

# Women in Postgraduate Programs of Engineering and Natural Sciences: A Case Study in Brazil

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## Abstract

Women are often under-represented in academic and professional fields of engineering and natural sciences. Retaining and strengthening them in these postgraduate programs is one of the most effective measures for promoting gender equality in the field. However, there is a lack of studies defining and analyzing the profiles and needs of these women. In 2018, we collected data about 916 women at the best university of South America, through an official request of information followed by an online survey. The results show they are between 21 and 30 years old, single, do not have children, and are strongly dependent on their scholarship income. The desire to become a professor/scientist motivated them to enter the program. The campus of their postgraduate program is not the same where they did their graduations, and their families do not live in the same town of their campus. One-third of them declared they want to have children in the medium-term. It is surprising that 65.12% refused to answer questions about their social status as postgraduate students, despite being informed that the survey was anonymous. This may indicate that being a woman doing a postgraduate program in engineering or sciences is a taboo in Brazil.

## Keywords

Women, Higher Education, Engineering, Natural Sciences, Brazil.

## 1. Introduction

The theme of gender equality and women empowerment grew in popularity after the United Nations Organization established it as one of the eight Millennium Development Goals (United Nations, 2020). Despite some governmental (Government of Canada, 2020) and organizational (IEEE, 2020) efforts, women are often under-represented in academic and professional fields of engineering and natural sciences (MentorNet, 2003). Particularly, women who undertake a postgraduate program are expected to become professionals who will mentor future students. Mentoring

is the strategy that proved to be efficient in retaining women in engineering and science, once it helps to improve their self-confidence in their abilities (MentorNet, 2003).

In this way, efforts to understand the barriers and strengthen the presence of women in postgraduate programs may act as a double positive effect for attracting and retaining women in the career: firstly, acting on the postgraduate woman and secondly on the future generations of students that will be mentored by these women. Although the transformative potential of investing in postgraduate women, studies on gender inequality are majorly focused on primary education, and fewer encompasses secondary education and/or university studies (Rosemberg, 2001; Psacharopoulos, Patrinos, 2002; Psacharopoulos, Tzannatos, 1992; UNESCO Institute for Statistics, 2016). There remains a need for data collection about women in postgraduate programs around the world in order to support effective initiative for reducing gender inequality in engineering and natural sciences.

The purpose of this paper is to describe and examine the profile of women in postgraduate programs of two campuses of the University of São Paulo (USP), Brazil, considered the best high educational institution of South America (The World University Rankings, 2020). Firstly, official data about the total of postgraduate women were required to the five units of the two campuses: a school of engineering, an institute of architecture, a department of mathematics, a department of physics, and a department of chemistry. Secondly, an online survey with questions regarding reasons that brought these women to postgraduate programs, their current condition on the programs, their future expectations about future and professional life, and their social image in the community. The results reveal a surprising refusal to answer questions about their social status of being a woman in a postgraduate program.

## 2. Contextualization

The University of São Paulo (USP) is a public university created in 1934 (The World University Rankings, 2020). In 2018, the USP had 59,084 undergraduate students, 29,926 postgraduate students (14,306 at Master's and 15,557 at Doctoral), and 8,954 special students. Women represent 47,15% of the total students (University of São Paulo, 2018).

The USP has 11 campuses: four in the city of São Paulo, one in Bauru, one in Piracicaba, one in Pirassununga, one in Lorena, one in Ribeirão Preto and two in São Carlos. There are 42 Units of teaching and research, 32 Central governing and service bodies, 6 Specialized institutes, 4 Hospitals and related services, and 4 Museums (University of São Paulo, 2018).

São Carlos town has 116,765 inhabitants and it is 236 km far from São Paulo city. There are 2 campuses of USP in São Carlos. The distance between campus 1 and campus 2 is 5.7 km and there is free public transportation between campuses for students. There are five USP units in São Carlos: São Carlos Engineering School (EESC), Institute of Mathematical and Computational Sciences (ICMC), Institute of Architecture and Urbanism (IAU), São Carlos Chemistry Institute (IQSC), and São Carlos Physics Institute (IFSC). The IAU is the unique unit with buildings exclusively on campus 1. All other units have buildings on both campuses for undergraduate and graduate programs (Campus City Hall, 2020).

