Analysis of the inclusion of female students in STEM/ICT majors at the Gerardo Barrios University of El Salvador: a gender perspective

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Abstract

The main objective of this study is to analyze the inclusion of female students in STEM and ICT majors at the Universidad Gerardo Barrios in El Salvador, through the analysis of the critical factors that influence their inclusion during the training process. Prior to the development of the study, factors affecting the inclusion of women in STEM/ICT majors were examined. This is an exploratory and descriptive study, with a quantitative approach, focusing on students of six majors belonging to the School of Engineering and Science and Technology. In order to carry out the study, a survey was used to collect students' opinions on three key aspects: their participation in the educational environment, the support, and resources available, and the inclusive culture at the university. The results of the study indicate that, in general, there is an acceptable perception at the university regarding inclusive participation and access to resources and technology, but there are still opportunities for improvement. However, the inclusive culture had positive results, suggesting that students feel included and valued in the educational environment. In conclusion, the study suggests that the university is on the right track towards the inclusion of female students in STEM/ICT majors.

Keywords

El Salvador, inclusion, gender, higher education, female

1. Introduction

Inclusion in higher education is vital for the progress of society and access to quality education is essential. In recent years, there has been a high growth in university enrollment among women in Latin America [1]. However, prejudices, social norms and expectations still limit the quality of education they receive, especially in STEM (Science, Technology, Engineering and Mathematics) discipline. According to the UNESCO report *"Descifrar las claves: la educación de las mujeres y las niñas en materia de STEM (Deciphering the keys: STEM education for women and girls)"* [2], only 35% of students enrolled in STEM related majors in higher education are women and only 3% of female students in higher education study ICT (Information and Communication Technologies [3]. Access to education is an essential human right and it is important to note that women have made significant progress in the field of education in recent decades. However, despite these achievements, women continue to be underrepresented in STEM/ICT majors. There are several factors that contribute to the lack of female representation in STEM/ICT majors [4], such as lack of female role models, lack of information about these majors, and gender discrimination.

This study is focused on analyzing the inclusion of female students in STEM/ICT majors at Gerardo Barrios University in El Salvador from a gender perspective, "The gender perspective makes it possible to analyze the way in which social systems are created and endure based on a certain point of view of sex, gender and sexual orientation" [5] [6], where examined the critical factors [7] that affect the

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participation and access of female students to these majors during their formative process. The critical factors that foster participation are, first, the importance of inclusive participation [8][9] that engages female students in academic and extracurricular activities, which allows them to broaden their experience and develop skills in areas beyond the classroom [10]. Secondly, the importance of support and resources to help students during their formative process [11], such as tutoring programs, scholarships, and access to technology and educational resources. Finally, the need for an inclusive culture in educational institutions that promotes inclusive values and appreciates diversity, fosters integration and collaboration among students, and ensures the physical and emotional safety of students [12] .

By assessing inclusion from a gender perspective, we seek to understand the challenges and barriers faced by female students in STEM/ICT majors and provide valuable information to propose effective strategies to promote equitable inclusion [13]. In addition, this research can also serve as a tool for other universities seeking to improve the inclusion of female students in STEM/ICT majors.

2. Methodology / Design of study

Type: The research is exploratory and descriptive with a quantitative approach. Primary and secondary data sources were combined to gather relevant information.

Population: The population selection was carried out according to the object of study, the female students from the following majors: Civil Engineering, Industrial Engineering, Technical in Civil Engineering and Construction, Database Management and Administration Engineering, Computer Systems and Network Engineering, and Technical in Computer Systems and Network Engineering in face-to-face modality from the School of Engineering and Science and Technology at Gerardo Barrios University in El Salvador, which has a population of 220 active students.

Sample: A representative sample was selected from the population with a 95% confidence level, obtaining a result of 141 students. The sample was taken in a general way, and it was not considered necessary to stratify the sample, based on the premise that the entry of women is homogeneous in these majors.

Techniques: The survey technique was used for data collection, which design was built under a quantitative structure. And following a deductive analysis, an operational matrix of variables was established with the study's indicators.

