionally, affecting emotion management, focus on tasks, and concentration [13,14].

In the first academic period of 2025, Universidad Tecnológica de Bolívar (UTB) had 2846 students enrolled in STEM fields, of whom only 25% were women. Among the strategies to promote the participation and persistence of women in STEM are support networks and mentoring [2,3]. The W-STEM project was developed at UTB between 2019 and 2021 to promote the involvement of women in STEM fields [1]. One of the sustainability strategies of the project is the consolidation of the W-STEM student group, which offers support, learning, and networking opportunities, and mentorship to female STEM students, helping them overcome academic and employment barriers [15]. Since 2021, a mentoring program has been implemented to accompany first-year female engineering and data science students. The mentors are advanced female engineering students trained in leadership, multiculturalism, causes and consequences of the gender gap, strategies to avoid gender bias, among other topics.

Many interventions have been implemented globally to promote women's motivation and persistence in STEM higher education programs. However, the medium and long-term impact of these interventions has not been analysed in detail,

especially in Latin American higher education institutions. This article evaluates the impact of mentoring and support networks on the self-efficacy and self-regulation of women studying STEM programs. In addition, we explore the experiences of female students and engineering graduates involved in these programs.

Throughout this article, the main results of the surveys on self-efficacy and self-regulation, as well as testimonials, are discussed. Data and emotions of young women students and graduates of STEM careers were analysed to understand the impact of support networks on their academic and professional development, particularly at the University.

## II. MENTORING PROGRAM

In 2021, the Faculty of Engineering of UTB developed a mentoring program with a gender perspective to accompany first-year female students in their first year of study. The mentoring offered guidance and practical advice to the students to help them adapt to university life and promote their academic and personal development. The mentors are female engineering students in the fifth semester or above. Before the start of mentoring, the mentors are trained by two professors and senior mentors. Previous studies have shown that mentoring can strengthen academic commitment and resilience in students [14,15,16].

## IV. METHODOLOGY

The purpose of this study was to evaluate the impact of support networks and mentoring on self-efficacy, self-regulation, and personal and professional development of women engineering students and graduates. The following specific objectives were proposed:

- Analyse self-efficacy through closed-ended questions to measure their confidence and personal skills in STEM courses.
- Analyse self-regulation through closed-ended questions to explore study strategies and skills.
- To know the impact of the mentoring program on the improvement of academic and professional performance.

We used a questionnaire developed by the Institute for the Future of Education (IFE) of TEC de Monterrey to assess self-efficacy and self-regulation in female engineering students. In addition, we developed a qualitative analysis of the responses to open questions from three graduates and two students who were mentors. The questions were related to their experience as mentors and the skills that this program helped them to strengthen. Sentiment analysis was used to identify positive and negative feelings about how the mentoring program has provided tools to face the challenges that they have in STEM areas.

### A. Participants

The questionnaire was administered to 554 students. The participation in this study was voluntary. After data cleaning and classification by gender, the female students surveyed were 141, of whom 24 were mentors. All the students are from STEM programs, distributed as follows: Biomedical Engineering 22, Systems and Computer Engineering 8, Mechatronics Engineering 6, Electrical Engineering 7, Industrial Engineering 24, Naval Engineering 2, Mechanical Engineering 3, Electronic Engineering 3, Chemical Engineering 17, Civil Engineering 37, and Environmental Engineering 12. For the sentiment analysis, the testimonies of three graduates and two students of STEM programs were collected. The students share their experiences as graduates and as students in the mentoring program.

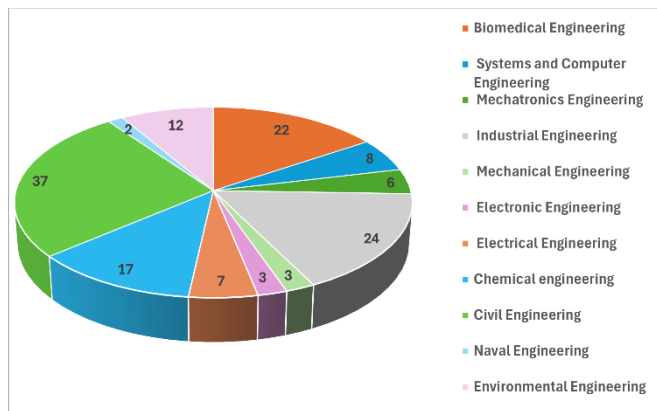


Fig. 1 Classification of the students surveyed according to STEM Program.

