https://doi.org/10.1590/198053149076_en

FEMALE GRADUATES IN MECHANICAL ENGINEERING: AN EXPLORATORY APPROACH

Maria Eulina Pessoa de Carvalho [I]
Mayanne Júlia Tomaz Freitas [II]
TRANSLATED BY Daniel Jalil de Carvalho Dana [III]

[I] Universidade Federal da Paraíba (UFPB), João Pessoa (PB), Brazil; mepcarv@gmail.com
[II] Universidade Federal da Paraíba (UFPB), João Pessoa (PB), Brazil; mayannetomaz51@gmail.com
[III] djcdana@gmail.com

Abstract

Based on quantitative data, interviews and literature on gender, science & technology, and the sociology of education and work, the text addresses the shortage of women as students and professors in the Mechanical Engineering program at a higher education institution in Northeastern Brazil. Six female students who entered the program in 2012 are monitored, up to the present. The analysis of their trajectories, obstacles, and personal and professional perspectives illustrates how the gender filter operates in the area of Science, Technology, Engineering and Mathematics. It indicates the challenges of including a gender perspective to achieve gender parity in higher education and the labor market.

GENDER RELATIONS • HIGHER EDUCATION • FEMALE GRADUATES

ALUNAS EGRESSAS DE ENGENHARIA MECÂNICA: UMA ABORDAGEM EXPLORATÓRIA

Resumo

Com base em dados quantitativos, entrevistas e referências dos estudos de gênero, ciência e tecnologia, e da sociologia da educação e do trabalho, o texto aborda a raridade de mulheres como alunas e professoras no curso de Engenharia Mecânica em uma instituição de educação superior nordestina. Seis alunas que ingressaram no curso em 2012 são acompanhadas até o presente. A análise sobre suas trajetórias, obstáculos enfrentados e perspectivas pessoais e profissionais ilustra como o filtro de gênero atua na área de Ciência, Tecnologia, Engenharia e Matemática, e indica os desafios da inclusão da perspectiva de gênero para o alcance da paridade de sexo na educação superior e no mercado de trabalho.

RELAÇÕES DE GÊNERO • ENSINO SUPERIOR • ALUNA EGRESSA

ESTUDIANTES GRADUADAS DE INGENIERÍA MECÁNICA: UN ENFOQUE EXPLORATORIO

Resumen

A partir de datos cuantitativos, entrevistas y referencias de los estudios de género, ciencia y tecnología, y de la sociología de la educación y del trabajo, el texto aborda la escasez de mujeres como estudiantes y profesoras en la carrera de Ingeniería Mecánica en una institución de educación superior en el Noreste de Brasil. Se realiza un seguimiento actualizado de seis alumnas y graduadas, que se incorporaron a la carrera en 2012. El análisis de sus trayectorias, obstáculos enfrentados, y perspectivas personales y profesionales ilustra cómo funciona el filtro de género en el área de Ciencia, Tecnología, Ingeniería y Matemáticas, indicando los desafíos de incluir la perspectiva de género para lograr la paridad de género en la educación superior y en el mercado del trabajo.

RELACIONES DE GÉNERO • EDUCACIÓN SUPERIOR • ALUMNA GRADUADA

ÉTUDIANTES DIPLOMÉES EN GÉNIE MÉCANIQUE: UNE APPROCHE EXPLORATOIRE

Resumé

A l'appui de données quantitatives, d'entretiens et des études de genre, sciences et technologies et de la sociologie de l'éducation et du travail, ce texte aborde la rareté des femmes étudiantes et enseignantes dans les licences de Génie Mécanique d'un établissement d'enseignement supérieur au Nord-Est du Brésil. Six étudiantes qui ont accedé au cours en 2012 ont été suivies jusqu'à présent. L'analyse de leurs trajectoires, des obstacles rencontrés et des perspectives personnelles et professionnelles illustre la mise en place du filtre de genre dans le domaine des Sciences, de la Technologie, de l'Ingénierie et des Mathématiques, indiquant les défis posés à l'obtention de la parité des sexes dans l'enseignement supérieur et dans le marché du travail.

RAPPORTS DE GENRE • ENSEIGNEMENT SUPERIEUR • DIPLÔMÉS

Received on: OCTOBER 14, 2021 | **Approved for publication on:** FEBRUARY 23, 2022

The enduring scarcity of women in Natural Sciences, Technology, Engineering and Mathematics (STEM)

IN THE SECOND HALF OF THE 20TH CENTURY, BRAZILIAN WOMEN ADVANCED IN ACCESS TO education and paid work, including in traditional and prestigious professions such as Medicine and Law. In the turn from the 20th century to the 21st century, they were already the majority of the student body and almost half of the faculty in higher education. However, in the field of Natural Sciences, Technology, Engineering and Mathematics (STEM) their inclusion was minimal.

The question "why so few?" has been posed by feminist scholars from several countries to understand the reduced presence of women in this field. Examining research conducted in the United States, Hill et al. (2010) attribute it to social and environmental factors; in Brazil, in a review about women in engineering, Lombardi (2016) highlights cultural and educational factors. And, although arguments about innate (mathematic, spatial and technological) skills by sex/gender do not have scientific credibility, gender stereotypes persist amid the lack of female models, as pointed out by Bermúdez et al. (2021) when discussing the insufficient progress in the inclusion of women in STEM in the European Union (EU).

To understand the enduring sexual division of labor amid the current educational success of women, it is important to underscore this analytical category, articulated to that of social relations of sex (analogous to gender relations), from the perspective of French feminist sociology. According to Helena Hirata and Danièle Kergoat (2007, p. 599), the sexual division of labor is both the form of division of social work resulting from social relations of sex, and the material basis of these power relations, which structure and cross the social field (Kergoat, 2009). This division is based on the destination of women to the reproductive sphere (where free, invisible work is performed for others), in the name of nature, love and maternal duty), and of men to the productive sphere, where the socially valued functions (i.e., political, religious, military) take place (Kergoat, 2009). Its organizing principles – men's work and women's work and the hierarchy/overvaluation of male work – are based on the naturalistic, biological, essentialist ideology that reduces gender to sex (Hirata & Kergoat, 2007).

