

# An analysis of the participation of women in Information and Communication Technology courses at State University of Maringá (UEM)

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## Abstract

This paper presents an analysis about the number of incoming and graduate students, considering women and men, at the Department of Informatics (DIN) at State University of Maringá (UEM), in Brazil. The data were collected considering three graduate courses, Data Processing Technology (extinct in 1997), Computer Science and Informatics. The results show that the number of women is dropping drastically from the late 1990s. In Computer Science, from 1994 to 2016, of the 622 graduate students, 127 were women. In Informatics, from 2000 to 2016, only 38 women had graduated, of the 275 students. In 2017, there were 211 students enrolled in Computer Science, and 208 in Informatics. On average, 8.11% were women (34), being 8.65% in Informatics (18), and 7.58% in Computer Science (16). These percentages are lower than the national one in Brazil, which is 14.19%.

**Keywords:** Women in ICT, Incoming students, Graduate students, State University of Maringá.

## 1 Introduction

In her book about some women scientists, Ignatofsky [1] describes how these women have faced out the sexism and have changed the world. Elizabeth Blackwell (1821-1910), who was a medical doctor and is one of the scientists described in the book, said "If the circumstances of the society do not accept the free development of women, thus the society needs to be remodeled".<sup>1</sup>

Many initiatives have been created to increase the number of women in ICT (Information and Communication Technology) courses and in the job market, corroborating the message of Elizabeth Blackwell.

The Meetup DevGirls project makes efforts to promote the creation of an inclusive and participatory culture of women's representatives at events and in the technology community through events and discussions. The Rails Girls Summer of Code project<sup>2</sup> aims to bring more women to the community of open source code.

In Brazil, the Brazilian Computer Society (SBC) has supported, since 2016, the program named "Meninas Digitais" (Digital Girls)<sup>3</sup>[2], which already has many partner projects spread around the country in several Universities. Our project, named Conectadas<sup>4</sup>, is one of them. The project was formalized as an extension one in March, 2017, at the State University of Maringá (UEM). Teachers, graduate<sup>5</sup> and undergraduate women participate.

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<sup>1</sup>Free translation done by the authors

<sup>2</sup><https://railsgirlssummerofcode.org/>

<sup>3</sup><http://meninas.sbc.org.br/>

<sup>4</sup><https://www.facebook.com/conectadasuem>

<sup>5</sup>A person who has completed a university degree course (Longman Dictionary)

UEM is the oldest and the most traditional one in Maringá, Paraná, Brazil. It offers two ICT courses, Computer Science (integral) and Informatics (at night). Aiming to understand the participation of women along the last two decades in those courses, this paper presents an analysis about the number of incoming and graduate students in the Department of Informatics (DIN).

The paper is organized as follows: Section 2 discusses women in ICT area; Section 3 presents an overview of the students enrolled in ICT in Brazil; Section 4 presents the data about incoming and graduate students, considering women and men, at DIN-UEM; and Section 5 presents some discussions and conclusions.

## 2 Women in Information and Communication Technology

Many advances in Computer Science have had women as their main responsible. Ada Lovelace, Grace Murray Hopper, the six ENIAC programmers: Kathleen McNulty Mauchly Antonelli, Jean Jennings Bartik, Frances Snyder Holberton, Marlyn Wescoff Meltzer, Frances Bilas Spence, and Ruth Lichterman Teitelbaum, Margareth Heafield Hamilton, Joan Clarke, Virginia Rometty and Sheryl Sandberg are examples of women who have revolutionized or still are revolutionizing the area.

In the 19<sup>th</sup> century, Ada Lovelace was responsible for developing the first algorithm to calculate mathematical functions in Charles Babbage's analytical machine. She is known as the first programmer in history, helping Babbage in the development of the first calculating machine.

Margaret Heafield Hamilton, who is a computer scientist, a software engineer, and an entrepreneur, managed the Software Division at the MIT Instrumentation Laboratory that developed the flight program used in the Apollo 11 project, the first manned mission to the moon. Her team was at the forefront of Apollo's on-board guidance software, required to navigate and land on the moon, and its variations used on several missions. It was thanks to her and her team that astronauts Neil Armstrong and Buzz Aldrin were able to walk on the moon. In November 2016, Margaret received from President Barack Obama the highest US honor, the Presidential Medal of Freedom [3].

Many other women have also contributed to the evolution of Computer Science, such as Dilma M. da Silva, who is a systems software researcher in the fields of Cloud Computing, Operating Systems, Distributed Computing and High Level Computing. She has received several awards, among them the ACM Distinguished Scientist in 2011. She is currently Department Head, Professor, and Holder of the Ford Motor Company Design Professorship II of the Department of Computer Science and Engineering at Texas A&M University.

According to Castro [4], until the mid-1980s, the number of women in the area of Computer Science had grown significantly. Representing for just over 1% before that time, in the middle of that decade they accounted for 36% of people working in the area. Nowadays, however, this reality has changed. While in 1984 women held almost 40% of jobs in the area, in 2011 that number dropped to 12%.

Some researchers have investigated the aspects influencing the women's quitting of the ICT area [5, 6, 7, 8, 9, 10, 11], and according to their findings, several factors contributed to this drastic change. Among them are gender stereotypes that lead women to choose more traditional careers, such as Medicine, Administration and Law, since they are perceived as being more appropriate for women. Stereotypes regarding the ICT professional (a "nerd" man with a natural talent to math and poor communication skills) also play its role in preventing women from choosing this area [8]. Cheryan [8] notes that this stereotypical image still is disseminated by the media, and that the start of its promotion (during the 1980s) coincide with the beginning of the decline of the number of women in ICT in US.

It was also in the early 1980s that began to emerge a narrative about computers as a masculine item, since the first personal computers were almost exclusively marketed to men, as had been said by Steve Henn: "The share of women in computer science started falling at roughly the same moment when personal computers started showing up in US homes in significant numbers" [12]. Teague [7] also mentions misperceptions about the nature of computing and professional computing careers ("... done in isolation, sitting at a screen all day, and is either programming of office administration...") as a factor that contributes to women averting a career in this area.

