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Women in Computing:
Attitudes and Experiences

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ABSTRACT

This paper presents research in progress about the attitudes and experiences of women in computing. The study was conducted within female students, aged between 16 and 25 years old, and teachers in high schools and universities. A survey was also presented to professional women in the computer science area. The questionnaire was prepared with 18 questions concerning general information about the motivation to choose computer sciences and computing/informatics as a thematic area to be followed at university level; the context they had at home using a computer; the use by other family members; the influences they had to use a computer, either at home or in other places; and their thoughts about computing. To complement the data gathered, semi-structured interviews were designed. The conclusions were that the number of females in computer science studies are increasing comparing to male positions; however, more work should be done to improve their motivation. The main contribution of this paper is the testimony of the Portuguese situation concerning the topic.

KEYWORDS

Computer Sciences/Informatics, Gender, Grounded Theory Methodology, Women in Computing

1. INTRODUCTION

In this paper, authors use the terms computer science, computing, informatics and information technologies indistinctly, i.e. the goal is to talk about the reasons to ingress in a degree where computers are the main study tool and to understand the reasons for unbalanced number of men and women studying and working in the area.

Technology has been a 'thing of men'. The majority of names associated to technology are from men. But, in the beginning of the 1980´s, women started to have a great expression for programming. However, the number of women in informatics diminished towards the end of this decade. There are no concrete answers to this situation but some events probably contributed for it. For example, personal computers were used as entertainment for games played by men. Jan Margolis (1990) interviewed female and male computer science students about their experiences studying computer science at Carnegie Mellon University. Margolis (1990) concluded that families offered more computers to boys than to girls. So, girls when arrived at the university, they did not had previous contact with computers.

The literature about women in Computer Sciences (CS) in several countries, along decades, presents a colorless image, and according to current data it continues to do so. The question we pose is: "Are women really interested in computer science?" According to statistics' results, little progress

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in the participation of women in computing, is presented; this in spite of numerous studies, reports and recommendations on the topic. The reasons for the situation remain clearly unidentified. However, we do not believe that the situation is that enigmatic. Indeed, women are moving in computer science in some cultures and environments.

This paper is organized in six sections: introduction, related studies, the study, methodologies and methods and before conclusions, discussion and results are presented. Since the paper reports a work in progress study, authors gave a considerable importance to the methodologies and methods section, which is the most extended, to explain how the data was gathered and analyzed and why the results, although expressive, are not yet auto justified clearly.

This paper presents the use of mixed methods research. Mixed methods are generally used when we consider the use of both quantitative and qualitative techniques (Creswell 2014). According to Johnson (2004) mixed research deals with compatibility and pragmatism. The idea is that quantitative and qualitative methods are compatible: "researchers should use the approach or mixture of approaches that works the best in a real world situation". Qualitative research is more subjective, based on smaller, targeted sample sizes, and is concerned more with how and why questions. (Saffer, 2010) Quantitative research, on the other hand, is often about large, random, statistically significant sample sizes and is designed to answer what questions. The quantitative methods permitted to obtain numerical data concerning, for example, in general, the number of prospective users for our applications, the number of those that were used with similar applications, the tendency of use, etc. Both qualitative and quantitative research, in combination, provided a better understanding of the research problem.

2. RELATED STUDIES

Historically, it is known that women had an important role in computing. History lessons on computer science narrate that women were the first software engineers until men actively pushed them out. Ada Lovelace in 1843 became the first computer programmer by designing the first computer algorithm. Hedy Lamarr invented the frequency-hopping technology, which was important to the invention of wireless signals. In 1952, Rear Hopper created one of the world's first compilers. Adele Goldberg was one of the seven programmers that developed Smalltalk in the 1970's among others.