Thus, the concept of sexual division of labor refers to the differential, hierarchical, and systematic distribution of men and women in domestic work, in the labor market, and in the professions, although with variations in time and space, intersected with class, ethnic-racial, North--South relations. In addition, it points out that these inequalities create a "gender system" (Hirata & Kergoat, 2007, p. 596) that undervalues women's work both in the family and in the labor market and limits their autonomy and individual and collective participation (Hirata, 2010; Biroli, 2016). In short, the two categories – sexual division of labor and social relations of sex – explain the asymmetric distribution of work, knowledge, and power between men and women (Hirata, 2010).

However, as Kergoat (2009) explains, there are displacements, ruptures, and new configurations within social reproduction, which apparently hide the division. Nevertheless, conditions change – such as the increase in female education, the expansion of their employability, or their entry into male fields – but the lower status of women remains when they enter the labor market and take on the double shift. They encounter gender barriers, more or less subtle, and pay a symbolic price that is not asked of their male colleagues.

Converging with the feminist critique, Bourdieu (1999) recognizes three practical principles of the sexual division of labor and the exclusion of women from technological careers: the first associates women with domestic roles (care, service, teaching); the second associates her with subordinate roles (she cannot have authority over men); and the third associates men with technical

objects and machines. These principles correspond to occupational segregation and the "glass ceiling": the shortage of women in the area of STEM and the subalternity of the positions occupied by them in all areas. Moreover, in STEM, there is the occurrence of the phenomenon called *leaky pipeline*, the exclusion of women, produced by gender filters (Blickenstaff, 2005).

Several factors divert girls from early STEM careers in an apparent context of co-education: from primary socialization, in the family, to secondary socialization, at school, their occupational aspirations remain gendered. At school, the curricular experience and the relationships with teachers and peers stand out (Roger & Duffield, 2000); girls feel alienated from traditional male subjects such as mathematics; boys dominate the classroom environment and have a negative effect on girl's learning; some male and female teachers have lower expectations about girls' performance and consider teaching boys more stimulating (Warrington & Younger, 2000; Lima, 2013). Since the school curriculum is a context of identity/subjectivity construction, it is within it that girls build a supposed incompetence for so-called male subjects (Stepulevage, 2001), and stop investing in the acquisition of mathematical and spatial skills (Hill et al., 2010). This is a learned incompetence (Bourdieu, 1999). Consequently, the traditional gender socialization, reinforced at school, causes women's low self-esteem, low self-confidence, and low self-efficacy, resulting in their self-exclusion from non-traditional careers and the preference for courses related to care (Donoso-Vázquez et al., 2013).

The first "gender filter" operates in the transition from high school to higher education, but, but the "leakage" continues during higher education, graduate school, and professional placement (Blickenstaff, 2005). Regardless of course, proportion of female students, and country, they abandon scientific careers in much higher numbers than men at all stages, and especially after their doctorate (Rees, 2001; Burger et al., 2010; Lacampagne et al., 2010). As pointed out in the expert literature, namely in STEM, the reasons are: difficulty in accessing resources; curricular contents disconnected from experience and distanced from concrete applications and social contributions; hostility in academic relations; exclusion from male social networks, and the consequent lack of a sense of belonging to a community of practice; and the scarcity of female professors, especially in research (Burger et al., 2010; Lacampagne et al., 2010).

Since the 1990s, there have been countries that have developed initiatives to encourage the inclusion of girls and women in STEM courses and careers. In the European Union, gender equality policies in universities and research institutes have taken three approaches: equal treatment between men and women, affirmative action, and gender mainstreaming. However, even where inclusion policies are carried out, the advancement of women in the male scientific and technological fields has been slow (Rees, 2001). According to Cooper et al. (2010), in the 21st century, academia is still not friendly towards women, and the "chilly climate" and the "glass ceiling" persist, even in countries where there are laws and policies to fight inequality (Kjeldala et al., 2005), especially in the fields of knowledge dominated by men.

As for vertical segregation, in the 21st century, for the most part, women continue to perform the least qualified tasks and are excluded from leadership positions, even in countries where feminist struggles have already generated gender equality policies. In professional development and promotion, the "glass ceiling" functions both as an external (socially imposed) and internal barrier (internalized by women, who do not aspire to the most valued jobs) (Sarrió et al., 2002). In this context, there is also the psychological barrier of fear of negative evaluation, and the lack of models and mentors that can inspire, teach "the rules of the game", offer support, protection, and opportunities for shared learning (Donoso-Vázquez et al., 2013; Cooper et al., 2010).

The interaction of these factors affects the trajectories of female students, professors, and other professionals in subsequent work relations, creating gender-specific disadvantages, which add up to the challenge of reconciling children and career if they so choose. In the academic field,

in particular, the lack of successful female professors, researchers, and managers, affects the few female students, who tend to feel odd in the dominant male homosocial culture in the STEM area.

According to Leonard (2001), the culture of universities is rooted, on the one hand, in a masculinity project based on super rationality, scientificism, independence and antagonism, competitive and self-promotional behavior, which excludes elements associated with femininity (the body, emotions, personal connections, and openness to human diversity); and, on the other hand, in a heterosexual project, which provides advantages and privileges to men and excludes women from male networks and formal organizations, enclosing them into heterosociability: as wives, docile and diligent colleagues in subsidiary positions, and objects of sexual harassment. Consequently, as a minority in the area of STEM, they tend to be isolated, insofar as they are not easily included in male networks, nor able to rely on their own female support networks in horizontal relations or on the support of superiors and mentors of the same sex in vertical relations (Lacampagne et al., 2010; Öhrn et al., 2009; Leonard, 2001).

