OTHER THEMES

Gender Dynamics in Physics Teacher Education Programs at Federal Institutes in Santa Catarina

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ABSTRACT – Gender Dynamics in Physics Teacher Education Programs at Federal Institutes in Santa Catarina. This paper aims to analyze the gender dynamics that occur in the daily academic life of undergraduate Physics students at the Federal Institutes of Santa Catarina (IFs/SC), Brazil. It is an exploratory and descriptive study, with data produced through a questionnaire sent to students from its four campuses and interviews with five female students. Data analysis used the hermeneutic interpretation technique, based on theoretical frameworks of gender studies and feminism, in their interface with science. The research reveals that gender dynamics impact female representation, by generating sexist effects: disqualification, exclusion and invisibility of women.
Keywords: **Gender Dynamics. Physics Teaching Degree. Female Representation.**

RESUMO – Dinâmicas de Gênero na Licenciatura em Física em Institutos Federais de Santa Catarina. O presente artigo objetiva analisar as dinâmicas de gênero que ocorrem no cotidiano da licenciatura em Física nos Institutos Federais de Santa Catarina (IFs/SC). É um estudo de natureza exploratória e descritiva, cujos dados foram produzidos por meio de questionário enviado a discentes dos quatro *campi* dos IFs/SC e de entrevistas com cinco alunas. Utilizou-se da técnica de interpretação hermenêutica para a compreensão das informações, com base em referenciais teóricos dos estudos de gênero e do feminismo, em sua interface com a ciência. A pesquisa revela que as dinâmicas de gênero impactam a representatividade feminina, ao gerar efeitos sexistas: desqualificação, exclusão e invisibilidade das mulheres.
Palavras-chave: **Dinâmicas de Gênero. Licenciatura em Física. Representatividade Feminina.**

Introduction

In recent decades, studies have pointed to rising levels of education among women, including in higher education. Data from the 2023 Higher Education Census (INEP, 2024) indicate that women predominate among students entering undergraduate programs across all administrative categories of higher education institutions. They also predominate among graduates in most broad fields, except for Computing and Information and Communication Technologies (ICT) and Engineering, manufacturing and construction. Although in Natural sciences, mathematics and statistics they already account for 51.4% of graduates, there are variations across programs, most notably the scarce presence of women in Physics. Thus, in the so-called hard sciences[1] and in the field of Natural Sciences, Technology, Engineering and Mathematics (STEM), women's representation is far lower than that of men.

According to Maria Margarete Lopes and Maria Conceição Costa (2005), women have been absent from scientific practice throughout history and have taken little part in the hard sciences. Against this backdrop, a question arises: what has been driving women away from these scientific fields? Debates in the literature indicate that gender dynamics — such as the lack of recognition and the devaluation of women scientists, sexism, and exclusion — mark women's trajectories in the scientific world, especially in Physics, the field of interest of this study.

In the history of Physics we find few women who were recognized for the scientific work they carried out after overcoming countless barriers to entering and remaining in the scientific world, such as denials, deprivations, and devaluation. This was evident in the trajectory of one of the most illustrious scientists of Physics and Chemistry, Marie Curie. She was barred from entering higher education in Poland because she was a woman, which led her to begin her studies at a clandestine institution. Later, in Paris, she earned a bachelor's degree in Physical Sciences, but when she tried to return to her country to teach at the University of Kraków she was again rejected for being a woman. The same argument was used when she applied for a faculty position at the French university of the Sorbonne in 1906, a position that had fallen vacant after the death of her husband, Pierre Curie, even though she had won the 1903 Nobel Prize in Physics, shared with her husband and with the physicist Henri Becquerel. Only after interventions by important members of the academy was she able to take up the post of "lecturer in charge of courses" and, later, in 1908, to be accepted as a professor (Saitovitch et al., 2015).

In Brazil, women gained access to higher education from 1879 onward, with the Leôncio de Carvalho Reform. In hard science programs, however, they entered decades later, so that the first woman engineer, Edwiges Maria Becker, graduated in 1919. It should be noted that women's participation in Physics, compared with Medicine or Law, came later because initially there was no training in Physics in Brazil (Barbosa; Lima, 2013).

It was only in the 1940s that Yolande Monteux graduated, followed by Elisa Frota Pessoa and Sonja Ashaue, the country's first women physicists. Also in that decade, Neusa Amato graduated in Physics and worked for a period as a "volunteer" researcher, that is, without pay, until she was hired as a researcher at the Brazilian Center for Physics Research (CBPF) in 1951, going on to produce 116 scientific articles on cosmic rays (Melo; Rodrigues, 2006).

In the 1960s, with the expansion of the university system in Brazil, we saw the first women to earn doctorates in Physics: Amélia Império Hamburger, in São Paulo, and Victoria Hercowitz and Alice Maciel, in Rio Grande do Sul. All three pursued careers at their respective universities, USP and UFRGS. But it was only from the 1970s onward, with the leading role played by feminist movements, that women began to take greater part in the sciences, including the exact and natural sciences (Barbosa; Lima, 2013).

In the 21st century, given women's limited representation, gender equality policy initiatives emerged — in part in response to the requirements of UN international treaties to which Brazil is a signatory — aimed at balancing or minimizing women's disadvantages and at increasing their participation in science, encouraging them to pursue scientific careers.

