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ORIGINAL ARTICLE

COULD DISTANCE EDUCATION BE AN OPPORTUNITY TO PROMOTE GENDER EQUALITY IN ENGINEERING?

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ABSTRACT

This article explores the history of government initiatives that allude to the participation of women in exact sciences, with emphasis on Engineering. To this end, a qualitative approach was applied, adopting bibliographic procedures, based on the exploration of primary sources. We sought to emphasize the distance education, which can be understood as a public policy with the potential to promote more inclusive education with less gender disparity, aligned with Sustainable Development Goal 4. A gap is observed in this field of research and the potential for reflection should not be underestimated. The main objective of the article is to bring a discussion about gender (in)equality in Engineering, based on a look at the socioeconomic data from Enade 2023, with a focus on distance education. The analyzes showed that the percentages of female participation, in the four Engineering qualifications evaluated, have undergone little change, with no significant increase in any of the modalities, face-to-face or distance learning. It is understood that even though distance education is an important instrument for the democratization of access to higher education and an opportunity to increase the presence of women in these areas, the scenario needs to be studied in more depth and other initiatives need to be thought of and adopted. The greater presence of girls and women in education and careers therefore requires holistic and integrated responses that involve those interested in identifying solutions.

Keywords: Gender, Distance education, Engineering, Exact sciences, STEM.

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A EDUCAÇÃO A DISTÂNCIA PODERIA SER UMA OPORTUNIDADE PARA PROMOVER IGUALDADE ENTRE GÊNEROS NAS ENGENHARIAS?

RESUMO

Esse artigo explora o histórico das iniciativas governamentais que aludem à participação de mulheres na área de ciências exatas, com destaque para as Engenharias. Para tal, foi aplicada uma abordagem qualitativa, com adoção de procedimentos bibliográficos, a partir da exploração de fontes primárias. Procurou-se enfatizar a educação a distância, que pode ser entendida como uma política pública com potencial para auxiliar na promoção de uma educação mais inclusiva e com menor disparidade de gênero, alinhada ao Objetivo de Desenvolvimento Sustentável 4. Observa-se uma lacuna de pesquisa neste campo e o potencial de reflexão não deve ser subestimado. Assim, o objetivo principal do artigo é trazer uma discussão sobre a (des)igualdade de gênero nas Engenharias, a partir de um olhar para os dados socioeconômicos do Enade 2023, com foco na educação a distância. As análises apontaram que os percentuais de participação feminina, nas quatro habilitações de Engenharia avaliadas, têm sofrido poucas alterações, sem aumento significativo em nenhum dos formatos de curso, presencial ou a distância. Entende-se que mesmo que a educação a distância seja um importante instrumento para a democratização do acesso ao ensino superior e uma oportunidade para a ampliação da presença de mulheres nas áreas exatas, o cenário precisa ser mais profundamente estudado e outras iniciativas precisam ser pensadas e adotadas. A maior presença de meninas e mulheres na educação e nas carreiras exatas exige, assim, respostas holísticas e integradas e que envolvam as próprias interessadas na identificação de soluções.

Palavras-chave: Gênero, Educação a distância, Engenharia, Exatas, STEM.

¿PODRÍA LA EDUCACIÓN A DISTANCIA SER UNA OPORTUNIDAD PARA PROMOVER LA IGUALDAD DE GÉNERO EN LA INGENIERÍA?

RESUMEN

Este artículo explora la historia de iniciativas gubernamentales que aluden a la participación de las mujeres en las ciencias exactas, con énfasis en la Ingeniería. Para ello se aplicó un enfoque cualitativo, adoptando procedimientos bibliográficos, basados en la exploración de fuentes primarias. Se buscó enfatizar la educación a distancia, que puede entenderse como una política pública con el potencial

de ayudar a promover una educación más inclusiva y con menor disparidad de género, alineada con el Objetivo de Desarrollo Sostenible 4. Se observa un vacío en este campo de investigación y el potencial para la reflexión no debe subestimarse.
El principal objetivo del artículo es traer una discusión sobre la (des)igualdad de género en la Ingeniería, a partir de una mirada a los datos socioeconómicos del Enade 2023, con enfoque en la educación a distancia. Los análisis mostraron que los porcentajes de participación femenina, en las cuatro titulaciones de Ingeniería evaluadas, han sufrido pocos cambios, sin aumento significativo en ninguna de las modalidades, presencial o a distancia. Se entiende que si bien la educación a distancia es un instrumento importante para la democratización del acceso a la educación superior y una oportunidad para incrementar la presencia de las mujeres en estas áreas, es necesario estudiar más profundamente el escenario y pensar en otras iniciativas. y adoptado. Por lo tanto, la mayor presencia de niñas y mujeres en la educación y las carreras requiere respuestas holísticas e integradas que involucren a aquellos interesados en identificar soluciones.