### B. Data Preparation and Analysis

The data was cleaned up by eliminating tests, records of students who did not consent, those from minors, incomplete responses, and duplicates.

After applying the described filtering methodology, 381 valid and complete records were obtained, of which 141 were from women and 238 from men.

For the qualitative analysis, the texts were obtained from the transcription of the meeting audio to carry out the sentiment analysis. After the sentiment analysis, it was possible to identify the tone and type of feeling. Sentiment analysis was performed using natural text processing (NLP) and machine learning techniques.

## V. RESULTS

### A. Data analysis

To assess self-efficacy between female mentors and non-mentors, we analyzed the responses to the following Likert questions:

1. I am confident in my ability to learn the material in my courses.
2. I can learn the material in my courses.
3. I can achieve my goals in my courses.
4. I feel able to perform adequately in my courses.

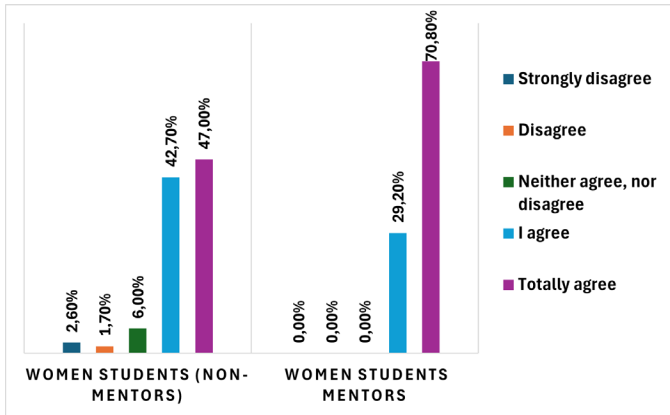


Fig. 2 Self-efficacy question 1: I am confident about my ability to learn the material in my courses.

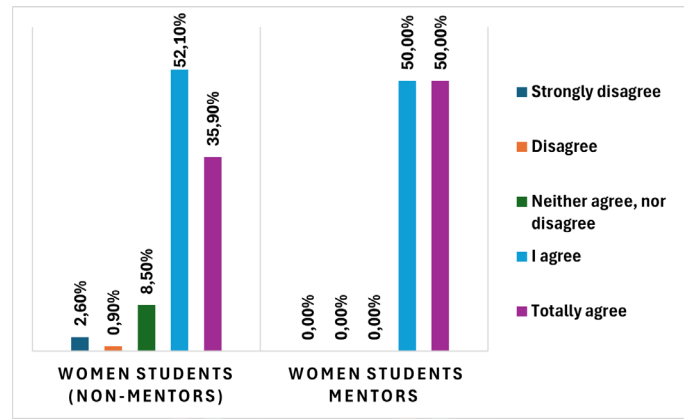


Fig. 5 Self-efficacy question 4: I feel able to perform adequately in my courses

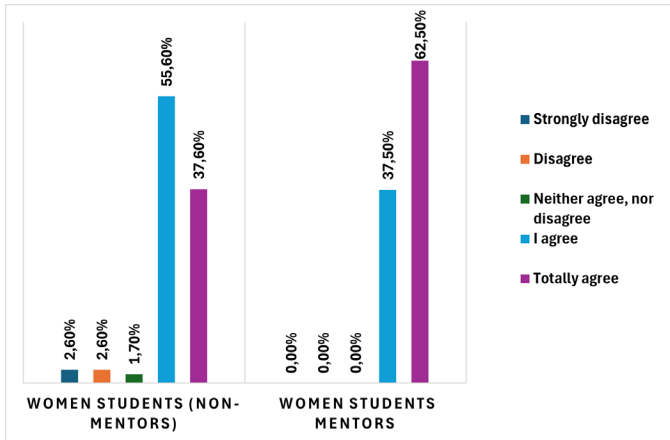


Fig. 3 Self-efficacy question 2: I can learn the material in my courses.

