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TOPICAL REVIEW

Women's Journey in STEM Education in Brazil: A Rapid Review on Engineering and Computer Science

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ABSTRACT Challenges related to gender equality are being researched by different institutions, universities, and companies worldwide. In particular, there are still gaps concerning higher education in Science, Technology, Engineering, and Mathematics (STEM). Through a Rapid Review, this work aims to present the factors that affect women's journey in STEM education in Brazil, mainly in engineering and computer science. More specifically, we seek to describe the barriers, motivators, and strategies present in the researched academic literature. Barriers include stereotypes, oppression, patriarchal relations, prejudice, segregation, isolation, lack of support from colleagues and teachers, judgment, fear of mathematics, and mansplaining – the unnecessary explanation made by a man of something a woman says. Motivators include support from the school and teachers, exposure to the STEM area during high school, teamwork, and support from family, friends, and classmates. The strategies to overcome barriers women face in STEM education include exposure to STEM topics, the inclusion of teachers in encouraging and training, role models, participation in technological competitions, a friendly environment, and women participating in technical evaluators' work. This work presented data revealing women's challenges in STEM, highlighting existing barriers, motivators, and strategies tested to address the low female participation. This information significantly expands the discussion on this topic, especially in the labor market and education. In our view, quality and excellence depend on an inclusive policy where selection is based solely on merit, regardless of gender, ethnicity, or religion.

INDEX TERMS Higher education, gender equality, STEM, Brazil.

I. INTRODUCTION

Interest in gender equality is broad on the world stage [1], especially regarding student access to higher education. This interest is reflected in the engagement of organizations such as the UN [2], [3], [4], [5], UNESCO [6], [7], the World Economic Forum [8], and the European Union [9], and organizations dedicated to bridging gender gaps [10], [11], [12], often participate in academic discussions on gender equality. Highlighting the prominence of the UN's involvement, the UN's Sustainable Development Goals (SDGs) explicitly identify education and gender equality as key objectives [13]. Ongoing research and initiatives aim to understand whether there are differences, their magnitude, and how to reduce such differences. This debate is fundamental for fostering an inclusive society, with significant ramifications for academic communities, where there is still a noticeable gender disparity among the student population.

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Amidst this discussion on gender equality in higher education, there is an area of particular interest for the future of society. STEM is the acronym for Science, Technology, Engineering, and Mathematics, which brings together significant research, teaching, and work areas. STEM is fundamental for advancing several technologies, such as Artificial Intelligence, Robotics, and the Internet of Things. Such technologies make up the 4th Industrial Revolution and have a crucial role in diverse areas of our lives, ranging from health to law, passing through education, Government, and entertainment [14], [15]. Education and work opportunities for all social groups – STEM included – are fundamental for building a plural society [16], [17]. Gender equality is estimated to be achieved worldwide in 135.6 years at the current rate [8].

The gap between women and men concerning access to higher education and the insertion in the job market in STEM is unequal in countries like Brazil. In Brazil, female participation in higher education (56%) is greater than male participation. However, female participation drops to only 30% in STEM. Such inequality is even worse in some Engineering courses – such as Mechanical Engineering (11%) and Electrical Engineering (13%) – and in Computing courses – such as Computer Science (10%) and Computer Networks (8%) [18], [19].

Examining the factors hindering female participation in STEM higher education is crucial to developing effective strategies for reducing inequality. Some STEM careers, such as Engineering and Computing, present severe gender disparities.

In this work, we aim to present *barriers* that hinder the insertion of women in STEM education, *motivations* that lead women to STEM education, and *strategies* that different social actors can adopt to increase gender equality in STEM education. We analyzed the literature using the Rapid Review (RR) methodology [20], which provides a protocol to define the research questions, search strings, inclusion and exclusion criteria, and a detailed analysis process.

We expect that our results can support companies, educators, and universities looking to enhance gender equality in STEM education. Besides, discussions in this work, based on data from Brazil and compared with the UN framework, also contribute to these goals, especially Goals 4 (Quality Education) and 5 (Gender Equality). Our contributions go further than just the results we present. Researchers can use our framework for identifying barriers, motivators, and strategies in future studies, allowing for direct comparisons.

The rest of this paper is structured as follows. Section II presents a literature review of gender equality in Brazil, gender equality in STEM, and the gender gap worldwide. Section III covers the methodology used to perform this research. Section IV presents our findings, which we further discussed in Section V. Finally, Section VI presents our final remarks and conclusions about this research while pointing out further research opportunities.

II. LITERATURE REVIEW

Before moving forward, we present some central concepts for discussing gender equality. We begin with some basic concepts to the discussion of gender equality and move on to discuss three specific topics: (i) the gender gap in STEM worldwide, (ii) the gender equality in Brazil, and (iii) the gender equality in STEM.