Palabras clave: Género, Educación a distancia, Ingeniería, Ciencias Exactas, STEM.

1. INTRODUCTION

When the term “exact sciences” is used, it generally refers to fields of study grounded in scientific experimentation as a criterion for scientific validity and the accuracy of data and information, which are fundamentally addressed in quantitative terms. The exact sciences have highly specific disciplinary developments, even though they branch into areas such as Mathematics, Physics, and Chemistry (Francelin, 2004). For this reason, the Coordination for the Improvement of Higher Education Personnel (CAPES), a foundation linked to the Brazilian Ministry of Education, maintains a classification of Knowledge Areas with the practical purpose of providing educational and research institutions with a way to systematize and report information related to research projects. Among these categories are the Exact and Earth Sciences and Engineering (CAPES, 2022).

The scenario in the fields of exact and technological sciences worldwide is marked by a well-recognized gender imbalance in women’s participation, both in terms of education and in the domain of scientific research. Moreno and Murta (2023) analyzed the dynamics and evolution of research on women in STEM fields (Science, Technology, Engineering, and Mathematics) published in two major databases, Scopus and Web of Science, through a bibliometric review. Although the analysis considered studies published since 1969, it was found that more than 70% of the publications were produced after 2011 and that over half of the works originate from institutions in the United States of America, indicating that much of the discussion is relatively recent and that developing countries require further research in this area (Moreno & Murta, 2023).

In Brazil, the Gender Statistics, a publication by the Brazilian Institute of Geography and Statistics (IBGE) that seeks to systematize key information for analyzing women’s living conditions in the country, show that although women are in a clear advantage in terms of overall access to higher education, they still face barriers in certain fields of study, particularly those more closely related to the Exact Sciences and to the sphere of production (IBGE, 2024).

Given the existence of multiple sources of information pointing to disparities in women's participation in the exact sciences, the proposal for the development of this article emerged. Its main objective was to foster a discussion on gender (in)equality in Engineering, based on an examination of the socioeconomic data from the 2023 National Student Performance Exam (Enade), with a focus on distance education. The field of Engineering and the distance training of engineers are particularly emphasized, as a gap in the literature was identified: no studies were found in indexed databases addressing gender, distance education (DE), and Engineering in an integrated manner.

The justification for focusing on distance education (DE) stems from its importance in the process of public policies aimed at expanding higher education in Brazil (Assumpção; Castro; Chrispino, 2018). In general, the provision of distance undergraduate programs in Brazil has increased significantly over recent years. In Engineering, Garcia et al. (2022) demonstrate the growth in the number of Engineering fields offering distance education programs, as well as the increase in the number of courses, enrollments, and graduates, in contrast to the decline in on-campus education figures.

However, this scenario of expansion of distance education in Brazilian higher education has led to a series of discussions that culminated, in May 2025, in the publication of a new Distance Education Policy. For the purposes of the discussion developed in this article, it is important to highlight that distance education was previously considered a teaching modality, alongside face-to-face education. With Decree No. 12,456/2025 and MEC Ordinance No. 378/2025, it was established that higher education programs in general could be offered in three formats (face-to-face, hybrid, and distance). Engineering programs, however, may only be offered in face-to-face or hybrid formats, and institutions that previously offered distance education programs are required to make the necessary adjustments (Santos; Assumpção; Castro, 2025). As these changes are still recent, this article is based on the results of the most recent evaluation period for undergraduate Engineering programs, prior to the regulatory changes introduced by the 2025 Distance Education Policy. Thus, the discussion considers the terminology previously adopted in Brazilian legislation, as well as the context in which distance undergraduate Engineering programs were permitted, which may contribute to future assessments of the impacts of these regulatory changes.

2. THEORETICAL FRAMEWORK

The theoretical framework supporting the discussions presented in this article is divided into a brief historical overview of women's participation in the education system and general statistics and information regarding women's participation in higher education within STEM fields.

2.1Historical Background of Women's Participation in the Education System

The Brazilian educational space has a history characterized by exclusion, which is associated with the combination of one or more factors, including economic status and gender. The arrival of the Portuguese Royal Family led to the need to train professionals to serve the interests of the Empire, resulting in the creation of higher education institutions, with priority given to this level of education to the detriment of primary schooling.

Thus, higher education was essentially reserved for men who would occupy public positions or who came from landowning families (Martins, 2019).

The inclusion of women in schooling became possible only after the imperial law that "established the free provision of primary education to all citizens, mandating the creation of schools for girls" in 1827 (Azevedo; Ferreira, 2006, p. 235). Although this was a highly significant milestone for the Brazilian educational system at the time (Westin, 2020), both primary education and girls' schooling remained precarious, particularly for the poorest populations. The formal admission of women into higher education would only occur in 1879, with the first woman obtaining a university degree in the country in 1887 (Ribeiro; Vieira, 2023).

