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Research

Towards the SDGs for gender equality and decent work: investigating major challenges faced by Brazilian women in STEM careers with international experience

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Abstract
This paper aims to understand the main difficulties faced by women throughout their careers in Brazil and abroad. Based on the information gathered from these experiences, it seeks to advance the discussion on women's participation in STEM focusing on SDG 5 (gender equality) and SDG 8 (decent work). The main difficulties experienced by women in STEM as discussed in the academic literature were mapped. This provided input to develop a questionnaire containing qualitative and quantitative questions used to conduct interviews with women working in STEM. The sample consisted of highly qualified professionals working in high positions in the hierarchies of multinational companies in the STEM field with experience both in Brazil and abroad. The data collected was analyzed using a mixed-methods approach, including content analysis for qualitative questions and the Grey Relational Analysis for quantitative questions. The results revealed that the lack of flexible work systems, the scarcity of gender-sensitive organizational policies and labor policies, and the prevalence of traditional cultural models are some of the main difficulties faced both in Brazil and abroad by the women interviewed. The need to discuss issues of gender equality and decent work in the early stages of education is important for increasing women's participation in STEM, which is a critical factor in the development of inclusive organizations and in fully achieving the sustainable development of society. This paper presents a unique perspective of the perceived difficulties faced by executive women who worked in Brazil and in different countries (i.e., Canada, Denmark, France, Germany, Switzerland and the United States). Gender equality in organizations is highly context-dependent, and cross-cultural analysis generates relevant insights to face the challenges and advance the discussion on women's participation in STEM.

Keywords Gender equality · Diversity · Sustainable development · Decent work · Barriers · Leadership · Women

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1 Introduction

Despite positive changes in the global landscape in terms of greater gender diversity in the business world in general, women continue to be underrepresented when it comes to STEM (Science, Technology, Engineering and Mathematics) companies [1, 2], which reflects the low female representation in university STEM programs [3, 4]. These issues have received increasing attention from academia and companies, since STEM professionals play a critical role in achieving the Sustainable Development Goals (SDG) [5, 6] and impacting global sustainability [7–9].

From a broad perspective, the obstacles to professional advancement for women pursuing STEM careers represent a barrier to the development of sustainable organizations [10, 11]. Research has shown that companies with improved gender balance engage in more positive corporate social responsibility (CSR) activities and reduce negative or controversial CSR activities [12]. Other studies have found that women directors have an imperative role in improving corporate sustainability disclosures [13], while board gender diversity positively impacts environmental innovation [14]. More specifically, the issue of women's under-representation in STEM careers has a direct impact on SDGs 5 (gender equality) and 8 (decent work and economic growth), particularly the targets 5.5 (ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life) and 8.5. (achieve full and productive employment and decent work for all women and men, and equal pay for work of equal value). In this sense, it is important that such issues are addressed collaboratively by higher education institutions (HEI), companies, and policy makers [5, 15].

What prevents women from increasing their participation in STEM careers has nothing to do with mathematical aptitude, since it does not differ between men and women [3]. In fact, in a study on the role of gender in sustainability-related activities, Henderson et al. [16] found that women reported significantly higher systems thinking, futures thinking, and leadership development than men, which are crucial qualities both for STEM positions and for developing organizational sustainability [17–19]. Even when women have the same qualifications as men, social pressure and working conditions are additional barriers to advancing STEM careers [20–22].

In STEM careers, men receive more encouragement and opportunities, while women have to deal with various stereotypes and social barriers [1, 23, 24]. For Saxena et al. [2], most women in STEM careers face complex and challenging circumstances that cause harmful and unfavorable experiences for their professional performance. Academic literature has shown that, historically, women have faced barriers to entering and remaining in STEM fields [25, 26], as they are discouraged from pursuing such careers throughout their school, professional, and personal lives [27–29].

Several strategies have been implemented to increase the number of women pursuing STEM education and careers [7, 8, 21], but nonetheless, the level of female under-representation in these fields has been stable for decades [30]. The image of STEM careers as primarily male professions has perpetuated the perception that they are unsuitable for women [31, 32]. These persistent and widespread stereotypes in society can influence decision-making and result in choices that perpetuate gender discrimination and inequality in social coexistence [33].

Given the context presented, this study seeks to comprehend the major challenges faced by women throughout their careers in Brazil and abroad, and to contribute to advance women's participation in STEM with a focus on SDG 5 (gender equality) and SDG 8 (decent work). In this sense, the research question that guided this study was what are the main difficulties experienced by women in STEM positions, and what measures can be developed to overcome them? It is important to note that legislation and labor policies in Brazil are constantly changing and are relatively new, with women's work only being regulated in 1932 [34] and important specific policies such as maternity leave being implemented in the Brazilian Federal Constitution in 1988 [35]. In fact, the gender issue received special attention during Brazil's presidential elections in 2022. Despite progress in the legal and normative spheres, such as alignment with International Labor Organization conventions [36], gender discrimination at work continue to be observed in various ways in Brazil [20, 37], as will be explored in this study. The relevance of the topic for organizations, HEIs and society as a whole is emphasized, as STEM fields have grown in strength and importance for sustainable development and the global economy.

2 Background

The lack of gender diversity in STEM fields reduces the plurality of the ideas and perspectives required for the development of new technologies; it also prevents organizations and nations from reaching their full potential, diminishes global competitiveness, and undermines sustainable economic growth [10, 19, 38]. According to Makarem and Wang [3], attracting and retaining women in STEM professions while not perpetuating erroneous gender inequality in the workplace would be a great solution for the shortage of highly trained professionals.

Even when women meet all of the prerequisites for the STEM standard, it is common to see professionals in the field pass judgment on values [8, 21]. According to Friedmann [1], it is necessary to break the existing sexism full of prejudices from basic education through higher education in order for women to have effective participation in STEM, until they establish themselves and remain in the career throughout their lives.

Women earn less than men on average around the world, and the few countries where this disparity is slightly lower is only because the men's wages are lower [39]. Many factors contribute to the gender pay gap, including taking time off to take care of children, working shorter shifts and more flexible hours, and holding more administrative positions than managerial positions [20, 40, 41].

