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GENDER BIAS IN CHOOSING STEM STUDIES

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Abstract

The gender bias in STEM exists, and this work intends to make this reality visible. The principal objectives of the study are to reduce the gender gap in STEM studies and learn about experiences lived around the STEM field reported by women. For this, a qualitative research method has been created in the form of an interview, which helps us answer the questions raised from the life stories told by the fourteen girls and women interviewed, all of them belonging to different age ranges, to be able to observe and analyze gender bias when choosing STEM studies. The data resulting from the research are the least bleak in the framework of the development of gender equality. A minimum change could be expected. However, the changes we observe are specific. We must remember that most of the participants have alluded to society and culture to explain the bias. The generational shift that is observed through the interviews is minimal. Although the educational administrations seek absolute equality and promotion of research and development of ICT among

girls and adolescents, we must make visible that these actions need a more significant effort to be part of the educational community.

Keywords

Gender Bias, STEM, Generational Change, Education, Vocation

1. Introduction

Women´s education has undergone significant changes throughout history. It is surprising how in a few decades. They have gone from receiving specific classes in sewing and housework at school, aimed only at girls, to having a wide range of possibilities open. However, it is very prevalent for women to have degrees such as medicine, teaching, nursing, or psychology, a situation that is invested in careers such as computer science, INEF, or engineering, where men score much higher than women. Female students (Martínez et al., 2016; Gonzalez-pérez et al., 2021), could be the reflection of the history of women, who have been seen as the perfect caregivers and educators in contrast to the "characteristic" skills of men. For this reason, we think that the vocation comes as standard. It doesn't seem like a negative seen in this way, it shouldn't be a negative that we have that virtue, but there are several reasons why this does not benefit us. On the one hand, what role does man play in something so essential for life such as care and education, not only of sons and daughters but of all the people around him? And on the other, this stereotype makes Let's see our future possibilities in the STEM world as something distant or brave women even. Although the academic results of men and women in STEM are increasingly similar, the presence of women in studies and professions linked to some STEM fields is still very scarce (Sáinz, 2017; Vinni-Laakso et al., 2019).

Undoubtedly, the gender gap continues to exist in STEM careers. One of the questions that education professionals must ask ourselves in this regard is what are the reasons why this bias continues to be perpetuated (Reinking & Martin, 2018; Wang & Degol, 2017).), what motivations and what barriers women have had in recent years to keep it that way and to know if a change is happening and what are the reasons that drive it if the generations to come are aware that their possibilities are very wide or because on the contrary, they continue to perceive social limitations when choosing careers, ignoring stereotypes.

We consider that to eradicate a problem the first thing is to know its causes, so these questions that are proposed help us to know a small part of the problem, which is why this work

is directed towards the knowledge of those motivations and/or limitations, both of women who have completed STEM careers, and adolescents who are in the process of election.

The term STEM refers to the acronym in English of the words Science, Technology, Engineering, and Mathematics. This concept has been increasing its relevance in recent years since with it we can refer to both scientific-technological disciplines, as well as an educational field about the set of knowledge and skills (López et al., 2020; Wang et al., 2017). That is why the increase in the use of new technologies both in education and the workplace implies that increasing demand for STEM-based education.

However, this term was not concluded, but it was Georgette Yakman who suggested improving. It is that, in the author's opinion, By studying the common factors of teaching and learning in all STEM disciplines, it was difficult not to include the influences of the artistic disciplines, in this way, it is how the term STE@M arises, to make it more integrative and not in a multidisciplinary way, since what this new concept intends is that all branches that complete it have a connecting link, we can easily interpret it with the author's description: STE@M refers to science and technology interpreted through engineering and the arts, all based on mathematical elements (Yakman, 2010).

An essential source of knowledge and visibility for the gender gap in STEM and to minimize it are the projects, programs, and campaigns that are carried out both in educational centers and in social entities. There are many interesting ones to know. Below, several that are considered of interest will be highlighted.

At the local level, the University of Valencia has created a project called Girls4stem (Girls4stem, 2021) to promote STEM education, mainly among the female gender, especially in the pre-university academic stage, the stages from primary to high school and training cycles. The primary resource used is outreach activities.

The activities carried out by the so-called “STEM Experts” are focused on dissemination, and for this, they have two types of talks:

- Family talks: The educational centers must first register as participants, and later interviews are arranged according to their interests. STEM experts participate in this type of talk, along with the center´s students, families, and teachers.

Talks professional: these talks are aimed at adult audiences, especially the education sector, as teachers and professionals in the center.

On the other hand, from the official website of the Ministry of Education and Vocational Training, several programs and initiatives related to the objective are available. It is of interest to make a brief description of some of these.

