An analysis of female participation in informatics research at UFRJ's PPGI

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Abstract. *In a sociocultural view, women and men do not participate or are perceived equally in the computing or informatic area. This paper presents a descriptive research using data analysis and statistics, based on data science and feminist theories, on women's participation in the UFRJ/PPGI between 2004 and 2018. The participation of women in the UFRJ/PPGI follows the current socio-cultural scenario? Is there gender equity?*

Resumo. *Sócio culturalmente, mulheres e homens não participam ou são percebidos igualmente na área da computação ou informática. Este trabalho apresenta uma pesquisa descritiva utilizando uma análise de dados e Estatística, baseada em Ciência de Dados e Teorias Feministas, sobre a participação de mulheres no PPGI da UFRJ, entre 2004 e 2018. A participação quantitativa das mulheres no PPGI da UFRJ segue o cenário sociocultural de gênero atual? Há equidade de gêneros?*

1. Introduction

In a Statistics course, in the Graduate Programme in Informatics (*Programa de Pós-Graduação em Informática* - PPGI) at the Federal University of Rio de Janeiro (*Universidade Federal do Rio de Janeiro* - UFRJ), we had the thematic goal of analyzing student databases for various, mainly predictive, analysis based on Data Science techniques (GRUS, 2018). "Gender" was one of the attributes, or dimensions, found and analyzed in the database, separated out in this scenario in binary form, "masculine" (men) or "feminine" (women).

We synthesized and gathered the information in the databases into one. The "gender" became one of several dimensions associated with each student. Superficial analyzes exposed specific phenomena associated to this dimension. This aroused our interest and motivation for this work, in combination with our awareness of feminist theories in Information Systems (IS) (ROSSER, 2005) (ADAM, 2001) and, in the spectrum of education, gender inequality in this domain (POSSE E TEIXEIRA, 2016).

This paper aims to shed light on the quantitative situation of women in the UFRJ's PPGI. Using statistical methods and Data Science (DHAR, 2013), building a descriptive research (RECKER, 2013). Contributing to the debate and exposition of data on this topic, so little addressed at the postgraduate level.

This paper is structured as: Section 2 contains theoretical bases and concepts grounding this work; Section 3, related works; Section 4 presents the contributions and discussions; Section 5 concludes the paper.

2. Theoretical foundation

Adam (2001) discusses feminist epistemology in IS. Epistemology is the study of the nature of knowledge, justifications and reason of beliefs (BONJOUR, 2002). In IS there is a power imbalance between genders, among the actors that define which are the interesting objects to the sociocultural debate of the area. The debate about feminism is not prestigious by actors who dominate the area, and with it the respective discourse. Women, as members of the subordinate group, are pertinent to the construction of the emancipatory process itself. Without women and without the debate about the gender situation in IS, there is stagnation of power.

A visible and tacit male norm (ADAM, 2001) incorporates a gender bias and influences the traditional IS epistemology. Women and men perceive and interact with reality in different ways and several aspects (ROSSER, 2005). This work focus on the sociocultural. The graduate level build most of the formal and structured scientific knowledge (or artifacts) in the university. There is quantitative inequality in the participation of men and women in this field. Dominant male actors trivialize or silence the debate about gender inequality in the construction and epistemology of knowledge (or artifacts). There is a risk to social sustainability that threatens the plurality of perceptions and interactions with reality.

Analyzing, by simple regression, the constancy or increase of this trivialization or silencing behavior, the tendency is that the presence of women in Informatic courses will become or, optimistically, constant in inequality or at some point in the future, tiny or null. Maia (2016) argues that "in the face of the economic warming of the computer services sector and the growth of the electronics industry, the number of graduates of informatic courses has grown, but unbalanced by gender. From 2000 to 2013, while the number of graduating men grew by 98%, that of graduating women decreased by 8%, constituting a rare phenomenon in Brazilian undergraduate education, even when fields of traditional male presence are taken, such as engineering." (MAIA, 2016).