According to Oh and Lewis [27], a career in STEM pays slightly more than others in the administrative or business sectors for men, whereas earnings for women are significantly different when comparing STEM and non-STEM careers. Even with exceptional skills, women in STEM earn less than men in the same positions on average, and this disparity persists throughout their lives, reaching its peak for women aged 45 to 49 when compared to men of the same age [39]. Xu [42] conducted a longitudinal study of gender-based earning gap focusing on women in STEM and found a "glass ceiling" in their pay progression when approaching ten years after graduation. According to this author, the timing of this change appears to coincide with women's fertility age, so employers may become hesitant to offer competitive salaries to women because they assume that women will have lower productivity due to pregnancy and family obligations.

The effort to increase the female workforce in STEM fields should improve economic pay equity by relocating women to traditionally high-paying fields [8, 27]. Women continue to earn less than men in STEM, despite having higher remuneration than women in other fields [39]. The gender wage gap affects all women at all levels of economic, social, and political life, and because no country has yet achieved pay parity, interventions to address this gender gap are required [40, 41].

Gender equality in organizations is heavily influenced by the cultural, legislative, and social norms in which businesses operate [24, 43]. When women enter male-dominated environments, they are forced to manage the tension between the competing personal, professional, and social identities [22, 31]. Some of them manage to deal with these issues, while others remain silent; by remaining silent, they end up inadvertently favoring the maintenance of gender prejudice and a hostile environment toward women, as struggles for gender equality are sidelined [3, 42].

According to Stoet and Geary [30], if performance, interest, joy, willingness, and self-efficacy were the only criteria for choosing a career, there would be more women in STEM fields. However, when the 'gender' variable is included in this choice, the number drops dramatically, as the constant struggle of women to pursue a STEM career in the midst of the great gender inequality attributed to these professions discourages them from persevering in the profession [8, 21, 32].

3 Materials and methods

This research was developed through four well-defined stages, as shown in Fig. 1.

In stage one, the theoretical foundation was established, allowing us to map the main challenges faced by women in STEM fields. The databases Scopus, ScienceDirect, Taylor and Francis, and Emerald Insight were used to conduct the literature search. The search terms were 'STEM', 'women', 'career', 'difficult*', 'equality', and 'gender', considering publications

Fig. 1 Research stages

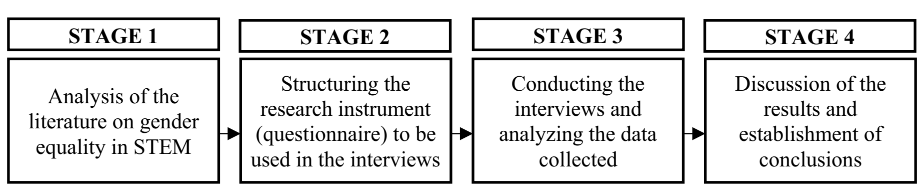

Table 1 Difficulties experienced by women in STEM areas

#	Description	References
1	Discrimination in the male-dominated workplace	[2, 3, 25, 44, 45]
2	Lack of support and professional encouragement throughout the career	[1–3, 8, 46, 47]
3	Lack of female mentors and references in STEM areas	[1, 3, 26, 44, 48]
4	Difficulty balancing career with family and personal life	[1, 3, 29, 44]
5	Social pressure to occupy culturally pre-established roles	[3, 22, 28, 42, 49, 50]
6	Low retention of women in STEM areas	[25, 26, 44, 51–53]
7	Difficulty in self-acceptance as qualified professionals	[3, 23, 54, 55]
8	Lack of flexible work systems and gender-sensitive policies	[1, 42, 44, 45, 51]
9	Wage gap between men and women	[20, 27, 39, 42]

Source: authors

from 2010 to 2022. The analysis of the literature allowed us to compile a list of nine difficulties faced by women in STEM fields (Table 1).

3.1 Structuring the interviews and selecting the participants

The list of difficulties served as a basis for structuring the interviews. Table 2 shows the questionnaire developed, consisting of six open questions (from Q1 to Q6) and one closed question (Q7).

The sampling process was conducted based on a non-probabilistic and judgmental procedure, following the recommendations of Apostolopoulos and Liargovas [56], in which the researchers chose the audience based on the research

Table 2 Questionnaire used in the interviews with women working in STEM fields

Q1	According to Monserrat et al. [48], women who had a female mentor expressed greater enthusiasm for the area and long-term commitment to the career. Have you had the presence of a female mentor in your professional journey that has helped you? If so, how did that inspire you? If not, did you miss it? How does the lack of female representation in STEM areas affect the work environment?
Q2	How do you feel about working in a male-dominated environment? Have you ever experienced any kind of discrimination in the workplace for being a woman?
Q3	How do you balance your professional career with your personal and family life? What are the main difficulties for women in STEM areas in reconciling these two fields?
Q4	According to Makarem and Wang [3], women end up choosing alternative careers when their jobs were perceived as incompatible with traditionally accepted female values, roles, identities and life goals. Why do you think there is a large evasion of women from STEM areas? Describe if at any time you thought about changing professions and what were the reasons
Q5	How do you see the future scenario for women working in STEM fields?
Q6	Have you found significant differences in culture and management in the STEM areas in Brazil and abroad? What are the difficulties faced by STEM professionals when they leave their home countries to work abroad?
Q7	Based on your professional experience in Brazil and abroad in STEM environments, assign a score from 1 to 5 for each difficulty (D) presented in each location. Feel free to check scores with decimals. As a guide, use the following milestones: Score 1: Difficulty in female professional experience in STEM areas is very subtle Score 2: Difficulty in female professional experience in STEM areas is subtle Score 3: Difficulty in female professional experience in STEM areas is medium Score 4: Difficulty in female professional experience in STEM areas is intense Score 5: Difficulty in female professional experience in STEM areas is very intense (D1) Difficulty associated with discrimination in the male-dominated workplace (D2) Difficulty associated with lack of support and professional encouragement throughout the career (D3) Difficulty associated with lack of female mentors and references in STEM areas (D4) Difficulty associated with balancing career with family and personal life (D5) Difficulty associated with social pressure to occupy culturally pre-established roles (D6) Difficulty associated with low retention of women in STEM areas (D7) Difficulty associated with self-acceptance as qualified professionals (D8) Difficulty associated with lack of flexible work systems and gender-sensitive policies (D9) Difficulty associated with wage gap between men and women