In 2005, the first federal program designed to strengthen women's participation in science was launched: the Women and Science Program (PMC), created by the Secretariat of Policies for Women together with the Ministry of Science and Technology. The PMC pursued the following objectives: to stimulate scientific production and reflection on gender relations, women, and feminisms in the country, and to promote women's participation in the sciences and in academic careers, becoming a reference point in the struggle for the recognition of women in science (Lima; Costa, 2016).

Since then, other initiatives have emerged and were incorporated into the III National Plan of Policies for Women (PNPM) 2013-2015[2]. That document recognized that "the sexist language of texts and everyday practices, the invisibility of women in science and in history, responds to patriarchal ideology and to the androcentrism of knowledge [...] elements in the construction of gender inequality" (Brasil, 2013, p. 23). In the general objectives of the axis *Education for equality and citizenship*, it emphasizes the importance of reducing gender inequality and of confronting prejudice and discrimination, setting out, as a specific objective, "to promote policies for expanding women's access to and retention in professional and technological education and in higher education, with an emphasis on scientific and technological fields, with gender, race, and ethnic equality, considering women in their diversity [...]" (Brasil, 2013, p. 23). Nevertheless, advances in women's participation in science remain modest.

The 2024 Global Education Monitoring Report, by the United Nations Educational, Scientific and Cultural Organization (Unesco), highlights the male predominance in undergraduate STEM programs, with

a representation of 65% for men against 35% for women. These figures widen further in the workplace, since women hold only 25% of the jobs in the field (Unesco, 2024). The same occurs in Brazil, where the percentage of women graduating from STEM programs has remained almost unchanged over a decade, that is, between 2010 and 2020 it went from 31% to 34% (Unesco, 2024, p. 43). When Physics is isolated, female representation is even lower.

The study by Elisa Saitovitch, Betina Lima, and Márcia Barbosa (2015), covering the period from 2001 to 2012 and examining research scholarships in the categories of undergraduate research, master's, doctoral, and postdoctoral studies, found that in all programs women held the largest number of scholarships, except in Physics, where in no period and in no category did they exceed 38%, dropping to 17% at the doctoral level.

The study by Débora Menezes et al. (2018), in turn, on entry rates, dropout, and gender in the Physics teaching degree and bachelor's programs at UFSC between 2000 and 2017, showed that the percentage of women entering the teaching degree program was 23.5% and that of graduates 22.4%; in the bachelor's program the figures are equally low for women, that is, 22.9% and 20.9%, respectively. Therefore, unlike what has occurred in other fields of knowledge, where in recent decades there has been a process of feminization, with an increase in the number of women at the various stages of training, in Physics this is not perceptible even in the teaching degree program.

Recent research focusing on the Physics teacher education program at the Federal Institutes of Santa Catarina showed that the average proportion of women entering the program between 2017 and 2023 was 41%, while that of male students was 58%. Over the same period, women accounted for 42% of program completions and men for 58% (Paixão, 2023). This shows that, in Physics, even in the teaching degree program — which generally attracts more women — they do not reach the desirable parity with men in the education of teachers for basic education.

Statistical data, according to Londa Schiebinger (2001), provide an objective measure of the *status* of women in science, including equality and inequality, and serve to map possible changes. Given the persistence of women's low representation in Physics, whether at the professional, in the bachelor's or in the teaching degree program, the aim of this article is to analyze qualitatively the gender dynamics that occur in the daily life of Physics teacher education programs at the Federal Institutes in the state of Santa Catarina (IFs/SC). This is a segment of a master's thesis by Hilda Geni Alves Paixão (2023) in which, for the present article, we have prioritized the analysis of students' accounts of the disqualification, exclusion, and invisibility of women in academic relations.

Theoretical and Methodological Framework

For Joan Scott (1995, p. 72), the concept of gender seeks to give meaning to social relations based on the perceived differences between

the sexes, and is a primary way of signifying relations of power. It is used to "refer to the social organization of the relationship between the sexes," indicating that the distinctions between feminine and masculine are cultural and social constructions, socially learned and reproduced. Understanding gender as a social and relational construction of notions of masculinity and femininity means that "gender behavior varies across regions and cultures" (Lins; Machado; Escoura, 2016, p. 25). In this way the differences between men and women are problematized, showing that they cannot be reduced to the biological dimension. The social meanings of the feminine, tied to a biological reading, have historically been used to create social hierarchies and to exclude women from positions of power, including in science (Furlin, 2021).

It was only from the 1970s onward, with widespread access to education and the struggle led by the feminist movement, that women began to gain more space in the scientific world. Today, however, their participation, especially in the hard sciences, is still low, as already noted. Using the number of women awarded the Nobel Prize as an indicator, one finds that few women have been honored and that, of these few, most shared the prize with male scientists (Chassot, 2003). Since science is a "field of power relations, of socially defined hierarchies and inequalities" (Grossi; Rea, 2020, p. 2), gender relations must not be ignored, lest "invisible hierarchies of power" be perpetuated, as Schiebinger (2001, p. 140) warns. The author explains that many of the differences between men and women are historical, and that gender behaviors come to us so naturally that we do not even notice them and engage in them unconsciously.