Campus 1 is the only campus with subsidized student housing, sports club and a daycare center for kids of professors, university employees, and students (with this priority order) (Campus City Hall, 2020). According to an official note from USP in 2017 (Press Release, 2017), it informs the university needs to reduce its spending by 25%. Therefore, teaching, production, and transfer of knowledge will be prioritized for the distribution of resources (it is understood that daycare centers are not a priority). The USP has 5 daycare centers for all 11 campuses, which serve 10% of the children of teachers and staff (children of students are not mentioned).

According to Art. 44, III, Law 9.394 / 1996, Brazil has two categories of postgraduate programs: *lato sensu* and *stricto sensu*. *Lato sensu* postgraduate programs comprise specialization programs and include courses designated as MBA (Master Business Administration). With a minimum duration of 360 hours, at the end of the course, the student will obtain a certificate and not a diploma. Besides, they are open to candidates with degrees in higher education and who meet the requirements of educational institutions (Ministry of Education, 2020).

The *stricto sensu* postgraduate courses comprise master's and doctoral programs open to candidates who have graduated from undergraduate courses and which meet the requirements of educational institutions and the selection

of students. At the end of the course the student will obtain a diploma (Ministry of Education, 2020). When a Doctorate is done without doing a Master program, it is named Direct Doctorate. The term for the Master's degree varies from 24 to 48 months and for the Doctorate from 36 to 60 months, the Direct Doctorate can be completed in up to 72 months, depending on the program and/or the course. The *stricto sensu* graduate enrollment process varies depending on the chosen program (USP Dean of Graduate Studies, 2020).

Whether the postgraduate students dedicate exclusively to the postgraduate program, they can apply for a scholarship. According to an undated text from the Ministry of Education (but probably written at the beginning of the decade of 2010 by references), the state of São Paulo has 21,161 master students and 27,716 doctoral students (Ministry of Education, 2020b). According to these numbers, the USP would have 67.61% of the master's students of the state of São Paulo and 53.13% of the doctorate candidates.

A postgraduate student in São Paulo state can compete for a scholarship of federal institutions CAPES (Coordination for higher Education Staff Development) and CNPq (Brazilian National Research Council) or state institution FAPESP (The São Paulo Research Foundation). None of them spread out the number of scholarships they concede, just some specific financial values.

FAPESP informed that, in September 2018, they changed values of scholarship (in Brazilian Reais): Master and Direct Doctorate I from 1,988.10 to 2,043.00; Master and Direct Doctorate II from 2,110.20 to 2,168.70; Doctorate I from 2,929.80 to 3,010.80; and Doctorate II from 3,626.10 to 3,726.30 (FAPESP, 2020a). Assuming there were twice more doctorate scholarships than masters, the yearly average of a scholarship value was 34,658.10 Brazilian Reais. FAPESP (2020b) informed that paid 363,247,000.89 in scholarships in 2018. That means, on average, 10, 480 scholarships, i.e., 21.44% of the postgraduate students in the state of São Paulo.

In 2018 (until 2020), the value of a scholarship (in Brazilian Reais) of CAPES or CNPq was 1,500 per month for a master candidate and 2,200 per month for a doctorate candidate (CAPES, 2020). Assuming there were twice more doctorate scholarships than masters, the yearly average of a scholarship value was 23,600.00. Assuming the quotation of a dollar in 2018 was 3.88 Brazilian Reais (ADVFN, 2020), FAPESP annual scholarship was USD 8,932.50 and CAPES/CNPq was USD 6,082.47.

For having a scholarship, it is required to have the exclusive dedication to the postgraduate program. The accumulation of scholarship is forbidden (CNPQ, 2020). There is no legal guarantee that the scholarship contract will be respected by funding institutions during the whole postgraduate program during, and some CAPES scholarship were temporally interrupted in 2019 (CAPES, 2019). Postgraduate students with a scholarship are not considered professionals; scholarships have no associated social protection, as a contribution to retirement, accident insurance, unemployment assurance or maternity leave. Whether the student gives up on the postgraduate program due to personal desire, disablement or death, he/she/his family/her family has to repay all used scholarships to funding institutions.

