kriativ.tech

Edição Nº 9 – 11-10-2021
ISSN Print: 1646-9976 | ISSN Online: 2184-223X |
http://www.kriativ-tech.com
DOI: 10.31112/kriativ-tech-2021-10-51

The (weak) involvement of women in ICT and IS: the case of ISTEC-Porto

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ABSTRACT: *The aim of this article is to point out some insight at the low female presence in higher education courses related with ICT/IS. What are the reasons that lead most students to seek courses linked to new technologies, such as computing, artificial intelligence, cybersecurity, internet, and cloud computing, to be male whilst fewer female students follow that direction? To better contextualize this issue, data from the last 15 years at ISTEC-Porto are presented, where gender inequality is evident. Some of the reasons found in the literature are indicated and possible solutions to reduce this gender imbalance are pointed out.*

KEYWORDS: *Gender inequality, digital inclusion, higher education, information technologies.*

I. INTRODUCTION

Gender inequality in ICT (information communications technology) and IS (information systems) starts very early when a child is asked what he/she wants to be when they grow up: boys prefer technology while girls like other areas more [1].

A study carried out in a secondary school in Finland to understand why young girls do not prefer the IS/IT sector as an option when accessing higher education, found out that one of the reasons given is that it is a profession where one spends many hours alone in front of the computer [2]. One of the most interesting conclusions of this study is young women's lack of knowledge about the panoply of possible careers within the ICT/IS area.

Another reason is that this sector is often perceived as uninteresting to most girls [3]. Additionally, stereotypes associated with women are one of the barriers felt that prevent not only choice, but also their permanence in the ICTs sector [4].

In general, high school students have a very different perception of an IS/IT career than female specialists in the field. Students are not aware of the available career options [5]. The same article also reinforces the need to imply that a career in the IS/IT sector can enable the creation of great achievements for society.

This paper briefly presents and discusses the gender inequality issue. After this introduction, the next section presents some of most famous women at ICT/IS,

pointing out some of the reasons that might explain that gender gap. The third section discusses some of the gender factors that might shed some light into the reasons why women and technology are many times not compatible and not in the same room. At last, and before the conclusions are drawn, some numbers on the student's participation at ISTEC-Porto are presented.

II. BACKGROUND

Contrary to popular belief, there were many women with a fundamental role in the development of information systems and ICT in general.

Countess Ada Lovelace, daughter of the famous poet Lord Byron, is considered the first woman to create the first algorithm in computer history. Lovelace met Charles Babbage and his Difference Engine in 1833. Ada had been interested in mathematics for most of her adult life. When Babbage developed his Analytical Engine, Lovelace followed closely the intricacies of the development. Later, in 1844, she translated the article on Babbage's Analytical Engine written by the Italian mathematician Luigi Menabrea. Lovelace appended a set of notes explaining the Analytical Engine's function and how the Analytical Engine differed from the original Difference Engine. The notes include a method for calculating a sequence of Bernoulli numbers using the Analytical Engine, which might have run correctly had it ever been built. Based on these notes Lovelace is now considered to be the first computer programmer and her method was called the world's first algorithm [6].

Many years later, in 1945, six women who were part of a group of about seventy women at the University of Pennsylvania, working as human "computers", were selected for the ENIAC project. These women were hired to perform hand calculations for the army, having a degree in mathematics. The ENIAC was the first Digital Computer made in the USA. The group consisted of Jean Jennings Bartik, Marlyn Wescoff Meltzer, Ruth Lichterman Teitelbaum, Betty Snyder Holberton, Frances Bilas Spence, and Kay McNulty Mauchly. Built solely by male engineers, the ENIAC is credited to John Mauchly and Presper Eckert at the University of Pennsylvania. Challenged by Mauchly to discover how they could program the ENIAC, the group of six women ended up creating the concept of subroutine. In this way, certain parts of the code, which were repeated, could be reused. In 2011 Jean Jennings Bartik said that, at the time she worked at ENIAC, "American science and engineering was much more sexist" [6].