Women's education became an acceptable argument during the Republican period, driven by ideological changes resulting from positivism and the reduction of the Church's influence over the State (Martins, 2019). Such changes, however, were more present in discourse than in practice, under the perspective that "female education and work constituted a necessity for the progress and civilization of the country" (Azevedo; Ferreira, 2006, p. 236).

In fact, the process of expansion of education occurred gradually throughout the twentieth century; however, at the same time that public policies promoted access to primary education for the population, they also "proposed specialized forms of schooling, defined according to individuals' social class and/or gender" (Azevedo; Ferreira, 2006, p. 241). Thus, women's vocational schools were established to provide "technical training in domestic, commercial, artistic, and pedagogical activities" (Azevedo; Ferreira, 2006, p. 241). In the 1980s, the economic crisis pushed young people and women into the labor market, requiring higher levels of education in order to achieve better wages (Rosemberg, 2012). It can be seen that, over these years, in response to new economic and cultural demands in society, women were gradually incorporated into different levels of education, while also beginning to gain some participation in public life.

A major change occurred with the 1988 Federal Constitution (CF/1988), the first to establish "equality of rights and obligations between men and women (Article 5, item I)." The provisions incorporated into the text guaranteed women several fundamental rights, such as 120 days of maternity leave, protection of the labor market, and the prohibition of wage discrimination, differences in job responsibilities, and admission criteria (STF, 2022). According to Oliveira (1999), it is important to highlight the significance of the CF/1988, since "for the first time in our constitutional history, the declaration of Social Rights is explicitly stated, with education being given prominence" (pp. 61–62). Thus, "the formulation of free education is innovated, ensuring it at all levels of the public system, extending it to secondary education, which had been treated in previous constitutions as an exception, and to higher education, never addressed in earlier constitutional texts" (Oliveira, 1999, p. 62).

The 1988 Federal Constitution (CF/1988) generated numerous discussions regarding the educational system, which culminated in a new Law of Guidelines and Bases of National Education enacted in 1996 (LDB/1996). As part of a set of public policies aimed at establishing the guidelines for national education, it was the LDB/1996 that encouraged the development and dissemination of distance education programs at all levels, through its Article 80 (Brazil, 1996).

Since then, one of the main measures adopted to expand and democratize access to higher education has been the promotion of distance education (DE) (Assumpção; Castro; Chrispino, 2018), particularly following Decree No. 5,622 of 2005, considered the regulatory milestone of this modality in Brazil, which in 2017 was replaced by Decree No. 9,057. With the 2017 decree, several innovations were introduced into the Brazilian DE system, including the possibility for Higher Education Institutions (HEIs) to be accredited to offer undergraduate and graduate programs exclusively through distance education, as well as greater autonomy for HEIs in the establishment of learning centers. Consequently, a continuous growth in distance undergraduate programs has been observed (Assumpção; Santos; Castro, 2023).

This significant increase in the number of distance education programs has led to several discussions and to the establishment of different measures beginning in 2022, which culminated in the publication of the Distance Education Policy in May 2025, through Decree No. 12,456/2025 and a set of other legal documents (Santos; Assumpção; Castro, 2025).

Due to the flexibility that distance education offers, particularly in adapting students' schedules to study demands, this format becomes an attractive alternative for expanding women's access to education, since a substantial portion of them have daily routines heavily influenced by domestic responsibilities. In this sense, some studies allow for an initial overview of female participation in distance education programs. A survey conducted with students at a higher education institution in Southern Brazil shows that they align with the profile identified in national official reports, which indicate that most students are women beginning higher education for the first time, aged between 19 and 29 years (Borges, 2016). In a study conducted by Rossi and Fontes (2022) with graduates of History and Mathematics teacher education programs, an average trend of increased intergenerational educational mobility was observed, particularly among adult women whose parents did not have higher education degrees, through distance education.

This brief contextualization makes it possible to observe that the Brazilian educational system was historically shaped by socioeconomic and gender-related issues, many of which still need to be overcome; however, progress over time can also be identified.

2.2 Women in STEM Fields

In 2006 in Brazil, it was observed that more than half of total higher education enrollments (55.7%) were female students (Ristoff, 2008), a trend aligned with the global increase in women's participation at this level of education, despite regional differences (UN, 2010). Data provided by the National Institute for Educational Studies and Research Anísio Teixeira (INEP) confirm the trend of strong female presence in higher education. According to the 2024 Higher Education Census, female students predominate in both on-campus and distance undergraduate programs (Brazil, 2025).