To extract knowledge and multidisciplinary reflections on the database structured with methods, processes, algorithms and scientific principles we dialogue with the field of Data Science (DHAR, 2013) (GRUS, 2018); thus, analyzing phenomena based on data and, in this work, gender. The field connects with the discipline of Statistics and the practice of data analysis. In this paper we will analyze trends (GRUS, 2018) and numerical data extracted from subsets of the initial base [1], having as key dimension "gender". We were able to collect data from 2004, even though the program started before that.

The UFRJ's PPGI starts in 1997, with the opening of the master's program [2]. In 2010 the doctoral program opens [2]. It is headquartered at the Center for Mathematical and Natural Sciences (*Centro de Ciências Matemáticas e da Natureza* - CCMN), in Rio de Janeiro. 708 (seven hundred and eight) students accessed the PPGI between 2004 and 2018, 530 (five hundred and thirty) men, 178 (one hundred and seventy-eight) women.

At PPGI, the master's degree consists of five lines: Models and Architectures for Intelligent Systems (*Modelos e Arquiteturas para Sistemas Inteligentes* - MASI), Algorithms and Numerical Methods (*Algoritmos e Métodos Numéricos* - AMN), Information Systems (*Sistemas de Informação* - SI), Informatics, Education and Society (*Informática, Educação*

[1] encurtador.com.br/aK478. Available at 15/09/2019

[2] encurtador.com.br/ilrwP. Available at 15/09/2019

e Sociedade - IES), Computer Networks and Distributed Systems (*Redes de Computadores e Sistemas Distribuídos* - RCSD). The doctorate, for three: Complex Systems Management (*Gestão de Sistemas Complexos* - GSC), Complex Systems Analysis (*Análise de Sistemas Complexos* - ASC), Adaptive Complex Systems (*Sistemas Complexos Adaptativos* - SCA).

Since students are oriented by teachers, and teachers build PPGI student orientation and have a gender dimension, we include this subset in the analysis. We considered teachers who have advised 5 (five) or more students who concluded their graduation, totaling 31 (thirty-one) teachers, 9 (nine) women and 22 (twenty-two) men.

Having presented the information and foundations to the work, we proceed to the analysis of the related works.

3. Related works

Related works present descriptive research associating technical or undergraduate courses in informatics with the presence of women in them, in various locations throughout Brazil (OLIVEIRA *et al*., 2018) (HANSEN *et al*., 2018) (MARINHO *et al*., 2019) (MARQUES *et al*., 2019) (MELLO *et al*., 2019).

By using the search expression "computer science graduate woman Brazil" and "computer science graduate woman Brazil" and searching for descriptive works associating women students and Informatic or Computer science graduate in Brazil, two results were found in the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES) [3] journal portal and in *Google Scholar* [4], demonstrating little production on the topic.

Nakamura *et al*. (2017) describe the quantitative scenario of informatics graduation in the Federal University of Amazonas. On access, men constitute a significant majority. In conclusion numbers, there is balancing, with more women than men completing in few of the years. The number of women was higher in only one of the years analyzed, in 2015, in the doctorate. There is less abandonment among women.

Holanda and Araújo (2019) deal with the informatics graduation at the University of Brasilia. In this scenario the numbers are unequal in access and completion, with a significant majority of men both accessing and concluding, without gender balance. No woman has completed her professional master's degree in infrastructure.

The present work follows the recommendation of future works present in Nakamura *et al*. (2017) and Holanda and Araújo (2019), presenting a data analysis on a new regional and institutional context, extending the theme.

4. Analysis by gender of PPGI student data between 2004 and 2018

The PPGI consisted of ≈74.9% students and ≈25.1% students, concluding or not, approximately three times more men than women. Access, with its respective linear regression (GRUS, 2018), is graphically exposed in Figure 1, general and divided by master and doctorate program.