According to Schiebinger (2001, p. 11), women's access to a scientific career is restricted for three reasons: "the social structuring around male interests and power; the complete split between the public sphere (directed toward and by men) and the private sphere (directed toward and by women); and the dissociation between knowledge considered scientific and that of common sense." The author argues that the prestige of a science has been linked to the degree of difficulty it involves and to the proportion of women present in the field. Thus, the more mathematics a given program or position required, the greater the prestige or the salary and the lower the rate of women's participation. In this way, hard science programs enjoy greater prestige and lower female participation, and women are directed toward lower-*status* programs (Tabak, 2011; Velho; León, 1998). According to Carvalho and Rabay (2015, p. 131), "the first evidence of gender inequality is quantitative: there are fewer women in valued positions and positions of power."

The *status* attributed to Physics is socially constructed on the basis of its cultural image, reinforced in teaching materials and media publications that portray the image of a male scientist. Nevertheless, "the hardness of Physics does not fully explain the low number of women in the field" (Schiebinger, 2001, p. 301), since there is an entire social and cultural order in which power dynamics, more or less subtle,

reproduce gender inequalities in academic relations, as we illustrate below.

In the field of the sciences, the failure to recognize women's contributions is attributed to the *Matilda effect*, a term coined by Margaret Rossiter[3] to refer to the fact that the work of women researchers does not receive due recognition. Thus, although women produce important research, it is "less recognized than that produced by men," or they are "reduced to collaborators and the prominent name in the research is male" (Pandini; Bartelmebs; Tegon, 2021, p. 1214). Moreover, women students and researchers encounter various obstacles, invisible and visible, in their academic trajectories, which lead them to abandon their careers or to advance slowly and stagnate at a given professional level (Lima, 2013), a phenomenon defined by the concept of the *crystal labyrinth*.

It is important to stress that the theoretical assumptions of feminist theories — such as the analytical category of gender and the concepts that express the gender dynamics unfavorable to women in the scientific field — are endowed with a critical perspective that makes it possible to reflect on changes in these relations and on the construction of gender social justice. These theoretical considerations underpin the analysis of the gender dynamics that run through academic relations in the Physics teacher education program at the IFs/SC.

Methodologically, this investigation adopted a qualitative approach, a perspective that opens "windows" through which subjects may express their deeper motivations and the meanings they attach to their actions and worldviews. This type of research is concerned with the meanings that subjects express in their beliefs, aspirations, and values, as "processes and phenomena that cannot be reduced to the operationalization of variables" (Minayo, 1994, p. 21). As to its objectives, the study is exploratory and descriptive, and its subjects are the students of the Physics teacher education program at the four campuses of the IFs/SC[4].

The data were produced through two movements. The first was the distribution of a questionnaire to male and female students enrolled from the third semester onward in the Physics teacher education program at the four campuses of the IFs/SC. The link to the questionnaire on *Google Forms* was sent to the students on each campus by the program coordinators, together with the Informed Consent Form (TCLE), approved by the Research Ethics Committee (CEP) of the IFs/SC. We received 23 completed questionnaires, 11 from male students and 12 from female students, most of them young people between 20 and 27 years of age; of the 12 female students, only one was married with children[5].

The questionnaire made it possible for students interested in giving interviews to provide their contact details. Five students, from different campuses, volunteered to take part in the second movement of the research, which involved semi-structured interviews conducted on the *Google Meet* platform in May 2023, recorded and transcribed for

later analysis. Of the students interviewed, four were white and one was brown (*parda*), all of them young, between 20 and 24 years of age, single and without children. For women, not being married and not having children is, in general, one of the conditions that enable them to remain in higher education. On the other hand, the small number of interviewees and their social profile may represent an analytical limitation of the research; we recall, however, the difficulties of conducting empirical research owing to the unavailability of subjects. We also recall the richness afforded by interview data, considering the small number of qualitative studies carried out in Physics programs in Brazil and, in particular, in Physics teacher education programs at the Federal Institutes, a program that still has a low proportion of women.

To protect the young women's identities, we gave them the code names of women scientists who achieved renown in the scientific world: four scientists awarded the Nobel Prize in Physics from its creation in 1901 to the present, Marie Curie, Maria Goeppert-Mayer, Donna Strickland, and Andrea Ghez; and one of the pioneers of Physics in Brazil, Sonja Ashauer.

The information collected through the interviews and questionnaires was grouped into six categories[6], which made it possible to analyze the gender dynamics established in the Physics teacher education program. However, given the length constraints of a scientific article, in this text we have prioritized the analysis of only two categories: a) "They cut me off and repeated the same thing I said": sexism and the disqualification of women in academic relations; b) "They tossed them into a corner, left them there, hidden away," in which we grouped empirical information drawn exclusively from the interviews, given the richness of these accounts for the objectives set. We adopted the hermeneutic interpretation technique in order to analyze and categorize the students' accounts, a strategy carried out through immersion in these accounts, made possible by multiple readings of the interviews and by continuous interpretation.

According to Minayo's (2014) conception, hermeneutics is grounded in the understanding of language, in the sense of grasping narratives, biographies, interviews, and other texts, seeking to understand the other on the basis of their social and historical context, through a relational movement. Understanding is thus not a mechanical, closed operation, but one that is open to disclosure, such that to understand implies to interpret, "to establish relations and draw conclusions in all directions" (Minayo, 2014, p. 337).

In this text, the hermeneutic understanding of the students' accounts was carried out on the basis of the theoretical frameworks of gender studies and feminist theory in their interface with science, in accordance with the concepts presented.