UNESCO (2019) created the Report on the education of girls and women in science, technology, engineering, and mathematics, which comes to information about education in STEM disciplines and its relationship with the 2030 agenda for Sustainable Development, therefore, considers that this agenda requires the development of transformative thinking and skills that lead to the progress of innovation and creativity. For this reason, and to achieve the objectives, the guarantee of equal access to STEM qualifications is included, and access to employment.

From the Ministry of Economy and Business of the Government of Spain, the White Paper on women in the technological field was developed in 2019 (Mateos & Gómez, 2019) whose main objectives are two: on the one hand, it is intended to give visibility to the gender gap in the technology sector, and on the other, the generation of proposals that facilitate the reduction of the digital gender gap. Throughout five chapters, this book covers exciting topics about the gender gap in technology, which start from a contextualization, an analysis of the influence of gender stereotypes and how social factors influence them. It also provides contrasted information about the employment situation of women in the digital sector, presents a case study about women in the "gamer" world, and finally reports on how gender biases are still valid in the technological field despite science being shown as a neutral field.

For its part, the CSIC (Higher Council for Scientific Research) proposes an interesting project called "The CSIC at school," which received in 2016 the National Education Award for the Promotion of Scientific and Humanistic Vocations and Artistic.

Finally, at the international level, it is worth describing an important non-profit organization called "STEM for Her" located in Washington DC, whose main objective is based on the promotion of education to create awareness and enthusiasm in girls and young women so that they can have successful careers related to STEM but also acts as a facilitator of resources, starting with the creation of scholarships and grants for the study of STEM.

STEM for Her has helped thousands of girls and young women to achieve their goals and learn about their opportunities in the field of STEM, and it is considered an organization committed to continuing to grow. The objectives pursued in this work are the following.

- To reduce the gender gap in STEM studies.

- To learn about experiences lived around the STEM field reported by women.
- To find out the factors and motivations that women have had over the years for immersion in STEM degrees, check if there are significant differences regarding gender stereotypes in STEM degrees with generational change.

2. Methodology

One of the main specific objectives of the research is to know the reasons and possibilities that women have when choosing degrees in Engineering, Technology, and Mathematics, and thanks to the information obtained, to know qualitatively if there are differences concerning the generational difference of the different female components of the sample. For this reason, and since it is necessary to investigate the opinions and life experiences of the people who represent the chosen sample, the research will be carried out through a qualitative study of these opinions and experiences, through interviews of own elaboration, and validated by a committee of experts. *"The qualitative interview is a key way to explore how subjects experience and understand their world. It provides unique access to the lived world of the subjects, who describe in their own words their activities, experiences, and opinions"* (Kvale, 2008).

2.1. Design of Research

Our interest in knowing the experiences described by the interviewees themselves leads us to decide that the interview is the most suitable research method. Thus, as Kvale (2008) explains, I try to access that "Lived world of the subjects."

According to the classification of the different types of interviews carried out by Gil (2011), in general, the interviews can be structured, unstructured, and group, and within these, in the second-mentioned typology is the ethnographic interview characterized by its Conversational nature, which is considered more appropriate for this research since this methodology allows adding comments, questions, or auxiliary explanations to find the answer that best suits the purpose.

2.2. Population

A total of 14 women, aged between 17 and 52, participated in the research (table 1).
The sample has been chosen under the criteria of having studied or planning to study a type of engineering, technology, or mathematics. However, contact with women with degrees in technology has not been possible. Therefore, the final degrees are engineering and mathematics.

The distribution of the sample is as follows:

Table 1: *Sample Distribution*

Interview No.	Age	They Are Going to Study	Have studied	Title	University
1	18	X		Industrial Engineering	University of Zaragoza (UNIZA)
2	23		X	Math	University of Valencia (UV)
3	45		X	Agricultural Technical Engineering	Polytechnic University of Valencia (PUV)
4	17	X		Engineering of Design Industrial	UNIZA
5	25		X	Biomedical Engineering	PUV
6	18	X		Biomedical Engineering	PUV
7	52		X	Industrial Engineering	PUV
8	46		X	Mechanical Industrial Engineering	PUV
9	31		X	Mechanical Industrial Engineering	PUV
10	46		X	Industrial Engineering	PUV
11	42		X	Mechanical Industrial Engineering	PUV
12	26		X	Engineering of Design Industrial	UNIZA
13	25		X	Multimedia Engineering	UV

14	36		X	Mechanical Industrial Engineering	UNIZA

(Source: Self)

The respective age ranges for the different educational laws in the pre-university stage are as follows:

Table 2: *Age Ranges*

Group	Range of age	No. of women
1	52	1
2	36 - 46	5
3	23 - 31	5
4	17 - 18	3

(Source: Self)

2.3. Interview Validation

To corroborate the instrument´s validity, we have had the collaboration of four professionals, who have adjusted and corrected the first interview model. Thus, the final model is corrected according to the first model´s constructive criticism.