Several countries have been wounded with this subject and have tried to study the contexts and reasons for the unbalance between men and women studying and working in the field. Nancy Leveson, associate professor of information and computer science at the University of California at Irvine, reported (in Women and Computer Science report) that in 1986, women earned only 12% of computer science doctorates compared to 30% of all doctorates awarded to women in the sciences. Frenkel (1990) considered that there are disproportionately low numbers of women in academic computer science and in the computer industry. The situation may be perpetuated for several generations since studies show that girls from grade school to high school are losing interest in computing. Kick and Wells (1993) did a research study to justify the declining enrollment of women in computer sciences programs. The Kick's evidence indicated that women possessed innate abilities to excel professionally in computer science-related fields. The results showed that women are becoming a more significant force in higher education, as well as, as working professionals in computer science.

Other studies revealed that women seemed to be playing an increasingly insignificant role in computer science programs in colleges and universities in the United States. Much has been written about the small percentage of undergraduate women in computer science in the U.S. during the past twenty years, and of the resistance of that percentage to change (Camp, 1997; Randal 2003).

Valpin (2002) described in a paper the participation of women in computing in more than 30 countries, by focusing on participation at undergraduate level. The author was interested on how societal and cultural factors might affect women's participation. Statistics from many different sources showed that participation was low – most countries fell in the 10-40% range with a few below 10% and few above 40%. Female undergraduates are interested in computer science not so much for computers but rather for how they can be used for problem solving. According to Fisher and Margolis, women and men have different motivations for studying computer science (Fisher et al 2002).

The history in Australia is not far different from the history in other countries. Zagami et al. (2015) stated that the numbers of women participating in many STEM areas (Science, Technology, Engineering, Arts, and Mathematics) has been steadily increasing, and in some areas achieving parity. The number of women participating in Computer Science has continued to steadily decrease. US workforce statistics show a peak of almost 40% in the mid 80's, to less than 30% in 1995, and less than 20% in 2015 (National Science Foundation, 2015). Meanwhile, the US National Science Board (2012) reported female participation in Computer Science declining to 18% in 2012 from a 37% peak in the mid 80's. While in Australia, only 2.8% of girls compared to 16.3% of boys contemplate pursuing careers in engineering or computing (OECD, 2015), just17% female participation. Table 1 presents some summarized findings from different authors 'studies.

Table 1. Summary

Authors	Findings
Kick et al (1993)	Women possess innate abilities in Computer Science
Camp (1997)/ Randal (2003)	Small percentage of Women in Computing
Valpin (2002)	Societal and Cultural facts that affect Women's participation – 40%
Fisher (2002)	Women and man have different motivations for studying Computer Sciences
Zagami et al. (2015)	In Australia only 2,8% of girls and 16,3 of boys pursue careers in Computing
Salomi (2016)	25% Computer Science jobs for women
Deloitte (2016)	Fewer than 25% of IT jobs held by women
Lopes (2017)	Higher level of males vs females in Computer Science; Women have interest in Computer Sciences; this is an area in evolution; it is a male field; there are some stereotypes (nerd); no benefits for being women in CS; CS has high level of employment....

In spite of these studies, a question still arises: why is there a decline in the proportion of women in computer science programs when there is an increase in the proportion of women as working professionals?

Side by side with universities there are professional associations that are concerned with the unbalance between men and women in computer science professions. Recently, IEEE Computer Society starts recognizing the women contributions to the computing profession. The same was made by ACM (Association for Computing Machinery), which supports, celebrates, and advocates internationally for the full engagement of women in all aspects of the computing field.

In Portugal, the Women in Technology (WIT) group, which is part of the Microsoft Partner Network (IAMCP), was established in 2016. It is a "community of dynamic, creative women committed to the Microsoft ecosystem for the purpose of promoting mutual personal and professional goals in order to attract women to the area of Information Technology (IT)". The organization contributes "in this way to the diversity of gender, age and training of IT professionals in Portugal". The goal is to grow by integrating "high profile" profiles, including corporate CEOs, university professors, lawyers, all linked to the IT area". Microsoft Portugal has created the challenge for more women to pursue careers in information technology. At Microsoft Portugal, 50% of executive directors are women, as women represent 31% of people managers. Portugal is integrated on the Western Europe region, where there are 12 markets, 7 of which are led by women.