Looking at Figure 1, the tendency is that, in the master program the number of men increases, and women decreases. In the doctorate, that the two increase, more sharply for men. Considering that the vacancies are limited, and that the behavior analysis of the graph

[3] http://www.periodicos.capes.gov.br/. Available at 15/09/2019
[4] https://scholar.google.com.br/. Available at 15/09/2019

cannot be dissociated from reality (DHAR, 2013), the tendency is for men to either keep their numbers in the doctorate, or to assume all vacancies. The normalization of the trend towards access to masters and doctorates generates the behavior in Figure 1, that is, men will still be the majority, even if there are very few women in PPGI.

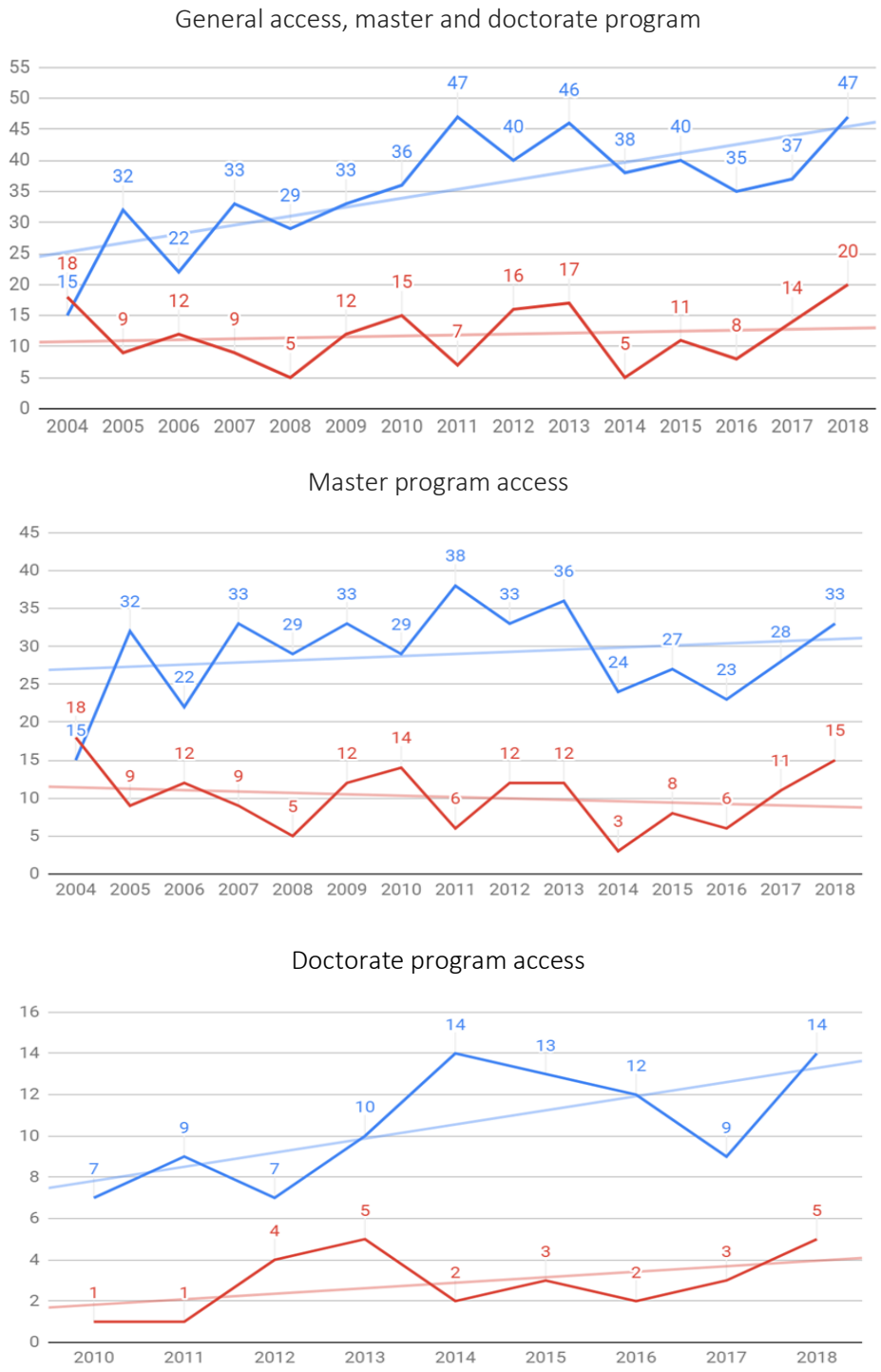

Figure 1: Access to UFRJ's PPGI, 2004 to 2018. Blue, men; red, women.

Analyzing the 2014 to 2018 subset, the scenario of women's access to PPGI is increasing and tending to increase, however the time series is too limited to make

consolidated predictions (GRUS, 2018). This behavior may lead to a quantitative balance between men and women in the student body, different from the current three-to-one.

In the causes of inactivity, the numerical behaviors are similar or almost equal. Disregarding conclusion and abandonment, conclusion: ≈43,2% men and ≈52,9% women; abandonment: ≈17.6% men and ≈8.6% women. This phenomenon may come from greater sociocultural pressure for men to work and make a living. This undermine their graduate dedication and performance, so, resulting in abandonment or lower conclusion rate.

About the area of the most recent and initial under graduation, we divided into three areas: (i) Exact Informatics (EI), related to Informatics and Computing; (ii) Exact, but Not Informatics (ENI), such as Mathematics, Physics, Statistics, among others; (iii) Not Exact (NE), such as Design, Pedagogy, Communication, Geography, among others. Table 1 exposes the respective numbers.

Table 1: Available data on most recent and initial under graduation area by gender, compensated in parentheses