It is within this context that the scarcity of women in STEM is reproduced: they tend to self--exclude, and those who get through gender filters are the exception. Few female Mathematics teachers go to elementary and secondary schools, few girls go to higher education in the area of STEM, where there are few female professors and mentors to inspire them to academic and professional success. Universities do not routinely follow up on graduates, so there is a lack of qualitative and biographical research on the trajectories of the rare successful women in these fields, stereotyped as masculine.

This paper, stemming from a project financed by the Conselho Nacional de Desenvolvimento Científico e Tecnológico [National Council for Scientific and Technological Development] (CNPq/Brazil) (Carvalho, 2017), presents historical and current data from a public federal institution of higher education (IHE), in the Northeast of Brazil, on the in(ex)clusion of women from Mechanical Engineering (hereinafter referred to as ME), one of the most masculine of all engineering majors. To illustrate the gender filter, we highlight experiences of students from the 2012 class, followed up on to the present.

The scarcity of women in the student body and faculty in Mechanical Engineering

In engineering, the inclusion of women has slowly increased since the 1990s (Lombardi, 2006), reaching 9.3% in mechanical and metallurgical engineering programs in 2011 (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira [Inep], 2013), strongholds of the most enclosed engineering programs (Carvalho & Sobreira, 2008). Specifically, ME ranked 15th nationally in number of enrollments, with a total of 132,267 students in 2016 according to the Censo da Educação Superior [Census of Higher Education], of which 10.2% were women (Inep, 2018, p. 26). As for program admissions in 2016, of a total of 40,040 students, women totaled 10.5% (Inep, 2018, p. 32).

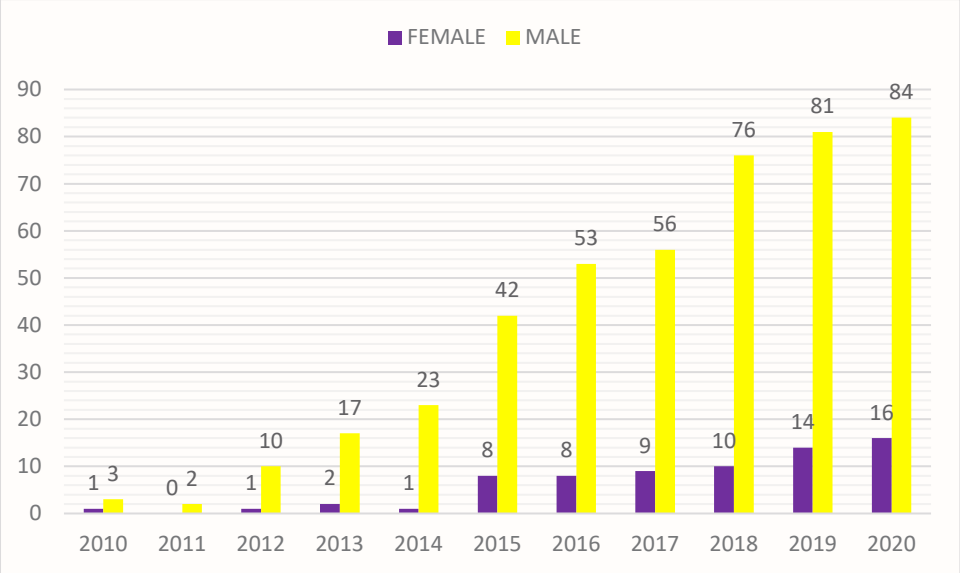
At the IHE researched, enrollment of students in ME has been growing, but they remain mostly male. In a historical series presented in a previous study (Freitas & Carvalho, 2018), female admission doubled from 6.5% in the 1970s to 12.9% in the 2010s. However, in the 47 years of the program's existence, until 2017, they represented 6% of the graduates, that is, the IHE had only 72 female mechanical engineer graduates.

In the first semester of 2017, 9 female students and 52 male students joined the ME program; and, in the second semester of 2017, 5 female students and 46 male students joined. Therefore, out of a total of 112 freshmen in 2017, 12.5% were women.

Currently, the ME program in this IHE has 566 enrollments, 491 of male students and 75 of female students (13%). In 2020, 16 women joined versus 84 men, resulting in 10% female admission.

Figure 1 summarizes enrollment numbers today, per year of admissions, over the last decade, allowing us to visualize that, for at least 55 men and 5 (8.3%) women, admitted from 2010 to 2014, graduation exceeds five years; of the 2015 freshmen, 84% of male and 16% of female students have not yet finished the program. The largest "leak" of students in high-dropout programs, such as ME, was noted, for example, by Kohler and Ioshiura (2017) at the Universidade Federal de Santa Catarina, where one in four students dropped out.

Figure 1
Distribution of students with active enrollment status in the Mechanical Engineering program, by gender, in 2010-2020



Source: Authors' elaboration based on official data from the IHE system (Aug. 2021).

On the whole, according to Lombardi (2016, p. 4), the reasons for the scarcity of women in engineering are both practical, due to the "limitations imposed by the profession, for example, its military origin, the adverse working conditions encountered by professionals in some specialties, the command of male teams", and of symbolic nature, that is, an "incompatibility between engineering and a given conception of femininity, hostile to mathematics, to rationality and objectivity, undisposed to competition". On the other hand, the "the slow process of feminization in engineering" would be due to the construction of professional identity and culture, which would demand the masculinization of female engineers "as a form of survival, resistance and defense", in order to be successful (Lombardi, 2017, p. 126). In this context, female engineering professors are rare in higher education, resulting in a vicious cycle of female exclusion in this area.