Instrument: An online questionnaire was developed using the Google Forms tool, consisting of 17 items (see tables 2, 3 and 5) based on the indicators established in the operational matrix of variables, systematically organized with the purpose of exploring three dimensions: inclusive participation, support and resources, and inclusive culture. Each item is valued on a scale from 0 to 10. Additionally, to obtain secondary income data, a document review was conducted, which allowed for obtaining information from various sources to support the research.

Sampling: The online questionnaire application was carried out through simple random sampling, in which the female students from the following majors were considered: Civil Engineering, Industrial Engineering, Technical in Civil Engineering and Construction, Database Management and Administration Engineering, Computer Systems and Network Engineering, and Technical in Computer Systems and Network Engineering in face-to-face modality.

Instrument validation: In this study, the instrument was validated at two levels:

a. Content validation through the judgment of experts who determined the relevance of the respective items and to minimize subjectivity.

b. Validation of reliability through the pilot test with 30 students whose results were applied to the Cronbach's Alpha test, obtaining a coefficient of 0.88.

These two criteria ensure that the instrument captures what it is intended to measure.

Data Analysis: The instrument included a total of 17 items with a scale of 0 to 10 in the degrees of satisfaction, defined as follows:

Table 1
Acceptance levels

Level	Rank	Color
Excellent	(8, 10]	
Acceptable	(5, 8]	
Unacceptable	[0, 5]	

3. Discussion of results

For data analysis, averages were used as parameters for each dimension, section, and indicator. The tables by dimension were created in an Excel workbook, one sheet for each one of them, giving way to generate the proper hierarchy of the data in each table, starting with the grouping of the items that make up each indicator, followed by the grouping of the respective indicators that belong to each section and finally the analysis of each section that makes up each of the dimensions. The analysis is presented in the form of a Bullet chart which includes the following elements:

- A standardized scale from 0 to 10.
- Shades of black, light blue and light green; corresponding to unacceptable, acceptable and excellent levels of acceptance, respectively (see table 1).
- A red stripe corresponding to the desirable goal, indicating the level of acceptance of an indicator, section, or dimension according to the perspective of the sample population, which has a value of 8.
- A blue bar indicating the average value of an indicator, section, or dimension, which is analyzed with respect to whether it exceeds the desirable target.

3.1.1. Female representation

The first section to be analyzed is the female representation and was carried out through documentary research by studying the enrollment records of the Universidad Gerardo Barrios (UGB).

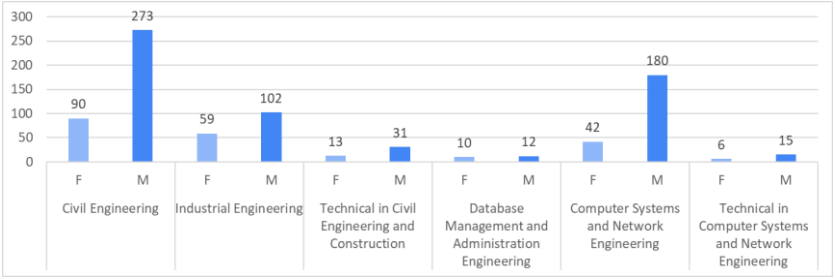

Figure 1 UGB STEM/ICT majors enrollment statistics for the year 2023

Figure 1 shows that female enrollment was higher in the Civil Engineering program and the lowest enrollment was in the Computer Systems and Network Engineering Technician program, it is also observed that the difference in enrollment between men and women is greater in Civil Engineering and the smallest in Database Management Engineering.

3.1.2. Dimension: Inclusive participation

For the Inclusive Participation dimension, a table was used composed of the 141 respondents with the first two indicators belonging to the Academic Experience section, from which the analysis for the dimension is made. An acceptable level of 8 on a scale of 0 to 10 is established.

Table 2 Organization of the Inclusive Participation Dimension

Section	Indicators
Academic experience	Participation in academic and extracurricular activities
	Participation in conferences, seminars or events related to STEM/ICT

Academic experience section

For each indicator, the data obtained based on the collection instrument was averaged. This procedure was carried out in the Excel program, where several tables were created, which allowed the following graph to be generated.