Besides the difficulties for women to choose a career in ICT, Castro [11] also discusses barriers for the permanence of these women in the ICT labor market in Brazil, which include excessive mobility and work in deregulated hours.

## 3 An overview of the students in ICT in Brazil

According to a report published by the Brazilian Computer Society (SBC) and the National Institute of Studies and Educational Researches (INEP) in 2016 [13], the number of undergraduate courses in ICT in Brazil has been increasing consistently over the past 15 years. As can be observed in Figure 1, which shows the cumulative number of courses created by geographic region over the years, the number of ICT

courses offered in 2016 is approximately 4.7 times higher than in 2001. It can also be noted that the distribution of these courses is not equal among the five regions of the country, with the southeast region concentrating most of the courses and the northern region having the fewest courses. These calculations take into account different courses in the ICT, namely: Computer Science, Computer Engineering, Information System, Software Engineering, Degree in Computer Science, Technologies in general, and other related courses (such as Computational Mathematics and Administration with emphasis in Computing) [13].

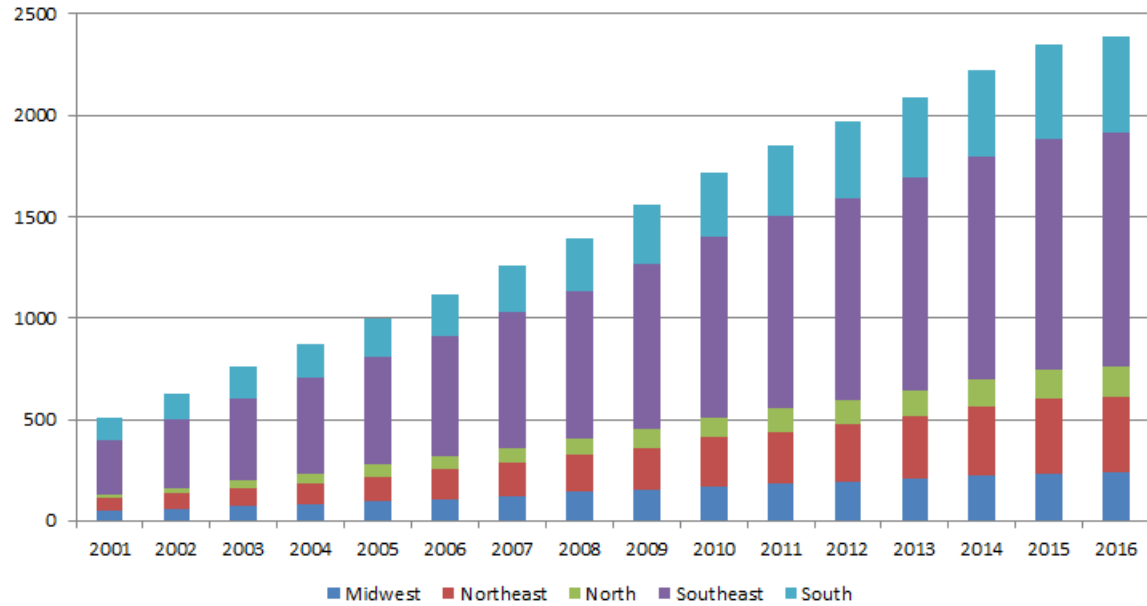


Figure 1: Cumulative number of ICT courses created from 2001 to 2016 in Brazil [13]

Although the number of courses has increased (at a higher or lower rate) year by year, the number of incoming students in ICT courses did not follow this growth. Figure 2 shows the number of incoming students in ICT courses per year of the considered period, as well as their distribution by gender <sup>6</sup>. As it can be noted, there was a growth starting in 2006, representing an increase of 50.17% over the previous year, and reaching its peak in 2008, with 238,919 incoming students. In 2009 there was a decline of 48.61% compared to the previous year, and numbers continued to drop, but at a slower rate (8.11% in average), until 2016, when a new increase (of approximately 42%) was observed. Even with this last increase, the number of incoming students in 2016 was still 44.29% lower than in 2008.

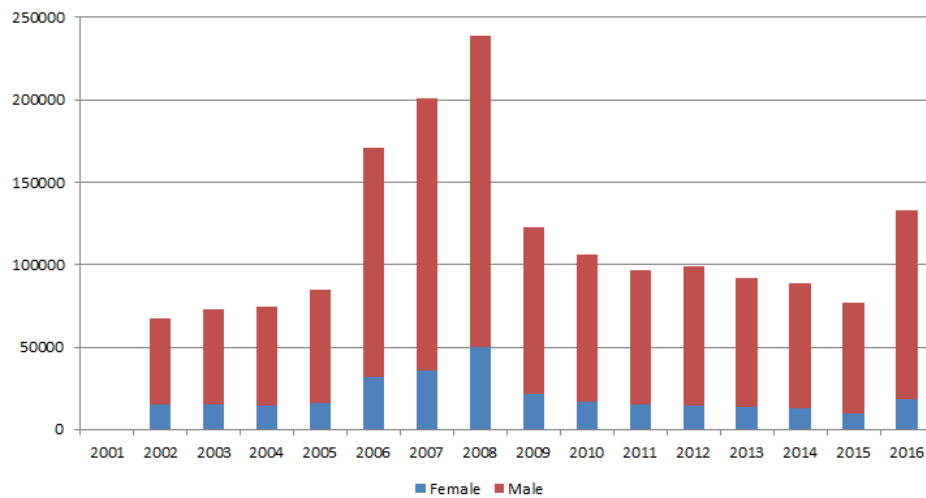


Figure 2: Evolution of incoming students in ICT from 2002 to 2016 in Brazil [13]

<sup>6</sup>The year of 2001 was not included due to the lack of data separated by gender for that year.