Looking at the data presented thus far, it appears that women have managed to overcome the barrier of access to the schooling system and to higher education, which for a long time functioned as an interdiction. However, it is still necessary to examine how this inclusion process has unfolded in the country. During the period in which women already accounted for more than half of higher education students, the study conducted by Ristoff (2008) found that men were the majority in fields such as Agronomy, Economics, Computer Science, Physical Education, and Engineering, whereas women accounted for more than 90% of enrollments in Speech Therapy, Physiotherapy, Executive Secretariat, Pedagogy, Social Work, and Occupational Therapy.

Data from INEP regarding higher education show that among the 20 largest programs in terms of enrollment in 2023, female participation was higher in 15 of them, led by Pedagogy (92.2%), Social Work (89.8%), Biomedical Sciences (86.9%), Nursing (83.7%), and Human Resource Management (81.6%) (Brazil, 2024). At the other end of the spectrum, the five programs with the highest male participation were Information Systems (80.8%), Civil Engineering (71.4%), Logistics (69.5%), Agronomy (67.8%), and Physical Education (63.2%) (Brazil, 2024a).

Taking a more specific look at gender in STEM fields, now based on data from graduates, the IBGE study indicated that women accounted for 60.3% of all higher education graduates in 2022; however, this proportion dropped to approximately one-third in STEM fields, where women's lowest representation was found in Computing and Information and Communication Technology, as well as interdisciplinary programs encompassing these areas, reaching only 15.0% (IBGE, 2024).

Similarly, the study conducted by Nascimento et al. (2023) analyzed gender parity in undergraduate STEM programs by considering the number of graduates from 2010 to 2019. According to the research, among the 20 STEM programs with the largest number of students in 2019, the most pronounced gender disparities were found in Engineering and Information Technology programs, particularly in Computer Networks, where only 8% of graduates were women. Within Engineering programs, the lowest levels of female representation among graduates were observed in Mechanical Engineering (11.36%), Control and Automation Engineering (11.68%), and Computer Engineering (13.26%).

It can thus be seen that certain fields of knowledge are strongly marked by gender disparities and that a time span of more than fifteen years since Ristoff's study (2008) has not led to significant changes in this pattern. Over time, women have been and continue to be more present in fields related to health and care, whereas areas linked to the exact sciences remain highly male-dominated.

This scenario is not limited to Brazil (Moreno; Murta, 2023) and has led to the recent development of studies, programs, and policies, particularly following the establishment of the 17 Sustainable Development Goals (SDGs) and their 169 targets agreed upon by member states of the United Nations (UN) in 2015. These goals and targets "seek to realize the human rights of all and to achieve gender equality and the empowerment of all women and girls. They are integrated and indivisible and balance the three dimensions of sustainable development: economic, social, and environmental" (UN, 2015, p. 1). In this regard, Target 4.3 emphasizes the need to "by 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university" (UN, 2015, p. 23).

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2018, p. 58), "specific measures to promote gender equality, such as legislation and gender mainstreaming policies, including quotas, financial incentives or others, can increase the participation of girls and women in education and in STEM careers." The "Women and Science" Program of CNPq, the L'Oréal Women in Science Award, and the "Elas nas Exatas" call for proposals, a partnership between Instituto Unibanco, Fundo ELAS, and Fundação Carlos Chagas, are examples of initiatives implemented in recent years in Brazil (Oliveira; Unbehaum; Gava, 2019).

In Engineering, the Women's Engineering Society established International Women in Engineering Day in 2014 to honor the remarkable achievements of women engineers and to encourage more girls and women to pursue careers in this field (WES, 2024). In Brazil, it is also possible to identify initiatives aimed at stimulating women's participation in Engineering education and in the labor market.

The Federal Council of Engineering and Agronomy (Confea) created the "Women's Program," which seeks to "promote and encourage gender equity within the Confea/Crea System and professional associations, aiming to expand women's participation in a leading role, taking into account the differences between men and women" (Confea, 2021, p. 22). The program was approved in 2019, although its initial milestone can be traced back to the 2018 survey entitled "Female Mapping within the Confea/Crea System." The study showed that, at that time, women represented only 15% of all professionals registered in the system.

In the context of professional education, the Brazilian Association for Engineering Education (Abenge) created the Women in Engineering Working Group, which aims, among other objectives, to "propose policies to increase the interest of girls and young women in STEM careers" and has fostered discussion and research on the topic through data analyses, lectures, and projects designed to encourage girls' interest in mathematics (Abenge, 2024).