The Department of Mechanical Engineering (MED) at the IHE researched came to have two female professors, who joined in 1976 and 1978, and retired in the 1990s (Carvalho, 2017). Although it had a substitute female instructor in 2000, the MED did not have any women on its full-time (tenured) staff until December 2011, when a female candidate, graduated in Civil Engineering, with a master's and doctorate in ME, joined through a public recruitment procedure. In 2014, another female professor, with a B.A., master's and doctorate in ME, joined by transference from another IHE, but left the MED in 2016 because she did not feel welcomed (Carvalho, 2017). Therefore, until the year 2020 there was only one female professor (3.4%) in contrast to 28 male

professors in the MED. Recently, in 2021, a new female professor was hired, so the MED teaching staff [comprised] two women (6.6%) among its 30 male professors, not taking into account two volunteer and one visiting professors.

There are well-known, yet not faced, problems in the engineering area, such as the lack of female role models in the labor market (starting in professional training), the enormous retention and dropout rates in the graduation programs of this field, as well as the migration of trained professionals to other areas (Watanabe et al., 2015). These problems, related to multiple factors, are pertinent to androcentric culture, with its "hard"[1] epistemology and methodology, as illustrated below in the formative and work experience of ME students.

Following up on students

In the class of the 1st semester of 2012 of the Mechanical Engineering program, 61 students joined, according to institutional data registry, of whom there were 8 women (13%) and 53 men (87%). However, when we got in touch with the class, in the context of the research mentioned (Carvalho, 2017), we only found 6 female students. Identified as S1 through S6, they were interviewed, at different times,[2] about their perceptions of gender relations in academic life and their professional and personal plans after graduation.

In December 2012, a questionnaire[3] was administered to and a focus group was conducted with these students. S1, S2 and S4 joined the ME program via affirmative action for black, indigenous and public-school students. Table 1 below presents their characterization.

Table 1
Characterization of the students of Mechanical Engineering admitted in the 1st semester of 2012

Student	Age	Color	Father's occupation	Mother's occupation
S1	18	Brown	Informal trader	Unemployed
S2	20	Black	Basic education teacher	Basic education teacher
S3	18	White	Electric engineer	Physical Education teacher
S4	18	White	Driver	Nursing technician
S5	18	White	Bank clerk (incomplete higher education)	Basic education teacher
S6	18	Brown	University professor (architect)	Math teacher (electric engineer)

Source: Questionnaire administered in December 2012 (Carvalho, 2017).

All of them pointed out having an ease in Mathematics and a liking for machines and engines as reasons for the choice of ME, so they got through the gender filter throughout their school years. S3 has an electrical engineer father and S6 has an electric engineer mother, another of the engineering fields with male predominance. S6 claimed to be "passionate about mathematics". All of them declared to be satisfied with the program at the end of the first year, but S6 was still in doubt as to her choice and permanence.

1 In analogy to the use of "hard" sciences.

2 The original project provided for the approach of students in early and late semesters of the program.

3 In addition to the characterization of the subjects, the questionnaire focused on reasons for choice of program, perception of the female minority in it, initial experiences, and perspectives after completion.

Questioned about girls' low interest in ME, they pointed out cultural conditioning. According to S3, "*due to the lack of interest of some women in machines/engineering, and the fact that there is already a historical relationship linking men to machines*". To S5, "*as ME is a program usually associated with cars and grease, I believe women don't have the curiosity to find out more about it, let alone choose it as a professional career*". Likewise, S6 reflected:

> *There is an idea that women are more interested in human sciences, while men are interested (and are better) in exact sciences. I don't think it's true, but the repetition, conscious or not, of this pseudofact must result in blockages in the girls when they choose a program.*

These statements indicate that they are aware that they are out of the cultural mainstream.

After the first year attending the program, they reported not having suffered prejudice because as women or witnessed episodes of gender discrimination. Referring to colleagues, S5 noted that "*women engage more than men with coursework. Proportionally, they participate more in projects, and the current president of the student council is a woman*". However, S3 noted that, in her project's lab work, women were not "*as demanded as men, because it involves in which there is need of a greater physical strength*".

As for professional perspectives and job opportunities in the field, all of them were optimistic and wanted a full-time job, in the private or government sector, with stable income. S1, S2 and S4, who joined through affirmative action programs, emphasized the desire to promptly get a job and achieve financial stability, ratifying what Huff and Koppe (2016, p. 8) point out about the lack of qualified professionals in the area of STEM having aroused "the interest of women for professions that offered better job opportunities, with higher salaries".

None of them contemplated an academic career, except S6, who revealed that she wanted to "*do a master's and doctorate and then move on to the research area*". S3 stated that she aspired to graduate studies, but not teaching: "*When I graduate, I intend to specialize or start a master's degree in the area and begin work at the same time. I don't intend to pursue a teaching career*". She mentioned high professional and social contribution aspirations: "*In the future I hope to be successful, in a significant leadership position, to enjoy my work, do research and offer new ideas and products for the well-being of society*".

Marriage and plans to have children were recalled by half of the students. S4 projected "*to have a full-time job, with stable income, in the research area of Petrobras* [Brazilian oil company] *or in an automobile maker. Personally, I see myself starting a family with children*". S5 also included marriage along with professional success in her plans:

> *I have a great interest in the field of Energy, (and) I hope to be working with something related to this, have a full-time job, be a successful and professionally respected person. Personally, I hope to raise a family and maintain frequent contact with my parents and sister.*

And S6 professed: "*I hope to get married or live together. Currently, I do not like children very much... but I'm probably going to have one or two kids*".

Through 2017, the students were interviewed again, and it was found that the class had dispersed. Only S4 intended to graduate within five years – in the in the middle of 2017, due to the strike schedule –, which did not occur. Of the others, S6 had migrated to the Mathematics program in the third semester of ME; S3 and S5 were a year late due to participation in the Science Without Borders Program,[4] and S1 and S2 were also delayed, but for failing in courses.

4 Created in July 2011, during Dilma Rousseff's government, and funded by Capes, CNPq and partner companies, it aimed to expand and internationalize science, technology and innovation, as well as to promote Brazilian competitiveness through

According to an interview with S3, throughout the program, she never had a ME female professor. The only female professors that she had were in Mathematics and in Chemistry in the first year, and later in Ergonomics and Industrial Safety, both from the Department of Production Engineering. She said she felt included in the program, although, at first, she was seen as a preppy,[5] and had to prove that she was a good student. She then began to intentionally dress in a masculine and discreet manner, to counter the stereotype.