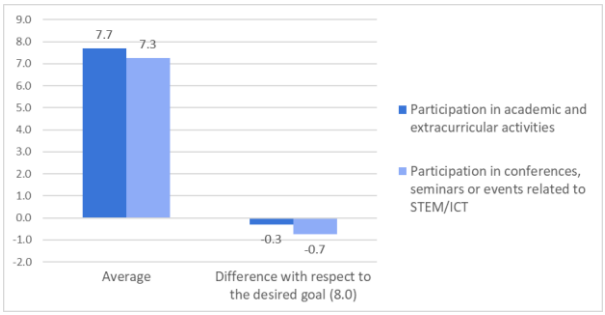

Figure 2 Average results for the academic experience section of the indicators

Figure 3 below shows the result obtained for the section.

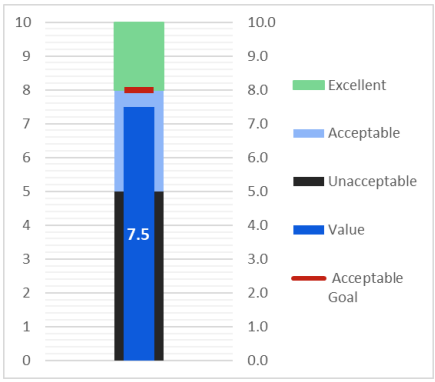

Figure 3 Average results for the Academic experience section of the indicators

According to the previous graph, the perception that the population has regarding the academic experience is 7.5 on a scale of 0 to 10, which means that there is a difference between the score obtained (7.5) with respect to the desired goal (8) thus finding an acceptable level; however, a more detailed analysis (see Figure 2) shows that the differences between the values of each indicator (participation in academic and extracurricular activities and participation in conferences, seminars or events related to STEM/ICT) with respect to the desired goal are -0.3 and -0.7 respectively, thus providing a picture that expresses the perception of students indicating that they have not participated in conferences, seminars or events related to STEM/ICT and that they have not participated in academic and extracurricular activities.

In conclusion, analyzing the 2 indicators belonging to the academic experience section, we obtain the following graph with the summary results of the indicators grouped by section of the Inclusive Participation dimension.

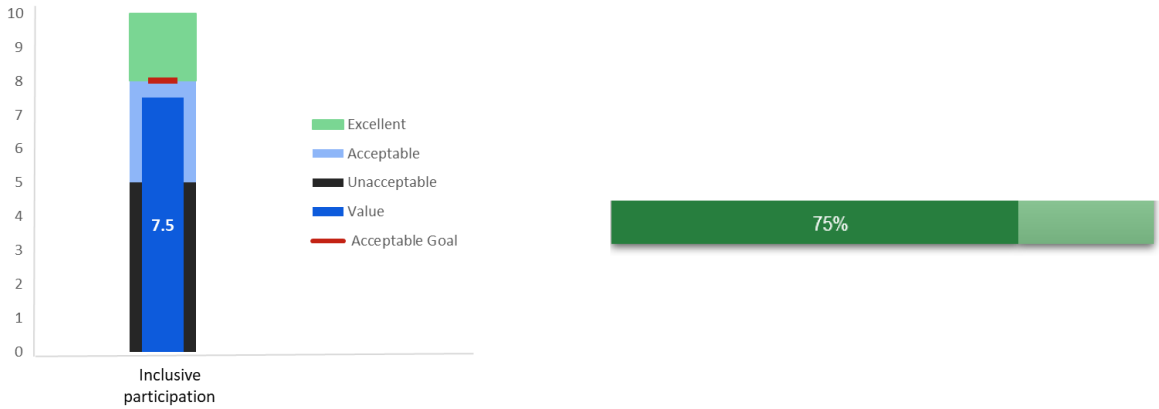

Figure 4 Average results for the inclusive participation dimension

Figure 4 shows that the level of inclusive participation according to the students is 75%, that is 7.5 on a standardized scale from 0 to 10, which is an acceptable level.