Meanwhile, in 1944, Grace Hopper who was a naval officer, was selected to join the team working on the Harvard Mark 1 built by Howard Aiken. Grace held a PhD in mathematics and was a university lecturer. She joined the navy in 1941 after the Pearl Harbor attack. Aiken instructed Hopper to write the instructions manual for the Mark 1. She wrote the first computer manual ever whilst giving her ideas for the development of the computer [6].

While developing mathematical routines for the Mark 1 Grace was reading about Ada Lovelace founding out that she wrote the first loop. She met Von Neumann during that period, both working side by side. The Mark 1 was

largely an electromechanical very slow and difficult to program. Von Neuman became acquainted with the ENIAC, a fully electronic computer developed by Eckert–Mauchly. In 1947 a moth trapped in a relay on panel F of the Mark II computer was found. This fact was registered in the electromechanical computer's log, with the bug taped to it, giving birth to the famous term "bug" when some computer malfunction arises. The original logbook can be seen at the Naval Historical Center, and a photograph of that page showing the bug taped is available online [8]. The credit of reporting this is given to Grace Hopper although it was found by operators. Later in 1949 Hopper joined the Eckert–Mauchly Computer Corporation helping in the development of the UNIVAC I, the first commercial computer. With Betty Snyder Holberton, Grace Hopper developed the COBOL computer programming language, presented at CODASYL Conference in 1959. Based on the Hopper's FLOW-MATIC language that she had previously developed. FLOW-MATIC compiler was originally known as B-0, following the first compiler made for the UNIVAC by Hopper in 1952, the A-0 [6,7].

The internet also has a "mother": Radia Perlman [9]. Radia created the STP protocol (Spanning Tree Protocol) using the Spanning Tree algorithm which is vital to the operation of LAN networks and bridges. This development occurred back in 1984 when she was working at Digital Equipment Corporation (DEC). She was elected a member of the National Academy of Engineering in 2015 for contributions to Internet routing and bridging protocols. Nowadays Dr. Radia Joy Perlman is a software designer and network engineer specializing in network and security protocols for Sun Microsystems, now Oracle. She holds more than 50 patents from Oracle alone [10]. Prior to that, whilst working at the MIT, Radia developed the first educational programming language for children, TORTIS, back in 1974-76 [11,12].

Another famous woman in ICT/IS is Frances Allen (born 1932, died 2020), a computer scientist that worked at IBM from 1957 for 45 years. Allen was elected to the National Academy of Engineering in 1987, was the first woman to become an IBM Fellow in 1989 and to win the Turing Award in 2006 [13, 14]. She also worked for the National Security Agency (NSA).

The next section will address some of these concerns and discusses the gender factors.

III. GENDER FACTORS

This section describes the main differences between men and women; starting with the idea that discrimination begins in childhood during the selection of toys.

The ICT/IS sector needs more qualified professionals to satisfy the existing offer [2]. Although the career choice of women is mostly made as students, the lack of interest in the area starts at this stage. Consequently, the gender inequality is observed in higher education courses in the ICT/IS area, where there is a lower participation by women. However, it is expected that the increase of women in the sector can lead to a greater gender balance and, eventually, minimize the shortage of professionals registered [3].

Therefore, it is of paramount importance to know the main factors that inhibit the choice of women for a career in the ICT/IS sector. B. Almeida published a research study in which identifies five main factors presented in Table 1 [3].

Gender Factors	Description
GF1	Stereotypes associated with gender and profession
GF2	Time flexibility/work-family conflict
GF3	Lack of examples to follow
GF4	Ignorance of the profession and career options
GF5	Lack of positive experiences with computers as children

Table 1: Five gender factors (adapted from [3])

To better understand the impact of the identified factors, B. Almeida (2020) interviewed a focus group of women, comprising pre-university students and ICT/IS professionals.