S3 considered the treatment in the program egalitarian, but recalled a markedly sexist episode:

> *In the last semester we presented a project, just the four of us, an all-female group, and we got the best score, 9.5,[6] that's when the boys said that the professor was sucking up to us, you know? He's a very rough professor, very rude...* [laughs].

This account that male colleagues attribute female success to being favored by male teachers or advisors, with implicit sexual connotations, is commonplace and was heard in the broader research, including from female professors recalling their experiences as students (Carvalho, 2017). In their research with engineering students, Carvalho and Sobreira (2008) also highlighted the existence of intellectual devaluation of female students, due to their gender.

At that point and time in their educational trajectory, both S3 and S4, who were about to graduate, changed their professional perspectives and began to consider the possibility of pursuing an academic career. "*We hope to get in a trainee program soon, as soon as we graduate, if the market is good, not the way it is now, but if not, we think of ourselves, me and the others, in the academic career as well*". All of them want to do a master's degree, but somewhere else, because according to S3 "we *think that the course here needs more stimulus, better professors, who motivate and encourage*". She talks about the need to go to the industry before pursuing an academic career, because she realizes that her professors are lacking in terms of a theory-to-practice relationship.

At the end of 2017, S4 had failed to graduate and was preparing to participate in a public hiring tender for the career of Intelligence Officer in the Brazilian Federal Police; therefore, she had given up on ME, either in industry or academic occupations. S1 intended to complete the program in mid-2018, was doing an internship, and said she would seek a trainee opportunity after graduating. S2, S3 and S5 projected graduation by the end of 2018; S3 and S5 were doing an internship and S2 was looking for an internship.

According to S2, job opportunities after graduation were difficult for all, men and women, so most graduates sought to get into graduate school, study for a public hiring tender or work in another state.

S6, who had dropped ME and migrated to mathematics, reported not having completed the program. When she was interviewed at the age of 23, in September 2017, by e-mail, she reported:

> *I transferred to the Unicamp[7] program because it is the best university in Brazil in Mathematics. It was a happy year, I got a Fapesp[8] scholarship for scientific initiation and exchange to France, but I ended up getting disgusted with the program. In the third semester, I couldn't take the castrating environment anymore . . . and I changed from a bachelor's degree to a teaching degree.*

exchange and international mobility, by providing up to 101,000 scholarships for undergraduate and graduate students over the period of four years.

5 "*Patricinha*", in Portuguese, expresses a stereotype that clearly denotes a frivolous and anti-intellectual young woman.

6 Out of 10 (the adopted scale in Brazil is 0-10).

7 Universidade Estadual de Campinas, located in the state of São Paulo, Brazil.

8 A state research foundation in São Paulo, Brazil.

> *I did the Pedagogy part and liked it, but when I had to go back to topics and subjects, professors, and the environment of Mathematics, I could not take it anymore and dropped out of the program.*

Despite her affinity with mathematics, S6 stressed her displeasure with the academic environment and colleagues, especially the symbolic violence of the sexist jokes also reported by Casagrande and Souza' (2017) and Kohler and Ioshiura' accounts (2017).

> *I always had an easy time in the program's subjects, before getting disgusted and dropping it. My grades had always been above 9. But I heard jokes that I only got a good grade because I had a thing with the teacher . . . . Comments, when my advisor was a man, like "oh, but he's only got female advisees, why is that?". "And when my advisor was a woman 'she's a feminist, she just advises women". Nothing was ever because I was good, it was all "facilitated" either by sex or by political bias. Work takes up a lot of adult life and I was terrified of having to stay, in the future, 8 hours/day in an environment with people like that.*

A6 reported that she was teaching French and thinking about taking entrance exams for the Dance program. Her professional and personal plans became countercultural and counter-androcentric:

> *I want to be a* doula *and work with art therapy, do tarot, be an astrologer, and a teacher (not necessarily at the same time). To take care of my body, learn natural cures, have children, take care of my orixá,*[9] *be part of an all-female coconut dance*[10] *group, travel a lot, learn other languages, have a stable non-abusive relationship.*

Following up on former students

In July 2021, the young female mechanical engineers graduating from the program of the IHE surveyed were sought once again to collect information about their professional placement and future plans. Table 2 summarizes the information obtained, through WhatsApp, from four of them, as S6 dropped out of ME, and S4 could not be located, neither through colleagues, nor through social networks.

S1 had graduated in the second half of 2018, S2 in the first half of 2019, and S3 and S5 in the second half of 2019. The four female mechanical engineers, therefore, completed the program within seven to eight years after admission.

Table 2
Job placement of Mechanical Engineering graduates

Student	Conclusion	Job placement	Post-graduation	Current job	Future plans
A1	2018/2nd semester	Out of the ME field	Certificate course in Occupational Safety Engineering (Unifip)	Math and Physics teacher in a public school	To participate in a public hiring tender for Security Engineering
A2	2019/1st semester	Internship in the innovation lab of the IHE	Master's in ME – thermofluids (UFPB)	–	To undertake in a startup or get engaged as a trainee

(*to be continued*)

9 African deity.

10 A circle dance and rhythm from the Northeast region of Brazil, with influences from African drumming and indigenous dances.

(*continuation*)

Student	Conclusion	Job placement	Post-graduation	Current job	Future plans
A3	2019/2nd semester	Internship in plastic and thermoelectrical industries	Master's in ME – energy generation (Unicamp)	Freelancer in a cogeneration project company	To develop applied research in energy generation. To do a PhD
A5	2019/2nd semester	Internship in a plastics industry	Certificate Course in Operations Engineering (UFRN)	Production coordinator in a local plastics industry	To continue in the same job in the plastics industry

Source: Authors' elaboration based on follow-up interviews conducted in July 2021.