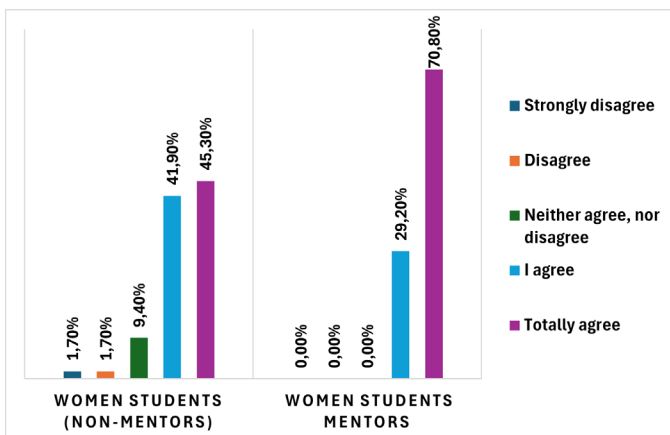


Fig. 4 Self-efficacy question 3: I can achieve my goals in my courses

The students had five response options: strongly disagree, disagree, neither agree nor disagree, agree, strongly agree. Figures 2-5 show the answers to these questions.

In all questions, there was a higher percentage of “strongly agree” responses in women mentors compared to non-mentor students. Mentoring can have a positive impact on strengthening women's self-efficacy in STEM by providing support, guidance, and validation of their academic and professional capabilities.

To assess self-regulation between female mentors and non-mentors, responses to the following questions were assessed:

1. I ask myself questions to make sure I know the material I've been studying.
2. I solve additional or revision exercises, even if it is not my obligation.
3. Even when the study materials are boring and uninteresting, I keep working on it until I'm done.
4. Before I start studying, I think about what I must do to learn.
5. When I read, I stop from time to time to review what I've already read.
6. I strive to get a good grade, even if I don't like a class.

The results of the self-regulation questions are shown in Figures 6-11. In this case, there were no notable differences in the students' responses between the two groups. In general, women students are likely to engage in autonomous learning activities and exceed academic expectations.

A statistical analysis was conducted to determine whether the differences observed between women mentors and non-mentors were statistically significant. The **t-test results (Table I)** indicate that a **majority of self-efficacy measures showed significant differences** ( $p < 0.05$ ), supporting the hypothesis that mentoring positively influences self-efficacy in female students.

However, no significant differences were found in **self-regulation behaviors** between the two groups, suggesting that self-regulatory learning strategies are consistently used by female students regardless of mentorship experience.

These findings highlight the potential benefits of mentorship programs in boosting confidence and self-efficacy among women in STEM, while also suggesting that intrinsic motivation and self-regulated learning behaviors may already be well-established in women students.

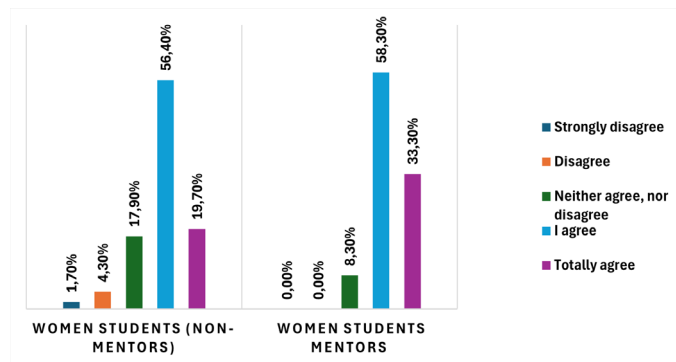


Fig. 6 Self-regulation question 1: I ask myself questions to make sure I know the material I've been studying

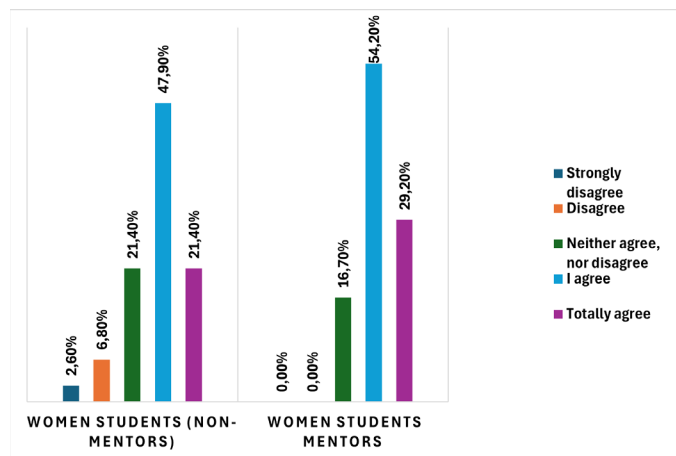


Fig. 7 Self-regulation question 2: I solve additional or revision exercises, even if it is not my obligation