It is necessary to acknowledge the relevance of these various initiatives for reducing gender inequalities in STEM fields, since, as discussed in the UNESCO report:

> "[...] research on biological factors, including brain structure and development, genetics, neuroscience, and hormones, shows that gender disparity in STEM [...] is not the result of sex-based differences related to these factors, or of innate abilities [...]. Spatial and linguistic skills, particularly written language, show a positive correlation with performance in Mathematics and can be improved through practice, regardless of sex, especially during the early years of life" (UNESCO, 2018, p. 11).

Despite all the initiatives discussed, explaining and reducing disparities in STEM fields is not a simple or trivial task, as they result from multiple factors, particularly cultural and social ones. Moreover, this is a relatively recent discussion that will still require time and sustained effort from society as a whole, involving girls and boys, women and men, both within and beyond the educational context.

3. METHODOLOGY

Based on the authors' research developed over recent years, and on the perception that little research has been conducted on gender issues and distance education in the exact sciences, a search was carried out in the CAPES Journal Portal using a combination of descriptors (gender, exact sciences, STEM, distance education, and online education), focusing on the last five years. The results were significant: a low number of studies addressing "gender" AND "exact sciences" and "gender" AND "STEM," and an almost nonexistent number of studies when the descriptors "DE" and "distance education" were combined.

With the identification of a research gap in the field, this study adopted a qualitative approach with exploratory objectives and bibliographic procedures, drawing on primary data sources, particularly data on the characteristics of Engineering students participating in the 2023 ENADE (National Student Performance Exam).

It can be stated that the research focuses on analyzing undergraduate Engineering programs in Brazil, based on the four fields with the highest enrollment, according to data from the 2024 Higher Education Census. It was found that the programs with the largest number of enrolled students were Production Engineering, Civil Engineering, Mechanical Engineering, and Electrical Engineering. Since the objective of this article involves analyzing students enrolled in both on-campus and distance education programs, the Higher Education Census data made it possible to verify that all four fields offered programs in both modalities regulated during that period, making the selection viable for the intended analysis.

After the selection of the fields of study, the Area Summary Report for each one was consulted. This document is produced based on the implementation of ENADE and addresses, among other aspects, the socioeconomic characteristics of participating students, which are collected through the instrument known as the Student Questionnaire. Thus, the reports for the four Engineering fields included in ENADE 2023 were reviewed.

For bachelor's degree programs in the aforementioned assessment cycle, ENADE was administered to students who met the following criteria: "expected to complete the program by July 2024; had completed 80% or more of the minimum curricular workload by the end of ENADE 2023 registration; and had not yet graduated by the last day of registration correction" (Brazil, 2024b, p. 10).

It is important to note that the study has limitations, as it considers Engineering programs based on only four fields of study. Nevertheless, these fields represent those with the highest total number of enrolled students and that had active offerings of both on-campus and distance education programs prior to the establishment of the 2025 Distance Education Policy, drawing on the most up-to-date ENADE Engineering data available from 2023.

4. ANALYSIS AND DISCUSSION

The discussion in this article begins with an exploration of data from the most recent ENADE assessment in Engineering. In order to understand the current situation of female participation in the four fields of study with the highest total enrollment in these programs, socioeconomic questionnaire data were used. Table 1 presents information on participating students from distance education programs in Production, Civil, Electrical, and Mechanical Engineering, by age group and gender.

Table 1 – Distance Education Engineering Students Participating in ENADE 2023 by Age Group and Gender (in %)

Age group	Production Engineering			Civil Engineering			Electrical Engineering			Mechanical Engineering		
	Total	M	W	Total	M	W	Total	M	W	Total	M	W
up to 24 years	5,3	2,7	2,6	9,2	5,8	3,4	5,0	4,6	0,4	8,1	6,9	1,2
25 to 29 years	16,9	10,4	6,5	16,6	11,3	5,3	13,5	12,1	1,4	17,7	15,6	2,1
30 to 34 years	20,5	14,0	6,5	18,0	14,4	3,6	19,5	18,0	1,5	16,4	15,8	0,6
35 to 39 years	21,7	17,3	4,4	17,9	14,6	3,2	22,6	21,6	1,0	21,5	20,4	1,1
40 to 44 years	19,0	15,2	3,7	17,4	15,0	2,4	20,7	20,0	0,7	18,0	17,2	0,8
over 45 years	16,6	14,4	2,2	20,9	18,9	2,0	18,8	18,4	0,5	18,2	17,5	0,7
Total	**100,0**	**74,0**	**26,0**	**100,0**	**80,0**	**20,0**	**100,0**	**94,7**	**5,3**	**100,0**	**93,5**	**6,5**
Average age	**36,6**	**37,7**	**33,5**	**37,0**	**38,0**	**33,0**	**37,6**	**37,8**	**33,8**	**36,5**	**36,8**	**32,5**

Prepared by the authors. **Source:** Brazil, 2024b; 2024c; 2024d; 2024e.