This validation also allows the interview´s structure, language, and composition to be understood for the people who make up the sample and those who read the research.

2.4. Design of The Results Matrix and Composition of Results

For the writing of results, the methodology consists of generating a matrix, where the categories that have been designed for the investigation are established.

The matrix is made up of a table divided into four differentiated categories made up of different subcategories, all of which are directly related to the objectives of this research so that the categories refer to the objectives and the subcategories are related to the questions asked in the interviews.

The matrix and its sections are distributed as follows:

Category I: Knowledge of the term STEM and participation in its promotion Knowledge of the term participation in STEM programs.

Category II: Pre-university experience factors influencing the decision to study STEM Prior educational orientation pressures from the environment.

Category III: Gender bias in STEM settings differences between the number of men and women (Only for groups of 1 to 3) opinions on significant differences (Only for groups of 1 to 3), criticisms, and comments received by the environment Influence of gender on the ability to succeed in STEM existence of a glass ceiling in STEM and work experience.

Category IV: Satisfaction with the degree Satisfaction with the chosen degree.

3. Results

The categories correspond to the different sets of information, the responses received by the interviewees correspond to each subcategory. Except in the case of group No. 1 (table 3), to which only one woman belongs, and therefore the answers are unique, the subcategories are broken down according to the number of interviews carried out in said group and the number of interviews as a reference.

Table 3: *Group 1*

Group	Range of age	No. of women
1	52	1

(Source: Self)

She is knowledgeable about STEM and actively promotes it from a gender perspective. The decision to opt for a STEM degree was her own, driven by the need to have a job and not memorize studies.

During the career, there was a significant difference between the number of men and women, because of the self-limitation of women and the established social roles. She is unaware of having received criticism and considers herself capable of success in STEM regardless of gender.

There is a glass ceiling, and she considers that it shows in the data and the management positions. However, she feels satisfied with the degree she chose.

Table 4. *Group 2*

Group	Range of age	No. of women
2	36 - 46	5

(Source: Self)

There is ignorance about the term STEM. Two of them (table 4) know it, but there is hardly any participation in programs that promote their knowledge from a gender perspective or at a general level.

They have been influenced to study STEM by job opportunities and a taste for science, one of which had direct parental influence. The previous orientation has not had a significant impact since they have it occasionally, or the received has not been considered great help. The pressure received for the choice of another degree has arisen in two of the stories. However, neither of them decided to change.

There are significant differences in all cases in terms of the number of men and women in the university, the number of women constantly being smaller. However, it is a difference that varies depending on the year of study or the specialty taken. The ignorance of certain degrees causes the differences, and the little promotion of these towards women, by culture, and by tendency. However, they do not consider that there is an influence of gender in the capacity for success and the criticisms or comments received by the environment have been scarce or consider that it has been positive.

Most of them consider a glass ceiling in STEM and all sectors, one of them does not perceive it personally and thinks it may be due to probability. They are all satisfied with the choice, although it was not their first choice in some cases.

Table 4: *Group 3*

Group	Range of age	No. of women
3	23 - 31	5

(Source: Self)

Three of the interviewees know the terminology (Table 4), only one has actively participated in its promotion. They are aware of talks or events they have not experienced on other occasions.

The decision to study STEM has been her own. In two cases, they have been driven by family influence, and in one of them, she was guided by the teachers. None of them have received direct pressure to study another career or choose this one but to choose a more formalized education.

The difference between men and women is varied depending on the degree. At the same time, in mathematics and design engineering, the number is equal, and in more technological

engineering, the gender bias is more pronounced. Still, all of them have received comments regarding their studies and gender. They consider that people are usually surprised. But none have perceived direct gender-related influence in pursuing a STEM degree.

There is no satisfaction with the choice on a single occasion, but she is satisfied with the physics career she did later.

Table 5: *Group 4*

Group	Range of age	No. of women
4	17 - 18	3

(Source: Self)

There is total ignorance about the term STEM (table 5). The institutes have held an event on Women's Day, but they do not relate it.

The influence is related to the taste for specific subjects. The information received for the career choice has been through talks, both by the professionals of the educational center and by students at the universities. Only on one occasion has there been some pressure from the parents to change the degree. However, the interviewee did not consider it vital. They accepted the decision of the engineering choice.

They have not received criticism regarding the choice and gender, but they have perceived a quantitative difference between boys and girls already in their classes and visits to the faculty. However, they do not consider that the ability to do the degree is influenced by gender.

As for the glass ceiling, they are aware that it exists, although it is not due to personal perception since none of them have yet been exercised. Despite this, they are satisfied with the choice they have made.