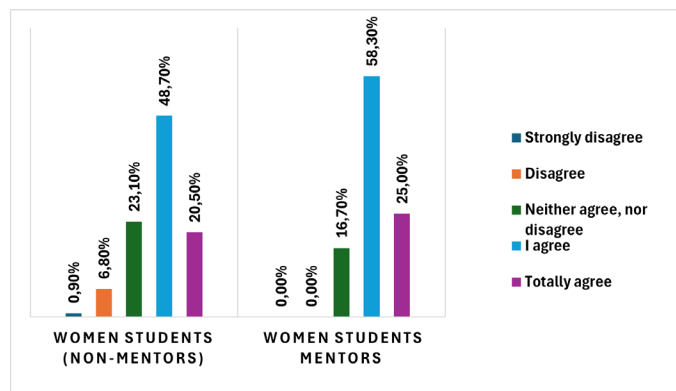


Fig. 8 Self-regulation question 3: Even when the study materials are boring and uninteresting, I keep working on it until I'm done

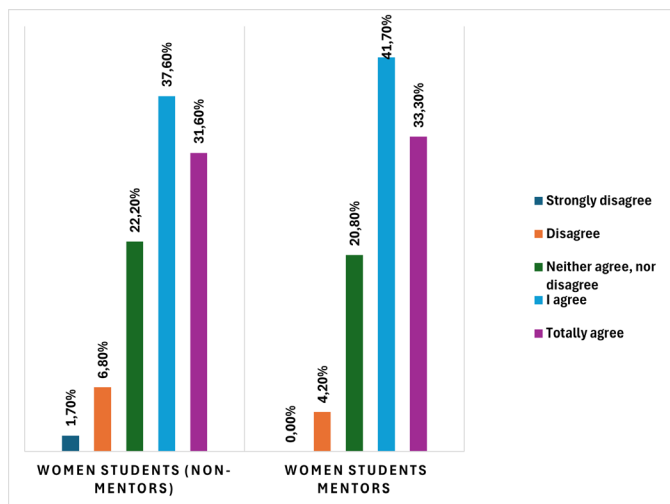


Fig. 9 Self-regulation question 4: Before I start studying, I think about what I must do to learn.

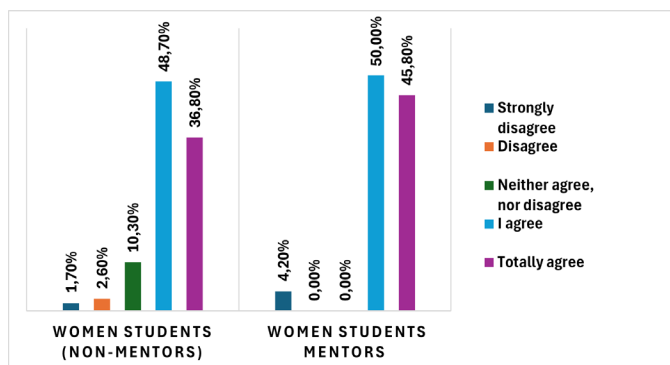


Fig. 10 Self-regulation question 5: When I read, I stop from time to time to review what I've already read

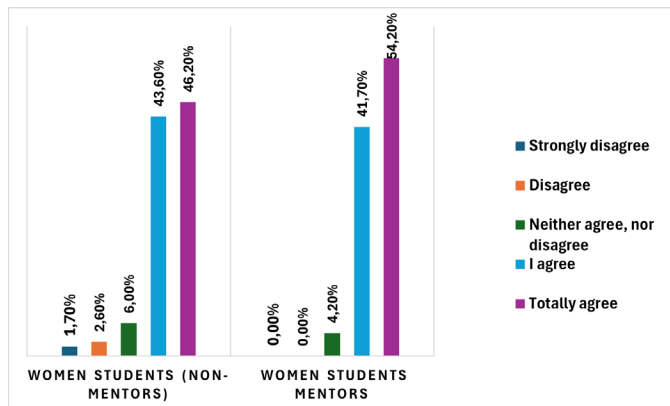


Fig. 11 Self-regulation question 6: I strive to get a good grade, even if I don't like a class