'Do it, girls!' is a Portuguese program organized by Microsoft whose aims are to empower the next generation of women with the knowledge and resources to become more innovative in a world where technology is present in every aspect of life, demonstrating that this is an industry that offers numerous opportunities that go far beyond the more technical professions. The initiative is committed to uplifting the achievements of innovative women who have been pursuing a career in this industry in an event that features roundtables with successful women with careers in the world of technology and digital.

According to our research, we did not find qualitative studies, in Portugal, concerning the role of women in computing. The one we found focuses on the Gender equality in politics in Portugal: Evolution of women's participation and impact of the Law of Parity. In this study, authors concluded that it is true that there exists a presence of structural gender inequalities in politics, and that the Parity Law is necessary but not sufficient condition for correcting the disparity between men and women in political power.

In Deloitte Global, by Salomi (2016) it was expected that by the end of 2016 fewer than 25 percent of information technology (IT) jobs in developed countries would be held by women, i.e. women working in IT roles. The arguments in this study was that: getting more girls and young women into streams that will lead to careers in IT will likely be difficult. To improve gender parity in STEM (Science, Technology, Engineering and Mathematics) at levels of the education pipeline, it may take the time for those improvements to translate into IT job parity.

Our study seems to be pioneer in Portugal, and although it is a pilot study, we are engaged in applying the survey to a substantial number of participants, either in high schools and universities or in Information Technology (IT) companies, to arrive to more unambiguous reasons that justify the unbalanced number of women vs. men in computer science degrees, and working in computer science area.

3. THE STUDY

The study was conducted within female students (aged between 16 and 25 years old) and teachers at high schools and universities. In a second research stage, women working in computer science field were questioning. The research question to be answered was "What makes a female student get into computer science studies and working in this field?"

We did three types of studies: one was made with teachers and female students in the same high school; the other study was conducted in different academic institutions: high schools and universities and finally we questioning women working in the field. The data was obtained through questionnaires and interviews.

We designed a questionnaire, which was available through Google Forms. High schools were invited to disseminate the questionnaire along female students and teachers in computer science/ informatics field. Four sections composed the questionnaire: section one - background questions (Did you grow up with a computer in the house? Who used it most? Do you have your own computer? When did you get it? When and how did you first get interested in computers and computing? Why did you decide to major in Computer Science? Who was most influential in your decision to major in CS?); section two - questions concerning the computer science female students characteristics; in section three we posed questions about female students' interests in computer science and finally, section four - questions about their thoughts on computer science.

The general context section aims to raise awareness of what has aroused people's interest in information technology. The second section aimed to characterize computer science female students, their position, first impressions about computer sciences and stereotypes. The next section took away thoughts about the person's school journey. The last section, aimed to draw conclusions about diversity in the area.

Participants were informed that the survey responses would be strictly confidential and data from the research would be reported only in aggregate. The participation was voluntary and they were free to stop at any point. The survey took approximately 10 minutes to complete. The answers aimed to inform the researcher about student attitudes, experiences, and about the computer science context. In order to complement data from survey, we designed semi-structured interviews. These interviews were to obtain complementary information, and the content was the same for teachers and students with adequate changes. The main difference between those questions was on the content of the second set (women and their position about computer sciences). For the first case (teachers), we wanted to know their relationships and professional experience. For students, we wanted to know the type of students who followed an informatics carrier thinking on professional opportunities. An example of the questions for female students can be understood from table 2.

Table 2. Questionnaire organization

	Questions	Results
Background	How did the interest in computer sciences come about?	With my first computer Recently Since I was young Curiosity Challenge
	Did anyone inspire you to arouse this interest?	My parents No My brother My best friend
Computer Science Students	What type of students are more predisposed to pursue a career in computer science?	Persistence to learn Good Programmer Intelligence Be fun of computers
	Students follow the field of computer science for professional output?	Yes For Socio Economic reasons
Computer Science Thoughts	Do you believe that women are discouraged from getting in the computer science area?	No Multidisciplinarity Market Demand More freedom to find a job Networking Constant learning
	In your opinion, what is the positive side of having a career in computer science?	
Diversity in Computer Sciences	Despite the computer science market's grow, why there is still a small number of women on it?	Lack of interest Health and Arts are more fashion
	What are the best forms of actions or attitudes that professionals, schools and companies can take to accelerate the integration of women in the area?	Greater interest by women Schools should foster a taste for computers earlier Greater dissemination about professional careers