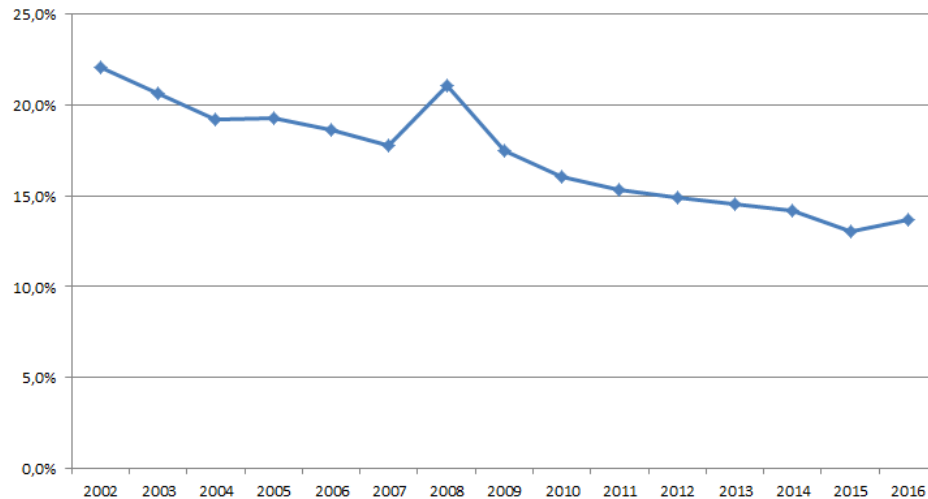


Figure 3: Percentage of incoming women in ICT courses from 2002 to 2016 in Brazil

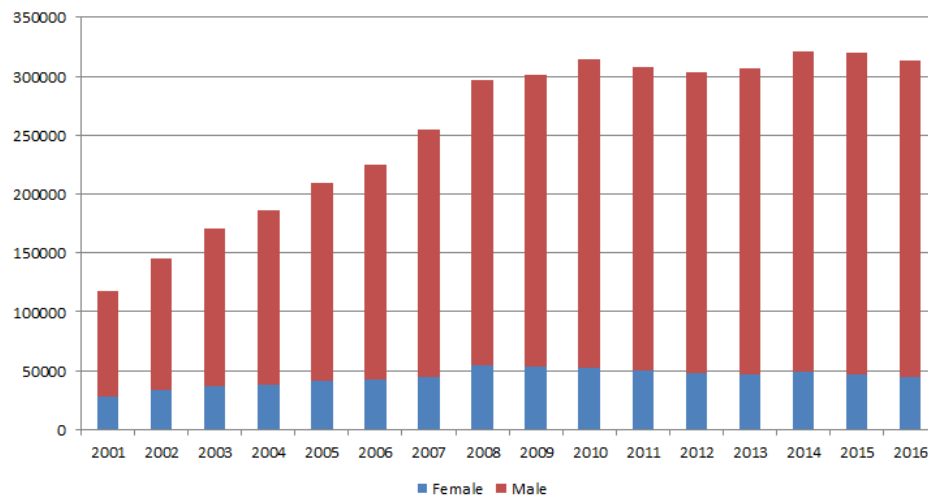


Figure 4: Evolution of enrollments in ICT from 2001 to 2016 in Brazil [13]

As can be observed in Figure 2, in absolute values, the number of incoming men and women in ICT courses followed similar distributions over the years. However, if we consider the percentage of women entering ICT courses in the period, there was a consistent drop, as showed in Figure 3, which presents the percentage of incoming women from 2002 to 2016. The percentage of women varies from 22.11%, observed in 2002, to 13.03%, observed in 2015. Even at the peak of 2008, the percentage of women continued to be below the level observed in 2002. The percentage of women in 2016 was 13.66%, which is minus 8.45 percentage points when compared to 2002.

Figure 4 shows the number of students enrolled in ICT courses from 2001 to 2016, separated by gender. As can be observed there was a consistent growth from 2001 to 2010. The number of enrollments in 2010 was 2.7 times higher than in 2001. After that, the number of enrollments varied up and down, but at a lower rate.

During the whole period, the enrollment of women varied at a low rate, but presenting a growth trend. In fact, the number of women enrolled in ICT courses in 2016 was 1.6 times higher than in 2001. However, if we consider percentages instead of absolute numbers, there was a drop, as showed in Figure 5, which presents the percentage of women enrolled in ICT courses from 2001 to 2016. In 2001, there were 24.10% women enrolled. In 2016, this number had dropped to 14.19%, which is minus 9.91 percentage points.

Figure 6 shows the number of graduates in ICT courses from 2001 to 2016, also separated by gender. It is possible to notice that the number of graduates, both women and men, is low when compared to the number of incoming and enrolled students. From 2001 to 2009 there was a considerable growth, reaching its peak in 2009, when the number of graduates was 4.26 times greater than in 2001. After that, the numbers

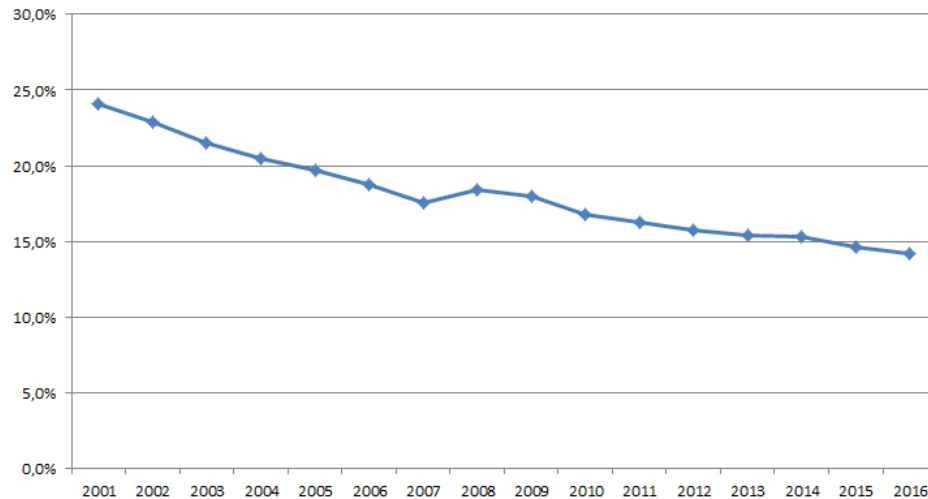


Figure 5: Percentage of enrolled women in ICT courses from 2001 to 2016 in Brazil

dropped, but increased again from 2013, reaching 42,012 graduates in 2016.