TABLE I  
STATISTICAL ANALYSIS

Question	Women (non mentors) vs women mentors t-stat	Women (non mentors) vs women mentors p-val
Self-efficacy 1	3,30183	<b>0,00161</b>
Self-efficacy 2	3,11725	<b>0,00294</b>
Self-efficacy 3	3,55405	<b>0,00076</b>
Self-efficacy 4	2,47966	<b>0,01647</b>
Self-regulation 1	2,53185	<b>0,01510</b>
Self-regulation 2	2,06548	0,04487
Self-regulation 3	1,74126	0,08902
Self-regulation 4	0,68731	0,49623
Self-regulation 5	0,88348	0,38348
Self-regulation 6	1,40536	0,16690

### B. Sentiment Analysis.

We collected the testimonies of three graduates and two engineering students about their experience as mentors and the skills that this program helped them to strengthen. The results of the sentiment analysis are shown next.

Graduate 1: The sentiment analysis of this text shows a neutral to positive tone:

#### Main Feelings:

- **Collaboration:** The description of how student volunteers organize activities highlights the importance of teamwork and cooperation.
- **Commitment:** She demonstrated commitment to the project and how responsibilities were distributed, indicating a sense of **dedication** and **seriousness** towards the initiative.

#### Secondary Feelings:

- **Autonomy:** Although there is a professors' guide, it is emphasized that the students have the initiative and responsibility to coordinate, which transmits a feeling of **independence**.
- **Support:** She mentioned that the activities are carried out considering the mentors and the accompaniment of the professor, which reinforces the feeling that there is a support network behind the participants.
- **Enthusiasm:** Although the tone is informative, talking about the activities clearly and without hesitation suggests a feeling of **interest** and **enthusiasm** for the project.

**Summary:** the sentiment in the text is mostly positive because of the way it describes collaboration, training, and organization, with a practical and academic approach.

Graduate 2: the sentiment analysis shows a mixture of positive and reflective feelings, where motivation, empowerment, and solidarity predominate. Throughout the

narrative, both the challenges faced and the opportunities and achievements achieved are highlighted, creating a balance between feelings of self-improvement and inspiration for other women.

#### Main Feelings:

- **Motivation:** The graduate highlights how her participation in the chapter and the experiences she has lived, such as the event of the Day of Women and Girls in Science, have been a source of inspiration for both her and the young women to whom she is supported. The importance of motivating young women to pursue their studies, especially in engineering, is highlighted.
- **Empowerment:** The text emphasizes the message that women can pursue careers in male-dominated fields, despite obstacles such as gender inequality and judgment of others. This feeling is reflected when Nicole mentions how to deal with criticism and others' lack of confidence in her ability.
- **Solidarity:** Throughout the text, there is a strong feeling of mutual support among the members of the chapter. She talks about how the goal is to help girls, especially first-semester students, overcome fears and continue their education, which conveys a message of companionship and a support network.

#### Secondary Feelings:

- **Challenge or Difficulty:** Although the text has a mostly positive approach, difficulties are also mentioned, such as the judgment that she faces due to her youth and her appearance, as well as the barriers that women encounter in the workplace and academics.
- **Pride:** She expresses pride in the chapter's accomplishments and the impact it has had, especially as she sees the number of women in engineering careers increase. She is proud of how women are managing to make space for themselves in areas traditionally dominated by men.
- **Overcoming:** The reflection on the difficulties she faced at the beginning, being one of the few women in her course, highlights a feeling of **personal** and collective improvement, recognizing that women are making progress in university and in their respective careers.

**Summary:** The overall tone of the text is positive, inspiring, and motivating. Although the difficulties faced by women in fields such as engineering are mentioned, the focus is on improvement and growth. She speaks from her personal experience, providing a clear message of empowerment and motivation for other women, especially young women starting their studies. In addition, the tone has a touch of solidarity and care, as she is willing to help and support students who need guidance.