"They cut me off and repeated the same thing I said": sexism and the disqualification of women in academic relations

Science is a human construct and, as such, is subject to the same influences that shape society at large. These include prejudice and discrimination based on gender, ethnicity/race, and social class, among others. In this context, we direct the present discussion to the sexism and the disqualification of women that manifest themselves in gender relations in the field of Physics. The gender dynamics that emerge in the daily life of universities, educational institutions, and research — the settings in which science is forged — are crossed by power relations that place women at a disadvantage in relation to men, and this is reflected in the opportunities available to them in the scientific field (Schiebinger, 2001).

In this category we grouped the narratives of students that illustrate sexism in the relations between students and faculty in the Physics teacher education program at the IFs/SC. It is worth noting that some of them appeared to be aware of the gender dynamics at work in the program, especially Marie and Donna, which shows that they are attentive to the cultural transformations driven by feminism and by the affirmative action policies of recent years in Brazil. Not all the students demonstrated this understanding, however, particularly at the beginning of the interviews, when Maria, Andrea, and Sonja stated that they did not perceive male-chauvinist or sexist attitudes in the program. Yet, over the course of the interviews, they gradually reported explicit situations of sexism and discrimination in the gender relations experienced there.

Sexism reveals itself in differential, pejorative/negative treatment of the female sex, in gender stereotypes unfavorable to women, in low expectations and the devaluation of women's achievements and contributions, as well as in sexual harassment which, although it may affect other groups, generally occurs against women (Nascimento, 2017). It is recognized that in Physics, as in STEM in many countries, sexism is a reality that affects women and girls, producing processes of inequality and constituting one factor (among others) responsible for driving them away from the field (Agrello; Garg, 2009). Accordingly, students' lack of awareness of sexist practices and their failure to take a stand against them may favor the perpetuation of sexism in the academic context.

Sexist attitudes are expressed in various ways in academia and, according to Silva (2017, p. 104), "prejudice does not affect all women equally; it often operates in a subtle, veiled manner," while at other times it manifests itself explicitly. In the case of the students who took part in the research, they reported situations of sexism experienced in their interactions with classmates and, in some cases, with professors, which caused them discomfort, unease, and embarrassment, such as being disqualified when they voiced opinions or arguments during

Physics classes. They pointed to insinuations from classmates that their arguments were not correct:

> I notice that, in some classes, in some things, my opinion or my answer to a question is not considered all that valid, and it gets questioned among the students themselves. [...] it seems that my opinion is always the least valid one (Andrea).

> When I explained something, people would look at their classmates, as if... wanting confirmation of what I had said: 'Is that really right? Does what she said make sense?' (Marie).

This shows that, in the imagination of students and professors, women "do not have the same 'capacity' as men for abstract reasoning" (Tabak, 2006, p. 31). From Bourdieu's (2012) perspective, we may understand that the behavior of male peers in the scientific field of Physics tends to reinforce the idea that they are the legitimate subjects, while women require male validation. Andrea's perception, "it seems that my opinion is always the least valid one," carries the effect of a symbolic structure that hierarchizes voices according to the legitimacy conferred by the field and, at the same time, reveals that, although she perceives differential treatment, she is unable to name it as a discriminatory act that disqualifies women's speech and knowledge.

The notion that rationality, an attribute considered necessary in the exact sciences, would be inherent to the male subject manifested itself explicitly in another situation reported by Marie. She recounted that several female classmates chose to take the calculus course at another institution after professors repeatedly told them that they need not worry about low grades because "calculus really is difficult for women," a statement that naturalizes a supposed female incapacity, treating it as a biological given rather than as a product of social and historical relations. Marie herself reported having withdrawn from a course as a result of comments of this kind.

This type of discourse expresses an essentialist and androcentric view which, by associating rational capacity with the male universe, disqualifies women's knowledge and contributions, so that their ideas are perceived as less valid or less reliable. From the standpoint of gender studies, this is a symbolic mechanism of exclusion that operates diffusely in everyday academic life: without resorting to formal barriers, it produces concrete effects on students' trajectories, discouraging their participation in classroom discussions, undermining their intellectual self-confidence, and compromising their academic development. Such dynamics show how gender structures are reproduced within scientific institutions, even in contexts that claim to be neutral or strictly technical.

The disqualification of and disrespect for the female students' opinions on the part of their classmates led Marie, like Donna, to feel embarrassed. They reported situations of *bropriating* and *manterrupting*:

> Male classmates try in some way to belittle what I said or to correct me. Or like... you speak, you offer an idea and nobody listens. Then the guy says the same thing you said, and everyone goes: 'wow, that's it!' (Donna).

> [...] some students cut me off and repeated the same thing I had said, but in other words, and what he said was more readily accepted by the class than what I had said (Marie).

Bropriating is a form of disqualification of women's speech and even of women's participation. According to Barros and Busanello (2019, p. 4), the term designates situations in which men appropriate "the ideas that women put forward in debates" and claim authorship of them, "with no concern to credit the respective authors of those ideas." The appropriation and reproduction of the female students' speech by their classmates illustrates unequal power relations, such that women's voices are frequently silenced or belittled by men. The attitude of Donna's classmates, who try to diminish her contributions or to correct her, reinforces the gender stereotypes mentioned regarding women's incapacity, rendering their contributions invisible. According to Donna, the situation she described also occurred with faculty members, which shows that sexism is reproduced in educational systems, lowering the self-esteem and self-confidence of women students and women professors alike (Louro, 1997).