Source: authors

purpose, the conceptual and practical knowledge of the respondents that qualifies them to participate in the research, and the relevance of the information to be obtained. The study sample consisted of seven highly qualified professionals working in high positions in the hierarchies of multinational companies in the STEM area. All study participants have Brazilian nationality, hold a degree in engineering, and have worked in Brazil and abroad, including the following countries: Canada, Denmark, France, Germany, Switzerland, and the United States (US). At the time of the research, all of them were working abroad.

Semi-structured interviews were used in the study, allowing the researchers to balance focused and reflexive questions while maintaining objectivity and flexibility [57]. The interviews were conducted using the Google Meets platform between March and June 2021. It should be mentioned that this research was approved by the Research Ethics Committee of the authors' university (process no 40702520.4.0000.5404).

3.2 Data analysis

The open questions (from Q1 to Q6) were analyzed using the content analysis technique. Elo and Kyngäs [58] define content analysis as having three stages: preparation, organization, and reporting. Preparation entails defining the research object and the unit of analysis. In this study, the difficulties faced by women in STEM careers are studied from an individual perspective. To analyze the data, a deductive content analysis approach was adopted. In this approach, Elo and Kyngäs [58] recommend that the researcher has a pre-defined categorization matrix to guide data collection, which was done using the mapped difficulties faced by women in STEM (Table 1) and the questionnaire (Table 2) as the primary tool for data collection. In the final stage, the data generated by the open questions of the interviews was analyzed, taking into account the participants' perceptions, experiences, and opinions and relating them to the mapped difficulties. Initially, each interview was considered individually in order to identify the specificities of each context and gain a deeper understanding of each participant's work experiences. Subsequently, an integrated analysis of the collected data was performed, identifying convergences and divergences between the interviews and establishing a relationship with the literature on the subject related to the difficulties faced by women in STEM. This enabled the authors to organize and discuss the main findings presented in this paper.

The quantitative question (Q7) was analyzed using the Grey Relational Analysis (GRA) method, with the purpose of ranking and comparing the difficulties presented by the participants.

In question 7, participants were asked to assign a numerical score to each of the difficulties presented, and their responses were analyzed using the GRA method proposed by Kuo et al. [59]. The GRA is based on grey systems theory, which assumes that there is information about a given phenomenon that can be known and information that is incomplete and poorly defined [60–62]. The application of the GRA is recommended for situations where there is prior knowledge about the topic [59]. Therefore, this method is suitable for analyzing the difficulties of women in STEM careers based on the knowledge available in the academic literature, comparing it with the reality of professionals working in this area.

To calculate the grey relational coefficients and the grey relational degree, it is necessary to start from a set of observations $\{x_0, x_1, x_2, \ldots, x_m\}$, where x_0 is the reference and $x_1, x_2, \ldots, x_m$ are the observations to be compared. Each observation x_e has *n* attributes and is denoted by $x_e = \{x_e(1), x_e(2), x_e(3), \ldots, x_e(n)\}$, thus, a process analogous to normalization is needed to handle these values [59]. It is important to note that x_{ij} [Eq. (1)] assumes values between 0 and 1, and the closer to 1, the greater the similarity between the attribute of the comparative series and that of the standard series. In this study, the attributes are represented by the 'respondents'. Following Kuo et al. [59], Eq. (1) was used to normalize the data, which implies that the difficulty ranked highest by respondents corresponds to the most intense. Following in this line, the difficulty that appears last is the mildest, since the lower the assigned score, the less challenging the difficulty experienced as considered by the respondent.

$$x_{ij} = \frac{y_{ij} - min\{y_{ij}, i = 1, 2, \ldots, m\}}{max\{y_{ij}, i = 1, 2, \ldots, m\} - min\{y_{ij}, i = 1, 2, \ldots, m\}} \text{for } i = 1, 2, \ldots, m \, and \, j = 1, 2, \ldots, n \tag{1}$$

Following the normalization process, the relational coefficients γ for each attribute of each series were calculated. The Eq. (2) was used to calculate these coefficients:

$$\gamma\left(x_{0j}, x_{ij}\right) = \frac{\Delta_{min} + \xi\Delta_{max}}{\Delta_{ij} + \xi\Delta_{max}} \text{for } i = 1, 2, \ldots, mej = 1, 2, \ldots, n \tag{2}$$

$$\text{Where,} \quad \Delta_{ij} = \left| x_{0j} - x_{ij} \right| \tag{3}$$

$$\Delta_{min} = min\{\Delta_{ij}, i = 1, 2, \dots, m; j = 1, 2, \dots, n\} \tag{4}$$

$$\Delta_{max} = max\{\Delta_{ij}, i = 1, 2, \dots, m; j = 1, 2, \dots, n\} \tag{5}$$

$$\xi \in [0, 1] \tag{6}$$

According to Kuo et al. [59], the value of $\xi = 0, 5$ is usually used as this does not affect the final ordering of the series, only the distance between the compared items. Following this recommendation, the next step was to determine the grey relational degree of the comparative series with the standard series using Eq. (7):

$$\Gamma\left(X_0, X_i\right) = \sum_{j=1}^{n} w_j \gamma\left(x_{0j}, x_{ij}\right) \text{ for } i = 1, 2, \dots, m \tag{7}$$

The variable w_j represents the weight assigned to each respondent, which depends on the researcher's judgment. All respondents were given the same weight because their opinions were regarded as equally important. As the sum of all weights must be 1 to represent the sample, the value of each weight was $w_j = \frac{1}{7}$.