### 3. Methodology

The data used in this article was collected empirically inductive, acquired by the departments of the university chosen. The number of postgraduate students was personally requested to each unit of the São Carlos campus in June 2018. All units provided the number of regular postgraduate students by biological sex, program, concentration areas, and course (master's, doctoral, and direct doctoral) in up to 3 workdays after the formal request. They did not express concerns regarding the publication of the supplied data. The information was compiled, analyzed, and translated to English.

Considering the data collected, a brainstorming session was executed among a group of 5 postgraduate women at the São Carlos Engineering School (focus group). Based on the discussions, an online survey (in Portuguese) for the campus feminine postgraduates was elaborated. This survey was constructed with a Google Survey and spread through institutional e-mails and social media. The survey was available for 30 days (June and August 2018) and the respondents were not requested to identify themselves for answering it. The 5 women also answered the survey.

Table 1 presents the 18 questions of the survey. The questions belong to four pillars: the past period before Postgraduate program (questions 9 and 12), the current period of Postgraduate program (questions 1, 2, 3, 4, 5, 8, and

10), the future projections after Postgraduate program (questions 6, 7, and 11), and social status of being a woman doing Postgraduate program (question 13, 14, 15, 16, and 17). And a final open question (18) to permit that students share their opinions freely. Question 7 asks about what the student would do if she got pregnant during the postgraduate program. The option of abortion is not available because abortion is illegal in Brazil (except in case of life-threatening to the woman caused by the pregnancy, the pregnancy is the result of a rape or the fetus is anencephalic) (Law No. 2,848 of December 7, 1940).

Table 1. Questions of the online survey.

1. Which is your Postgraduate course? <input type="radio"/> Master ( <i>stricto sensus</i> ) <input type="radio"/> Doctorate ( <i>stricto sensus</i> ) <input type="radio"/> Direct Doctorate ( <i>stricto sensus</i> ) <input type="radio"/> Professional Master ( <i>lato sensus</i> ) <input type="radio"/> Another ( <i>lato sensus</i> )	2. In which unit of USP is your Postgraduate Program? <input type="radio"/> EESC <input type="radio"/> ICMC <input type="radio"/> IAU <input type="radio"/> IFSC <input type="radio"/> IQSC
3. How old are you? <input type="radio"/> Less than 21 years-old <input type="radio"/> 21 – 25 years-old <input type="radio"/> 26 – 30 years-old <input type="radio"/> 31 – 35 years-old <input type="radio"/> 36 – 40 years-old <input type="radio"/> More than 40 years-old	4. Which is your civil state? <input type="radio"/> Single <input type="radio"/> Married <input type="radio"/> Divorced <input type="radio"/> Widow <input type="radio"/> I prefer not to say <input type="radio"/> Another civil state
5. Do you have kids or dependents younger than 18 years old? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> I am pregnant	6. Would you like to have kids in the mid-term (up to 5 years)? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Maybe <input type="radio"/> I don't know
7. What would you do if you get pregnant during your Postgraduate program? <input type="radio"/> I would continue my Postgraduate program without interruption <input type="radio"/> I would stop my Postgraduate program for 6 months and continue it later <input type="radio"/> I would abandon my Postgraduate program	8. Does your family live in the same town where you do your Postgraduate program? <input type="radio"/> Yes <input type="radio"/> No
9. Do you do your Postgraduate studies in the same town you have done your Graduation? <input type="radio"/> Yes <input type="radio"/> No	10. Do you work on the market, besides doing your Postgraduate program? <input type="radio"/> Yes <input type="radio"/> No
11. What do you want to do after your Postgraduate program? <input type="radio"/> I want to follow an academic career <input type="radio"/> I want to be an entrepreneur <input type="radio"/> I want to find a job and exclusively work on the market <input type="radio"/> I want to follow an academic career and work on the market <input type="radio"/> I don't know what I want to do	12. Why have you chosen to do a Postgraduate program (You can choose more than one alternative)? <input type="radio"/> Because I wanted to be a Professor <input type="radio"/> Because I wanted to be a Researcher <input type="radio"/> Because I could not find a job <input type="radio"/> Because the characteristics of the career of public employee are attractive for me (e.g., salary, stability, etc.) <input type="radio"/> Because of another reason
13. Do you think your family and friends support your decision to do a Postgraduate program? <input type="radio"/> Yes, my family and friends are proud of what I do	14. Have you ever lied (or intentionally omitted) about doing your Postgraduate program? <input type="radio"/> Yes <input type="radio"/> No

