Using Student Profiles to Motivate and Understand How to Attract Women to Computer Science

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Abstract. This article reports how to build and analyze student profiles to influence the perception that girls and young women have of the profession, and of the diverse work opportunities that exist in Computer Science in Costa Rica. The data presented corresponds to a broader work of the European-Latin American project called W-STEM, which also involves other STEM disciplines. The obtained results from the survey to build the profiles are analyzed. The most significant gender difference is in terms of a lower female self-perception of abilities before starting undergraduate studies, compared to the male counterpart. Fortunately, this difference disappears for female at graduate level.

Keywords: Gender, STEM, professional choice, professional models.

1 Introduction

Nowadays, the assertion that there are very few women in STEM careers (Science, Technology, Engineering and Mathematics) is not a novelty and is no longer being questioned. This is mainly due to the efforts of many pioneering women teachers-researchers, who dared to report their reduced number in university classrooms. Particularly in Costa Rica, and for the Computer Science career, the first paper to report the gender gap tried to call attention with its title "Are women in the Computer Science career becoming extinct?" (Marín, Barrantes, Chavarría, 2007a).

Many articles worldwide have reported the magnitude of the gap and have tried to determine its causes. The phenomenon is multi-causal, and according to the analysis done to information provided by different researchers, it is related to intrinsic and extrinsic motivations, and varies to a greater or lesser degree with the generation to which people belong, with their sex and culture (Turner, Bernt, Pecora, 2002; Jacobs, 2005; Blickenstaff, 2005; Carter, 2006; Barrantes and Marín, 2009; Beyer, 2014; Mishkin, Wangrowicz, Dori, Dori, 2016; Alshahrani, Ross, Wood, 2018).

In Costa Rica, for example, (Barrantes, Marín, 2009) correlates the lack of choice of Computer Sciences as a career to women's perception of what the discipline is and to different work expectations. On the other hand, (Calderón, Marín, 2014) points out that understanding *who or what they trust for taking the decision to enter a career* is important in trying to have an impact on that decision, and thus attract them to the

discipline. Their results show that women are more susceptible to be influenced, especially by their parents and, in particular, by the father figure. Besides, they found that the main source of knowledge about the career is *the conversation with others* and that the primary reason for selecting it *is the work availability*. Previous e*xperiences with computers or with toys during childhood* are not determining factors for female decisions on the career selected.

Our research focuses on finding the reasons that affect career choice to attract more women to computers in Costa Rica, and how to use student profiles to influence girls' and young women's perception of the profession, and their knowledge of various job opportunities that exist in the field. The presented data correspond to a broader work involving other disciplines in the STEM area, which has been carried out under the project "Building the future of Latin America: engaging women into STEM" (WSTEM), and whose funding comes from the European Union, specifically from the *ERASMUS + Capacity-building in Higher Education* program. The duration of the W-STEM project is 36 months, starting on January 15, 2019. The following European universities are participating in it:

- Oulu University - OULU (Finland)
- Polytechnic of Turin - POLITO (Italy)
- University of Salamanca - USAL (Spain)
- Nothern Regional College - NRC (England)
- Technological University Dublin - TUD (Ireland)

In addition, Latin American universities that are involved are:

- Tecnológico de Monterrey - ITSM (Mexico)
- University of Guadalajara - UDG (Mexico)
- Universidad Técnica Federico Santa María - UTSM (Chile)
- Pontificia Universidad Católica de Valparaíso - PUCV (Chile)
- Private Technical University of Loja - UTP (Ecuador)
- Technical University of the North - UTN (Ecuador)
- Technological University of Bolivar - UTB (Colombia)
- University of the North - UNINORTE (Colombia)
- Technological Institute of Costa Rica - ITCR (Costa Rica)
- University of Costa Rica - UCR (Costa Rica)

The W-STEM project aims to improve strategies and mechanisms to attract, access and orient women in STEM programs in Higher Education in Latin America. It aims to do this by transforming the current situation in Higher Education institutions in the region, and by influencing high school students, in order to convince girls and young women to enter STEM careers. The main actions of W-STEM are

- Measure gender equality in enrollment and retention rates in STEM programs.
- Implement policies, strategies and organizational mechanisms at participating universities to improve attraction, access and orientation in STEM programs.
- Promote vocation and choice of STEM studies in girls and young women in secondary schools.
- Give orientation to female students in the first year of entrance to the STEM university careers.