Area	Women	Men	Total	W. %	M. %
EI	98 (*294*)	356 (*118*)	454	0.22	0.78
ENI	37 (*111*)	119 (*39*)	156	0.24	0.76
NE	29 (*87*)	27 (*9*)	56	0.52	0.48
	164 (*492*)	502 (*167*)	666		

In this case the numbers showed a large discrepancy between women and men, so we made a compensation. As they are approximately three-to-one men to women, we apply this balance in the considerations. The number of incomings from ENI is balanced, from EI already start to show some imbalance. As for NE, the discrepancy is huge. To equate should be 87 (eighty-seven) men for the actual 29 (twenty-nine) women. In this indicator were 27 (twenty-seven) men, showing that, proportionally, much more women from the NE area accessed the PPGI. By subtraction, EI and ENI favor balancing men.

We can build hypotheses based on the analysis of the initial under graduation area of the entrants: (i) shortage of women in the EI or ENI under graduation areas, maintaining this phenomenon in graduate programs; (ii) lack of interest of men from NE areas in the PPGI; (iii) in the selection process, the scarcity of women and the plenty of men results in a selective predilection for more men from EI or ENI areas, while those from NE areas are not selected.

Table 2: Available data on access to research lines by gender

Level	Line	Women	Men	Total	W. %	M. %
Master	MASI	15	64	79	0.10	0.13
	AMN	24	64	88	0.16	0.13
	SI	49	156	205	0.33	0.32
	IES	28	42	70	0.19	0.09
	RCSD	5	55	60	0.03	0.11
Doctorate	GSC	13	50	63	0.09	0.10
	ASC	13	33	46	0.09	0.07
	SCA	2	26	28	0.01	0.05
		149	**490**	**639**	**1.00**	**1.00**

As for PPGI's research lines, three points show discrepant behaviors. RCSD has more male students, the continuation of this line in the doctorate is SCA, which also has more men; IES have more women. All other lines have a proportional balance, shown in Table 2. Interestingly, RCSD and SCA had two women as the most recognized and active teachers, Luci Pirmez and Flávia Delicato; but this area is predominantly male.