<ul style="list-style-type: none"> <li>○ Not exactly, some support my decision, but others criticize me</li> <li>○ No, they don't support me at all</li> </ul>	
15. Have you ever listened to jokes or commentaries about women doing a Postgraduate program that you considered offensive? <ul style="list-style-type: none"> <li>○ Yes</li> <li>○ No</li> </ul>	16. Do you think your colleagues (men/women) treat fairly the other colleagues (men/women) independently of the gender/sex? <ul style="list-style-type: none"> <li>○ Yes, I think they treat me fairly</li> <li>○ No, I think they treat women better</li> <li>○ No, I think they treat men better</li> <li>○ I don't have an opinion about this topic</li> </ul>
17. Do you think your adviser (a man or a woman) treats fairly all supervised students (men/women) independently of the gender/sex? <ul style="list-style-type: none"> <li>○ Yes.</li> <li>○ No, there is a favoring for women</li> <li>○ No, there is a favoring for men</li> <li>○ I don't have an opinion about the topic</li> </ul>	18. In your opinion, how USP-São Carlos could offer a better life quality and better professional opportunities to women at Postgraduate programs? (Open Answer)

#### 4. Results and Discussion

It was observed that there were 2,621 regular students at postgraduate programs and 916 of them were biological women (34.95%). The total of women is distributed into the units as follows: 410 at EESC (44.75% of the total women), 189 at ICMC (20.63%), 117 at IQSC (12.77%), 76 at IFSC (8.30%), and 124 at IAU (13.54%). Mastering courses have 446 women (48.69%), Doctorate courses have 440 (48.03%) and Direct Doctorate has 30 (3.28%). Table 2 shows the number of Postgraduate students per unit, sex, and course, followed by the percentage of women in each university unit.

Table 2. Distribution of students according to the postgraduate program, sex, and university unit.

Unit of the University of São Paulo (USP)	Biological sex	Master	Doctorate	Direct Doctorate	Total
São Carlos Engineering School (EESC)	Men	366	362	16	744
	Women	220	180	10	410
	Total	586	542	26	1,154
	% of Women	37.54%	33.21%	38.46%	35.53%
Institute of Mathematical and Computational Sciences (ICMC)	Men	330	256	19	605
	Women	83	100	6	189
	Total	413	356	25	794
	% of Women	20.10%	28.09%	24.00%	23.80%
Institute of Architecture and Urbanism (IAU)	Men	26	24	1	51
	Women	73	50	1	124
	Total	99	74	2	175
	% of Women	73.74%	67.57%	50.00%	70.86%
São Carlos Chemistry Institute (IQSC)	Men	47	82	12	141
	Women	40	69	8	117
	Total	87	151	20	258
	% of Women	45.98%	45.70%	40.00%	45.35%
São Carlos Physics Institute (IFSC)	Men	67	89	8	164
	Women	30	41	5	76

	Total	97	130	13	240
	% of Women	30.93%	31.54%	38.46%	31.67%

It can be seen in Table 2, that the majority of postgraduate students are at IAU are women, the number of men and women at this unit is only equal for the Direct Doctorate course. It is important to remember that IAU is the smallest unit (6.7%) of the campus. On the other hand, ICMC is the second greatest unit (30.3%) and presents the lowest percentage of women in Postgraduate programs, 23.80%. Considering the representativeness of each unit's Postgraduate program to the total number of Postgraduate students of the campus, the campus female percentage is 34.95%.

It was also observed that the percentage of women from Master to Doctorate decreases at EESC and at IAU, increases at ICMC and at IFSC, and remains equal at IQSC. The increase may be easily explained by the fact these units are national centers of excellence and female Masters come from other regions of Brazil (or even from other countries) to do their Doctorates at IFSC and at ICMC. The reasons for decreasing percentages at EESC and IAU are not intuitively explained, considering the non-favorable Brazilian economic context, and may be a topic of research for further investigations.