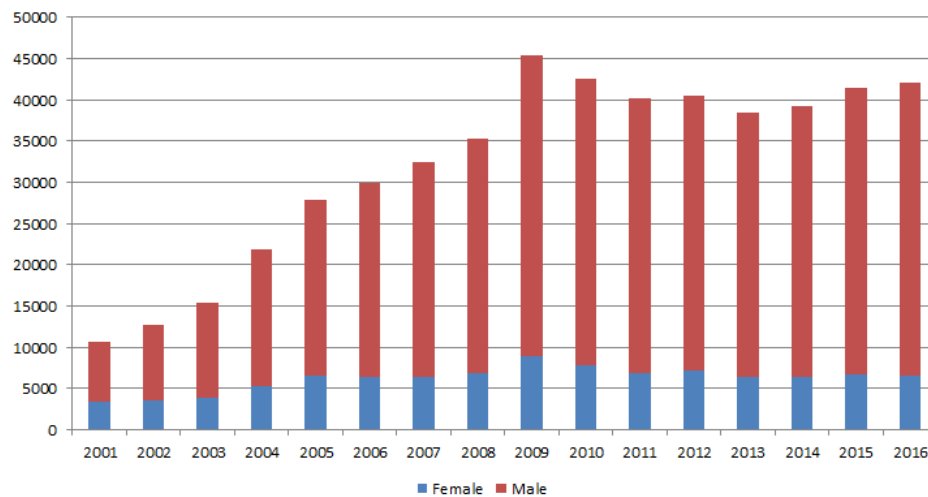


Figure 6: Evolution of graduate students in ICT from 2001 to 2016 in Brazil [13]

Considering the graduates distribution by gender, it is possible to notice a trend of growth from 2001 to 2009. Since 2009, however, there have been more declines than increases. This is most evident when we look at the percentage of women graduating from ICT courses, which are presented in Figure 7. In 2001 women accounted for 31.78% of the graduates, and in 2016 they represent only 15.48%, which is minus 16.30 percentage points.

Other recently published works also discuss women's participation in ICT courses at Brazilian universities.

An overview of the women enrolled in Computer Science and Informatics at ICMC-USP (Institute of Mathematical and Computer Sciences-University of São Paulo), from 2001 to 2013, is presented by Monard and Fortes [14]. The authors pointed out that the number of women is smaller than the number of men, but from 2008 to 2012 the number of women has increased a little bit. In 2013, there were 10% of women.

In 2014, Moreira et al. [5] discussed the participation of women in ICT. The authors presented a study considering the three courses at Federal University of Paraíba. In Computer Science and in Computer Engineering there were only 13% of women enrolled. Considering Degree in Computer Science, the number is a higher, 31%. From 2009 to 2013, of the 126 graduate students, only 14 were women, 11.11%.

Until 2016, Mochetti et al. [15] pointed out that of the 3000 graduate students at Computing Institute at Federal Fluminense University, only 16% were women. They also said that considering the last two decades (from 2000), the number of women has decreased. In 2008, only one woman had enrolled.

Monteiro et al. [16] carried out a study to outline the women profile in Computer Science at the Federal Institute of Ceará, campus Aracati, from 2012 to 2016. The data collected show that most of the students

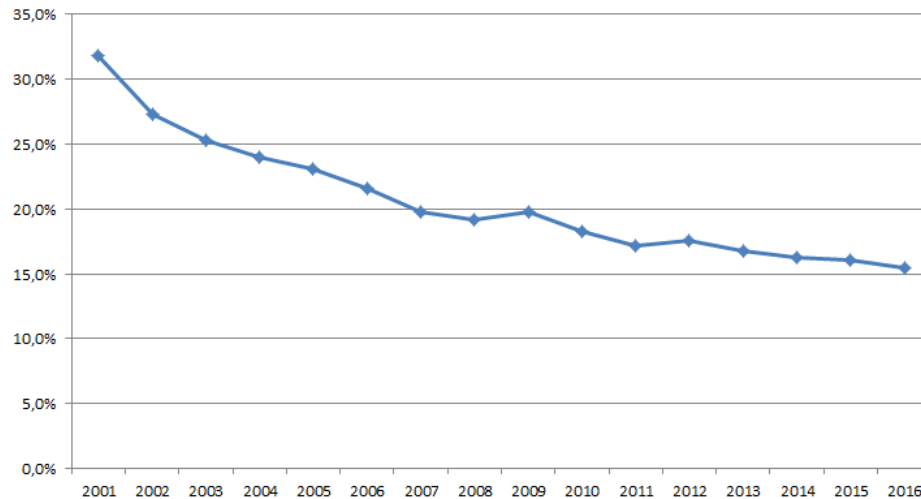


Figure 7: Percentage of graduate women in ICT from 2001 to 2016 in Brazil

were men. On average, there were 23% of women. In 2012, the year with the greater average, there were about 33% of women enrolled.

A study that was carried out at Computing Institute at Federal University of Amazonas, from 2000 to 2017, is presented by Nakamura et al. [17]. The Institute offers three courses: Computer Science, Computer Engineering and Information Systems. According to the study, the average of incoming women in Computer Science is 17.5%. The limits were 29.1% in 2003 and 10.5% in 2012. In 2017, 27.7% of incoming students were women.

The women profile at the Computer Department at the University of Brasília is discussed by Holanda et al. [18]. The researchers pointed out that considering the incoming students of all courses that are offered, there are more men than women. The difference between the number of men and women has increased over the years. The first class of Computer Science, for instance, had 46% of women. At the 1990s, the number dropped to approximately 30%. In 2013, the percentage of women dropped to 14%.

Other works such as the ones conducted by Vardi [19], Keinan [20] and Stout et al. [21] confirm the same reality in other countries. According to Anita Borg Institute<sup>7</sup>, women represent only 18% of enrolled students in ICT courses at US. If only the most important Universities are considered, the number drops to 14% [22].