Graduate 3: the sentiment analysis in this text reflects a positive, motivating, and empowering narrative:

### Main Feelings:

- **Positive/Motivational:** The person highlights her positive experience within the chapter, especially regarding the importance of mutual support between women in traditionally male-dominated fields, such as engineering.
- **Empowerment:** She highlights how support among women and having role models has been crucial to her success, as well as to the inspiration of other women. This is also reflected in the idea of "if you plan it, you can do it," which changes lives.
- **Gratitude/Support:** She expressed gratitude toward initiatives that provide support and guidance and how that support structure has been critical to her personal and professional progress.
- **Optimism:** The author sees these projects as an effective way to change the dynamics of engineering and other sciences, ensuring that more women can access these areas without feeling limited by gender bias.

### Secondary Feelings:

- **Reflection:** There is a reflective feeling when she mentions the difficulties that some girls face, such as the lack of support from family members or the belief that they cannot study scientific careers, which makes the initiative she mentions more relevant.
- **Overcoming Obstacles:** It describes how the author and other women face career challenges, such as being the only women in male-dominated professional settings. It also highlights the importance of supporting other women in overcoming these barriers.
- **Concern about the future:** There is concern about the lack of support in some families for women who want to study scientific careers but with a positive view of the possible changes through initiatives such as those mentioned.

**Summary:** the overall tone of the message is optimistic and empowering, reflecting gratitude for the experiences lived. In addition, it conveys a message of support and hope for more women to dare to study careers in science and engineering despite the barriers they may face.

Student 1: the sentiment analysis of the text reflects an overall feeling of motivation, empowerment, and solidarity, with a clear focus on mutual support and joint growth.

### Main Feelings:

- **Gratitude:** Gratitude for the opportunities you have received, such as scholarship, mentoring, and experiences (traveling to Spain, support from a mentor, etc.).
- **Motivation:** A positive drive toward personal and academic growth is reflected.
- **Empowerment:** This is a key theme in her text, especially when mentioning the importance of support networks for women in engineering and how they have driven her to keep going.

### Secondary Feelings:

- **Self-improvement:** Throughout the text, she highlighted that despite the challenges, she felt supported and has found ways to overcome them.
- **Hope:** The idea that lived experiences have given her a path to achieve her goals and that others can achieve them thanks to these support networks.
- **Confidence:** By mentioning herself as part of a supportive community, she feels that difficulties can be overcome and that she is not alone.
- **Solidarity:** There is a desire for other women to benefit from these networks and continue their careers, especially in areas such as engineering.

**Summary:** The overall tone of the text is positive, motivating, and reflective. Show an attitude of gratitude and optimism towards the experiences she has had, highlighting the opportunities she has had and how they have helped her grow. In addition, the tone has a touch of empowerment and solidarity, especially when talking about the support other women in her field can receive. It is a message of inspiration that seeks to strengthen women and motivate them to keep going despite the challenges they may encounter.

Student 2: the sentiment analysis of this text reflects a positive narrative of challenge or difficulty:

### Main Feelings:

- **Empowerment:** The text highlights the importance of supporting women in traditionally male-dominated fields, such as engineering, and how the chapter fosters confidence and leadership among its members.
- **Motivation:** The motivation to help students not give up and continue their studies is highlighted despite the difficulties they may face, such as the low representation of women in certain fields.
- **Collaboration and Support:** Teamwork and creating a "family" within the chapter is a key feeling, showing how mentoring and support between members become a strong network of collaboration.

### Secondary Feelings:

- **Solidarity:** By talking about the shared experience of being few women in engineering careers, a sense of solidarity is created, both among the mentors and with the students.
- **Pride:** She proudly mentions the growth of the chapter, the experiences lived, such as trips to Spain, and the positive impact that the chapter has had on the lives of the participants.
- **Confidence:** By mentioning the experiences in leadership and how they have been put together as a community, a feeling of confidence is conveyed both in the project and in the capabilities of women within the field of science and technology.
- **Overcoming:** Throughout the text, self-improvement is reflected, especially when mentioning the challenge of being the only woman in a predominantly male

work environment and how the chapter prepares participants for those realities.

**Summary:** the overall tone of the text is positive. Throughout the text, enriching experiences, the importance of mutual support, and the empowerment of women in fields such as engineering are highlighted. There is a focus on growth, motivation, and leadership, which conveys an optimistic and encouraging message about the opportunities and community created within the chapter. Although challenges are mentioned, such as being one of the few women in certain settings, it is presented in a way that underscores self-improvement and commitment.