4. METHODOLOGIES AND METHODS

Surveys and interviews were the used methods in this study. In survey research, the researcher selects a sample of respondents from a population and directs a standardized questionnaire to them. In this study, the goals of the conducted surveys were the measurement and categorization of attitudes or the collection of self-reported data that could help track or discover important issues to address on the motivation of women to get involved in computer science world.

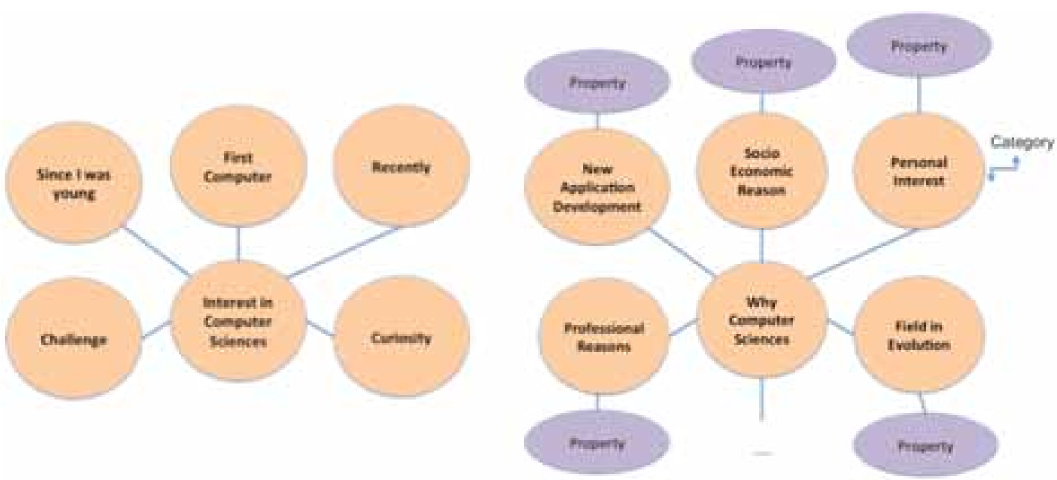
Grounded Theory Methodology (GTM) was used as a general method to use on any kind or combination of data, and it is particularly useful with qualitative data (Glaser 1998) (Denzin 1994), which argues that GT is only one of several different qualitative research methods available to those conducting exploratory research. The basic idea of the grounded theory approach is to read (and re-read) a textual database or observations of behavior, such as interactions and label variables (called categories, concepts and properties) and their interrelationships. The GT approach, particularly the way Strauss develops it, consists of a set of steps whose careful execution is thought to "guarantee" a good theory as the outcome. It involves two phases in the analysis of qualitative data. Data fragments are compared in order to derive general descriptors (concepts; categories), which catch their analytically relevant properties. The second phase is used to elaborate, refine and reduce results of the first phase.

The qualitative data was analyzed by NVIVO, which is software that supports qualitative and mixed methods research. It lets us collect, organize and analyze content from interviews, focus group discussions, surveys, audio and social media data as well as YouTube videos and web pages. To analyze the quantitative data GNU PSPP was used, which is a program for statistical analysis of sampled data.

A questionnaire was designed with eighteen questions concerning general information about the motivation to choose information sciences, and computing as a thematic area to be followed at university level. Then, we were interested to know the context at home using a computer, as well as, its use by other family members. Other questions were about the influences to use a computer, either at home or in other places. Finally, we had questions to get female thoughts about computing. To complement the data gathered we designed semi-structured interviews to obtain qualitative data. Interviews permitted, by asking questions that explore a wide range of concerns about a problem, to give interviewees the freedom to provide detailed responses. Interviews were used to follow the survey and complement data gathered. When the interviews were concluded a new phase arose: the data transcription and analysis. From that moment, different codes were defined to give rise to several categories (Figure 1). Each circle is a category and each category has properties. From here we got to the main concepts found on data analysis.