RCSD and SCA areas are associated with IS infrastructure, male-dominated. IES has humanistic and social foundations, which is lacking in most courses in IS and ENI areas [5] and is not considered "masculinized" (ROSSER, 2005), from where comes the largest number of students from NE areas and with women majority. Harming social sustainability, there is a phenomenon of inverse proportionality between the presence of women in an area and the associated payment [6], that is, the more women migrate to an area of male dominance, the lower the payment and prestige associated with it, regardless of qualification level.

About professors, student advising. There were 546 (five hundred and forty-six) student advisers, 216 (two hundred and sixteen) by male professors and 340 (three hundred and forty) by female professors. Considering the values at the end of Section 2, it is an average of 22 (twenty-two) student advised to each female advisor; 15 (fifteen) for each male advisor. In conclusion numbers, the ratio decreases to 12 (twelve) for female advisors and 8 (eight) for male advisors. There is an overload in the work of female advisors. One of the explanations may be the perception of work balance. To compensate for sociocultural prejudice, women need to excel in productivity for their work effectiveness to be perceived or recognized as that of men (Rosser, 2005).

In student advising, 9 (nine) advisers, one woman and 8 (eight) men, advised one or no female students. Only one student advisor, Claudia Motta, had more guidance from women than from men. In the master's program, of the six advisers with the most student advising, 4 (four) are women and 2 (two) are men. In the doctorate is the reverse, 4 (four) are men and 2 (two) are women.

The difference in the number of students advising and advisors in masters and doctorate program can be analyzed by a gender bias by the socio-cultural heritage of the twentieth century. While at one point in the twentieth century women were the majority in computing, there was a gradual decline in their presence in the area [7]. In order to advise students in the doctorate the teacher needs to fulfill some requirements, such as time interval after completing the doctorate, academic production or acting as a member of a graduate program. Thus, in this social race women were already lagging from the starting line, while men were already structurally, and academically, well established in the area. With the increase in the presence of women in PPGI, their orientation income surpassed theirs; demonstrating effort to move forward in this race and overcome the sociocultural deficit.

5. Conclusion

This paper presented a gender-focused data analysis aimed at describing women's participation in the UFRJ's PPGI between 2004 and 2018, using Data Science principles (GRUS, 2018) and from the perspective of Feminist Theory (ROSSER, 2005). As few studies are found at the Brazilian graduate level, this is a differential.

[5] encurtador.com.br/qzBQZ. Available at 15/09/2019
[6] encurtador.com.br/qFTZ8. Available at 15/09/2019
[7] encurtador.com.br/iDHU8. Available at 15/09/2019

There is still a large discrepancy in the participation of women in the construction of Brazilian informatics. As in the academic area, at the UFRJ's PPGI, where there is a three-to-one gender ratio, with most men. How to improve this scenario, consequently the social sustainability linked to it?

Meninas Digitais [8] is a program created in 2011, with several associated projects, with the objective of "disseminating the area of Informatics and its technologies to arouse the interest of female high school students (in its various modalities) and female students in the final years of elementary school" [8], because the imbalance starts at the roots. Female undergraduate students in an EI area students may be motivated to graduate in informatics or related fields, helping the construction of an area that is not exclusive to men, informatics research.

Since 2016, at UFRJ, there is the *SuPyGirls* [8] project, which seeks to include girls from public schools in the universe of technology through digital games. A pragmatic referral can be a dedicated project that encourages women, in this setting students from UFRJ, to attend graduate programs in EI areas, to encourage and motivate them for this academic area, following a graduate degree in Informatics.

As future work we suggest data analysis in other regional or organizational contexts; qualitative research on women's experience and their sense of participation in the UFRJ's PPGI or other programs; analysis and evaluation of other dimensions associated with gender; further analysis of gender inequality in the lines related to IS Infrastructure (RCSD and SCA), especially at UFRJ itself.

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