3.1.3. Dimension: Support and resources

This dimension uses a table composed of the 141 respondents and indicators 3-10 belonging to the sections: Educational Opportunities and Development and Resources and Technology, from which the dimension analysis is performed. The desired goal is 8 on a scale of 0 to 10.

Table 3 Organization of the Support and Resources Dimension

Section	Indicators
Educational opportunities and development	Access to mentoring programs
	Access to scholarships or financing programs
	Access to exchange programs
	Access to professional development courses or programs
	Advisory services
	Psychosocial support
Resources and technology	Access to the use of laboratories
	Access to technological resources

Educational opportunities and development section

For each indicator, the data obtained from the instrument were averaged through the Excel program, where tables were created, which allowed the following graphs to be generated.

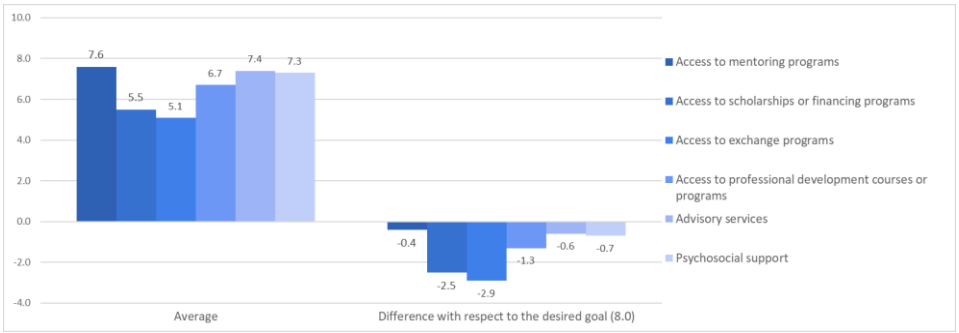

Figure 5 Average of the indicators in the section educational opportunities and development

Figure 6 below shows the result for the level of educational opportunities and development, which was elaborated with the average of the results of each indicator. As previously established, the desired goal is 8.

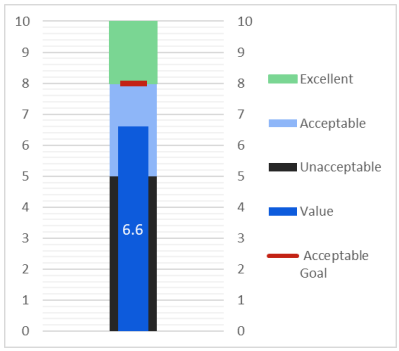

Figure 6 Average results for the Educational opportunities and development section of the indicators

According to the figure above, the population's perception of educational opportunities and development is 6.6 on a scale of 0 to 10, which means that there is a difference of 1.4 between the score obtained (6.6) and the desired goal (8); however, a deeper analysis (see Figure 5) shows that the differences for each indicator (access to tutoring programs, access to scholarships or financing programs, access to exchange programs, access to professional development courses or programs, advisory services and psychosocial support) with respect to the desired goal are -0. 4, -2.5, -2.9, -1.3, -0.6, and -0.7 respectively, thus providing a picture that expresses the perception of students indicating that students have felt that they have not had access to mentoring programs, scholarships, funding programs, exchange programs, courses, professional development programs, advisory services, and psychosocial support.

Resources and Technology section

For each indicator, the data obtained from the instrument were averaged through the Excel program, where tables were created, which allowed the following graphs to be generated.

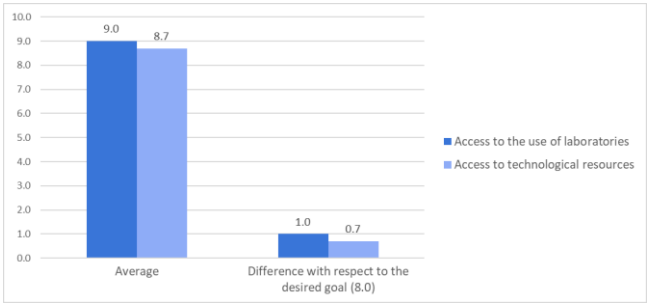

Figure 7 Average results for the resource and technology section of the indicators

Figure 8 below shows the result for the Resources and Technology section, which was elaborated with the average of the results of each indicator pertaining to the section. As previously established, the desired goal is 8.