- Develop an online training package to implement effective strategies to improve the attractiveness, access and orientation of women to STEM programs.

This article focuses mainly on reporting the results of the activities carried out for the latter objective. It analyzes the information obtained from a survey used to create profiles of men and women studying STEM careers, specifically describing the results of the student profiles of the Computer Science career at the University of Costa Rica. The following sections include the theoretical framework of reference and description of similar studies. The methodology is explained in section 4, Results, both demographic of the participants and of the survey, are included in section 5. Finally, the last section contains our conclusions.

2 Conceptual Framework

Increasing the participation of women in science, technology, engineering and mathematics (STEM) involves two distinct challenges (Drury, Siy, Cheryan, 2011): increase the retention of existing women and their recruitment for entering STEM fields. Women role models help in both of these efforts, by improving female's performance and sense of belonging in these disciplines.

According to (Wyss, Heulskamp, Siebert, 2012), students make decisions in high school years that will affect their desire and ability to pursue STEM careers. Therefore, providing them with accurate career descriptions allows them to make an informed choice. They argue that are few practical ways to help students understand the nature of STEM careers. Their study investigates the use of video interviews of STEM professionals as a method of informing students about the possibilities in these careers, and concludes that there is evidence that informational videos are a way to engage students in the pursuit of STEM disciplines.

On the other hand, in a large-scale field study, (Breda et al., 2020) reviewed whether exposure to external women role models changes students' perceptions of scientific careers, and affects their choice of field of study. In their study, a total of 56 female scientists intervened in the classroom with an audience of 20,000 high school students. From the analysis of results, they found evidence that the contact with female role models increased students' interest in science-related careers, and slightly improved their mathematical self-concept. They also determined that the presentation of female role models drastically reduced the prevalence of stereotypes associated with science jobs, and gender differences in self-perceived skills, but further evidenced, among students, the under-representation of women in science.

Finally, (Herrmann at al., 2016) claim that women are more likely to leave science, technology, engineering, and mathematics than men because they lack similar role models, such as peers, teaching assistants, and instructors. Therefore, facilitating the profiling of role models is relevant not only for attracting, but also for retaining, women in STEM disciplines.

3 Background

As stated by (Calderón, López y Marín 2017) and (Calderón, Marín y López 2019), the evolution of Computer Science (CS) professionals has been studied very little in Latin America, and specially in Costa Rica. Both studies aim to characterize the professional development model of people who studied CS in Costa Rica, and analyze the evolution in their professional roles and migration between industry sectors. The purpose of this study was to determine what roles and tasks are performed by professionals in the area, and whether these differ for women and men. In (Calderón, Marín, López 2017) it is reported how satisfied women are with their professional decisions, and the lack of gender differences with respect to professional evolution. On the other hand, in the second study, (Calderón, Marín, López 2019) reveal different behaviors in professionals of different generations. In general, greater changes occurred in the evolution of the male careers, regarding professional roles and industry sectors, in comparison with female professionals, who were more stable in their jobs. In this study, a large majority of the participants indicated that they felt successful in their professional lives.

The first time that professional profiles were attempted as "role models" in Costa Rica was through an article that tells the life story of three women who were pioneers in computers in the country (Calderón, Marín, 2015).

Since there is no systematic work prior to our project to create occupational profiles to promote the attraction of women to the discipline, this research is considered pioneering and important.

4 Methodology

Work and student profiles will be built after collecting information through a survey. The team in charge of designing and running the survey (*App and Profiling Tool Team*) was coordinated by Anita Tobacco, from the Politecnico di Torino. The authors of this article participated in this team as representatives of the University of Costa Rica. A description of the survey and the information collection process is described in the next section.

4.1 About the survey

The survey was inspired by the indicators of the SAGA project (García-Holgado, Camacho-Díaz, García-Peñalvo, 2019). The survey instrument is mostly made up of semi-open questions that allow for the selection of categories, while giving each participant the freedom to write his or her answer by selecting the "Other" category. Figure 1 shows the questions in the instrument. The first ones are used to characterize the set of participants, and the last ones, highlighted in bold, are the ones that build the profile of each participant.

Have you already graduated from college?
What is your gender?