## 4 An analysis of the students at DIN-UEM

Nowadays, the Department of Informatics offers two courses: Computer Science, created in 1988, and Informatics, created in 1998 to substitute Data Processing Technology, which was the first one created in 1976.

Some issues must be pointed out before presenting and discussing the data:

- The data are based on the unified college entrance examination report and on the information system (SISAV) that are used to manage the entrance examination process and the students, respectively.
- The incoming students are those who did the college entrance exam and indeed did the enrollment.
- Only data of consecutive years are considered.

Based on the 2017 report of the students that are enrolled in the courses, there are 211 students in Computer Science, and 208 in Informatics. On average, there are 8.11% of women, being 8.65% in Informatics (18), and 7.58% in Computer Science (16). Unfortunately, these values are below the average of the national number of 14.19% presented in the SBC report [13], and the averages described by [15], [17], [18] and [16].

Considering the number of students that did the registrations in the college entrance exam from 2010 to 2017, there were more men than women, as can be seen in Table 1. In 2010, of the 486 registrations in Computer Science, only 57 were women, or 11.73%. In Informatics, 11.76% were women (64). Both percentages are the highest ones in the period.

<sup>7</sup><https://anitab.org/>

It is possible to notice that the number of women is dropping along the years. In 2017, 47 (8.47%) did the exam in Computer Science, and 18 (8.33%) in Informatics. These percentages are equivalent to the number of women that are enrolled in both courses. The problem is more evident in Informatics, where the number of women dropped from 64 in 2010 to only 18 in 2017. Even the number of men has dropped, from 544 in 2010 to 216 in 2017, around 60%. Discussing these numbers are out of this paper, but it is an interesting and troubling fact.

Table 1: Evolution of registrations in the college entrance exam in Computer Science and Informatics at DIN-UEM from 2010 to 2017

| <b>COMPUTER SCIENCE</b> |               |             |              |
|-------------------------|---------------|-------------|--------------|
| <b>YEAR</b>             | <b>FEMALE</b> | <b>MALE</b> | <b>TOTAL</b> |
| 2010                    | 57            | 429         | 486          |
| 2011                    | 45            | 352         | 397          |
| 2012                    | 36            | 331         | 367          |
| 2013                    | 43            | 404         | 447          |
| 2014                    | 49            | 450         | 499          |
| 2015                    | 27            | 416         | 443          |
| 2016                    | 41            | 438         | 479          |
| 2017                    | 40            | 432         | 472          |
| <b>INFORMATICS</b>      |               |             |              |
| 2010                    | 64            | 480         | 544          |
| 2011                    | 50            | 488         | 538          |
| 2012                    | 40            | 464         | 504          |
| 2013                    | 28            | 261         | 289          |
| 2014                    | 28            | 250         | 278          |
| 2015                    | 12            | 163         | 175          |
| 2016                    | 16            | 194         | 210          |
| 2017                    | 18            | 198         | 216          |

Fig. 8 shows the incoming students from 1993 to 1997 in Data Processing Technology. It is interesting to notice that in 1993, 44.44% of the students were women. In 1997, when the last entrance exam occurred, of the 11 students, only three were women, or 27.27%.

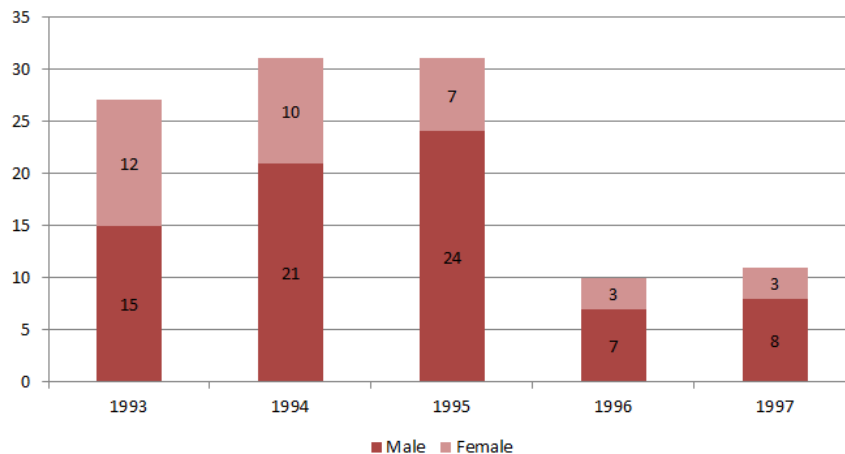


Figure 8: Data Processing Technology: incoming students from 1993 to 1997

Fig. 9 shows the graduate students from 1994 to 2000 in Data Processing Technology. In this period, 121 students concluded the course, 44 women and 77 men. This represents that, on average, per year, 6.29 women had graduated, with a standard deviation of 4.35. The highest number was in, when more women (13) than men had graduated, 52%. As in 1997 the last entrance exam had occurred, in 1998, 1999 and 2000, the last students had graduated.

Fig. 10 shows the incoming students from 1998 to 2017 in Informatics. In this period, the average of incoming women is 2.41, and the standard deviation is 4.7. In 2002, of the 43 incoming students, 10 were women, which is the highest absolute number in the period. In 2017, of the 40 incoming students, only four

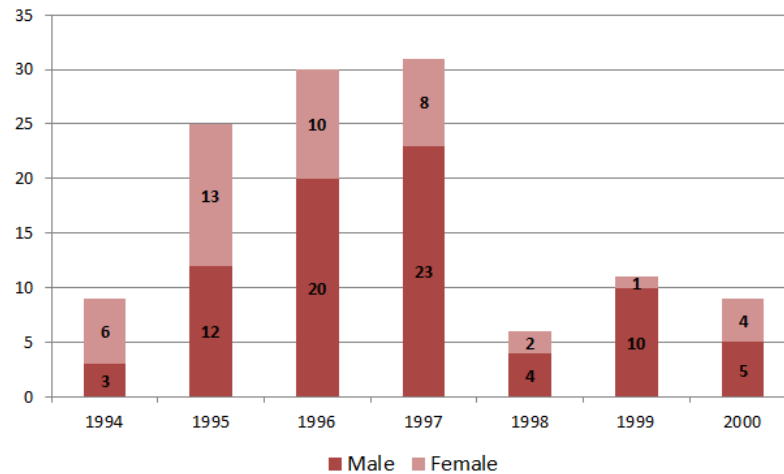


Figure 9: Data Processing Technology: graduate students from 1994 to 2000

were women. The smallest number has happened in 2008, only one woman of the 44 students.