On the first job placement experiences involving the ME labor market, internships were key as first job placement experiences in the ME labor market, but were not available for everyone. Only S3 and S5 interned, both in a local plastics industry, where S5 stayed and was promoted to production coordinator, a position she held at the time of contact. S3 did another internship in an also local thermoelectric industry and was later referred by her manager to work in a cogeneration company in São Paulo, where she continued working at the time of the interview, as a freelancer, in a temporary contract for two months.

S2 did an internship at the IHE innovation laboratory, from where she graduated, and moved on to a master's degree in thermofluids at the time. She was not working yet.

S1 did not get a job in ME, so she decided to look for work in other areas. She worked as a Physics teacher at a state school. Asked about how satisfied she was with the work, she replied:

> *It depends on how you look at it. I was surprised to find out that I really like teaching, I like the school and its importance to the community. I grew up a lot after I came across a reality totally different from the one I knew. But I'm not satisfied with the pay and unfortunately there's no professional development prospect. Even the highest hierarchical positions earn little or nothing more. I got the job when a friend, the moment she found out I was in need of a job, said that several public schools didn't have Math and Physics teachers. As they had an urgent need, since it had been a while that the school year had begun, they hired me even though I did not have a teaching degree.*

S3 also tried to find work for five months, without success, and decided to do a master's degree in ME. Graduate programs are part of the trajectory of the four female graduates, as in addition to S3 and S2, who are doing master's degrees, S5 and S1 are doing a certificate course: the first, in Operations Engineering, and the second, in Occupational Safety Engineering.

As for the young female engineers' future plans, S2 aims to "*undertake in a startup or get engaged as a trainee*" after the completion of her master's degree. S3 wants to work and continue doing research, including getting a doctorate. Eventually, she wants to "*create partnership programs/ incentives for implementation in the Brazilian scenario (through the government and private companies) within my research area – still little explored in the world*". S1, who is teaching in high school, therefore outside the field of ME, intends to "*participate in a public hiring tender in Safety Engineering, a position for which it is more common to find recruitment processes than Mechanical Engineering*".

A5 *intends to "stay in the plastics industry and continue developing and evolving as a professional".* Asked about her professional satisfaction and perception of relationships with bosses, colleagues, and subordinates, in a context in which women are a minority, she replied:

Yes, I'm content. About a sixth of the employees are women. The relationships are friendly, although at certain times, when I need to be assertive in the decision-making that is part of my job, I realize that the actions/reactions would not be the same if I were a man.

Therefore, of the five female students who graduated in Mechanical Engineering, only one (S5) was placed in the engineering labor market, particularly in the industry, countering the segregation of sex/gender in engineering, according to which men are mostly inserted in the industrial sector and women in traditionally feminine sectors, such as public administration (Carvalho & Sobreira, 2008).

Finally, one last personal question completed the interviews: did you get married and/or have children? All of them remain single and childless.

Conclusion

In this paper, we have explored the trajectories of six young women who got through gender filters and reached the Mechanical Engineering program of a northeastern IHE, in Brazil, one of the most masculine programs in engineering. In 2012, they got in with high aspirations for employment in the industry, and for professional and financial achievement. One of them "leaked" on the way, and five completed the program in 2019 and 2020, between seven and eight years after admission.

Sought in 2021 to verify their placement in the labor market, out of the five graduates, only one was employed in the short term, in a local plastics industry: she started as an intern and became the production coordinator. The others either have not yet worked as engineers or are doing graduate studies: one (not found in the last phase of the research) intended to apply for the Brazilian Federal Police, so was probably not working in the field; another (temporarily) became a teacher, due to the lack of employment opportunities in ME; two were pursuing a master's degree (and trying to get a job); and two were specializing through a certificate course (the one who was working as a teacher and the one who worked in the industry). Of the four interviewed in 2021, none had married nor had children, which indicates a priority for training and professional placement.

Longitudinal studies on training and entry into the labor market, or studies monitoring the trajectories of students and graduates of higher education programs, are not common in Brazil. Although dropout rates in engineering are high, and the students interviewed themselves recognized that job opportunities were difficult for everyone, men and women, the monitoring of Mechanical Engineering female students and *alumni* has special relevance for it refers to a minority in a traditionally male field. However, if on the one hand the small number of subjects followed up on (only six female students) and the absence of a comparative approach (in relation to the trajectory of male students) imply limits, on the other hand, the exploratory approach of this study can contribute to thinking about the inclusion of women in engineering towards gender equality, eliminating gender filters throughout basic schooling, minimizing the "leaks" in higher education, and transforming the male homosocial culture of the program and of the work environment.

As we know, "achieving gender equality and empowering all women and girls" is one of the 17 Sustainable Development Goals (SDGs) – Agenda 2030, proclaimed in 2015 by the United Nations (UN), precisely SDG 5.[11] Linked to the 2030 Agenda, in March 2015, UN Women launched the global initiative "For a 50-50 planet in 2030: a decisive step for gender equality", which Brazil has joined.[12] In this sense, supranational policies have emphasized the stimulus for girls to study STEM,

11 https://www.br.undp.org/content/brazil/pt/home/sustainable-development-goals.html
12 http://www.onumulheres.org.br/planeta5050/

the need to promote the participation and the advancement of women in the technological fields, and the change in gender stereotypes.[13]

A 50/50 planet requires the inclusion of the gender perspective in all educational, teaching, scientific, and labor/professional policies and practices, as a strategy to effect gender equality. Accordingly, the (Brazilian) National Strategy for Science, Technology and Innovation (ENCTI)[14] 2016-2019, launched by the Ministério da Ciência, Tecnologia e Inovação (MCTI), registered the Brazilian commitment to adopt specific policies and programs in scientific institutions for the "promotion of equality . . . in order to reduce inequalities and combat discrimination" (MCTI, 2016a, p. 55). In addition, it proposed reducing disparities in the development of ST&I (Science, Technology and Innovation) careers and mainstreaming gender in research, on the grounds that "ensuring and encouraging the full and effective participation of women in science and ensuring equal opportunities in the area of ST&I" brings "direct benefits to society as a whole" (p. 57). The ENCTI 2016-2022 maintained that commitment (MCTI, 2016b).