Marie's account that male classmates interrupted her speech exemplifies "*manterrupting*," a term that refers, according to Barros and Busanello (2019, p. 4), to "a typical form of expressive male chauvinism consisting in men's commonplace and recurrent habit of interrupting women's speech, whether in informal conversation or in statements made in public spaces." Along these lines, Schiebinger (2001, p. 162) points out that, in the hierarchy of power, those occupying higher positions tend "to interrupt speakers in lower positions." Thus, the events reported by Marie and Donna show that boys internalize cultural conventions of a supposed male superiority in science as well as in public speech, and that these gender representations entail power relations that construct social hierarchies (Scott, 1995).

On the other hand, Marie and Donna stated that they had never felt intimidated by their classmates' sexist stance. Both said in their interviews that they are quite participatory and inquisitive, a stance that may unsettle those who believe that women cannot have a voice, especially in the scientific field. Donna reported an episode that took place during a conceptual debate in class in which she and her female classmates were actively taking part. Faced with the students' interventions, a professor and a male classmate not only disagreed but systematically mocked them, so that, at the end of the discussion, the female students were labeled "hysterical." Marie, in turn, shared that whenever she "brought up... some question, something," the response would come: "oh, there she goes stirring up trouble, getting ideas into her head."

Both accounts reveal discursive mechanisms of disqualification, discrediting, and belittlement of women, triggered especially in situations of disagreement, a dynamic widely documented in gender studies (Lima, 2008). This reality points to the non-neutrality of science and to the persistence of gender hierarchies within it. According to Chassot (2003), contemporary science still shows signs of gender discrimination and prejudices that need to be overcome.

Along these lines, Marie further reports that some faculty members disqualify female students' questions about course content, treatment that, according to her, is not repeated when the questions come from male classmates:

> 'Oh... I already explained that, I'm not even going to answer you because you weren't paying attention.' So, it is very different treatment that the professors give the girls compared with the boys. It seems their question is more important than ours! (Marie).

This reveals explicit gender discrimination, anchored in the social imaginary that conceives of Physics as an essentially male field, so that investment in male students is prioritized. Discriminatory practices, even subtle and unintentional ones, may thus have a negative impact on women's learning and, according to Barbosa (2017), help to legitimize the persistent historical inequality between men and women, generating social segregation. Moreover, in the academic sphere, inequality in the professor-student relationship has a twofold effect, since it combines two hierarchies: the institutional one, in which students must respect their professors, and the gender one, in which women are supposedly less capable of rational thought in Physics. These are sexist practices experienced by women that lead them to drop out of the Physics program, affecting the figures for female representation in this field of knowledge (Klanovicz; Oliveira, 2021).

The underestimation of women deepens when their capacities are reduced to biological factors, associating them with the weaker sex and with a supposed intellectual inferiority, a view that, far from being neutral, serves the ideological function of naturalizing historically constructed inequalities (Schiebinger, 2001). These gender dynamics are reported by Marie:

> And with the professors it happened a lot, in terms of doubting my ability. [...] it's handling equipment. For example, there in the lab I had to work with a hole saw, if I had to do something more like carpentry. 'Hey, call..., let someone else do it.' I have to say two or three times that I can do it, 'let me do it.' With electrical work, too. 'No, but I know how to do this!' 'No, call that other guy over there, he knows better.' [...] 'let me carry that telescope because you can't.' 'Let me take this because you can't carry it, or let me do this part because you don't know how, let me speak because you don't understand this,' a lot, a lot (Marie).

This account presents gender dynamics that produce discouragement and insecurity. Cartaxo (2012) recalls that when a woman expresses an interest in theoretical Physics she is frequently warned that women do not have as much skill in mathematics, a fundamental requirement for theoretical Physics. When it comes to experimental Physics, in turn, women are frequently labeled as incapable of handling equipment as competently as a man. These everyday comments are draining and demand an additional expenditure of energy for female students to remain in the Physics program (Cartaxo, 2012).

Marie offers a reflective assessment of the unequal treatment on the part of the faculty, since, according to her, they think "we are not capable of understanding." When the question comes from the boys, the professors simply listen to them and say: "they just haven't

understood it yet." This differential treatment of male and female students, which tends to disqualify women's participation, reinforces the gender stereotypes according to which women have less aptitude for calculus and/or a cognitive incapacity for abstract matters, heightening their insecurity about persisting in the Physics program. Andrea reported that acts of disqualification and the questioning directed at her speech in class produce a feeling of insecurity in her:

> I myself, at many moments, felt very insecure, that I didn't know what I was doing here; things like that only reinforced it. [...] it can definitely drive girls away! It's something that really calls into question, sometimes, what we know [...]. Do I really know this? Do I deserve to be here? Is this my place? It really does cause insecurity (Andrea).

The two students' narratives reveal unequal treatment of men and women in the academic environment, manifested above all in the disparagement of women's intellectual capacity. The repetition of these negative interactions reinforces in girls a "learned helplessness" which, according to Bourdieu (2012), consists in women's internalization of the low social expectations attributed to them. In this sense, Louro (1997) warns that renewed attention must be paid to routine, ordinary practices, to gestures and words, since language defines social roles and positions for women and men, and educational institutions reproduce normative gender patterns.