Fig. 11 shows the percentage of incoming women in Informatics. It is possible to notice that the percentage is irregular, varying from 15% in 1998 to 10% in 2017, with maximum and minimum in 2002 (23.3%) and 2008 (2.3%), respectively.

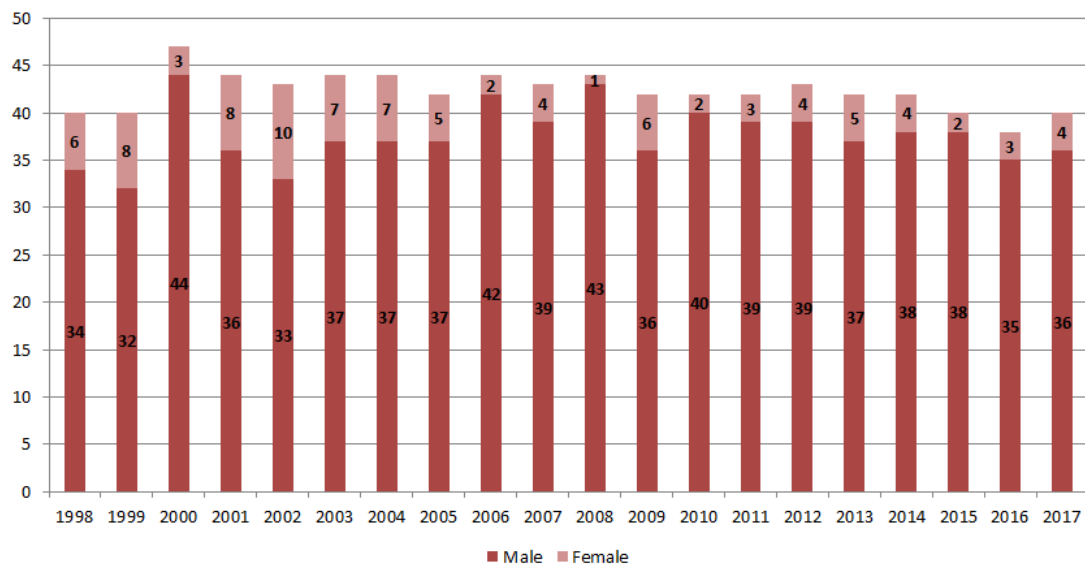


Figure 10: Informatics: incoming students from 1998 to 2017

Fig. 12 shows the graduate students in Informatics from 2000 to 2016. The average of graduate women is 2.24, and the standard deviation is 1.89. This average represents that, of the 313 graduate students, only 38 are women. Along this period, few women have graduated in Informatics. From 2011 to 2016, only six (6.90%) had finished the course, and, unfortunately, in 2013 and in 2015, there was none. The highest absolute number has happened in 2006, when seven women had graduated. This can be the consequence of the average of the incoming women in 2002 (10), as the course has five years.

Fig. 13 shows the percentage of graduate women in Informatics. The percentages vary a lot, from 37.5% in 2000 to 16.7% in 2016, which are the highest and the smallest ones, respectively.

Fig. 14 shows the incoming students in Computer Science from 1988 to 2017. In this period, the average of incoming women is 3.6, and the standard deviation is 2.21. From 1990 to 1999, the absolute numbers of incoming women are the highest ones. The best one has happened in 1993, when 17 of the 39 of incoming students were women. After 1999, the number has dropped a lot. In 2016, only one woman had enrolled in the first year.

Fig. 15 shows the percentage of incoming women in Computer Science. In 1990, 44.4% of the incoming students were women. The worst percentage has happened in 2016, when only 2.5% were women. From 2000





Figure 11: Informatics: percentage of incoming women from 1998 to 2017

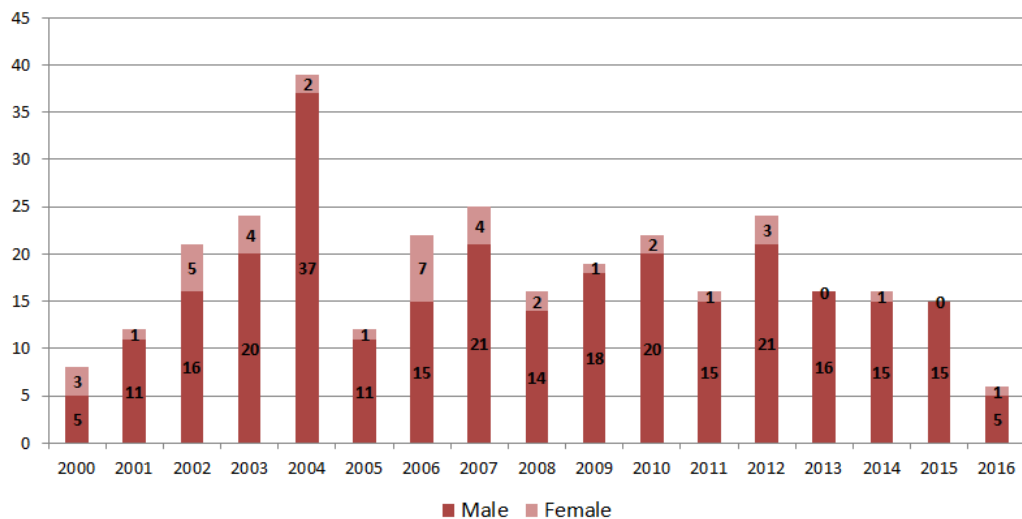


Figure 12: Informatics: graduate students from 2000 to 2016

to 2016, the percentages had varied from 9.5% to 10%, respectively, being 2015 the best year, with 14.6%.