A total of 195 women answered the online survey (21.29% of all women in postgraduate programs). Table 3 presents a summary of the answers to closed questions. According to answers for Question 1, 97 women were from Mastering courses or equivalent (21.75% of women of the course), 90 from Doctorate courses (20.45%) and 8 from Direct Doctorate (26.67%). According to answers for Question 2, the total of answers is distributed into the units as follows: 59 at EESC (14.39% of the women of the unit), 49 at ICMC (25.93%), 36 at IQSC (30.80%), 76 at IFSC (26.31%), and 124 at IAU (25.02%).

Table 3. Results of the online survey.

<b>Question 1</b>	<b>Total</b>	<b>%</b>	<b>Question 2</b>	<b>Total</b>	<b>%</b>
Master	93	47.69%	EESC	59	30.25%
Doctorate	90	46.15%	ICMC	49	25.12%
Direct Doctorate	8	4.10%	IAU	31	15.89%
Professional Master	2	1.02%	IFSC	20	10.25%
Another	2	1.02%	IQSC	36	18.46%
<b>Question 3</b>	<b>Total</b>	<b>%</b>	<b>Question 4</b>	<b>Total</b>	<b>%</b>
Less than 21	0	0.00%	Single	152	77.94%
21 – 25	61	31.28%	Married	36	18.46%
26 – 30	91	46.66%	Divorced	2	1.02%
31 – 35	34	17.43%	Widow	0	0.00%
36 – 40	6	3.07%	I prefer not to say	0	0.00%
More than 40	3	1.53%	Another civil state	5	2.56%
<b>Question 5</b>	<b>Total</b>	<b>%</b>	<b>Question 6</b>	<b>Total</b>	<b>%</b>
Yes	14	7.17%	Yes	63	32.30%
No	180	92.30%	No	86	44.10%
I am pregnant	1	0.51%	Maybe	32	16.41%
			I don't know	14	7.17%
<b>Question 7</b>	<b>Total</b>	<b>%</b>	<b>Question 8</b>	<b>Total</b>	<b>%</b>
I would continue my Postgraduate program without interruption	75	38.46%	Yes	28	14.35%

I would stop my Postgraduate program for 6 months and continue it later	112	57.43%	No	167	85.64%
I would abandon my Postgraduate program	8	4.10%			
<b>Question 9</b>	<b>Total</b>	<b>%</b>	<b>Question 10</b>	<b>Total</b>	<b>%</b>
Yes	81	41.53%	Yes	26	13.33%
No	114	58.46%	No	169	86.66%
<b>Question 11</b>	<b>Total</b>	<b>%</b>	<b>Question 12</b>	<b>Total</b>	<b>%</b>
I want to follow an academic career	97	49.74%	Because I wanted to be a Professor	113	57.94%
I want to be an entrepreneur	3	1.53%	Because I wanted to be a Researcher	52	26.66%
I want to find a job and exclusively work on the market	25	12.82%	Because I could not find a job	15	7.69%
I want to follow an academic career and work on the market	45	23.07%	Because the characteristics of the career of public employee are attractive for me (e.g., salary, stability, etc.)	6	3.07%
I don't know what I want to do	25	12.82%	Because of another reason	9	4.61%
<b>Question 13</b>	<b>Total</b>	<b>%</b>	<b>Question 14</b>	<b>Total</b>	<b>%</b>
Yes, my family and friends are proud of what I do	44	22.56%	Yes	6	3.07%
Not exactly, some support my decision, but other criticize me	22	11.28%	No	62	31.79%
No, they don't support me at all	1	0.51%	No answer	127	65.12%
No answer	128	65.64%			
<b>Question 15</b>	<b>Total</b>	<b>%</b>	<b>Question 16</b>	<b>Total</b>	<b>%</b>
Yes	20	10.25%	Yes, I think they treat me fairly	39	20.00%
No	48	24.61%	No, I think they treat women better	0	0.00%
No answer	127	65.12%	No, I think they treat men better	24	12.30%
			I don't have an opinion about this topic	5	2.56%
			No answer	127	65.12%
<b>Question 17</b>	<b>Total</b>	<b>%</b>			
Yes	60	30.76%			
No, there is a favoring for women	0	0.00%			
No, there is a favoring for men	7	3.58%			
I don't have an opinion about the topic	1	0.51%			
No answer	127	65.12%			

Answers to questions 3, 4, 5, 8, and 10 continue the characterization of the current scenario. The majority of respondents are between 21 and 30 years-old (77.94%), single (77.94%), do not have children (92.30%), does not have family in the same town of the campus (85.64%), and does not work on other jobs while doing their postgraduate programs (86.66%). Hence, it can be assumed that they depend on scholarships for their subsistency.