Donna was one of the interviewees who displayed a more critical perception of gender relations in the academic sphere. She reported that disqualifying treatment on the part of male students is not restricted to their female classmates but extends to women professors as well, and that, by contrast, students tend to show greater admiration for and recognition of the authority of male professors. She further stressed that she had felt uncomfortable at the way certain students questioned the statements of female classmates and professors regarding the solution of Physics problems, which clearly demonstrates a relational asymmetry structured by gender, one that tends to recognize only the male universe as the epistemic authority of science.

> I kept thinking: Gosh! if it were a male professor, would he talk like that? But when it was a male professor, he would keep to himself. I believe it isn't even, isn't even deliberate. I think they don't even notice this... this arrangement. When it's a man, I respect him more; when it's a woman ... then no (Donna).

Donna seems to understand that this unequal treatment is often unconscious, because gender relations are structural. The students have internalized cultural norms and social representations grounded in a male-chauvinist, prejudiced, and androcentric outlook. The accounts indicate that in male-dominated fields such as Physics, both women professors and women students are treated on the basis of gender stereotypes that affect them negatively, as if biology traced out the destiny of each sex, with some fit for abstract fields of knowledge and others not. Schiebinger (2001, p. 166) notes that "stereotypically feminine women" are seen as less competent, incompatible with the hard sciences.

In the academic environment, jokes and "teasing" of a sexist nature are part of the everyday repertoire of interactions among students, making up a diffuse yet persistent form of gender discrimination. Marie reported having experienced this type of situation frequently, in episodes in which her physical appearance became a pretext for comments that linked gender and intellectual credibility. When she shaved her head, she heard from classmates: "Wow, you cut your hair to look like Maria João, to look like a little boy. Maybe now someone will listen to you!" And when she wore her hair long and had to tie it back to work in the laboratory, complying with safety rules and using personal protective equipment, she became the target of taunts such as: "Oh, the little boy! The class's little tough guy has arrived! Where are the damsels?"

The comments directed at Marie reveal how gender stereotypes operate in an articulated way upon the female body and voice: short hair is read as an attempt to approximate the masculine in order to earn the right to be heard, while compliance with laboratory safety rules is turned into an occasion for ridicule. In both cases, what is at stake is not merely appearance, but the legitimacy of the female presence in scientific space.

In Bourdieusian terms, these episodes evidence the internalization and the updating of androcentrism as an organizing principle of the scientific field. The androcentric *habitus*, incorporated by students throughout their socialization, operates almost automatically, producing dispositions and practices that naturalize the association between masculinity and scientific competence. The symbolic violence that ensues is not imposed by force, but through the tacit complicity of a gender order that presents itself as self-evident and unquestionable and that, for that very reason, tends to be reproduced even by those who do not consciously benefit from it.

Processes of resistance may also be observed, for Marie reported that, faced with gender-normative comments, she reaffirmed her position as a woman-subject, stating: "I don't have to be a tough little guy in order to be something." In other words, she defended her identity and acknowledged her intellectual capacity, refusing to conform to masculine norms in order to succeed or to be taken seriously. According to the student, common clichés about "female incompetence" circulate in the Physics program: "whenever something happened, they would come out with that little joke, that it had to be a woman, right, who doesn't know how to do these things."

These are male-chauvinist and androcentric stances that are not neutral, for by disqualifying women's knowledge they reinforce science as a male preserve and, consequently, discourage girls from pursuing careers in Physics (Amorim; Dantas; Carvalho, 2017; Klanovicz; Oliveira, 2021).

Prejudice and the disqualification of women's intellectual capacity also affect the assessment processes of the Physics teacher education program at the IFs/SC, as becomes evident in the accounts of Marie and Sonja:

> There was a case in which I handed in [...] the same work, like a calculus problem set. So, same result, same work, same things, and I got a different grade. And then when I went to ask why the grade was different, 'Oh, because I didn't understand this line of reasoning here, oh because this here wasn't clear.' [...] so, it just reinforced what we had already seen in other situations (Marie).

> We once did an assignment comparing the attention given to people who are writing an article. So I wrote an article as an application exercise, I listed myself as first author, because I was the author, and second, my classmate from college. Except then we took that same article, written exactly the same way, and put my friend as first author and me as second author. The one that got the most views on the (internal) platform was his, and the one that got the fewest was mine. [...] So there was a difference, even though it was exactly the same article, the same words, and I was the original author. There was praise for his work and criticism of mine (Sonja).

These accounts show how women's intellectual production is assessed differently in academia. The test conducted by Sonja, who reversed the order of authorship of an article written jointly with a classmate and submitted it on the campus's internal platform, functioned as a strategy for verifying the structural character of sexism, a hypothesis that was confirmed. The overvaluation of male authorship reveals that, in STEM fields, "academic culture has valued the work of men above that of women"; even with identical content, it seems that "readers prefer articles authored by men" (Schiebinger, 2001, p. 106).

This phenomenon recurs in other fields, especially when professors do not include references by women authors in their courses. Such a practice points back to the *Matilda effect*, which manifests itself when the knowledge produced by men is more highly prized, while women's intellectual and creative capacity is excluded or disqualified (Pandini; Bartelmebs; Tegon, 2021; Schiebinger, 2001). Thus, "the feminine is constantly stripped of value, underestimated, belittled in the face of the masculine" (Lima, 2008, p. 58-59). In this sense, Sandra Harding (2019) explains that:

> [...] even feminist men benefit from an institutionalized sexism that they actively strive to eliminate. Objectively, no male individual can renounce sexist privileges, just as no white individual can abstain from racist privileges — gender and race advantages accrue regardless of the will of the individuals who enjoy them (Harding, 2019, p. 102).