What do you want your name to be? (name to generate the anonymous profile).
What year were you born?
What is your university?
What career are you studying or have you studied?
What type of school did you attend?
Please select the last academic degree obtained
What year did you graduate?
Are you currently working?
What are you currently working on (if not currently working, write "unemployed" or "looking for work")?
What year did you start college?
My college degree has allowed me: (or will allow me to:)
My big concern before starting my university studies was:
The most surprising thing about the courseI took was that: (or which course is that:)
What I liked best about my college studies was:

Fig. 1. Survey instrument questions.

4.2 About the process

The survey was conducted using LimeSurvey. Each participating university invited undergraduate and graduate students from the various STEM disciplines. In particular, at the University of Costa Rica, and for the area of Computer Science, the survey was sent to the graduate and undergraduate student mailing lists with a very motivating email, inviting students to contribute to attracting more women to the career.

5 Results

5.1 About the demographics of the responses

From the 1478 STEM students who participated in the survey, 98 belonged to the discipline of Computer Sciences, and it is on these 98 profiles that the present analysis was made. Table 1 and Fig. 2 show their distribution by gender and university level: undergraduate (undergraduate and graduate students) or graduate (masters and doctoral students). As usual at CS discipline, the sample of participants includes more men than women. This is because participation was voluntary and the population has a composition of 84% men and 16% women for undergrads (515 men and 105 women, during II-2019) and 80% men to 20% women for graduates (71 men and 18 women, during I-2020).

Table 1. Distribution of participants by university level and gender.

	Women	Men	Other	TOTAL	Women	Men	Otro	TOTAL
Graduate	16	37	2	55	29%	67%	4%	100%
Undergraduate	19	23	1	43	44%	53%	2%	100%
TOTAL	35	60	3	98				

Fig. 2. Distribution of participants by university level and gender

Another interesting dimension to analyze, regarding the demographics of the survey participants, is their work roles. This was a semi-open question addressed to graduate students. In Fig. 3 (next page), two word clouds are shown. The upper one corresponds to women (Fig. 3 a), and the lower one to men (Fig. 3 b). Because the male graduate population is much larger than the female population, the lower word cloud reflects many more categories. However, it is interesting to note that words like *Development*, *Software*, and *Engineer* appear to be categories that describe both the female and male graduate student roles. On the other hand, the word *Unemployed* draws attention in a discipline with a high-demand labor market. After reviewing the answers, we realize that this word is used by graduate students who have made the decision to become full-time students. The word clouds, in Fig. 3, do not appear to reflect significant gender differences in the occupational profiles of the survey participants.

5.2 Examples of generated profiles

Remember that the goal of the survey for the W-STEM project was the automatic generation of profiles to motivate more women to enter STEM careers. Below, we present two profiles automatically generated form the survey responses (these profiles are in Spanish since it is the language used in the survey for Latin American students). The first one is of a woman and the second one belongs to a man.

> *Hola mi nombre es Lidia. Tengo 23 años y me gradué de Universidad de Costa Rica en el año 2019. El título universitario obtenido me ha permitido entender cómo funcionan muchos elementos y encontrar algo que realmente me apasiona. Antes de comenzar los estudios universitarios me preocupaba porque los estudios podrían ser muy difíciles. La gran sorpresa acerca de la carrera que cursé fue que, aunque al principio el hecho de no saber me asustaba, ahora me motiva, porque siempre tengo mucho más que aprender. Ahora trabajo en el área de soporte de hardware y programación para aplicaciones de ingeniería y considero que el grado universitario obtenido de Universidad de Costa Rica ha sido indispensable para el trabajo que tengo. Lo que más me gustó de estudiar en la Universidad de Costa Rica fue la materia estudiada y los otros estudiantes que conocí.*

> *Hola mi nombre es Jason. Tengo 27 años y me gradué de Universidad de Costa Rica en el año 2016. El título universitario obtenido me ha permitido trabajar en proyectos de gran importancia. Antes de comenzar los estudios universitarios me preocupaba porque creía que podría no ¨calzar" con otras personas estudiantes de la carrera que seleccioné. La gran sorpresa acerca de la carrera que cursé fue que existen muchas opciones de dónde escoger y que la disciplina que elegí presenta un amplio campo de acción. Ahora trabajo en el área de Desarrollo web y considero que el grado universitario obtenido de la Universidad de Costa Rica ha sido indispensable para el trabajo que tengo. Lo que más me gustó de estudiar en la Universidad de Costa Rica fue la excelente reputación de la universidad.*

a. Graduate Women

b. Graduate men

Fig. 3. Distribution of jobs through word cloud by gender for graduate students

The profiles by themselves are very valuable, because they show the real life of students in our program, and their experiences and expectations about their professional career. They can be used to motivate students to study our discipline. However, from the academic perspective, it is interesting to ask ourselves if there are significant differences in male and female profiles. Furthermore, if there are differences on them as a product of respondent's professional maturity. In the following sections we report similar and different aspects of male and female profiles, and between undergraduate and graduate students.