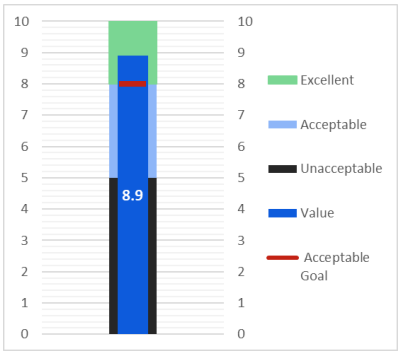

Figure 8 Average results for the Resources and Technology section of the indicators

According to the previous graph, which measures the population's perception of access to resources and technology, the result is 8.9 on a scale of 0 to 10, meaning that it exceeds the desired goal of 8; that is, the female population expresses that they do have access to practice laboratories and technological resources.

In conclusion, analyzing the 8 indicators belonging to the sections of educational development opportunities and resources and technology, the following chart shows the summary of results of the indicators grouped by sections of the dimension Support and resources.

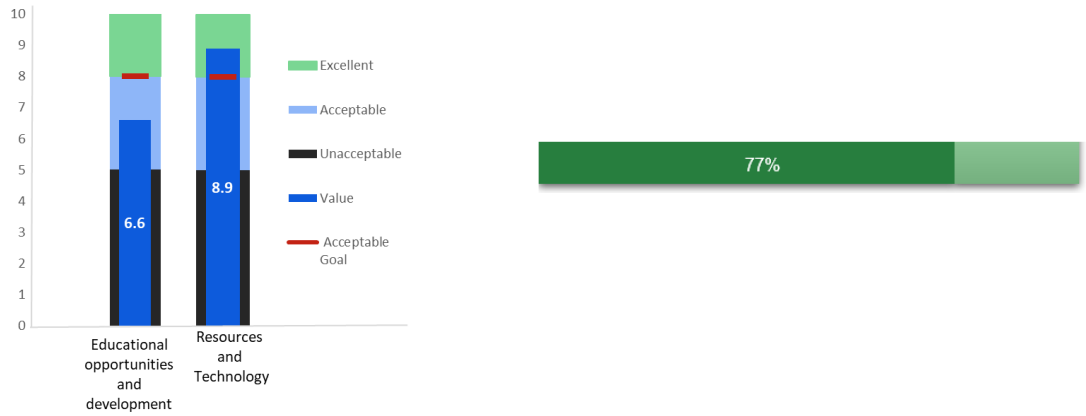

Figure 9 Results of the Support and resources dimension

It can be observed that when comparing the two sections of the support and resources dimension, the section with the highest score is that of resources and technology and the lowest is that of educational opportunities and development; expressing that, in spite of the difficulties in accessing educational opportunities and development, it does not interfere in the student's access to resources and technology in her training process. Overall, in the two indicators, the population perceives that they do have access to support and resources during their training process, thus achieving a level of support and resources of 77%, that is, 7.7 on a normalized scale of 0 to 10, which is an acceptable level.

3.1.4. Dimension: Inclusive culture

For the analysis of this dimension, a table was used composed of the 141 respondents and indicators 11 to 17 belonging to the motivational, personal valuation and inclusive environment sections, from which the analysis is made for the Inclusive Culture dimension. An acceptable level of 8 on a scale of 0 to 10 is established.

Table 4 Organization of the Inclusive Culture Dimension

Section	Indicators
Motivational	Belonging to the class group
	Family support
Personal assessment	Appreciation on the part of teachers and peers
	Appropriation of the student role
Inclusive environment	Freedom of expression
	Freedom from discrimination in the educational environment
	Safety in the educational environment

Motivational section

For each indicator, the data obtained from the instrument were averaged using the Excel program, where tables were created to organize the data and generate the following graphs.