Table 2 – On-campus Engineering Students Participating in ENADE 2023 by Age Group and Gender (in %)

Age group	Production Engineering			Civil Engineering			Electrical Engineering			Mechanical Engineering		
	Total	M	W	Total	M	W	Total	M	W	Total	M	W
up to 24 years	40,4	23,2	17,2	41,6	25,6	16,0	32,5	26,5	6,0	37,7	32,7	5,0
25 to 29 years	40,5	26,6	13,9	36,9	25,0	12,0	41,9	34,5	7,4	42,7	37,7	5,0
30 to 34 years	11,0	7,5	3,5	10,4	7,7	2,7	13,0	11,5	1,5	10,7	9,7	1,0
35 to 39 years	4,4	3,4	1,0	5,2	4,1	1,2	5,9	5,4	0,5	4,7	4,4	0,3
40 to 44 years	2,4	2,0	0,4	2,9	2,5	0,5	3,8	3,5	0,3	2,5	2,4	0,1
over 45 years	1,2	1,1	0,2	3,0	2,6	0,4	2,9	2,7	0,1	1,7	1,6	0,0
Total	**100,0**	**63,9**	**36,1**	**100,0**	**67,4**	**32,6**	**100,0**	**84,2**	**15,8**	**100,0**	**88,5**	**11,5**
Average age	**26,8**	**27,3**	**25,9**	**27,3**	**27,9**	**26,1**	**28,0**	**28,3**	**26,5**	**27,1**	**27,2**	**26,0**

Prepared by the authors. **Source:** Brazil, 2024b; 2024c; 2024d; 2024e.

Table 2 presents the results for the same fields of study among students enrolled in on-campus programs. By comparing Tables 1 and 2, it can be observed that, in general, the proportion of women in distance Engineering programs is even lower than in on-campus programs. In the on-campus modality, the lowest proportion of women is found in Mechanical Engineering, whereas in distance education the lowest proportion is observed in Electrical Engineering. In on-campus programs, a higher proportion of women is found in Production Engineering, accounting for approximately 36.1% of the total. In distance education programs, Production Engineering also shows the highest female participation, with a proportion close to that of Civil Engineering.

Similarly, ENADE 2023 data indicated a percentage of 26% of women in distance Production Engineering. Assumpção, Hamada, and Castro (2018), in a study analyzing the first distance Production Engineering program offered by a public institution in Brazil, identified percentages below 30%, namely 28% and 23% in its first two semesters of offering. The data presented thus far indicate that even the expansion of distance undergraduate programs has not altered the percentage of female participation in Engineering. In other words, women's underrepresentation in Engineering persists within the context of distance education.

4.1 Analysis based on the results obtained

Some remarks on the general age profile observed in the ENADE 2023 data for distance undergraduate education are also relevant to contextualize the scenario presented. Students enrolled in the four Engineering programs considered in this study are concentrated in older age groups than those in on-campus education, a fact that can also be verified through the average age of both men and women. In general, men present a higher average age than women, particularly in distance education.

It is important to highlight that, in Brazil, there is an overlap of social factors—known as intersectionality—that impact access to education, and disparities by race or color in the educational attainment of the adult population exceed those observed by sex. According to IBGE (2024), the proportion of white men with higher education is 2.4 times higher than that of Black or Brown men, while the proportion of white women with higher education is nearly double that of Black or Brown women.

Thus, to broaden the analysis, Table 3 presents data on female students, disaggregated by race or ethnicity. It can be observed that women's presence in the four fields studied is predominantly composed of white women, with higher percentages in on-campus education. Although this profile also prevails in distance education, lower proportions are recorded in Production and Mechanical Engineering compared to on-campus programs. In all Engineering fields analyzed, Black, Brown, and Asian women are more represented in on-campus education than in distance education programs. There is a modest presence of Indigenous women in Production and Civil Engineering, particularly in on-campus programs.

Therefore, ENADE 2023 data suggest that there has been no significant increase in inclusion of women—neither in terms of age group nor race/ethnicity—through distance education in the field of Engineering training.

Table 3 – Female Engineering Students Participating in ENADE 2023 by Race[1]/Ethnicity and Mode of Instruction (in %)

Race	Production Engineering		Civil Engineering		Electrical Engineering		Mechanical Engineering	
	DE	In-person	DE	In-person	DE	In-person	DE	In-person
White	13,8	21,5	11,3	17,9	3,1	8,1	3,5	6,5
Black	2,5	3,0	1,2	2,8	0,6	1,6	0,8	1,1
Asian	0,7	1,0	0,5	0,7	0,0	0,3	0,1	0,3
Brown (Mixed race)	8,7	10,2	6,5	10,8	1,6	5,5	2,2	3,4
Indigenous	0,0	0,1	0,1	0,1	0,0	0,0	0,0	0,0
Prefer not to declare	0,3	0,4	0,4	0,4	0,0	0,2	0,0	0,2
Total	**26,0**	**36,1**	**20,0**	**32,6**	**5,3**	**15,8**	**6,5**	**11,5**

Prepared by the authors. **Source:** Brazil, 2024b; 2024c; 2024d; 2024e.