Finally, the GRA is completed through the descending classification of the values calculated for the grey relational degree, resulting in the comparative ranking that shows sequentially the most intense to the least intense difficulty as evaluated by the respondents. Based on the results obtained, the qualitative and quantitative analyses described were used to support the discussion and establish the main findings of the research.

4 Results and discussions

Each of the participants was interviewed individually and was given the opportunity to ask questions, provide additional information and reflect on points they considered important, considering their path that led to reaching a high hierarchical position in a multinational organization in the STEM area. Each interview was subjected to content analysis, which allowed the most relevant points observed by each participant to be identified and integrated. As mentioned earlier, all participants are Brazilian with professional experience in STEM positions both in their home countries and abroad, and are identified as follows: Participants (A) and (C) worked in Brazil and Germany; participant (B) worked in Brazil and Denmark; participant (D) worked in Brazil and France; participant (E) worked in Brazil and Canada; participant (F) worked in Brazil and Switzerland; and participant (G) worked in Brazil and the US.

4.1 Integration of data and emergence of a convergent concept map

As recommended by Elo and Kyngäs [58], the content analysis of the individual interviews was used as a basis for the development of a conceptual map. This result is important because, on the one hand, it reveals that although the participants have similar professional profiles, they have different opinions on certain topics depending on their beliefs, personal contexts. and individual life experiences; on the other hand, it does not prevent the particularities from being integrated and the emergence of convergent concepts.

The majority of participants mentioned having a female mentor in their professional path, which they all described as very important and motivating. Instead, participants who did not have a female mentor stated that the absence of a female leadership figure was very much felt, as the presence of notable women in STEM areas is responsible for inspiring, stimulating, and creating a greater connection with the female group, as noted in the literature [26, 29, 48]. The participants stated that, unfortunately, shaping one's personality is a recurring and necessary attitude so as to fit into male-dominated environments in which women are excluded from formal and informal work moments, a difficulty observed in studies such as those of Kim et al. [22], Saxena et al. [2] and Makarem and Wang [3].

Many participants reported having experienced discrimination in the workplace or in college. They described most of their experiences as veiled rather than explicit prejudices, which led many of them to question whether the situation actually occurred. This prejudice arises because society's stereotype of the male figure in STEM positions is still very strong [32, 33], and the presence of women in these positions represents a shock to the traditional model. Participants noted that in Brazil, intolerance is frequently expressed through inconvenient pranks and jokes, whereas abroad the prejudice is less about gender and more about cultural differences [3, 25]. At this point, it is important to note the issue of machismo, which refers to behaviors associated with the negative characteristics of sexism and hypermasculinity [63]. Research on the subject demonstrates machismo is a cultural aspect with a strong presence in Latin America, including Brazil [64, 65], creating difficulties and barriers for women at work [66].

Even though the gender stereotype persists in STEM careers, it was observed that the younger the women, the less discrimination they experienced in the workplace, suggesting that paradigms are gradually shifting. Despite the prejudices they experienced, the participants stated that they did not feel inferior when working in environments where they are a minority, and some even consider coexistence within male-dominated spaces to be easier and more objective. It was found that women become accustomed to and learned to impose limits within this reality beginning in college and continuing throughout their careers.

Balancing work and personal life was identified as one of the most difficult challenges for women in STEM careers by several participants, which is consistent with the literature [1, 29]. As reported by one of the participants, in the job interviews she participated in Germany, she was asked about how she would take care of her children if she got the job, and she refuted by saying that she would only answer this question "if they also ask all the men who are parents, because they also have responsibility for their children." Due to the pressure and high demand that occupying a high hierarchical position requires, participants reported difficulty giving due attention to issues such as family and leisure, which ended up receiving low priority at some point during their career path. The difficulty in reconciling motherhood with a STEM career was a point of agreement among the participants, who had witnessed in the workplace the dismissal of other women because they had children. When comparing their experiences in their home countries and abroad, the difficulties observed in Brazil are even greater. To illustrate this, it can be mentioned the report of one of the participants who described the experience in a Brazilian company in which "all the women who had children, from secretaries to engineers, were fired after returning from maternity leave." Participants reported that they could not plan to have a family in Brazil, envisioning this reality only possible abroad. The reasons for this is that countries in which they currently reside have better laws, labor policies, and cultural dynamics that allow them to balance life and career, as opposed to Brazil, which is still a long way from this reality [20, 37, 41].

Based on their professional experience in STEM organizations, the participants claim that the evasion of women from STEM careers in Brazil is greater than elsewhere, but that the main reason for this remains motherhood, with women slowing down their careers even before becoming mothers, when they are still planning to have children [4, 51]. Other critical factors mentioned for women leaving STEM careers included: precarious infrastructure, particularly in manufacturing sites; gender culture based on traditional models; few examples of women in STEM professions; lack of flexibility at work; prejudices and discrimination in the workplace; unwelcoming environment; slower-than-usual career growth; and lack of recognition. Such reasons support what has been stated in the literature [3, 8, 26, 51].

When asked if they had ever considered changing careers, the participants' responses were mixed. Some stated that they would never leave because they enjoyed the technical specialty; others stated that they had already considered changing careers because they realized their values were incompatible with the reality of the profession at some point in their lives [52]. Another important finding is that many women do not leave STEM, but rather migrate to less technical positions within the field that require less time, dedication, responsibilities, and obligations. This can be related to the patriarchal and sexist view of women's obligation to take responsibility for domestic and care work [42, 65], as well as the existence of a distorted view of "feminine" skills, such as communication, and other "masculine" skills, such as those related to engineering knowledge and techniques [67, 68].