When asked about their background (questions 9 and 12), 58.48% of them do their postgraduate studies in a town different from where they did their graduate studies. The desire to become a professor motivated 57.94% of them to start a postgraduate program and the desire to become a researcher motivated 26.66% of them. When asked about future professional goals (question 11), 49.79% manifested the exclusive desire of following an academic career.

When asked about maternity desire (questions 6 and 7), 32.30% of the respondents wanted to have kids, and 23.48% declared that they were in doubt or did not know. If they get pregnant during their postgraduate studies, 57.43% would like to have an interruption of 6 months in their academic programs. It is interesting to note that the women who answered that they already have kids, also answered they would continue the postgraduate program without any interruption. This may mean they already have financial or social support to raise children.

When asked about social status and acceptance of being a woman in a postgraduate program (question 13, 14, 15, 16, and 17), 65.12% of the women refused to answer, despite being informed that the survey would be entirely anonymous since the first question.

The questions were: Do you think your family and friends support your decision to do a Postgraduate program? (3 options of answer); Have you ever lied (or intentionally omitted) about doing your Postgraduate program? (Y/N); Have you ever listened to jokes or commentaries about women doing a Postgraduate program that you considered offensive? (Y/N); Do you think your colleagues (men/women) treat fairly the other colleagues (men/women) independently of the gender/sex? (4 options); Do you think your adviser (a man or a woman) treats fairly all supervised students (men/women) independently of the gender/sex? (4 options).

This may indicate an error in survey methodology (for example, users got tired of answering the survey or the scale was not adequate) or may indicate that the theme (social judgment about a woman who does a postgraduate program and social judgment about a woman who identifies gender inequalities in her environment) is a taboo for Brazilian society, even for women at Postgraduate programs.

This refusal to answer may indicate that the statement “I do not think my adviser (a man or a woman) treats fairly all supervised students (men/women) independently of the gender/sex” (Question 16) may have a stronger social condemnation for woman in Brazil than the statement “I do not want to have children in the next 5 years” (Question 6). Maybe the period (5 years) made it easier to choose an option that could be interpreted as “I do not want to become a mother”.

There were twenty-three answers to the open question. The sentence “more psychological assistance” was mentioned 7 times, “more places for daycare centers”, 5 times, “more workshops about women and women empowerment”, 3 times, “assistance to find a job position”, 3 times, “more workshops about women and women empowerment”, 3 times, “I do not think the university can do anything”, 3 times, and “You should stop nitpicking with stupid surveys like this”, once.

## 5. Final Remarks

The present paper identified that women represent 34.95% of the postgraduate students at São Carlos, a campus focused on Engineering and Natural Sciences in Brazil. It was also observed that the percentage of women from Master to Doctorate decreases at Engineering and at Architecture, increases at Mathematics and at Physics, and remains equal at Chemistry. The reasons for this change is a recommended topic for future studies.

The results of the survey are underrepresented for Engineering and over represented for Architecture and Natural Sciences. The majority of postgraduate women are between 21 and 30 years-old, single, do not have children, and does not work on other jobs while doing their postgraduate programs. Hence, it can be assumed that they depend on



scholarships. It means FAPESP annual scholarship of USD 8,932.50 (for 21.44% of them, assuming FAPESP is sex neutral in attribution) and CAPES/CNPq was USD 6,082.47 (for 78.56% of them).

They desire to become a professor or a researcher motivated them to start a postgraduate program. The majority of them desires to follow the academic career exclusively and one third declared they want to have children in 5-year term. The women also do their postgraduate studies in a town different from where they did their graduate studies and do not have family in the same town of the campus. It may be assumed that it is essential to have access to daycare centers to achieve a full professional performance. This is also supported by the answers of open question, daycare center, psychological assistance, and professional coach.

When asked about social status and acceptance of being a woman in a postgraduate program (question 13, 14, 15, 16, and 17), 65.12% of the women refused to answer, despite being informed that the survey would be entirely anonymous since the first question. This may indicate an error in methodology or that being a woman doing a postgraduate program is a taboo in Brazilian society, at least, in Engineering and Natural Sciences.

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