Fig. 16 shows the graduate students from 1994 to 2016. The average of graduate women is 5.52, and the standard deviation is 5.51. This average represents that, of the 622 graduate students, only 127 are women. From 1994 to 2000, more women had graduated, which is equivalent with the number of incoming women. The best absolute number had happened in 1995, when 19 of 38 graduate students were women. In 2006, no woman had graduated. After that, until 2016, only 18 women had graduated, which represents 8.3% of the graduate students. This percentage is equivalent with the number of women actually enrolled in Computer Science.

Fig. 17 shows the percentage of graduate women in Computer Science. From 1994 to 2016, the percentages had varied a lot. In 1995 had happened the best proportion, when 50% of graduate students were women. It is possible to notice a little improvement in 2015 and 2016, 15.4% and 25%, respectively. However, as can be seen in Fig. 16, in both years, the absolute number of graduate men had dropped too.

Considering both courses from 2008 to 2016, the number of graduate women is low, as can be seen in Fig. 18.

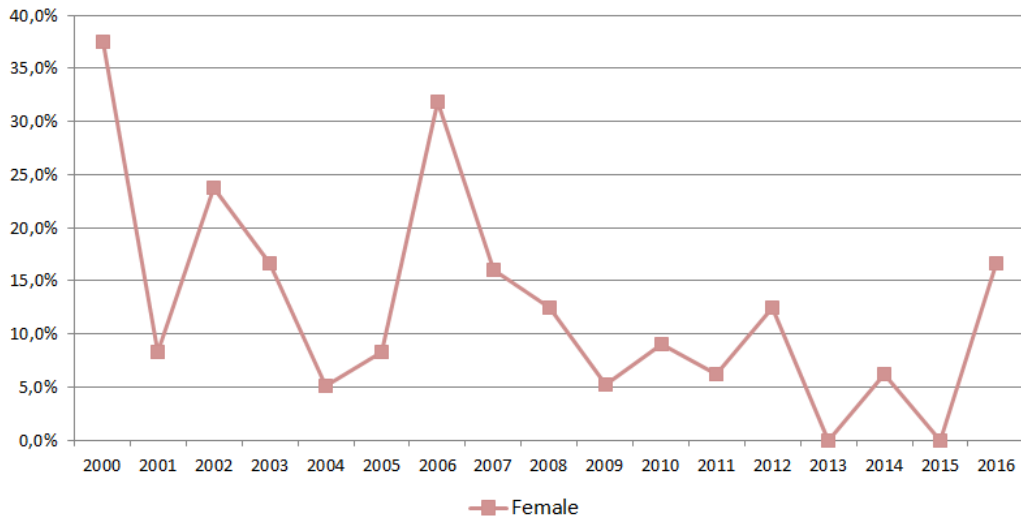


Figure 13: Informatics: percentage of graduate women from 2000 to 2016

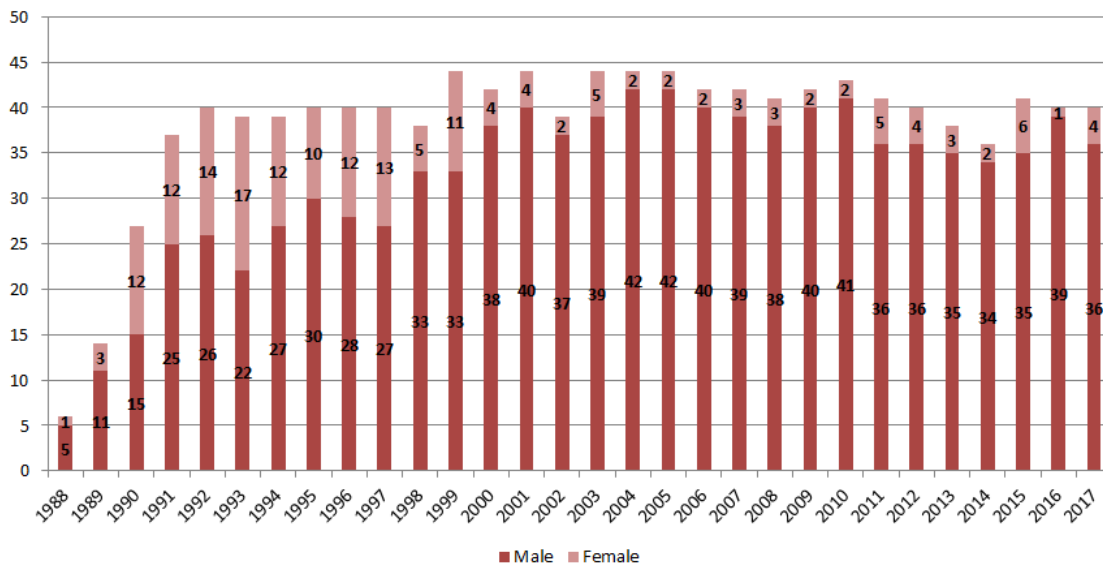


Figure 14: Computer Science: incoming students from 1988 to 2017

## 5 Discussions and Conclusions

According to the report published by SBC and INEP [13], from 2001 to 2016, meanwhile the number of graduate men has grown from 68.88% to 84.52% of the total, the number of women has dropped from 31.78% to 15.48%. These numbers reflect that less women are interested in ICT.

The 2015 National Science Foundation (NSF)/National Center for Science and Engineering Statistics report (NCSES) describes that the number of women in STEM (Science, Technology, Engineering and Mathematics) are dropping [23]. According to the report, in 2012, there were less women in Computer Sciences than in other areas, only 18% of the graduate students were women. Meanwhile, in Mathematics they were 43%, in Physical Sciences 40% and in Engineering 19%.

The 2017 NSF/NCSES report presents the proportion of women in Computer Science in 1995, 2004 and 2014, as can be seen in Fig. 19 [24]. The absolute number of graduate women has increased, but the percentage does not. On the other, there are more women doing masters and doctorates, which is a positive scenario. These numbers corroborate the data presented in Fig. 20<sup>8</sup>. As can be noticed, after 1984, the number of women in Computer Science began dropping rapidly, from 35% to approximately 17% in 2010.