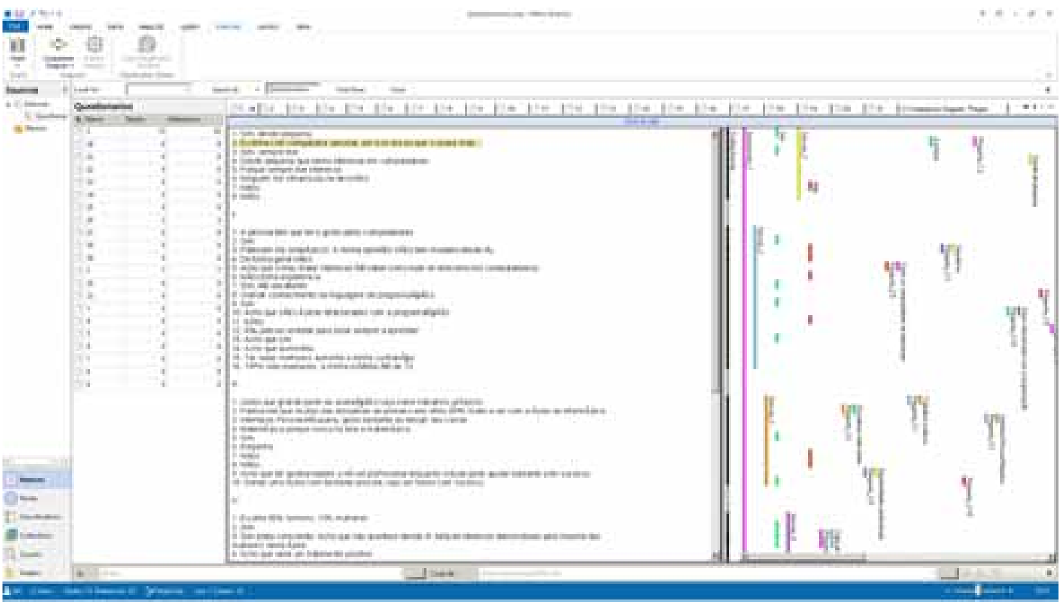
In order to generate GT, the researcher engaged in an iterative process of data collection and constant comparative analysis. Essentially, each line, sentence, paragraph etc. was read in search of the answer to the repeated question "What is this about? What is being referenced here?" our strategy was: the data from the recorded interviews and from survey questions was inserted in NVIVO software.

Figure 1. How the data was organised following GTM



Then, the textual data from interviews and questionnaires was coded and categorized following Charmaz (2006). The conceptual development was conducted, after transcribed, by using coding – open coding was used for the emergence of categories and properties. The categories were labeled with nouns and verbs. In a later stage, the researcher adopted another GT technique: the comparison among the participants' answers, to find relationships and differentiations in opinions. Then, the concepts were grouped to find categories. Figure 2 illustrates the data gathered from interviews. The point is to show that NVIVO tool is very structured and organized to interpret and design data results.

Figure 2. Example of data analysis using NVIVO



5. RESULTS AND DISCUSSION

Considering that we wanted to study the attitudes and experiences of young females and teachers, as well as, professionals, in computer science field, we gathered the answers from the questionnaires and present a succinct analysis.

The main conclusion, which does not explain the reasons, is that the number of females in computer sciences are increasing comparing with male positions, however more work should be done to improve their motivation.

In relation to the general context, we can conclude that the majority of the students who completed the questionnaires grew up with a computer at home (96,6%). Only 42% of the participants used a computer (Figure 3). Those who used the computer the most at home were brothers, followed by the father and finally the mother.

Most women have a computer at home (72,4%), (Figure 4). However, through the indirect relationship between this question and question 1: not having a personal computer is not directly related to the absence of using a computer during childhood.