The author reflects on the difficulty of deconstructing sexism, even among those who genuinely aspire to change. In sum, the accounts analyzed in this category, concerning gender relations in the field of Physics, show that vestiges of an androcentric and male-chauvinist scientific culture still persist, despite the significant advances achieved by feminism and by affirmative action policies. It can therefore be seen that cultural transformations are always a long and gradual process, one that demands creative strategies to eradicate practices and stances that have historically disqualified women.

"They tossed them into a corner, left them there, hidden away": exclusion and invisibility

In this category we analyze accounts that expose the processes of exclusion and invisibility of women in the scientific field. Recurrent targets of the feminist critique of the history of science (Svarcz, 2017), these phenomena are concrete ways in which a sexist culture that disqualifies women's knowledge materializes. Among the women who break through the initial barriers and enter programs in the so-called hard sciences, invisibility and exclusion do not dissipate; on the contrary, they tend to deepen and to branch out over the course of their entire academic and professional trajectory.

For the students of the Physics program at the IFs/SC, one of the forms of exclusion faced during their education was gender segregation. Some interviewees reported a feeling of loneliness in carrying out assignments and other academic activities, an experience that comes through in Sonja's words:

> [...] to do an assignment, they only pick their own little group [...] they always keep to themselves, they don't have that openness. With that, I don't know whether it's a gender issue too. Maybe it is, because then they feel better and more at ease with people who think exactly the same way. But there are plenty of situations that break me, because you end up alone, you have to do it alone.

Sonja showed embarrassment and sadness as she recalled the segregation she had experienced. Although at the beginning of the interview she stated that she had not experienced processes of exclusion or discrimination during the program, on revisiting certain experiences she seemed to become aware that the academic environment is permeated by gender dynamics that exclude girls, given that it is a predominantly male setting. This does not reveal incoherence or contradiction on the student's part, but rather that problems need to be named in order to be recognized. On finding words to name her experience, Sonja was able to cast a new look at situations that until then had remained invisible to her, even though they affected her directly. This is, then, a process of consciousness-raising that the interview itself was able to catalyze.

The feeling of isolation, stemming from the traditional gender socialization that separates boys and girls from childhood games through to the activities of adult life, was also reported by other students at different institutions, as the studies of Carvalho (2021), Narimatsu (2018), and Cartaxo (2012) indicate. Along these lines, an excerpt from Sonja's narrative reveals that, from the very beginning of scientific training, "women continue to be regarded as undesirable elements in scientific practice," as Svarcz (2017, p. 177) stresses.

The concealment of women in science even denies their contributions to scientific advancement, as Marie reports:

> Look, I believe it is because the *hard sciences* are... taken out of women's path, you know. So we have a great deal of the question of women working in health, in the humanities, in the biological sciences, but not in the exact sciences; they sort of try to take that out of our path. And if we look, if we do some research,

> there are many women before us who worked in the exact sciences, who are responsible for a great many things. Who took man to the moon, but what did they do? They tossed them into a corner, left them there, hidden away. So I believe it really is a concealment. Hidden away, so that we do it, stay there nice and quiet [...] society benefits, and nobody knows it was us who did it (Marie).

Marie's account emerged in the context of her attempt to explain the reasons for the low representation of women in science, especially in Physics. It is undeniable that the invisibility of women's contributions has directly affected their presence in the scientific field; this concealment of women's knowledge, however, stems from an epistemic sexism that has historically disqualified and marginalized women's intellectual production. In offering a historical reading of the careers that traditionally admitted a female presence, Marie demonstrated an awareness both of the sexual division of knowledge and of that of labor, recognizing the gender hierarchies that structure the academic field. Her words reveal an understanding that women have been systematically pushed away from the exact and natural sciences, a process of exclusion of a cultural order that continues to shape and to constrain the contemporary scientific world.

Marie demonstrates an awareness of women's historical contribution to science; she points out, however, that the holders of scientific knowledge "tossed them into a corner, left them there, hidden away." This systematic concealment reinforces the idea that women were not made for science, corroborating the male norm that excludes women's knowledge and renders women scientists invisible. This is an erasure that is not merely symbolic, because by denying recognition to the female subject in scientific production it strengthens the segregation of women into forms of knowledge and occupations of lesser prestige, "hiding" their effective participation in the construction of scientific knowledge (Louro, 1997; Schiebinger, 2001; Silva, 2017).

And indeed, throughout the history of science, men have been the beneficiaries of the unpaid and invisible work of women at home (thanks to mothers, wives, daughters, and sisters) and, on occasion, at work. In Physics, male professors, scientists, and students can still enjoy this "privilege," as may be read in Marie's account: "I saw my female classmates getting shy about presenting group work in front of the boys, work that they had generally done entirely themselves. The boys just presented it and the girls would stay there in the corner, all shrunken up."