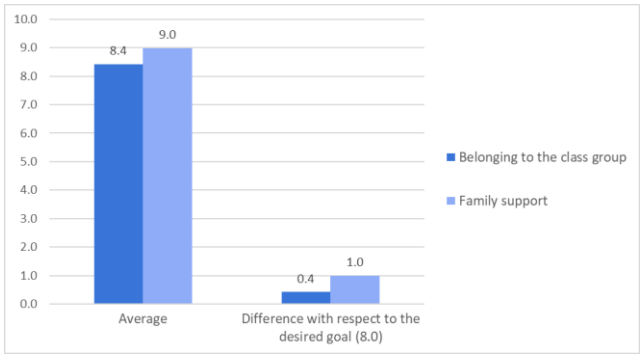

Figure 10 Average results for the motivational section of the indicators

Figure 11 below shows the result for the Motivational section, which was elaborated with the average of the results of each indicator belonging to the section. As previously established, the desired goal is 8.

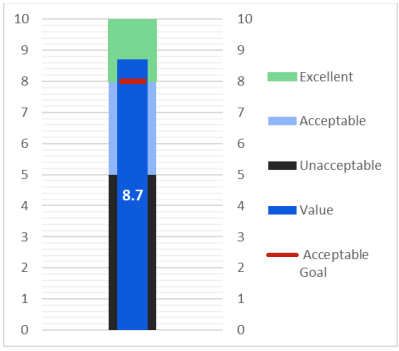

Figure 11 Average of the Motivational section indicators

8.7, which exceeds the desirable goal (8), indicating that from the perspective of the population the students feel that they belong to their study group and feel support from their family nucleus to continue their professional training process.

Personal assessment section

For each indicator, the data obtained from the instrument were averaged through the Excel program, where tables were created, which allowed the following graphs to be generated.

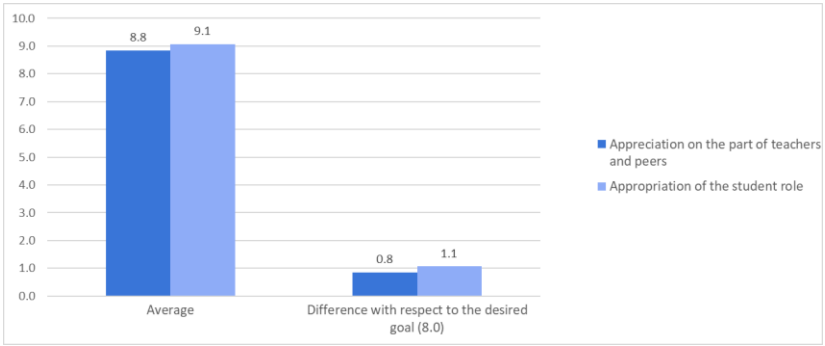

Figure 12 Average results for the personal assessment section of the indicators

Figure 13 below shows the result for personal assessment, which was elaborated with the average of the results of each indicator. As previously established, the desired goal is 8.

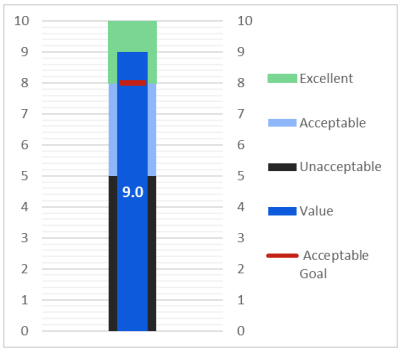

Figure 13 Average for the Personal assessment section of the indicators

According to the graph above, the level of the Personal Assessment section is 9.0, which exceeds the desirable goal (8) indicating that, from the perspective of the population, the students feel valued in their study group by their peers and teachers, and it is also observed that they feel ownership of their role as a student.

Inclusive environment section

For each indicator, the data obtained from the instrument were averaged through the Excel program, where tables were created, which allowed the following graphs to be generated.