The participants revealed their perception that the path to STEM professions is no longer welcoming, as they encountered prejudice for being women in many job interviews, both in Brazil and abroad. Nevertheless, when asked about the future scenario for women in STEM, the participants expressed optimism, despite the fact that the necessary changes will be gradual and that the male stereotype will persist for a few years before it is overcome. The participants imagined a promising future with less prejudice and more acceptance of diversity in the workplace. Discussions about representativeness have grown over time, awareness-raising campaigns have taken place, and beginning in primary school, there is already a strong incentive for girls to pursue technical careers [28, 50, 69]. In addition, the rapid evolution of technology and pressing challenges of sustainable development have also contributed to attracting and retaining more women in STEM [1, 28, 38]. Innovation necessitates mixed environments with a plurality of ideas, as a lack of diversity within work teams biases choices, preventing the creation of a modern, sustainable space [4, 70]. The most innovative and forward-thinking organizations have already recognized the importance of having women in STEM and diversifying work environments [71, 72]. In the perception of the participants, this mindset of combining diversity with individual ability is less advanced in Brazil than abroad.

The main challenge reported by participants when working outside their home country is the cultural impact. Adapting to new habits and behaviors takes time and effort, but living with different people is very enriching to one's life, according to all participants. Participants in all of the countries studied (i.e., Canada, Denmark, France, Germany, Switzerland, and the United States) described professional relationships as more private, straightforward, and impersonal. They see this as an obstacle to the routine of social interaction, because they are accustomed to Brazilian culture, which values personal relationships with greater proximity and intimacy.

Other difficulties in working abroad that were mentioned by participants included: the complexity of the process of academic education recognition and validation; the use of technical terms in a non-English language; different technical standards for academic papers; the need for a high degree of specialization in a given area; and the difficulty in making a career transition to other areas within STEM.

There were numerous differences reported by participants when working in Brazil versus working abroad. Overall, formal and technical education with a high level of specialization in a particular subject is more valued abroad. Professionals in Brazil tend to have a more general knowledge base and pursue managerial positions in STEM fields. According to the participants, engineering positions abroad are focused on research and development, whereas in Brazil, practical and implementation skills are most requested. Professionally, they stated that there is more incentive for women in STEM careers abroad, as there are examples of female leaders who inspire and motivate employees to grow and learn.

Another notable distinction between Brazil and the other countries mentioned by participants concerned labor laws and organizational infrastructure. Although the laws are not unified and differ from country to country, they are undeniably superior to those in Brazil. With more flexible rules, the work-life balance encounters fewer barriers and is easier to achieve, attracting more women to STEM. In terms of personal life, unlike in most cases in Brazil, housework and childcare are not outsourced. People tend to share household and childcare responsibilities, and gender distinctions and stereotypes are less prevalent among family members.

4.2 Comparative analysis of difficulties using grey relational analysis (GRA)

The participants' quantitative assessment of the challenges faced by women in STEM both in Brazil and abroad enabled a comparative analysis to be performed using the GRA. Figures 2 and 3 depict each participant's score for each of the difficulties (Table 1) presented in the questionnaire. In general, it was observed that the difficulties in Brazil are greater than those encountered abroad.

The first step of the GRA method is the construction of the relational matrix, which is accomplished through data normalization [59]. Tables 3 and 4 show the results of the normalization for the scores measured respectively in Brazil and abroad.

After normalizing the data, the relational coefficients γ were calculated, which required calculating the values of Δ_{ij}. The reference adopted was $(x_{01}, x_{02}, x_{03}, \ldots, x_{07}) = (1, 1, 1, \ldots, 1)$ and for ξ the value of 0.5 was considered. Tables 5 and 6 present the results of the analysis performed on the scores assigned by the participants for Brazil and abroad, respectively.

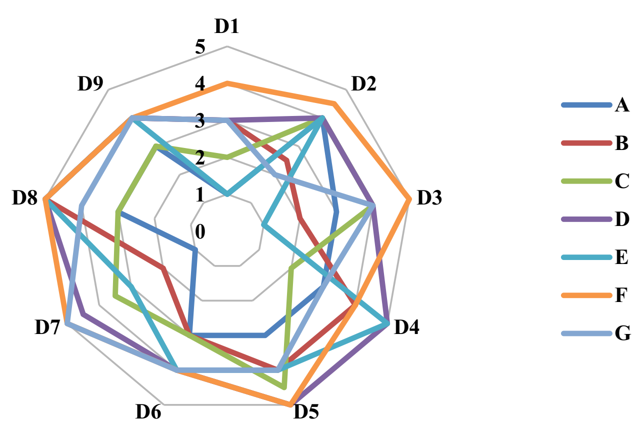

Fig. 2 Scores assigned by the participants for each difficulty in Brazil

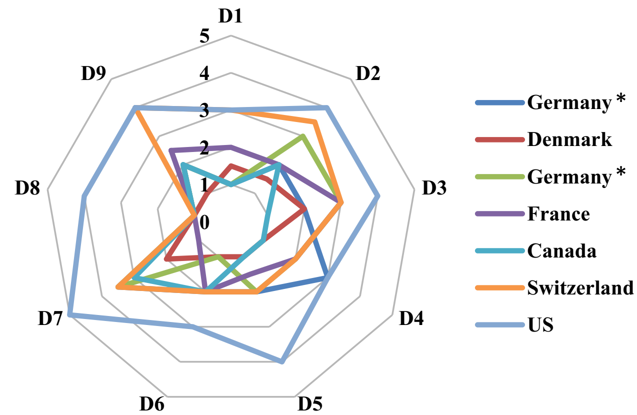

Fig. 3 Scores assigned by the participants for each difficulty abroad. *It should be noted that Germany appears twice because two participants (A and C) worked in this country

Table 3 Normalization of the scores assigned by the participants for each difficulty in Brazil

	BRAZIL							
	Difficulty	A	B	C	D	E	F	G
D1	Discrimination in the male-dominated workplace	0.00	0.33	0.00	0.00	0.00	0.00	0.33
D2	Lack of support and professional encouragement throughout the career	1.00	0.17	0.80	0.50	0.75	0.50	0.00
D3	Lack of female mentors and references in STEM areas	0.67	0.00	0.80	0.50	0.00	1.00	0.67
D4	Balancing career with family and personal life	0.67	0.67	0.00	1.00	1.00	0.00	0.33
D5	Social pressure to occupy culturally pre-established roles	0.67	0.67	1.00	1.00	0.75	1.00	0.67
D6	Low retention of women in STEM areas	0.67	0.33	0.40	0.50	0.75	0.00	0.67
D7	Self-acceptance as qualified professionals	0.00	0.00	0.60	0.75	0.50	1.00	1.00
D8	Lack of flexible work systems and gender-sensitive policies	0.67	1.00	0.40	1.00	1.00	1.00	0.67
D9	Wage gap between men and women	0.67	0.67	0.40	0.50	0.75	0.00	0.67