Throughout the session, the opinions diverged on several issues, however it was possible to identify some of the stereotypes associated with gender and profession (GF1). When asked about the courses most chosen by the boys, engineering immediately emerged as one of the selections. However, it was not part of the list of options for girls in general, with marketing, law and psychology courses being mentioned as the most common choices. Inherent in this relationship is the idea that there are male and female professions (GF1).

Regarding the impact of the need for flexible working hours to establish themselves in ICT careers (GF2), the students stated that they do not see this factor as something that inhibits women from opting for a career in this area. Nevertheless, female ICT professionals reported several stories of inequity. The role of women as a mother was highlighted as one of the most prone to discrimination. Work-family conflict is a potential barrier to women's entry and persistence in the sector. Some of the participants revealed that they had gone through recruitment processes, in which the fact that they were mothers gave them immediate rejection of the position (GF2).

The role of parents and older siblings was highlighted by the group of professional women as one of the most important. Educators are also considered to be influencers. Some of the professional interviewees were encouraged by their parents, older siblings and teachers to enter the ICT/IS area. However, none mentioned the importance of a renowned woman specialist for their own choice. Still, a greater visibility of female references in the area was mentioned as something that must be done, as there may be students who identify themselves with the examples to follow (GF3).

When asked about the reasons behind the choice of higher education course for most girls, the students mentioned the scope of the course, taking into account the number of professional opportunities, perceived employability, personal taste and the examples they had around them. (GF3, GF4).

The perception of the ICT/IS professional described in the session was very similar to that reported by Vainionpää et al. (2019) [2]. The students believe that an ICT/IS professional has to spend many hours in front of the computer and that it is a lonely, monotonous job without much contact with people. According to them, this perception may have an impact on the

choice of the profession to follow, as they believe that solitary work does not attract women (GF1, GF3, GF4).

All participants agreed that early exposure to computers may have some influence on awareness of this area. In fact, two of the participants reported that these experiences were relevant to their own career choice. This can be an interesting contribution at the curricular level, as the increase in activities related to ICT/IS may influence, directly or indirectly, the choice of a career in the area. (GF5).

IV. THE CASE OF ISTEC-PORTO

ISTEC-Porto (Instituto Superior de Ensino Superior de Tecnologias Avançadas do Porto) is a Polytechnic Higher Education Private Institution. In existence in the city of Porto since 1990, it was recognized as a public interest institution by a government decree-law recently on June 24, 2021. ISTEC's training offer is primarily focused on a set of courses that are part of polytechnic higher education. The Degrees given at ISTEC Porto - Informatics and Multimedia Engineering - were both accredited by the OET - Order of Chartered Technical Engineers -, in the Informatics college (Ad no. 13794/2012), which places its holders in socio-professional terms with the status of Technical Engineers .

For this manuscript data referring to the percentage of students of both genders who completed the Informatics degree at ISTEC-Porto, from 2006 to 2021, were used (Fig.1). In 10 of the 15 years there was not a single woman who completed the Informatics Degree. Only once there was an equal distribution, in the 2016/17 academic year.

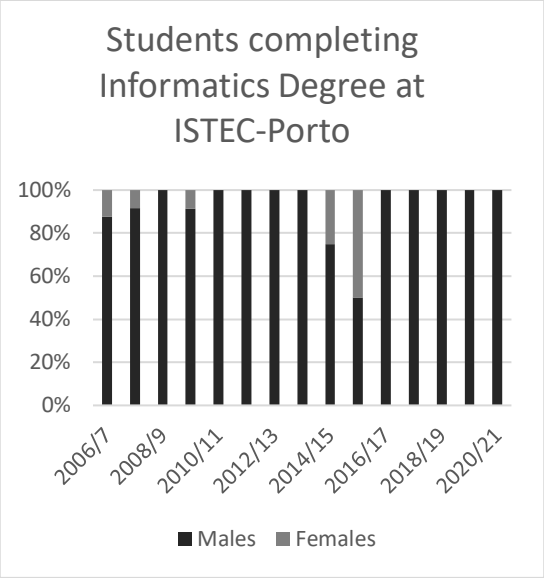

Figure 1: Students completing Informatics Degree at ISTEC-Porto since 2006

The distribution of men / women in the period is 95% men and 5% women. This example illustrates well the gender inequality that still exists today.