At the same time, the association between educational quality and equality, including gender equality, has been recognized in supranational and national policies (Unesco, 2003; Usaid, 2008) and is a springboard for ST&I policies. According to Donoso-Vázquez et al. (2014), the gender perspective is one of the fundamental pillars of a socially committed university at the service of citizenship and of a democratic and inclusive society because it allows adopting both a feminist epistemology, which highlights and recognizes the knowledge disqualified by traditional academic disciplines of androcentric bias, as well as a feminist/emancipatory pedagogy, which embraces diversity and gives voice to individuals and groups delegitimized by the academic tradition.

It is worth noting that the effort to attract more girls to STEM should start from early childhood education and continue throughout primary and secondary education, requiring specific incentive policies for higher education, such as the recent CNPq calls, from 2013 and 2018, under the Women and Science Program, entitled "Girls Doing Exact Sciences, Engineering and Computing", aiming to support projects for the inclusion of young women in STEM. As pointed out by Watanabe et al. (2015, p. 59), to mitigate the first gender filter, "initiatives with high school students to boost and increase the demand for these modalities of undergraduate programs" are strategic.

In higher education, the cultural, curricular, and pedagogical change needed to overcome the rarity of women in STEM, informed by the gender perspective, is decisive for the quality of the learning experience of all students, with "the adoption of pedagogical strategies that awaken and stimulate the interest of undergraduate students . . . reducing dropout rates" (Watanabe et al., 2015, p. 59).

In one of the interviews, conducted in 2017, S3 said that the lack of enthusiasm about graduating and entering the labor market which she perceived among colleagues was not only due to the moment of economic crisis that the country was going through. It also stemmed from the quality of the learning experience, in turn equally decisive for the empowerment of young female engineers in labor relations, as suggested by the testimony of S5, the production coordinator in the plastics industry, by demonstrating gender awareness in her work relationships.

Finally, it is worth emphasizing the importance of the presence of female professors in the Mechanical Engineering program to inspire students to continue and develop their own peer networks. As indicated in the literature, networks are vital for collective empowerment throughout training and in entering and performing in the labor market (Burger et al., 2010; Cooper et al., 2010).

13 https://brasil.un.org/pt-br/79167-onu-defende-aumentar-participacao-de-mulheres-em-ciencia-e-tecnologia
14 Initials in Portuguese (science = ciência).

In conclusion, we hope that the data presented here, although restricted to a small number of subjects and to a single program, higher educational institution, and region, can dialogue with Brazilian studies on gender, women, and engineering, in the training and labor spheres, considering regional, institutional, and program diversity, and the challenges of female inclusion in an uncertain and unequal labor market.

Acknowledgements

The research was funded by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), process 471892/2014-9, and a productivity scholarship.

References

Bermúdez, M. J. L., Carrillo, D. T. K., & Hernández, B. M. (2021). Las mujeres y las ingenierías. *IQUAL. Revista de Género e Igualdad*, *4*, 1-17.

Biroli, F. (2016). Divisão sexual do trabalho e democracia. *Dados – Revista de Ciências Sociais*, *59*(3), 719-754. https://doi.org/10.1590/00115258201690

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education*, *17*(4), 369-386.

Bourdieu, P. (1999). *A dominação masculina*. Bertrand Brasil.

Burger, C., Abbott, G., Tobias, S., Koch, J., Vogt, C., & Sosa, T. (2010). Gender equity in science, engineering, and technology. In S. S. Klein (Ed.), *Handbook for achieving gender equity through education* (2a ed., pp. 255-279). Routledge.

Carvalho, M. E. P. de. (2017). *Relações de gênero em cursos masculinos: Engenharias mecânica e civil, física, matemática e ciência da computação*. Relatório Técnico. Projeto 471892/2014-9: Chamada MCTI/CNPQ/MEC/Capes n. 22/2014 Ciências Humanas e Sociais. Universidade Federal da Paraíba.

Carvalho, M. G., & Sobreira, J. L. (2008). Gênero nos cursos de engenharia de uma universidade tecnológica brasileira. *ARBOR Ciencia, Pensamiento y Cultura*, *184*(733), 889-904. https://core.ac.uk/download/pdf/268084533.pdf

Casagrande, L. S., & Souza, A. M. F. L. (2017). Percorrendo labirintos: Trajetórias e desafios de estudantes de engenharias e licenciaturas. *Cadernos de Pesquisa*, *47*(163), 168-200. https://doi.org/10.1590/198053143658

Cooper, J., Eddy, P., Hart, J., Lester, J., Lukas, S., Eudey, B., Glazer-Raymo, J., & Madden, M. (2010). Improving gender equity in postsecondary education. In S. S. Klein (Ed.), *Handbook for achieving gender equity through education* (2a ed., pp. 631-653). Routledge.

Donoso-Vázquez, T., Gazo, P. F., & Moreno, M. L. R. (2013). Factores discriminatorios en función del género en la carrera profesional de las mujeres. In A. Montané, & M. E. P. de Carvalho (Coord.), *Mujeres y educación superior* (pp. 55-74). Editora da UFPB.

Donoso-Vázquez, T., Montané, A., & Carvalho, M. E. P. de. (2014). Género y calidad en educacion superior. *Revista Electrónica Interuniversitaria de Formación del Profesorado*, *17*(3), 157-171.

Freitas, M. J. T., & Carvalho, M. E. P. de. (2018, dezembro 4-7). Gênero e educação superior: Explorando o filtro de gênero na Engenharia Mecânica. In *Anais do Encontro Internacional da Rede Feminista Norte e Nordeste de Estudos e Pesquisa sobre Mulher e Relações de Gênero (REDOR)*, 20. Universidade Federal da Bahia.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in Science, Technology, Engineering, and Mathematics*. AAUW.

