

Applications, Admissions and Graduations of Women in Computer Science Careers for the Universidad Nacional de Asunción

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Abstract

The presence of women in higher education and, mainly, STEM careers is a topic of growing interest in recent years. Several works highlight the low representation of women in technology careers. Though a series of initiatives to promote reducing the underrepresentation of women in STEM careers, much remains to be done. To characterize and analyze the presence of women in computer science-related careers at the Facultad Politécnica of the Universidad Nacional de Asunción, we present in this paper a longitudinal analysis of cohorts associated with student applications, admissions, and graduations since 2010.

Keywords

higher education, women, gender equality, computing

1. Introduction

The UN WOMEN[1] defines gender equality as equal rights, responsibilities, and opportunities for women and men, girls and boys. At the global level, the Schedule for Sustainable Development includes gender equality as one of its pillars. The Schedule considers 17 Sustainable Development Goals (SDGs), including SDG-4, "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all," and SDG-5, "Achieve gender equality and empower all women and girls" [2].

According to UNESCO [3], a considerable increase in female enrolment in higher education in all regions of the world occurred, which tripled globally between 1995 and 2018, with a higher growth rate than that of male enrolment during that period. However, a significant gap remains regarding academic formation in Science, Technology, Engineering, and Mathematics (STEM). UNESCO [4] refers that only 35% of students in STEM-related careers in higher education are women, and differences in these disciplines have been reported. For example, only 3% of female students in higher education choose to pursue studies in Information and Communication Technologies (ICT).

In Paraguay, there have been some efforts at a national level to promote gender equality, but still with low impact. At the level of national policies and laws, Paraguay has defined a national policy on gender equality that includes references to STEM (2008) and a law on education and science that mentions gender equality (1998) [5].

The Universidad Nacional de Asunción (UNA), founded in 1889, is the first institution of higher education, the oldest and most traditional in the country. It currently has 55,281 students, 9,174 faculty

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members, and more than 7,700 graduates [6]. At the UNA level [7], the percentage of women enrolled in all undergraduate careers for the year 2020 was 54%.

This paper analyses applications for admission to careers associated with computer science, admissions, and graduates of female professionals and some relevant comparisons with the overall numbers. The article's organization is as follows: section II presents an analysis and definition of the academic context of the careers, section III details data obtained and their results, and section IV presents conclusions and questions answered with an integrative analysis of new data.

2. Analysis and context definition

The Facultad Politécnica (FP-UNA) is an academic unit of the UNA, created on February 8, 1979, by Resolution No. 1538-03/79 of the Higher University Council. On September 30, 1980 [8].

Among the first four careers offered by the FP-UNA is the Bachelor's Degree in Systems Analysis, one of the first academic offerings in the UNA related to ICT. As years went by, the academic proposals underwent modifications, reaching 2021 with 13 academic proposals, 2 of them associated with the specific area of computer science: Computer Engineering and Bachelor's Degree in Computer Science.

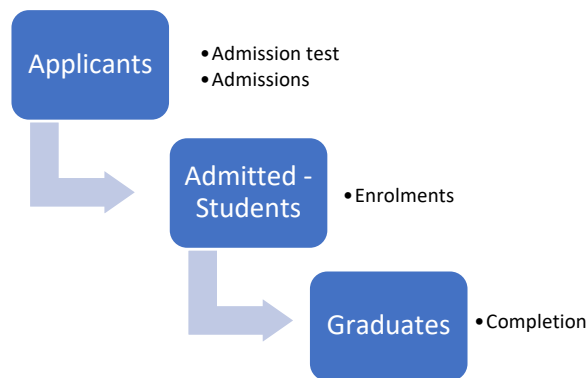


Figure 1: Main academic status of students

The FP-UNA defines specific procedures for the application, admission, and graduation of its undergraduate programs. These processes are framed within the regulations in force at the UNA level and with specific rules at the FP-UNA level [8]. Figure 1 shows that applicants can apply to an undergraduate program. To do so, they must take an admission test to evaluate their minimum knowledge of the career of their choice. If the applicant meets the admission conditions, they may enroll for academic periods in the degree program until they meet each program's requirements and graduate as professionals in the area. The general concepts of each process present below.

2.1. Applications and admissions

The UNA defines [9] an applicant as "a person who applies to one or more careers of the University." The process of admission by a test is regulated within the "Reglamento de Admisión a Carreras de Grado" [10] (Undergraduate Admissions Regulations for its acronym in English). It establishes the subjects that are part of the admission test. In addition, for the careers offered by the FP-UNA, orientations are defined where the careers related to computer science are included in Orientation A.

Applicants to the different degree programs offered in Orientation A may indicate, in the application form for the admission test, up to three career choices according to their preference and the FP-UNA's offer. For admission to any of the degrees offered by the FP-UNA, the minimum average percentage is 60% of the total accumulated score in the subjects that make up the entrance exam.