5.3 Concerns of the student body before starting their studies

It has been reported that the *perception of the potential difficulty of studies* or their *self-perception of inability to be successful* in them (e.g., difficulty with math) drives many women to not study Computer Science (Barrantes, Marín, 2009) (Calderón,

Marín, 2014). Given this perspective, it is interesting to determine what is the main concern of the participants when they start their study plan.

The specific survey question allowed for the selection of **one** of the following alternatives as a major concern: (a) *I would not get enough experience to work with other people on really interesting projects*, (b) *I might not get along with other people who are students in the career I selected*, (c) *I did not have adequate training to do the studies I chose*, or (d) *the studies might be very difficult*. Respondents could choose *Another* and freely express different concerns. The results obtained for each category are shown in Fig. 4 (Percentages are used to make comparisons due to different group sizes). The yellow bar corresponds to the answer *Another*, the blue bars are related to possible academic difficulties to be successful in the studies, and the green ones to possible obstacles due to interrelations with people.

The predominant answers are: 1) *I did not have adequate training to carry out the studies I chose*, and 2) *the studies could be very difficult*. In particular, it is interesting to note how, for **undergraduate** students, the relative importance of these two aspects is different. For women, the fact that *I did not have adequate training to carry out the studies I chose* is more important than the concern that *the studies might be very difficult*. This is consistent with the often-reported phenomenon of low self-esteem among women. Men, on the other hand, are much more confident in their abilities (only 26% consider that their previous training may be a problem), but are more distrustful of their interpersonal relationships than women (dark green category).

For **graduate** students the relative importance of these two aspects is opposite. The relative importance for women of *not having adequate training to carry out the studies I chose* is less than for men. Note that the concern that the *studies might be too difficult* does not present significant gender differences in these professionals. This is an important finding that can be used to promote the attraction of women to the discipline.

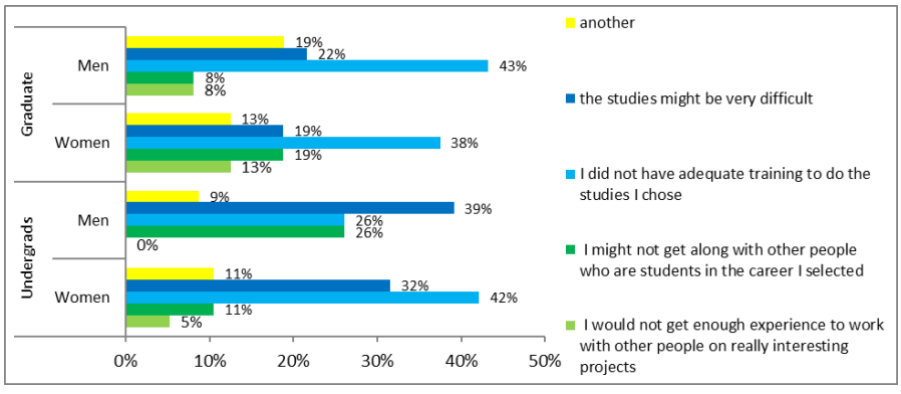

Fig. 4. Concerns before starting studies.

Few people selected *Another*, and freely expressed different concerns. The following are responses for women

- *the balance to work and study so that both activities reflect good quality and complement each other,*
- *not being able to get a well-paid job,*
- *not having enough financial resources for my career,* and
- *having to leave my baby (he is 4 years old) to go to college, knowing that it is not easy and that my baby is far away, but it motivates me that in the future we will not lack anything.*

In the case of men, the responses were:

- *did not have sufficient resources and did not have a computer of my own,*
- *study and work at the same time,*
- *that the career would not add value to my resume,*
- *lack of personal interest,*
- *my family economic situation and for not being able to finance my studies,*
- *the area of work within the country,* and
- *I had no worries.*

Most of the answers within this category of *Other* are related to socioeconomic and labor aspects. Only one man expressed no concern and only one woman expressed concern about the care of her baby. Only two expressed concern about the possible usefulness of studying Computer Sciences. This aspect is discussed further in the next section.