Hirata, H. (2010). Novas configurações da divisão sexual do trabalho. *Revista Tecnologia e Sociedade*, *6*(11), 1-7. https://www.redalyc.org/articulo.oa?id=496650332002

Hirata, H., & Kergoat, D. (2007). Novas configurações da divisão sexual do trabalho. *Cadernos de Pesquisa*, *37*(132), 595-609. https://doi.org/10.1590/S0100-15742007000300005

Huff, M. S., & Koppe, L. R. (2016). O espaço das mulheres na área da Engenharia Mecânica: Um estudo de caso referente às questões de gênero no Instituto Federal Sul-Rio-Grandense – *campus* Sapucaia do Sul. *Revista Liberato*, *17*(27), 1-118.

Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. (2013). *Censo da educação superior 2011: Resumo técnico*. Inep.

Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. (2018). *Censo da educação superior 2016: Resumo técnico*. Inep.

Kergoat, D. (2009). Divisão sexual do trabalho e relações sociais de sexo. In H. Hirata, F. Laboire, H. Le Doaré, & D. Senotier (Org.), *Dicionário crítico do feminismo*. Editora Unesp.

Kjeldala, S. E., Rindfleisha, J., & Sheridana, A. (2005). Deal-making and rule-breaking: Behind the façade of equity in academia. *Gender and Education*, *17*(4), 431-447.

Kohler, L. O., & Ioshiura, M. J. (2017). Machismo no curso de Engenharia Mecânica: Verdade ou mito? In *Anais do Encontro Nacional de Engenharia e Desenvolvimento Social*, 14. Itajubá, MG: Unifei. https://anais.eneds.org.br/index.php/eneds/article/view/506

Lacampagne, C. B., Campbell, P. B., Herzig, A. H., Damarin, S., & Vogt, C. M. (2010). Gender equity in mathematics. In S. S. Klein. (Ed.), *Handbook for achieving gender equity through education* (2a ed., pp. 235-253). Routledge.

Leonard, D. (2001). *A woman's guide to doctoral studies.* Open University Press.

Lima, N. R. L. B. (2013). *Quando as meninas não contam: Gênero e ensino da matemática*. Viva Editora.

Lombardi, M. R. (2006). Engenheiras brasileiras: Inserção e limites de gênero no campo profissional. *Cadernos de Pesquisa*, *36*(127), 173-202.

Lombardi, M. R. (Coord.). (2016). *"Por que são tão poucas?": Um estado da arte dos estudos em "Engenharia e gênero"* (Textos FCC: Relatórios Técnicos, 49). Fundação Carlos Chagas.

Lombardi, M. R. (2017). Engenheiras na construção civil: A feminização possível e a discriminação de gênero. *Cadernos de Pesquisa*, *47*(163), 122-146.

Ministério da Ciência, Tecnologia e Inovação. (2016a). *Estratégia Nacional de Ciência, Tecnologia e Inovação 2016-2019.* Ministério da Ciência, Tecnologia e Inovação (MCTI). http://www.propesq.unir.br/uploads/76767676/arquivos/Estrat_gia_Nacional_de_Ci_ncia__Tecnologia_e_Inova__o_2016_2019_1248378469.pdf

Ministério da Ciência, Tecnologia e Inovação. (2016b). *Estratégia Nacional de Ciência, Tecnologia e Inovação 2016-2022.* Ministério da Ciência, Tecnologia e Inovação (MCTI). https://portal.insa.gov.br/images/documentos-oficiais/ENCTI-MCTIC-2016-2022.pdf

Öhrn, E., Angervall, P., Gustafsson, J., Lundahl, L., & Nyström, E. (2009, March 5-7). *Gender and career in academia.* Paper presented at the NERA Congress in Trondheim, Norway.

Rees, T. (2001). Mainstreaming gender equality in science in the European Union: The 'ETAN Report'. *Gender and Education*, *13*(3), 243-260.

Roger, A., & Duffield, J. (2000). Factors underlying persistent gendered option choices in school science and technology in Scotland. *Gender and Education*, *12*(3), 367-383.

Sarrió, M., Barberá, E., Ramos, A., & Candela, C. (2002). El techo de cristal en la promoción profesional de las mujeres. *Revista de Psicología Social*, *17*(2), 167-182.

Stepulevage, L. (2001). Gender/Technology relations: Complicating the gender binary. *Gender and Education*, *13*(3), 325-338.

United Nations Educational, Scientific and Cultural Organization. (2003). *Gender and education for all: The leap to equality*. Unesco. http://unesdoc.unesco.org/images/0013/001325/132513e.pdf

United States Agency International Development. (2008). *Education from a gender equality perspective*. Usaid. http://www.ungei.org/resources/files/Education_from_a_Gender_Equality_Perspective.pdf

Warrington, M., & Younger, M. (2000). The other side of the gender gap. *Gender and Education*, *12*(4), 493-508.

Watanabe, F. Y., Francisco, C. A., França, C. A., & Ogashawara, O. (2015). A questão do gênero na engenharia e as iniciativas para a formação de mais engenheiras. *Revista Eletrônica Engenharia Viva*, *2*(1), 51-64.

Note on authorship

Maria Eulina Pessoa de Carvalho: reviewed national and international literature, outlined the methodology, participated in the empirical approach and in the final review. Mayanne Júlia Tomaz Freitas: reviewed the national literature, collected enrollment data, prepared the graph, participated in the empirical approach and in the final review.

Data availability statement

The contents may be available at the time of publication of the article.

How to cite this article

Carvalho, M. E. P. de, & Freitas, M. J. T. (2022). Female graduates in Mechanical Engineering: An exploratory approach. *Cadernos de Pesquisa*, *52*, Article e09076. https://doi.org/10.1590/198053149076_en