This account shows how the sexist culture that treats women as inferior and disqualifies their intellectual capacity ends up bringing benefits to the male subject, since such representations and practices produce submissive female subjectivities, women who believe they have less potential to act in the public sphere and who therefore end up staying "there in the corner, all shrunken up." With the reproduction of the masculine social order, men continue to benefit from women's work (Schiebinger, 2001).

Moreover, the girls' supposed shyness is not a naturally feminine attribute, but a cultural construction forged out of representations and

social norms that taught them, from an early age, a supposed male superiority. Within this logic, boys do not question this construction, since they benefit from it, while girls are not encouraged to confront it either.

The students' accounts of the processes of exclusion and of the invisibility of women's scientific contribution reveal that gender dynamics operate as a device of power that enables the reproduction of the androcentric social order and of male domination, perpetuating gender hierarchies of knowledge and power that hinder or prevent women's advancement in the scientific field. In other words, a markedly sexist social and academic structure persists, which makes it essential to formulate and implement public policies capable of neutralizing these dynamics and of confronting the gender inequalities that continue to be (re)produced within institutions.

Final Considerations

The aim of this article was to analyze the gender dynamics in the Physics teacher education program at the Federal Institutes in the state of Santa Catarina. To this end, we prioritized two empirical categories of analysis drawn from a broader study (Paixão, 2023), which reveal the processes of disqualification, exclusion, and invisibility experienced by female students within the androcentric culture that permeates the program.

The accounts analyzed corroborate the gender dynamics that run through relations in Physics and affect women's representation in this field of knowledge. The young women who enter the Physics teacher education program encounter sexist barriers such as discredit, disqualification, *manterrupting*, *bropriating*, and isolation, driven above all by male classmates whom they perceive as systematically overvalued. This set of experiences brings about low expectations, a lack of respect, and a scarcity of opportunities, generating discouragement and dejection that threaten the girls' persistence in Physics. It is worth stressing that some of them became aware of the gender dynamics permeating the program only as an effect of being interviewed about the subject, which reinforces the need for spaces of reflection and debate on the topic in educational institutions. Therefore, as long as gender remains an absent theme in the educational environment, processes of reproduction of sexism will continue to exist, as the students in this study recounted.

The study indicates that the androcentric culture of the hard sciences stems largely from the historically predominant presence of men in both research and teaching, with implications that are reproduced in everyday institutional life. In the Physics programs at the IFs/SC, for example, the faculty is still predominantly male, and the courses with the greatest academic prestige and status tend to be assigned to male professors, while women professors are generally left with the courses linked to pedagogical training, such as teaching practice, thereby perpetuating the gender hierarchy within the program itself. This scenario reinforces the importance of female representation in teaching, not only as a measure of equity but also as a strategy for attracting and

including new students, besides highlighting the urgent need to promote well-informed debates on gender equality in the academic environment.

The presence of more women teaching Physics may have a symbolic influence, leading more young people to take an interest in this field of knowledge. What is needed, however, are women teachers who are aware of the gender dynamics that structure social relations, so that their pedagogical work is not confined to the teaching of concepts but also problematizes the inequalities reproduced in the field. To this end, we argue that the curriculum of the Physics teacher education program should encompass an education for citizenship, inclusive and egalitarian, cut across by a gender perspective, since these students will go on to teach in basic education and may bring about ruptures in the sexist and male-chauvinist relations identified in this study. In sum, as long as gender remains absent from the educational environment, the reproduction of sexism will continue unshaken.

Finally, we consider that, by bringing to light the gender relations established in the daily life of Physics teacher education programs, this study contributes to the field of gender studies at its interface with science and education, with an emphasis on initial teacher education. At the same time, it constitutes a political and scientific strategy for keeping alive the debate on the need to advance gender equality, as advocated by UN Sustainable Development Goal 5 (SDG 5), focusing on sex parity and gender equity in higher education programs. This is because gender social justice and the defense of women's rights must be the horizon that mobilizes society as a whole in that direction.

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Notes

[1] According to Bourdieu (1999), this term refers to the gendered division of knowledge, hierarchical and dichotomous, which devalues the *soft* sciences, the humanities and social sciences, toward which women are directed.

[2] The III PNPM 2013-2015 set out 10 policy axes to be implemented, but it was not continued after the impeachment of President Dilma Rousseff in 2016.

[3] Margaret Rossiter is a professor of the History of Science at Cornell University, USA. The term honors Matilda Joslyn Gage, a 19th-century suffragist who fought against female invisibility.

[4] The research project was approved by the Research Ethics Committee (CEP) of the IFs/SC, Opinion no. 6.001619

[5] The total number of students enrolled in the Physics program in 2022 at the IFs/SC, based on information provided by the program coordinators, was 249, of whom 124 were female and 125 male. The questionnaire was directed to students from the third semester onward. Despite the low return rate of the questionnaires, the open-ended questions yielded significant information that was grouped into several empirical categories in the master's thesis, which were not selected for this article, as it had a specific focus.

[6] The categories created and analyzed in the master's thesis were the following: i) "All we ever see is male scientists": the representation of women in Physics; ii) "They cut me off and repeated the same thing I said": sexism and the disqualification of women in academic relations; iii) "They tossed them into a corner, left them there, hidden away": exclusion and invisibility; iv) "We had to do the most to get the least": gender inequalities in academia; v) "When you are a woman, it gets a bit harder": other gender dynamics that interfere with women's persistence in Physics; vi) "I am in a place that is mine, and that is that!": resistance and awareness of having rights.

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