In each career, each place fills according to the best scores above the established minimum, until covering all available places, according to the first option. If there are vacancies in a career, they fill following the second option of those applicants who could not enter their first option, according to the

best scores above the minimum, until covering all available places. If there are still vacancies, they fill according to the third option.

In addition to admission by test, the FP-UNA provides other mechanisms for access to careers, such as [11]:

- **Direct admission:** direct admission consists of incorporating into one of the careers the FP-UNA offers without resorting to the admission test. It applies to Graduates of the UNA, Students of academic units of the UNA, Graduates of national universities of public management, Students of national universities of public management, and Graduates of national universities of private management, with careers recognized by the Council of Universities and Graduates of foreign universities.
- **Transfers:** admission of a student to another career of the academic unit different from the one in which they first enrolled. A variant applies to transfers between campuses of the same academic unit.
- **Agreements:** admission through agreements signed by the UNA or the FP-UNA. Here are included those admissions due to student mobility.

Applicants who have met the admission requirements calls admitted students

2.2. Enrollment

Once a student enters the academic unit, they may enroll in the program to which they were admitted. These registrations are made per semester academic period, i.e., two academic periods are considered in one year.

In this process, a student may request a career transfer, once they have passed a number of subjects equivalent to (NAC/AC), where NAC corresponds to the total number of subjects of the career (of origin and AC, to the duration in years of that career [11].

2.3. Graduation

Once the student has fulfilled the requirements of the degree program in its entirety, they graduate from the academic unit. These requirements must be completed within a maximum period equivalent to twice the duration of the degree program. In the case of computer science careers, the Bachelor's Degree in Computer Systems has a duration of 4 years, while Computer Engineering has a duration of 5 years, so the maximum length of a student's stay is 8 and 10 years, respectively.

In cases justified, there is a process for an extent of this time based on customized analysis of their academic status.

3. Data Analysis

For this work, we elaborated a set of research questions (RQ) to obtain data on the application, admission, and graduation of those students who were admitted from the 2010 admission cohort until 2021 for the Computer Engineering and Computer Science degree programs (with emphasis on Computer Programming and Computer Systems Analysis).

RQ. 1. What is the ratio between male and female applicants per year from 2010 to 2021?

To answer this question, we have considered those applicants who have registered for the admission test and have selected any of the analyzed careers.

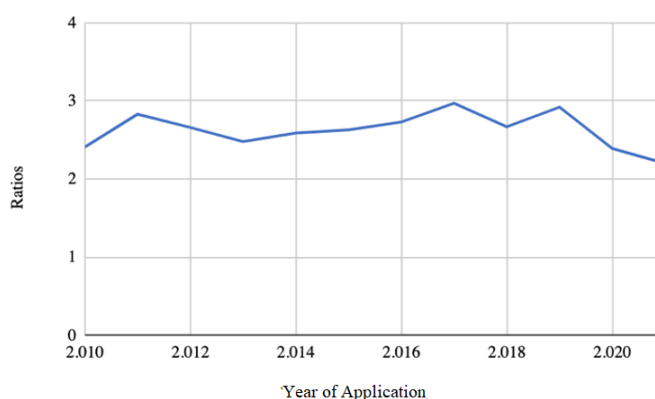
Table 1 shows the number of applicants per year of application according to their gender. Based on this information, we calculated the ratio of admission per year between men and women (ratio).

The ratio calculated per year is shown in Figure 2, where in the last 11 years, this value ranges between 2.2, as a minimum value, for the year 2021 and 2.97, as a maximum value, for the year 2017. On average, the ratio for the years analyzed is 2.62.

Table 1

Number of applicants per year of application based on their gender

Year of application	Gender		Ratio
	Male	Female	
2010	338	140	2.41
2011	362	128	2.83
2012	413	155	2.66
2013	335	135	2.48
2014	350	135	2.59
2015	342	130	2.63
2016	251	92	2.73
2017	276	93	2.97
2018	299	112	2.67
2019	266	91	2.92
2020	249	104	2.39
2021	207	94	2.2
Total	3688	1409	2.62

**Figure 2:** Ratios of applicants per year of application

RQ. 2. Considering students admitted, by type of admission, what is the ratio of male and female admissions per year?

The most significant flow of admissions within the careers is by the mechanism of admission tests. Table 2 shows the number of admissions by type of admission (admission test, direct admission, transfers, and agreements). This information has been discriminated by gender, and the ratio between men and women has been calculated.

At this point, it is important to mention that the information provided for the types of direct admission, transfers, and agreements correspond to the year 2015 onwards. In addition, it shows that only men were admitted by this mechanism, so the ratio cannot be calculated at this point.