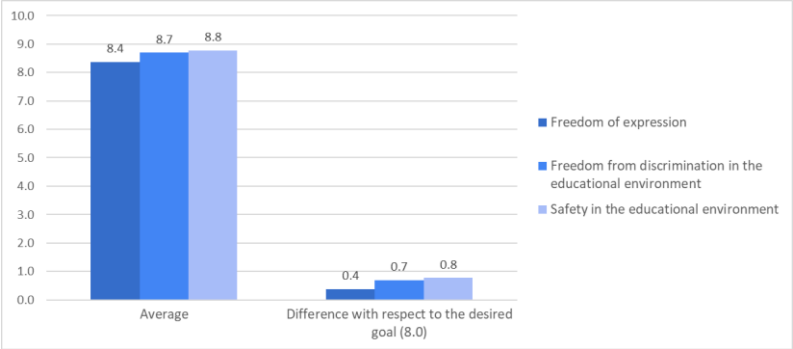

Figure 14 Results of average of the indicators in the inclusive environment section

Continuing with the analysis, Figure 15 shows the result for Inclusive Environment, which was created with the average of the results of each indicator. As previously established, the desired goal is 8.

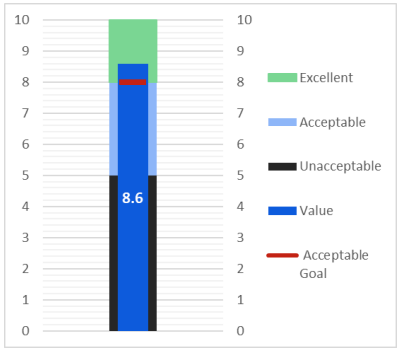

Figure 15 Average of the Inclusive environment section indicators

Figure 15 shows that the level of the Inclusive Environment section obtained is 8.6, which exceeds the desirable goal (8), indicating that, from the perspective of the population, students feel free to express their opinions, free from discrimination and also feel safe in the educational environment.

In conclusion, analyzing the 7 indicators belonging to the motivational, personal valuation and inclusive environment sections, the following graph shows the summary of results of the indicators grouped by sections of the Inclusive Culture dimension.

Figure 16 Inclusive culture dimension results

In Figure 16 it can be observed when comparing the 3 sections of the dimension of Inclusive Culture that the section with the highest level of acceptance is the level of personal valuation and the lowest is the level of inclusive environment; expressing that despite the difficulties that arise in their educational environment it does not interfere in their professional training process.

Analyzing as a whole, the 3 sections exceed the desired goal, and all sections exceed the desired goal, resulting in 87% for the inclusive culture dimension, that is, 8.7 on the normalized scale of 0 to 10.

3.1.5. Summary of acceptance levels

Based on the results obtained, the level of acceptance of each of the dimensions is summarized in the following chart:

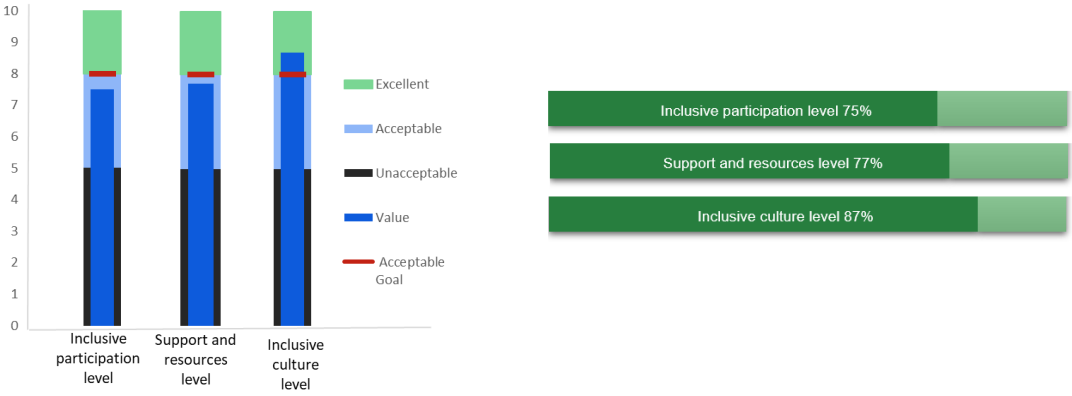

Figure 17 Comparative chart of acceptance level by dimension

As can be seen, the dimension with the best level of acceptance is the inclusive culture and the lowest evaluated is the inclusive participation dimension, being so the level of inclusive participation is acceptable, a strategy is required to strengthen this dimension.