It is noteworthy that, even if distance education (DE) were enabling greater female participation in Engineering programs, it would still be necessary to consider studies that discuss the quality of distance education training offered in undergraduate programs prior to the publication of the 2025 DE Policy. There are indications that most distance education students were enrolled in programs with low ENADE evaluation scores, although these programs were offered by institutions that demonstrated better performance indicators in the same on-campus programs, suggesting the existence of differentiated treatment between instructional modalities (Bielschowsky, 2018). A relevant example of this disparity is the student-to-faculty ratio, which was significantly higher in distance education programs at private institutions (Assumpção; Santos; Castro, 2023).

In Engineering fields, these questions have emerged, including within the Confea/Crea System, particularly because engineering education requires learning and experience in practical and laboratory activities. Thus, with the significant expansion of distance education learning centers in recent years, especially since 2017, it is necessary to reflect on whether these centers were equipped with adequate infrastructure and qualified personnel to offer Engineering programs. On the other hand, the first participation of public distance Production Engineering programs in ENADE demonstrated that, in some way, quality is possible, provided that a consistent and high-quality structure in teaching, research, and extension is established (Santos; Assumpção; Castro, 2020; Castro; Santos; Assumpção, 2023).

However, what is observed in the country is that the expansion of distance Engineering programs has occurred predominantly through private higher education institutions. Among the four Engineering fields analyzed in this study, only Production Engineering was offered in public institutions, which raises discussions regarding the actual extent of democratization in this process.

[1] According to Osorio (2003), there are essentially three methods of racial identification. One of them is self-ascription of belonging (self-identification), in which the individual being classified selects the group to which they consider themselves a member. The ENADE 2019 report indicates that students engaged in self-identification, and for this purpose several criteria may be used, such as family background, skin color, physical traits, and ethnicity, among others. It should be emphasized that "race" is a socially constructed category and not a biological concept.

The issue is that, under these conditions, the expansion of distance education may have enabled the entry of a greater diversity of individuals while still reproducing existing social inequalities within the higher education system (Bertolin et al., 2021). Such discussions also served as input for the development and implementation of the 2025 Distance Education Policy.

It is important to note that the results observed thus far are not accidental, but rather are related to the historical development of the educational system and of the Engineering field. Engineering education in Brazil began with the establishment of the Royal Academy of Artillery, Fortification, and Design in 1792. However, formal instruction emerged after the arrival of the Portuguese Royal Family and the creation of the Royal Military Academy in 1810 (Telles, 1994).

It can be observed that Engineering initially developed as a field with restricted access for women: on the one hand, professional practice was essentially linked to the military sphere, which was not accessible to women at that time and also constituted an activity outside the domestic environment; on the other hand, because when Engineering education emerged in Brazil, formal schooling was still not permitted for girls and women.

Over time, these spaces gradually became a reality for girls and women, with the possibility of participation in primary education beginning in 1827 (Azevedo; Ferreira, 2006), the detachment of Engineering from the military field in 1874 (Telles, 1994), and the possibility of entry into higher education starting in 1879 (Ribeiro; Vieira, 2023). Although these are important milestones, it is necessary to understand how this access actually occurred, particularly in the context of professional training, since it is a fundamental requirement for professional insertion. It is along this path that it becomes evident that girls' entry into the educational space occurred with explicit differences in relation to boys.

> The curriculum for girls' classes established limitations in the teaching of algebra, geometry, grammar, national history, and geography. For girls, Christian doctrine, reading, writing, and elementary arithmetic were considered sufficient instruction, in addition to lessons in needlework, embroidery, and sewing. [...] In fact, prior to this period, the number of public schools for girls remained much lower than the number of schools for boys (Schueler, 1999, p. 10).

It can be observed that girls' access to schooling was formally permitted, but not effectively ensured, especially for those from lower-income backgrounds. Despite the legal provision established in 1827, few schools for girls had been created by 1850 (Castanha, 2013), for example. Moreover, girls who did enter the school system were still unable to experience the same educational opportunities as boys, since their education took place in separate settings and without access to some of the subjects taught to boys, including foundational knowledge required for Engineering education. For women to reach subsequent levels of education, particularly higher education, it would still take time, even after legal permission had been granted. It is not coincidental that Brazil awarded its first Engineering degree to a woman only in 1917, more than one hundred years after the beginning of formal Engineering education in the country, and that the first Black woman to achieve the same milestone did so only in 1945 (Confea, 2022).