<sup>8</sup>Source: NSF, American Bar Association, American Association of Medical Colleges. Credit: Quoc Trung Bui/NPR



Figure 15: Computer Science: percentage of incoming women from 1988 to 2017

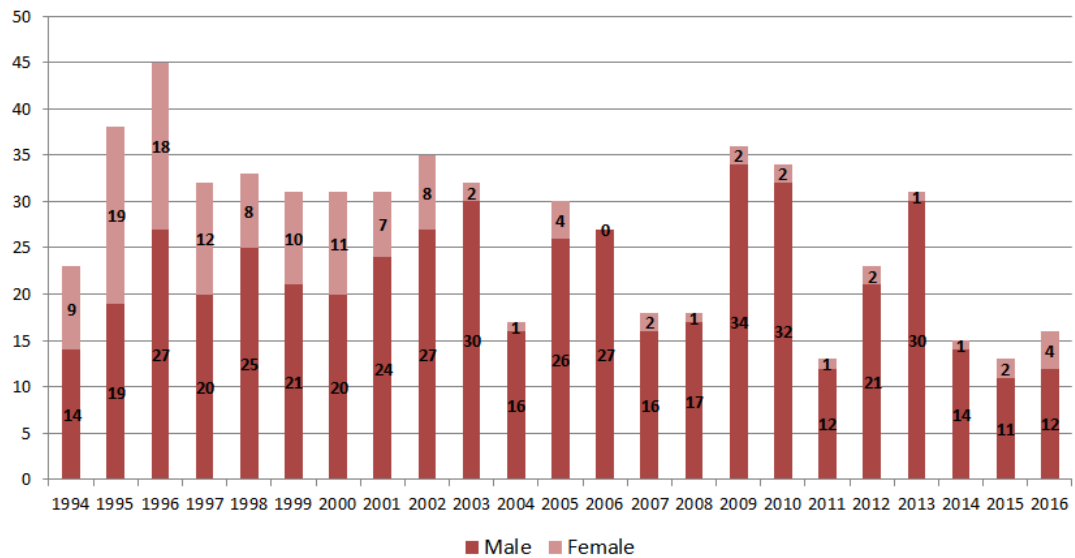


Figure 16: Computer Science: graduate students from 1994 to 2016



Figure 17: Computer Science: percentage of graduate women from 1994 to 2016

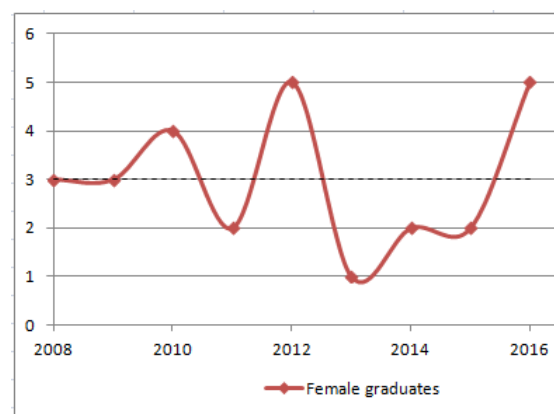


Figure 18: Number of graduate women from 2008 to 2016 at the DIN/UEM

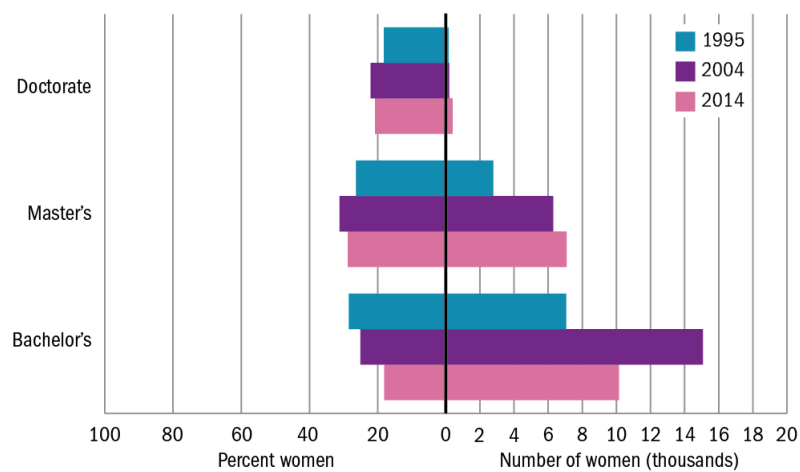


Figure 19: Women in Computer Sciences in 1995, 2004 and 2014 [24]

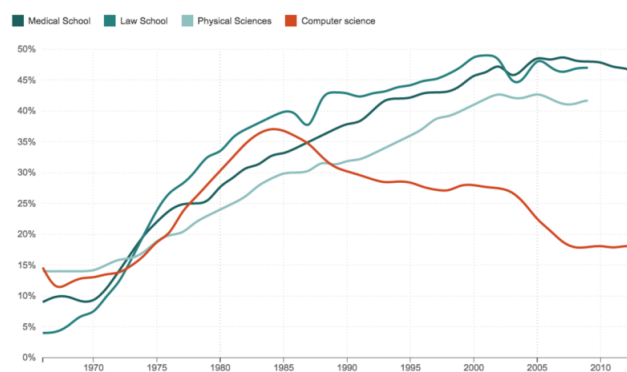


Figure 20: Percentage of women in STEM over the last 40 years

The data presented and discussed in Section 4 make it clear that at DIN-UEM the number of women are low. Unfortunately, the percentage of women enrolled in both courses, Computer Science and Informatics, are smaller than the national one (14.19%), 7.58% in Computer Science, and 8.65% in Informatics.

In this context, the main challenge is to motivate young women, from 10 to 12 years old, to be interested in ICT. Considering that, in 2017, the "Conectadas" Project in cooperation with the "Desafio do Código"<sup>9</sup> had carried out a 10 hour course to teach programming logic and basic maths using playful activities. Seven girls, from 10 to 12 years old, had participated. The girls were students of a public school that stays inside the campus at UEM. The activities of the programs Code Hour<sup>10</sup> and Khan Academy<sup>11</sup> were used. In 2018, another course was organized in cooperation with the Cidade Canção Institute<sup>12</sup> with 10 to 12 year-old girls.

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