5.4 Self-perception of the usefulness of the studies

To determine how useful students perceive their studies, it is important to evaluate their self-perception about what a college degree in the field has allowed them, or will allow them to do. The specific survey question asked to select **one** of the following alternatives: (a) *to impact people's lives*, (b) *to work on projects of great importance*, (c) *to work in and get to know other countries*, and (d) to *meet many really interesting people*. Respondents could choose the *Other* category, and freely express different possibilities. Note that Fig. 5 shows that for undergraduate men and women what they value most is *working on important projects* while the second most mentioned category by women is *impacting people's lives*, while for men it is *working in and getting to know other countries*. For undergraduates, *meeting many really interesting people* does not seem to be important to anyone.

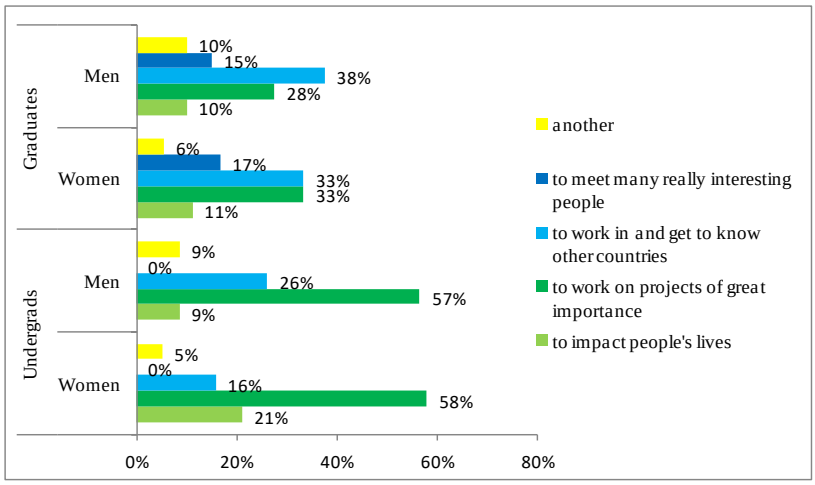

Fig. 5. Self-perception of what the university degree has allowed or will allow them to do

The profiles of graduate students are different from those of undergraduates, but almost identical to each other. The category *working in and getting to know other countries* appears in first place, and *meeting many really interesting people* **in second** place**. This is possibly because they value more the aspects that allow them to grow in the working world. For graduate students, all already professionals,** *impacting people's lives* **is** no longer **a big deal.** The category of *Another* was more popular for men than women. Men specified **the following:**

- ***make a lot of money,***
- ***flexibility: possibility to choose how I want to live, even if I don't want to devote myself to something related to what I studied,***
- ***support my management position with advanced knowledge,***
- ***work,***
- ***work with multidisciplinary teams in various industries,* and**
- ***work on highly complex projects, meet and learn from other engineers and participate in the design of network infrastructure systems.***

In the meantime, only one woman stated:

- ***As a young mother, the career opens many opportunities to give my son a good future and of course, a promising future for me.***

6 Conclusions

According to the analysis of the profiles of undergraduate and graduate students, the relative importance of not having adequate training to carry out the studies, is greater at the undergraduate level for women than for men, however at the graduate level, it is less important for females than males. The concern that studies could be very difficult, do not present significant differences by gender for professionals (people that have already received a Bachelor degree).

At the undergraduate level, both genders value working on important projects more than graduate students. However, the second important category for undergraduate women relates to impacting people's lives, while for undergraduate men it is working in and getting to know other countries. The profiles of graduate students are different from those of undergraduates, but they are almost identical to each other amongst different genders. This is because they value enhancing their professional growth and broadening their horizons by visiting other countries.

The sample analyzed corresponds mostly to young people, for whom the concern of having to balance work and personal life is almost absent. Only one woman expressed concerns about the care of her baby. This issue is more recurrent in older professionals or professionals from previous generations.

How to attract women to Computer Science is really a multi-faceted and evolving challenge. We hope that research and intervention actions, which are more numerous every day, will make the vision of our discipline more and more accurate and attractive, so that in the future we will have a greater female representation. In particular, our project will use the generated profiles as part of a mobile application (App) that will be disseminated to primary and high schools nationwide, with the help of the Ministry of Education and the Ministry of Science, Technology and Telecommunications.

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