Source: authors

Table 4 Normalization of the scores assigned by the participants for each difficulty abroad

	ABROAD*							
	Difficulty	A	B	C	D	E	F	G
D1	Discrimination in the male-dominated workplace	0.00	0.50	0.00	0.50	0.00	0.67	0.00
D2	Lack of support and professional encouragement throughout the career	0.40	0.50	0.80	0.50	0.50	0.83	0.50
D3	Lack of female mentors and references in STEM areas	0.40	1.00	0.80	1.00	0.00	0.67	0.50
D4	Balancing career with family and personal life	0.80	0.00	0.40	0.50	0.00	0.33	0.00
D5	Social pressure to occupy culturally pre-established roles	0.40	0.00	0.40	0.25	0.00	0.33	0.50
D6	Low retention of women in STEM areas	0.40	0.00	0.00	0.50	0.50	0.33	0.00
D7	Self-acceptance as qualified professionals	1.00	1.00	1.00	0.00	1.00	0.83	1.00
D8	Lack of flexible work systems and gender-sensitive policies	0.00	0.00	0.00	0.00	0.00	0.00	0.50
D9	Wage gap between men and women	0.40	0.00	0.40	0.75	0.50	1.00	0.50

Source: authors

*The countries included in this study were Canada, Denmark, France, Germany, Switzerland, and the United States

Finally, considering the same weight for each respondent, i.e. $(w_1, w_2, x_3, \ldots, w_7) = (\frac{1}{7}, \frac{1}{7}, \frac{1}{7}, \ldots, \frac{1}{7})$, the grey relational degree Γ was obtained and the difficulties were comparatively ranked from highest to lowest observation in Brazil (Table 7) and abroad (Table 8).

Table 5 Grey relational coefficients of the analysis of scores assigned for Brazil

	BRAZIL							
	Difficulty	A	B	C	D	F	G	H
D1	Discrimination in the male-dominated workplace	0.33	0.43	0.33	0.33	0.33	0.33	0.43
D2	Lack of support and professional encouragement throughout the career	1.00	0.38	0.71	0.50	0.67	0.50	0.33
D3	Lack of female mentors and references in STEM areas	0.60	0.33	0.71	0.50	0.33	1.00	0.60
D4	Balancing career with family and personal life	0.60	0.60	0.33	1.00	1.00	0.33	0.43
D5	Social pressure to occupy culturally pre-established roles	0.60	0.60	1.00	1.00	0.67	1.00	0.60
D6	Low retention of women in STEM areas	0.60	0.43	0.45	0.50	0.67	0.33	0.60
D7	Self-acceptance as qualified professionals	0.33	0.33	0.56	0.67	0.50	1.00	1.00
D8	Lack of flexible work systems and gender-sensitive policies	0.60	1.00	0.45	1.00	1.00	1.00	0.60
D9	Wage gap between men and women	0.60	0.60	0.45	0.50	0.67	0.33	0.60

Source: authors

Table 6 Grey relational coefficients of the analysis of scores assigned for abroad

	ABROAD*							
	Difficulty	A	B	C	D	F	G	H
D1	Discrimination in the male-dominated workplace	0.33	0.50	0.33	0.50	0.33	0.60	0.33
D2	Lack of support and professional encouragement throughout the career	0.45	0.50	0.71	0.50	0.50	0.75	0.50
D3	Lack of female mentors and references in STEM areas	0.45	1.00	0.71	1.00	0.33	0.60	0.50
D4	Balancing career with family and personal life	0.71	0.33	0.45	0.50	0.33	0.43	0.33
D5	Social pressure to occupy culturally pre-established roles	0.45	0.33	0.45	0.40	0.33	0.43	0.50
D6	Low retention of women in STEM areas	0.45	0.33	0.33	0.50	0.50	0.43	0.33
D7	Self-acceptance as qualified professionals	1.00	1.00	1.00	0.33	1.00	0.75	1.00
D8	Lack of flexible work systems and gender-sensitive policies	0.33	0.33	0.33	0.33	0.33	0.33	0.50
D9	Wage gap between men and women	0.45	0.33	0.45	0.67	0.50	1.00	0.50

Source: authors

*The countries included in this study were Canada, Denmark, France, Germany, Switzerland, and the United States

Table 7 Ranking of difficulties in Brazil

	BRAZIL		
	Difficulty	Γ	Ranking
D8	Lack of flexible work systems and gender-sensitive policies	0.81	1st
D5	Social pressure to occupy culturally pre-established roles	0.78	2nd
D7	Self-acceptance as qualified professionals	0.63	3rd
D4	Balancing career with family and personal life	0.61	4th
D2	Lack of support and professional encouragement throughout the career	0.58	5th
D3	Lack of female mentors and references in STEM areas	0.58	6th
D9	Wage gap between men and women	0.54	7th
D6	Low retention of women in STEM areas	0.51	8th
D1	Discrimination in the male-dominated workplace	0.36	9th

Source: authors

The darkest shade of red represents the difficulty most frequently identified by study participants, while the darkest shade of blue represents the least frequently identified difficulty

Table 8 Ranking of difficulties abroad

	ABROAD*		
	Difficulty	Γ	Ranking
D7	Self-acceptance as qualified professionals	0.87	1st
D3	Lack of female mentors and references in STEM areas	0.66	2nd
D2	Lack of support and professional encouragement throughout the career	0.56	3rd
D9	Wage gap between men and women	0.56	4th
D4	Balancing career with family and personal life	0.54	5th
D1	Discrimination in the male-dominated workplace	0.42	6th
D5	Social pressure to occupy culturally pre-established roles	0.41	7th
D6	Low retention of women in STEM areas	0.41	8th
D8	Lack of flexible work systems and gender-sensitive policies	0.36	9th