To conclude, the evaluation of the indicators is:

- In the dimension of Inclusive Participation, the indicators evaluated are participation in academic and extracurricular activities, and participation in conferences, seminars or events related to STEM/ICT. The average for participation in academic and extracurricular activities is 7.7, while the average for participation in conferences is 7.3. The results of the evaluation of female students' inclusion in the educational environment show that the overall perception of the respondents in the dimension of inclusive participation is acceptable, with an average of 7.5. However, it is observed that participation in academic and extracurricular activities, as well as in conferences, seminars or events related to STEM/ICT, do not reach the desired goal of 8, indicating that the students have not participated sufficiently in these aspects.

- In the Support and resources dimension, several indicators were evaluated, including access to mentoring programs, scholarships or funding programs, exchange, professional development courses or programs, advisory services, and psychosocial support. The highest average was for access to practice laboratories 9.0, followed by access to technological resources 8.7. The lowest averages correspond to access to exchange programs 5.1 and scholarships or funding programs 5.5. In the Support and Resources dimension, the population perceives that they have access to support and resources during their training process, achieving a level of support and resources of 7.7, which is acceptable.
- In the dimension of Inclusive Culture, the indicators evaluated are motivational, personal valuation and inclusive environment. In the motivational area, belonging to the class group, family support is evaluated with averages of 8.4 and 9.0, personal valuation and appropriation of the student role, with averages of 8.8 and 9.1. In the inclusive environment, freedom of expression, absence of discrimination and safety in the educational environment are evaluated, with averages ranging from 8.4 to 8.8. When analyzing the three sections together, it is concluded that the Inclusive Culture dimension obtained a score of 8.7, which indicates that, in general, the students feel included and valued in their educational environment.

The results suggest that students have an acceptable level of participation in academic and extracurricular activities, but more effort is needed to increase their participation in STEM/ICT related conferences and events. In addition, it is noted that students have access to technological resources and practice labs, which can enhance their educational experience. However, the low averages in access to exchange programs and scholarships or funding programs suggest that more financial support is needed for students. In terms of inclusive culture, the results are encouraging, as high averages are observed in the indicators of motivation, personal assessment, and inclusive environment. This suggests that students feel supported and valued in their educational environment.

4. Conclusions

Based on the evaluated dimensions, it is concluded that:

In terms of inclusive participation and support and resources, an acceptable perception is observed, suggesting that the university has implemented measures to foster inclusion and provide the necessary support to female students. However, areas are still identified where these actions can be strengthened to ensure an even more inclusive educational environment. The dimension of Inclusive Culture showed encouraging results in all sections of the evaluation. This means that students feel integrated, valued and motivated in their educational environment, which is essential for their academic success and personal development. The presence of an inclusive culture at the university demonstrates that values and practices that favor diversity and equal opportunities are being promoted, creating a space in which students can actively participate in their education.

Despite these positive results, the university must continue to focus on improving inclusive participation and educational opportunities for female students, especially in STEM/ICT majors. This could be achieved through the implementation of specific programs that encourage their participation and provide resources and support to address academic challenges. A supportive environment will be key to retaining and increasing female representation in these areas. This can be achieved by encouraging STEM/ICT-related academic and extracurricular activities, enhancing opportunities through tutoring, scholarship and mentoring programs, maintaining and improving access to resources and technology, and continuing to promote an inclusive culture with values of tolerance, respect and diversity in all areas of higher education. Creating an environment in which all female students feel supported and valued in their academic endeavors will be critical to retaining and increasing female representation in STEM/ICT majors.

As follow-up of this study complementary research is expected to assess the long-term impact of the measures taken based on the results of the study and their effect on the retention of female students in STEM/ICT majors, as well as their success in the subsequent job field. These data would be valuable for adjusting inclusion strategies and for sharing best practices with other educational institutions seeking to improve diversity in their academic programs.

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