Concerning the time since when the participants showed interest for the area, the answer was between recently and from when they were younger. The main reason for choosing the computer science course was the employability that exists in the area. Social media has a great impact in

Figure 3. Example of General Context Questions

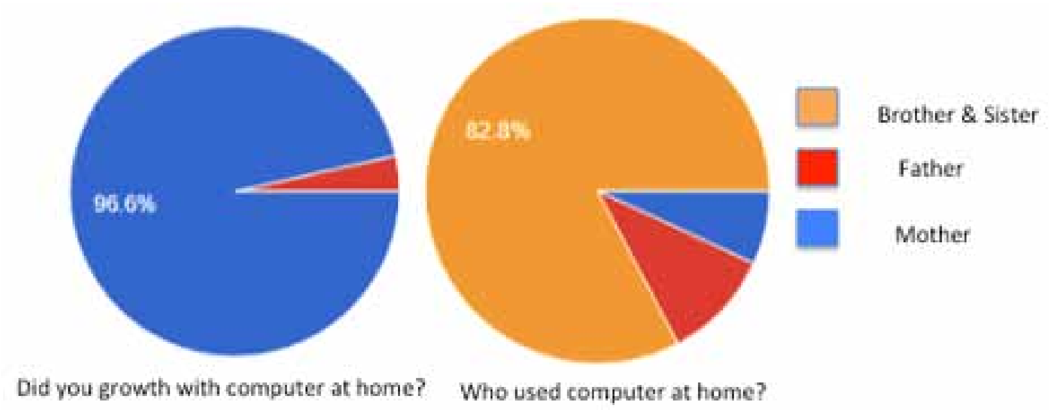
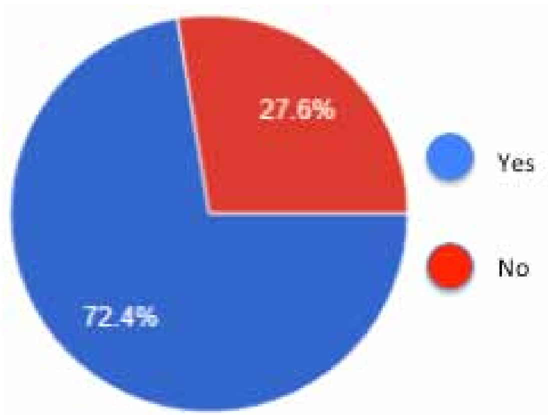


Figure 4. Do you have computer at home?



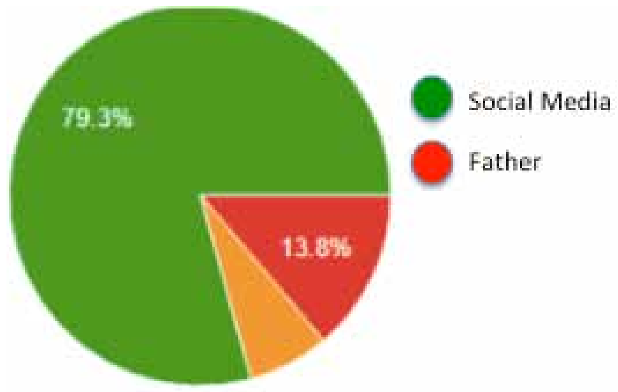
women's lives: 80% were influenced by social media to choose a course in computer sciences (figure 5). Other influencing factors were the parents or siblings. The interest in computers was the most relevant aspect, pointed out by the participants, for the decision of choosing the computer science area.

According to the data gathered, a student of computer science has to work hard, be interested, have good perception and be organized. Other respondents spoke about the computer science personal skills such as: problem solving, being analytical and focused. Some of the respondents still believe that there is prejudice in the area of computer science. They think that some of them can suffer some kind of reprisal (a masculine field), which can be an important factor to understand the unbalance of men and female students/professionals in the field. So, to a certain extent, this is also a reason related with pre-established stereotypes. Sometimes there is some condescension towards female students; however, both believe that opportunities are similar and that effort and dedication contribute to overcoming this stigma. In relation to the stereotypes associated with computer sciences, in the students' opinion society, in general, consider that those who study computer sciences are addicted to video games.