Source: authors

*The countries included in this study were Canada, Denmark, France, Germany, Switzerland, and the United States

The darkest shade of red represents the difficulty most frequently identified by study participants, while the darkest shade of blue represents the least frequently identified difficulty

It is possible to observe noteworthy points based on the rankings of difficulties in Brazil and abroad shown in Tables 7 and 8, respectively, that are in line with the data gathered from the interviews and the literature review. Women in STEM careers in Brazil face the greatest difficulty due to a lack of flexible work systems and gender-sensitive policies; this problem came in last place abroad, indicating that the Brazilian workplace still has a long way to go on these issues. Another notable difference was regarding the social pressure to fill culturally pre-determined roles, which ranked 2nd in Brazil and 7th abroad, suggesting that women in STEM face less stigma in other countries than in Brazil, where further deconstruction of traditional models is required.

The difficulty that appeared in 1st place abroad was low self-acceptance as qualified professionals. This may be related to the cultural shifts that professionals undergo when they work in contexts outside of their home countries. When the cultural component is taken into account, self-confidence suffers, although this difficulty ranks 3rd in Brazil, indicating that women have low self-confidence even in their home countries.

The lack of female mentors and references in STEM fields was ranked 2nd in the ranking internationally, and 6th in Brazil. It was unable to reach a definitive answer on this issue because, whereas female participation in STEM is low in other countries, it is higher in Brazil. The lack of support and professional encouragement throughout one's career came in 3rd place abroad, while it appeared in 6th position in Brazil. It was also hard to draw a clear conclusion on this matter since the participants had differing viewpoints, although they do demonstrate greater incentives for careers in science and technology abroad in general.

In Brazil, facing discrimination in a male-dominated workplace appeared in last place, confirming the findings of the interviews, which demonstrated that women have been dealing with similar situations since college. This difficulty was ranked 6th abroad, possibly due to the inclusion of the 'foreign' component. The difficulty of low retention of women in STEM fields placed 8th both in Brazil and abroad, with participants stating that there must be means (e.g., public policies, organizational policies, support systems) to overcome the obstacles in order to resist in their careers.

The difficulty of balancing career with family and personal life ranked 4th in Brazil and 5th abroad. The minor difference may be due to the fact that reconciling these two spheres remains challenging in any country and is heavily dependent on individual family and personal dynamics. Based on the interviews, this difficulty appears to be subtler abroad, as the countries included in the study have better laws and policies that contribute to a better work-life balance than Brazil. In terms of the wage disparity between men and women, Brazil ranked 7th and abroad ranked 5th, but no major generalizations can be drawn because it is a complex topic involving several factors and differences depending on the country.

4.3 Measures to advance women's participation in STEM: towards SDGs for gender equality and decent work

The findings of this study, derived from qualitative and quantitative analyses, contribute to the discussion on women's participation in STEM, which according to the United Nations [5], has an impact on all SDGs directly or indirectly. Table 9 summarizes the main results relating them to the SDGs 5 (gender equality) and 8 (decent work), which are the focus of this study.

Table 9 Relationship between the main difficulties observed and the SDGs

	Aspects related to the SDGs	Relationship with the difficulties observed								
		D1	D2	D3	D4	D5	D6	D7	D8	D9
Gender equality	End all forms of discrimination against all women	✓				✓	✓			
	Eliminate all forms of violence against all women in the public and private spheres	✓					✓			
	Recognize and value unpaid care and domestic work				✓				✓	
	Promotion of shared responsibility within the household				✓	✓			✓	
	Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life			✓	✓	✓		✓		✓
	Undertake reforms to give women equal rights to economic resources						✓		✓	
	Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women at all levels	✓	✓					✓		
Decent work	Achieve higher levels of economic productivity through diversification						✓			✓
	Promote development-oriented policies that support productive activities and decent job creation	✓	✓	✓	✓		✓		✓	
	Full and productive employment and decent work for all women	✓	✓							
	Equal pay for work of equal value		✓			✓	✓			✓
	Protect labor rights and promote safe and secure working environments	✓					✓			

Source: authors

The results obtained are particularly important for the SDG targets 5.5 (ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life) and 8.5. (achieve full and productive employment and decent work for all women and men, and equal pay for work of equal value). Thus, educators, researchers, and organizations can benefit from these results to promote discussions about gender equality and decent work for women in STEM, considering the Brazilian cultural context [20, 37].

Based on the experiences of the participants, there are many barriers to achieving target 5.5. In terms of ensuring women's full and effective participation in STEM fields, one of the most difficult challenges for women to enter, participate in, and sustain themselves in STEM careers has been identified as balancing work and personal life. Educators can use the participants' reports to propose discussions with students in Brazilian HEIs who intend to pursue a career in STEM. It is important that these students are taught from the early stages [22, 28, 46] that the paradigm in which the woman is solely responsible for housework and child care is shifting towards a new vision of the role of the man so that both men and women are allowed to dedicate the time and effort required to develop their careers [44, 73, 74]. The findings of this study can be used by managers and organizations to create organizational policies and support systems for women [2, 25, 45] and develop organizational practices from that basis to raise awareness and educate all of their employees, regardless of gender or hierarchical position. Researchers can conduct empirical research in Brazilian organizations to identify and disseminate these practices based on new paradigms that aim to increase women's participation in STEM fields [75].

Ensuring women leadership opportunities at all decision-making levels is also a major challenge to achieving target 5.5 [6], and the fact that the study sample consisted of women in high-level positions in multinational corporations strengthens the study's findings in this regard. The participants reported that the lack of a female mentor is a critical factor in inspiring, motivating, and connecting women in such leadership roles in STEM areas [29, 48, 53]. In addition, the literature demonstrates that the greater participation of women in leadership positions contributes to new management styles that are essential for competitiveness [76] and that the presence of women on the company's board positively impacted organizational performance [77].