From these historical roots, it is evident that women's late access to Engineering education has repercussions that persist to this day. There is no longer any legal differentiation between curricula, and girls now attend the same schools as boys. It is widely recognized that women do not possess lower cognitive capacity, as was previously assumed (UNESCO, 2018); however, differences in socialization persist, shaped by "various biases and by social norms and expectations that influence the quality of education they receive, as well as the subjects they study" (UNESCO, 2018, p. 10). In this context, women now predominate in higher education, yet continue to be concentrated in care-related fields, areas socially recognized as "feminine," thereby perpetuating, to some extent, a model of femininity shaped by conceptions developed in past centuries.

4.2 A more female Engineering field?

Among the four Engineering fields analyzed, ENADE 2023 data indicate that women are concentrated in Civil Engineering and, predominantly, in Production Engineering.

Production Engineering encompasses the study and development of procedures, systems, and processes considering people, materials, information, equipment, and energy (Batalha, 2008). It emerged from Mechanical Engineering as a result of industrialization and the need to develop management of production systems, business processes, and technology. Production Engineering is therefore a highly interdisciplinary field, integrating both the physical and social sciences in the search for solutions to problems across various domains, including factory and industrial facility design; logistics; modeling, simulation, and optimization; computational intelligence; organizational design; economic and cost management; occupational safety; and sustainable development.

Thus, the broad scope of Production Engineering enables graduates to work in different areas, not only in production and industrial systems, but also in financial systems and the service sector.

What ENADE 2023 data indicate is that there is greater female participation, regardless of educational modality, race, or age group, in the Engineering field that, to some extent, is associated with careers in the humanities and social sciences, often considered "feminine" professions. Within Engineering, Production Engineering is at times treated as a "non-engineering" field due to its close relationship with management areas.

From another perspective, it is possible to suggest that women's preference for Production Engineering may lie precisely in its wide range of career opportunities, which allows professionals to work as engineers without necessarily having to face the challenges of operating in predominantly male-dominated environments, such as industrial and manufacturing systems, where "discursive practices and sexualized power relations, embedded in hegemonic masculine domination within this professional field" are observed (Assumpção et al., 2023, p. 2).

There is still a need to develop initiatives that encourage more women to enter Engineering fields considered "traditional," as they serve as a foundation for others, such as Mechanical and Electrical Engineering, but which also require substantial knowledge of Mathematics, Physics, and Computer Science. In addition, more initiatives are needed to improve relationships among students, faculty, and professionals both in undergraduate programs and in the labor market.

5. Final Considerations

Throughout this article, it was possible to present a brief historical overview of women's participation in schooling up to their entry into the field of Engineering. The presence of women in the courses of the four main Engineering fields—Production, Civil, Mechanical, and Electrical Engineering—was examined in terms of student enrollments, in order to assess participation in both on-campus and distance education programs, using socioeconomic data from ENADE 2023.

The analyzed data indicate that female participation rates have changed little over recent years when compared with previous studies. No significant increase in the participation of female students in Engineering programs was observed in either modality, on-campus or distance education. In fact, a lower proportion of women was observed in distance education programs compared to on-campus programs.

Even though distance education (DE) is understood as an important instrument for democratizing access to higher education and, in this sense, as an opportunity to expand women's presence in STEM fields, the analysis of recent ENADE data indicates that this scenario requires deeper investigation and that other initiatives must be designed and implemented.

To increase the participation of girls and women in STEM education and careers, it is necessary to adopt holistic and integrated actions that involve the women themselves in identifying solutions; political will and investment are required to stimulate interest and foster their aspirations in STEM studies and careers (UNESCO, 2018). Overcoming gender inequalities with the aim of achieving equity requires actions that ensure equal participation of women across all spheres of social, economic, and political life, including scientific and technological production and development (Oliveira; Unbehaum; Gava, 2019).

It is also understood that it is necessary to "complexify common-sense explanations, based on an understanding of how gender differences are historically constituted as inequalities, often naturalized [...] which deepen gender inequality present in social relations" (Oliveira; Unbehaum; Gava, 2019, p. 155). This is because, from a historical perspective, it is evident that for women to enter the professional field of Engineering, it was necessary to overcome barriers related to access to basic education, higher education, and the labor market.

It is necessary to wait for future ENADE Engineering assessments to identify possible changes in this scenario. Thus, the authors consider that this study is relevant for jointly exploring Engineering fields, distance education training, and issues of gender (in)equality in higher education; however, further research considering other data sources is needed. In addition, the study also contributes to the field of Brazilian higher education research by providing input for future studies on the possible impacts of the 2025 Distance Education Policy on gender issues in Engineering education.

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