Figure 3 shows the ratio of admitted students by gender for the various types of admission. In the line corresponding to the admission test, the values are between 2.19 for 2021 and 4.29 for 2020. Based on the values of previous years, the minimum value obtained for 2021 and the maximum for 2020 could be influenced by the pandemic. Thus, the average of 3.23 is close to the values obtained from 2010 to 2019.

In the same figure, Figure 3, the most stable line corresponds to entry by admission test concerning the other types of admission, where the behavior may be attributed to circumstantial situations. In the line corresponding to the kind of admission exam, the values are between 2.19 for 2021 and 4.29 for 2020. Based on previous years' values, the pandemic could have influenced the minimum value obtained for 2021 and the maximum for 2020. Thus, the average of 3.23 is close to the values obtained from 2010 to 2019.

Table 2

Number of students admitted per year of admission, according to type of admission and gender

Year of admission	Admission test			Direct admission			Agreement			Transfer		
	Gender		Ratio	Gender		Ratio	Gender		Ratio	Gender		Ratio
	Male	Fem		Male	Fem		Male	Fem		Male	Fem	
2010	236	71	3.32	--	--	--	--	--	--	--	--	--
2011	261	73	3.58	--	--	--	--	--	--	--	--	--
2012	186	67	2.78	--	--	--	--	--	--	--	--	--
2013	168	57	2.95	--	--	--	--	--	--	--	--	--
2014	183	50	3.66	--	--	--	--	--	--	1	0	
2015	183	59	3.1	4	0		--	--	--	6	6	1
2016	112	29	3.86	2	2	1	--	--	--	20	2	10
2017	112	31	3.61	9	2	4.5	3	1	3	32	11	2.91
2018	146	45	3.24	3	2	1.5	1	1	1	22	7	3.14
2019	118	36	3.28	6	3	2	--	--	--	29	7	4.14
2020	120	28	4.29	6	4	1.5	--	--	--	16	4	4
2021	125	57	2.19	4	4	1	8	1	8	18	5	3.6
Total	1950	603	3.23	34	17	2	14	3	4.67	144	42	3.43

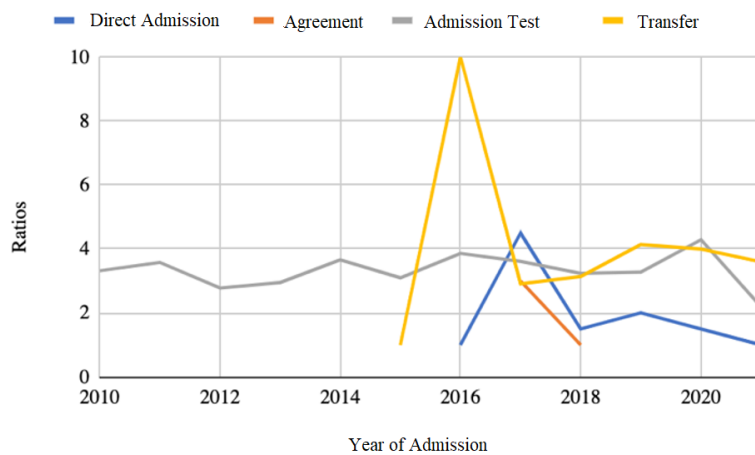


Figure 3: Ratios of admitted applicants through the different admission mechanisms per admission year.

RQ. 3. What is the ratio between women who applied and those who were admitted by admission test?

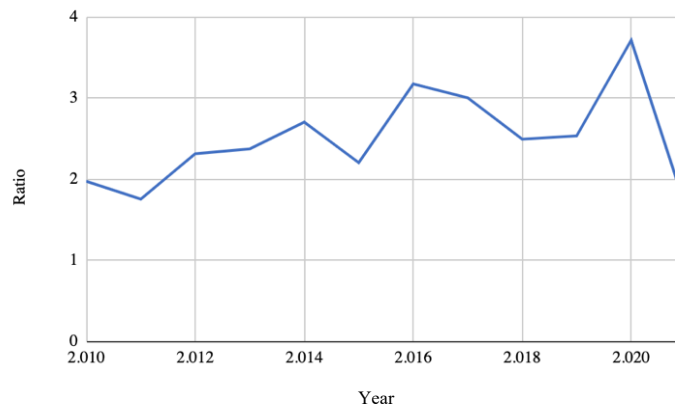
Table 3 compares women who applied and those admitted, according to the data on applications and admissions.

Figure 4 shows the relationship between women who applied and those admitted through the admission test; it exhibits an increase in behavior until 2020, indicating that the number of women admitted decreases over time. A specific case is that of the year 2017, where only 1/3 of the applicants managed to enter computer science careers, and in the year 2020, the minimum is found where approximately 1/4 of the applicants were admitted.

Table 3

Number of female applicants and admitted by year.