To better contextualize this inequality in the IT sector, in 2008/9 the number of Portuguese higher education graduates was 76567, of which 40.7% corresponded to males and 59.3% to females [15].

V. STRATEGIES TO INTEGRATE WOMEN IN ICT/IS

Initially, feminist theories about science focused on denouncing the male sovereignty in different areas of knowledge. From the ‘80s onwards studies on gender issues in science and technology, emerged in a epistemological perspective. This focused on biological, social and cognitive processes that start

from birth and that differentiate skills between boys and girls [15].

Studies show that girls "intentionally and voluntarily" self-excluded from the area, as already noted by some authors [1,2].

In short, the gender stereotype ends up influencing on many levels, affecting women's aspirations, expectations and vocational choices, both on a personal and professional level [15].

Strategies for female integration include increasing the dissemination of the area before the career choice stage, as well as increasing the visibility given to women specialists in the area. On the other hand, it is important to give the students the opportunity to have contact with ICT/IS through some initiatives such as the introduction to programming. Contrary to what is perceived by students, the most important skills to be a good IS/IT professional are to have good levels of communication, extroversion, creativity, proactivity, attention to detail, quick decision-making and business-oriented skills [3, 5].

Another inhibiting factor found is the existence of stereotypes associated with the profession and gender. Gender education, as well as the experiences made possible during childhood, may underlie this perception [3, 15].

It was also mentioned that the set of skills required of women, compared to those required of men, is substantially larger. One of the study participants reported that a woman to achieve a differentiating and challenging project has to assert herself as better than any other colleague. However, the same challenge is assigned to a male professional even if the competence that is recognized is average [3].

This type of behavior must be mitigated by company managers, making it necessary to create more egalitarian conditions for women, which modify masculine environments and practices, thus breaking the existing occupational culture [3, 5].

In addition, the factors most valued by Portuguese women professionals in the field include the flexibility of remote work, the limitation of events that initially exclude women, the increase in diversity within the company, the creation of good family support policies, and the presence of women in leadership positions [3].

A good Portuguese initiative is the Portuguese Women in Tech. Launched in April 2016, by Liliana Castro and Inês Santos Silva, this project has a dual mission: to support women in technology by providing visibility, networking, mentorship and by creating trainings and other opportunities. They also promote Portuguese Women in Tech Awards, a celebration of the Women of the Portuguese Tech Scene for the work done in the past few years. [17].

VI. CONCLUSION

The lack of professionals and the weak female participation in the ICT/IS area is a problem that affects the labor market.

Gender inequality is one of the barriers that most limits the freedom of choice of young boys and girls in academic and vocational terms, influencing their decisions throughout their life cycle. It is due to these factors that girls and women continue to avoid areas associated with the so-called exact sciences and the Computer Engineering opting for areas related to Humanities and Life Sciences (Medicine and Nursing) [16].

This article sought to understand the main gender factors that inhibit women's choice

to pursue a career in the sector. Based on an investigation centered on interviews to a focus group composed of secondary school students and women professionals within the ICT/IS area, in which some possible responses to the identified "gender factors" are presented, an attempt was made to point out suggestions that foster female students to pursue a career in the ICT/IS sector. The example of ISTEC-Porto in the last 15-years is presented exposing the low percentage of women (only 5% of the total). Some strategies to integrate women in ICT/IS are also presented, starting with the need of avoiding gender stereotypes and ending with the urge of implementing company policies such as family support and increase the presence of women in leadership positions.

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