Educators and researchers can use the information and findings of this study to hold discussions on female leadership in Brazil, disseminate academic references used in this study, and promote connections between women in leadership roles and students interested in STEM careers, so that they can serve as mentors or raise awareness about the importance of having one for young students [3, 26]. To note, a limitation of our study was its sole focus on gender. Although study participants spoke of having to navigate cultural differences, they did not speak of experiencing racism or other forms of discrimination in the workplace for example, nor were they prompted to. However, the broader literature shows that the types of penalties and social disapproval women face in the workplace varies. For instance, Black [78] and Asian American women [79] experience different penalties to those experienced by white women in the workplace. We thus need to facilitate research and discussion spaces on women in leadership which take an intersectional approach to talking about and assessing harm and discrimination, reflecting on how dominant norms can lead to discrimination (e.g., sexism) and can also confer advantage (e.g., to those of us racialized as white, or who identify as heterosexual).

Regarding target 8.5, reaching it depends directly on the development of sustainable organizations and business models [10, 11]. Allowing women to have decent, sustainable jobs entails incorporating work-related issues into corporate governance and sustainability guidelines, respecting labor laws and human rights, developing synergy between areas/departments toward sustainability, and creating work that is meaningful, pleasurable, and leads to recognition [80]. The research findings, as well as the comparative analysis of the difficulties, can assist Brazilian organizations in developing sustainable work systems that take cultural issues into account. Academic literature suggests that companies should incorporate diversity management into their management models through the implementation of affirmative policy actions, adherence to laws, and the formalization of human resource practices in order to reduce wage disparities [20, 37] and other forms of discrimination [2, 3].

It is critical that Brazilian HEIs incorporate into their STEM curricula the study of their countries' labor laws, the guidelines of the International Labor Organization (ILO) conventions, and the 2030 Agenda of the United Nations [81–83], providing women with the knowledge they need to demand and develop policies and systems that protect them in the organizations where they will work in the future. For companies, it is critical that they disseminate in their sustainability reports all the information recommended by the Global Reporting Initiative (GRI) standard [84, 85], specifically regarding the item 405-2, which focuses on issues related to 'Diversity and Equal Opportunities', including presenting complete information about the wage ratio by gender and the initiatives they have been performing to fill the gender gap [27, 39, 42]. If companies are more transparent in providing information, including work-related issues in their sustainability reports, society will have more arguments to demand organizational practices from companies that ensure decent work for women who want to start and develop their careers in STEM [20, 80].

Finally, it is critical to emphasize that HEIs, organizations, and society as a whole must oppose any practice that seeks to "fix" women in order for them to fit into existing systems, promoting a greater push for structural change and the need for men, and people from majority communities more broadly, to understand how existing systems confer both advantage and disadvantage, how dominant norms work, how harm and discrimination (explicit and implicit) is perpetuated, and what we can all do to interrupt and transform such norms and systems.

5 Conclusions

This paper aimed to understand the main difficulties faced by women throughout their careers in Brazil and abroad, and to contribute to advance women's participation in STEM with a focus on SDG 5 (gender equality) and SDG 8 (decent work). The questionnaire containing the main difficulties faced by women in STEM can be useful for educators in classroom discussions with students; for researchers, who can expand, improve and apply it in other samples and contexts; and for organizations, that can train all their employees and develop organizational practices that attract and retain women in STEM positions, from entry-level to leadership roles.

The analysis of the interviews conducted with the participants revealed that there are differences between Brazil and the other countries included in the study (i.e., Canada, Denmark, France, Germany, Switzerland, and the US), particularly in terms of work and gender policies. Brazil remains far behind in terms of labor laws that ensure women's well-being, health, and safety in STEM workplaces, which are critical factors in achieving targets 5.5 and 8.5.

When appropriate labor policies and an organizational culture to support them are in place, the dilemma of balancing personal and professional life is alleviated. Although work-life balance is more poorly managed in Brazil, the participants' experiences show that there are still areas where all countries can improve. Since modernity and innovation require mixed environments with a diversity of ideas, the participants expressed optimism about the future of women in STEM, with less prejudice and greater diversity.

Although qualitative and quantitative methods were used, as well as data triangulation through interviews and literature review, the main limitation of this study is the sample size, which opens the way for several possibilities for future research. On the one hand, it is necessary to recognize the difficulty of finding participants with the specific characteristics desired for the study (i.e., highly qualified professionals working in high positions in the hierarchies of multinational companies in the STEM area with experience both in Brazil and abroad) and who agreed to be interviewed on issues that could be sensitive. On the other hand, future research may replicate this study in other cultural contexts, use different methods of data collection and analysis, examine other SDGs that are influenced by women's participation in STEM such as SDGs 4 (quality education), particularly the target 4.3 (by 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university) [8]; SGD 9 (industry, innovation and infrastructure) [6]; and SDG 13 (climate action) [38, 70]; and mainly to expand the sample of participants. Other issues that deserve special attention in future research are race and ethnicity [see 73, 75, 79], seeking to understand how stereotypes affect women at work in various ways. In addition, future research can address the chronological evolution and recent developments in Brazilian labor legislation [34, 36], helping to understand the historical and structural conditions that have led to gender inequalities in this country. These studies can help to increase the presence of women in STEM, which will contribute, consequently, to the development of sustainable organizations and the full achievement of the SDGs.

As a final consideration, it is important to emphasize the need to discuss issues of gender equality and decent work beginning from the early stages of education. Such ideas and actions must be supported by educators, HEIs, and organizations, since limited participation of women in STEM constrains the ability to secure them highly skilled roles, leaving women's voices, leadership and solutions out of technological and society development.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Declarations

Ethics approval and consent to participate This study was approved by the Research Ethics Committee of the State University of Campinas (Unicamp/Brazil) and the Brazilian National Ethics Committee (Ministry of Health of the Federal Government of Brazil) in accordance with the 1964 Helsinki Declaration (CAAE nº 40702520.4.0000.5404). Informed consent was obtained from all individual participants included in the study.

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