Year	Applicants	Admitted	Ratio
2010	140	71	1.97
2011	128	73	1.75
2012	155	67	2.31
2013	135	57	2.37
2014	135	50	2.7
2015	130	59	2.2
2016	92	29	3.17
2017	93	31	3
2018	112	45	2.49
2019	91	36	2.53
2020	104	28	3.71
2021	94	57	1.65
Total	1409	603	2.34

**Figure 4:** Ratios of female applicants as a function of women admitted by admission test per year.

RQ. 4. What percentage of women and men who were admitted to a computer science career transferred to another unrelated career?

We have considered those admitted by sex in all types of admission from 2010 to 2021 who have not graduated from the careers under analysis. Table 4 shows that women have a higher percentage (13%) of transfers compared to men (9%) to careers not directly related to computer science.

RQ. 5. What was the ratio of graduates by entry cohort according to gender?

To answer this question, the graduation variable was standardised first according to the percentage of admission.

Table 5 presents the data on graduates and those admitted classified by gender. The standardised data also classified by gender have been included. According to the admission cohort, it shows the number of graduates by gender.

The last years of the entry cohort do not present data since there is no registration of graduated until the year 2021, due to the duration of both careers.

Table 4
Percentage of transfers by gender

Gender	Transfers	Admitted	%
Female	85	664	13
Male	202	2144	9

Table 5
Percentage of graduates per year of admission, according to gender.

Admission cohort	Graduates (E)		Admitted (A)		Percentage (E/A*100)	
	Fem	Male	Fem	Male	Fem	Male
2010	34	72	71	236	48%	31%
2011	24	82	73	261	33%	31%
2012	39	44	67	186	58%	24%
2013	23	40	57	168	40%	24%
2014	15	31	50	184	30%	17%
2015	16	20	65	193	25%	10%
2016	6	10	33	134	18%	7%
Total	157	299	416	1362	38%	22%

Figure 5 shows the percentage curves of graduates for both women and men. Both curves display similar behavior, and as the years go by, there is a decrease in the number of graduates. This is because a large percentage of students in the last years of the entry cohort are still taking the courses of each career. On average, up to graduates from the year 2016, only 38% of the women and 22% of the men admitted from the 2010 entry cohort have graduated.

It is important to mention that for each year analyzed, the percentage of graduates observed with respect to the number of women admitted is higher than the percentage corresponding to men.

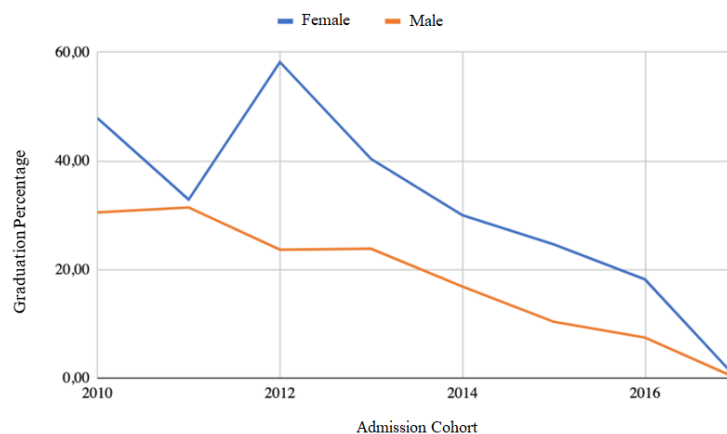


Figure 5: Percentage of graduates according to cohort of admission

RQ. 6. How many women graduated in relation to the number of women admitted in their entry cohort?

Considering the data for women in Table 5 and Figure 5 up to 2019, we find that the ratio of females admitted to female graduates, in general, is 33%. In the information by entry cohort, of 67 women admitted in 2012, 39 graduated, which corresponds to 58%, the highest percentage of graduates in the years analyzed.

4. Conclusions

Based on the research questions asked and the evidence exposed, we concluded that:

1. In relation to the applicants, the distribution tends to be linear since, per year of admission, two men apply for each woman who applies to computer science careers.
2. Concerning those admitted, the admission test has shown to be the method that attracts the most significant number of students and the most constant over time. For every woman admitted by test, there are three more men admitted. For transfers, this ratio is similar, while for direct admissions, it decreases to one woman and two men.
3. In general, slightly less than half of the women are admitted by the admission test method.
4. There is a higher percentage of women relative to men for changing careers.
5. The percentage of women graduating in relation to men is always higher in the years analysed.
6. Currently, the ratio of graduates in relation to those admitted shows a decrease in recent years. This may be due to students not finishing their studies in the time established for the degree program, so they are still completing their courses within the course curriculum of each program.

As future work, an analysis based on the enrolment of students by academic period, critical subjects, follow-up of causes of abandonment, among other points expects to be analysed.

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