At the student level in this area, they recognize that it is an area of constant change that requires investigation and follow-up.

Teachers stated that they have always had a fascination for computers and programming. Their professional area was decided through personal reasons. During their years at school, about 63% of men attended computer science courses, whereas only 36% were women. They state that there are

Figure 5. Advisors



stigma values by each one aptitude. This area is of great interest to men despite that some of the schools are making efforts to attract, and retain a more diverse student group in computer science. Teachers agree that each school should advertise in different forms the computer science degrees. This could also be done with more information about the professional market in the area. Students could have an important role to play within the advertisement process. Both students and teachers used expressions such as persistence and self-talk.

For the question: How has it been, being a woman in this area? Professional women gave different answers. A list of sample answers follows:

- Just like being a man
- Horrible
- Something extraordinary, because whenever I know guys in this area they are fascinated by it.
- Easy
- Difficult, especially to be taken seriously and see the merit recognized, as well as having access to the same opportunities
- Normal.
- Very challenging.
- I have been privileged but in general we have to try harder to prove that we can sit at the same table
- I do not notice significant differences
- Scary and intimidating
- It is not always easy but it has been a challenge and I have enjoyed it a lot
- Complicated, I hear many prejudices from even my family, but it does not affect me.
- So far I have been treated similarly to men
- Complex. There are spectacular people, but there are others very negative. In general people are surprised that a woman wants to get involved in it.
- A little difficult, because there are still many courses that do not accept women due to the fact that they think that we are not able to carry out the work or the course
- It has been easy as a teacher but with some admiration on the part of the students
- Positive
- Prejudice is notorious. Some people consider that women are more incapable for the same task. It is always necessary to prove the value of being a woman while men do not have to do it. I have been many times in this situation.

We can conclude that, although the results show that about half of the women consider that they are "treated as men", most of them still report negative aspects in the work in the area of computer sciences: to be taken seriously and to see the merit recognized, they have different opportunities, they feel intimidated and they are considered less capable than men.

There is a general conscience that the number of women comparing to male in computer science studies is below the number we would like to see. The same happens in the market place: there are more male than women in professional careers. The problem is not about skills or abilities. It could be a question of culture and tradition, and also a situation unsorted by government and high education institutions. This study was the beginning of several studies that we intend to make. We have findings from female teenagers, teachers and professionals however, we want to understand the cultural and social reasons that lead to this situation.

6. CONCLUSION

In this paper, we present the results of a study carried in high schools and universities with female students and teachers, and also among computer science women professionals. The objective was to understand if there is or not a balance between men and women studying computer sciences. The results are not very expressive since the sample is reduced. However, this study permitted to understand that a great work must be done to obtain a larger amount of data to verify motivations and constraints within female students and teachers that are engaged in the field. Though the absence of fluency of results (we know as common sense), there are some guidelines which could be followed to balance the number of women's and men's participation in the computer science field. For example:

Companies could use software to screen for job descriptions that use words that are likely to give women same opportunities. Having both men and women as part of the hiring process is likely to help. Another possible solution may be for governments to take the lead, and attempt to increase the percentage of women in IT jobs in the public sector. Districts should provide extracurricular activities through either a computing or robotics club, or a school-based business that requires application developers. It is also important to note that the retirement and withdrawal of teachers of some age will give way to new experiences and younger teachers, which is a way to rejuvenate and bring new mentalities to the environment and computer science education.

A combination of in - and out-of-class activities can help encourage more students to study a computer science curriculum and be prepared to pursue further education and employment in computer-related fields. Teachers could integrate coding and programming activities into language arts, mathematics and science instruction in elementary school so that, students are exposed to computer science concepts at a young age. Schools could also increase interest in computing among girls, for example, trying to find women working in computer science careers to connect with them, giving testimonies.

This work has the advantage of being a basis for a following project about the study concerning the reasons why men and women have different intellectual capabilities (e.g. pink brain/blue brain thinking). The focus for the next project will be on culture and how culture helps determine women's participation in computing fields and also on the different social and biological expectations, which are powerful determinants of women's lives.

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