The testimonies were classified into categories such as empowerment and leadership, challenges and obstacles, solidarity and support, impact and achievements, and inspiration and motivation, to break down the feelings, thoughts, and experiences the participants share in a structured way. Table II shows the categories, keywords, and descriptions of the categories.

TABLE II  
KEYWORD CATEGORIES

Category	Keywords	Description
Empowerment and Leadership	Empowerment, leadership, confidence, motivation, self-improvement, example, growth	It reflects the feeling of women taking control of their professional and personal lives, facing obstacles and demonstrating that they can lead and achieve success in male-dominated fields.
Challenges and Obstacles	Inequality, difficulties, judgment, discrimination, limitations, obstacles, fear, professional practices, challenges	It recognizes the challenges women face in science and engineering, such as gender inequality, judgment in work and academic environments, and fear of not being accepted or taken seriously because of their gender or youth.
Solidarity and Support	Support, network, family, companionship, mentoring, collaboration, help, guidance, sisterhood, community	It reflects the importance of teamwork, the creation of support networks and collaboration between women to overcome barriers, share experiences and help each other.
Impact and Achievements	Experiences, changes, success, achievements, participation, impact, events, results, pride	It highlights the achievements achieved through collective and personal effort, such as the impact of the events, the increase in the participation of women in engineering

		careers, and the transformative experiences lived by the participants.
Inspiration and Motivation	Inspiration, motivate, example, future, possibility, advancement, hope, change	It refers to the ability to inspire other women to move forward, study, and enter scientific and technological fields, regardless of obstacles, and the power of a positive example.

### C. Chronological diagram

The diagram in Figure 12 reflects the continuous development of women engineering students who participated in mentoring programs. Feelings of empowerment, leadership, and pride are recurrent, and challenges during their internships and jobs are seen as opportunities for growth. In addition, there is a positive change in the presence and recognition of women in STEM careers, especially in engineering.

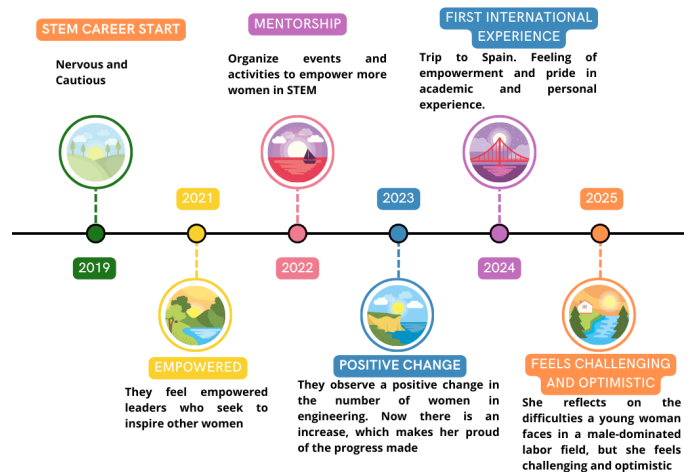


Fig. 12 Chronological diagram.

## VI. DISCUSSION AND CONCLUSIONS

The results of the survey applied to the 141 female students of engineering programs show that women who participate in mentoring programs have a higher level of self-efficacy compared to those who do not participate in the program. Mentoring helps improve confidence to succeed in their studies and prepares women to overcome challenges in traditionally male-dominated fields.

The sentiment analysis and the categorization of the keywords show that the mentoring program and the support networks strengthen abilities such as empowerment, leadership, solidarity, and motivation. They feel that they have control over their own academic and professional careers, as well as confidence in their ability to overcome barriers despite social and academic obstacles. They also underline the relevance of

support networks that provide mentoring and guidance in the initial stages of academic development, as well as in decision-making about their professional future. In terms of challenges and obstacles, they highlight the barriers women face in male-dominated areas, such as gender inequality, judgment about their ability, and fear of not being taken seriously in professional or educational settings. The testimonies reflect that support among women is a constant, and the importance of community as a key factor for success is highlighted.

Self-efficacy can be cultivated through successful experiences, mentoring, and social support. Women who have role models, access to adequate resources, and are exposed to experiences that reinforce their sense of competence are more likely to develop strong self-efficacy.

#### ACKNOWLEDGMENTS

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