Regarding the generational difference, it can be observed that the girls belonging to this group had greater knowledge about the different degrees of engineering to which they can choose, at least that is how it has been perceived throughout the interviews since they appeared a broader notion about the subject of engineering, something that has not been seen in previous stages, or that they should be informed. However, we must consider the progress of information sources and the ease students have today to access them in a particular way. On the other hand, we must bear in mind that the girls agree that the help has been through the experiences of former students.

About bias, we do not have information on the classrooms of the grade. However, they do make the significant difference between boys and girls noticeable already in high school, the

number of boys always being very high, which is why we can affirm that in this sense, the gender gap continues to exist since high school.

4. Conclusions

The results obtained through the research give us a generalized idea of the knowledge about STEM in the sample and what interests us most. Check if there is a generational difference both in the knowledge and perception of the gender bias belonging to STEM degrees.

In a general way, the matrix has been helpful for the breakdown of the information and to make the differences or similarities to the generational change more visible so that comparisons can be made automatically. Considering this aspect, we can verify that there are not very noticeable differences in any of the categories.

Regarding category I, Knowledge of the term STEM and its promotion, we can observe in the first subcategory the fact that the knowledge of the term is null in the third group and considering that the girls belonging to this They are those that are in high school, it lets us know that it is a term whose knowledge appears in later stages, in higher education.

The second category, experience before university, highlights a minimal generational change in terms of the girls' knowledge regarding the different options for university careers before their choice, the knowledge is less in the first groups, however in what specifically We know as pre-university educational orientation, all of them have been participants in talks and/or psychological tests, but it was groups 1 and 2 that indicated that they obtained a book on the different university careers to expand their knowledge in this regard, somewhat This does not happen in later stages, possibly due to the increase in the use of ICTs or because the information received from institutes and/or universities has been more extensive. On the other hand, regarding the factors influencing decision-making, we cannot observe any generational change. In most cases, they refer to the taste for science or specific subjects, except for particular circumstances in which the family.

The category referring to gender bias in STEM contains the most objective and alarming data, since the numerical difference between men and women in STEM, specifically in technological engineering degrees, continues to be alarming until the last group, we can see that already in high school the bias is very large.

One of the aspects that draw attention in this category is the way of dealing with the criticism or comments received since, on several occasions, the words are in the form of astonishment. However, several consider that this is not a good thing for them. On the contrary, a woman shows that it is still something unusual and reflects that we need more "courage" to face it. On other occasions, the astonishing comments have not experienced criticism in the interviewees, something that can attend to several cases, being that the scarcity of critical vision with gender perspective originated by lack of experience.

To conclude with the general analysis regarding the categories and generational change, we discuss satisfaction with the chosen degree, which does not cause generational differences. Still, we must bear in mind that it was not expected, but rather that the question was trying to find out if the gender bias causes some dissatisfaction for women´s experience in STEM. We can verify that this is not the case and that except on one occasion, the rest of the girls have shown total or almost satisfaction total in some cases.

To find out what are the barriers generated by the stereotypes that women whose academic objective is based on STEM studies have suffered and suffer, we have mainly based on category II: previous university experience, we can conclude that it is mainly due to the lack of information, or the cultural belief that women tend to carry out studies related to health or teaching, that is why several of the women, but to a greater extent in the first groups, the barrier is based on the disinformation.

Finally, to find out the knowledge that the people in the sample have regarding the STEM concept and considering the information received, the analysis shows that there are cases of ignorance of the terminology in groups 2, 3, and 4, but calls especially pay attention to the total ignorance of group 4, which may refer to the fact that they have not yet completed higher education. However, it is not considered a justification since they study the baccalaureate of science/technology. It would be convenient for it to involve knowledge of STEM terminology and gender bias in degrees.

The data resulting from the research are the least bleak in the context of the development of gender equality. A minimum change could be expected. However, the changes we observe are specific. We can lean the most to consider that work should continue to eradicate the gender gap in quantitative data, although it is not encouraging that the percentage of women in engineering degrees has not changed at all in recent years. We must bear in mind that most of the participants

have alluded to society and culture to explain the bias and that it will only be thanks to the progress that a total inclusion of women in science and technology will be achieved (González-Pérez, Mateos de Cabo & Sáinz, 2020; Beasley & Fischer, 2012).

On the other hand, it was expected to find more unique STEM programs in younger age groups since the educational field promotes immersion in research and technology. However, we have found that participation is minimal apart from the fact that they do not know the terminology. In some cases, specific events are discussed on women's day.

In conclusion, the data obtained can only push us to continue making the gender gap visible, so that primary and secondary school students can carry out any study that not only has to do with health and education, that life presents them all the possibilities without any type of filter and are motivated to free choice, which should not appear only at this point, but from birth, freely choosing if they want to play with cars, get their hands dirty or even not be pushed To be the only ones in charge of family maintenance, only in this way will we break stereotypes, and with it, hopefully also, that glass ceiling that everyone has experienced and that forces us to stay in lower positions in any sector, not only in STEM.

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