To define the basic concepts, we rely mainly on UNESCO's STEM and Gender Advancement (SAGA) methodological toolkit, used by different countries to analyze the topic [6]. SAGA differentiates sex and gender as *sex* relates to the biological differences between women and men. In contrast, *gender* is associated with a social construction around the expected roles and responsibilities of women, men, and other genders in a given context [6]. SAGA also defines the concepts of gender parity, gender equity, and gender equality. *Gender parity* refers to the quantitative view that represents the point at which the participation of women and men in a given context is equal, which would be 45-55% in the case of SAGA [6]. *Gender equity* refers to the historical and social disadvantages of gender, which we should compensate with fair measures to allow women and men to coexist in society equally [6]. *Gender equality* refers to women and men having equal opportunities, treatment, and conditions to achieve their potential, exercise their human rights, and benefit from social, economic, political, and cultural advances [6]. Another concept relevant to our work is *intersectionality*, an analytical tool to understand social divisions created by power relations of class, race, gender, ethnicity, citizenship, sexuality, and ability [21].

In Brazil, the issue of gender equality, which surrounds legal aspects, education, and career progression, has been debated. Despite the constitutional guarantees of equal rights for men and women and recent laws promoting gender equality – e.g., law 14.611/2023 regarding the gender wage gap – there are still significant disparities in the STEM field, where women have historically been underrepresented. This section presents the literature on gender equality in Brazil and the challenges of achieving gender parity in STEM.

A. GENDER GAP IN STEM WORLDWIDE

According to UNESCO [22], female students choosing STEM-related fields of study in higher education worldwide is only 30%. Enrollment of female students is particularly low in ICT (3%), natural sciences, mathematics and statistics (5%), and engineering, manufacturing and construction (8%). The highest rate is in health and welfare studies (15%). The report also highlights significant regional and national differences, with high rates of female students enrolled in engineering, manufacturing, and construction in Southeast Asia, the Arab States, and some European countries. At the same time, they found lower proportions in Sub-Saharan Africa, North America, and Europe.

In Europe, the significant drop in the percentage of women in STEM classes occurs in two moments: in the transition from primary and secondary education to university and from university to the workforce. Women hold only 22% of all technology positions in European companies [23]. According to the ''Women in Tech'' report, if Europe could double the share of women in the technology workforce to around 45%, or about 3.9 million additional women by 2027, it could close this talent gap and benefit from a GDP increase of up to €600 billion [23]. Existing information about the European continent indicates no evidence that girls lag behind boys in STEM classes during primary and secondary education. For example, in Bulgaria, Finland, Latvia, and Sweden, girls slightly outperform boys in science and math tests. A strategy pointed out to correct this disparity in the workforce is to improve retention rates, retrain women for technical roles, and motivate girls to take STEM classes early in their education [23].

Meanwhile, American women continue to be underrepresented in mathematics [24]. Data from the US Department of Education showed that females only account for 18% of computer and information sciences, 19% of engineering, 38% of physics and technology science degrees, and 43% of mathematics and statistics degrees [25]. Through research conducted over 30 years, Wang and Degol [24] assert that this low participation is due to various factors, including lifestyle values or work-family balance, beliefs about specific abilities, stereotypes, and gender-related biases.

Latin America also faces challenges in providing equal opportunities for women, besides the progress in reducing the gender gap in STEM fields. Chile leads the way in STEM education, followed by Uruguay, Mexico, Costa Rica, Colombia, Peru, and Brazil. However, the number of women researchers in the region remains relatively low, with only 44 women out of every 100 researchers. Venezuela (56%), Paraguay (55%), and Argentina (53%) lead the region in gender parity in research, with more women than men. On the other hand, Colombia (38%), Honduras (38%), Chile (32%), and Mexico (32%) have the worst performance in gender equality indicators. Despite the high representation of women in medical sciences, there is still a significant gender gap in engineering [26].

B. GENDER EQUALITY IN BRAZIL

Feminist movements have advocated for Gender Equality since the 1960s [27]. This subject appears in discussions involving legal aspects, access to education, continuity of studies, remuneration, and career progression. Laws and cultural factors can positively or negatively influence equal gender opportunities [28]. The Brazilian constitution is comparatively recent and guarantees equal rights to men and women [29].

Due to historical patriarchal relations, Brazilian society seems to embrace higher education diplomas as a symbol of social status [30]. For example, the Civil Engineering course in the imperial period concerned the defense of the territory by constructing a city fortress. Later, new urban projects in Brazil also needed engineers [31]. Another example is the military, which has a predominantly male and hierarchical structure. The military encouraged men to enter these higher education courses, with status and power within Brazilian society [32]. Besides the cultural symbology of higher education diplomas, each additional year of study in Brazil represents a 15% gain in future income, 6% more than the global average [33]. Therefore, to create a future with gender equality in STEM, we need to understand women's challenges in accessing and staying in STEM education and adopt strategies for women to overcome such challenges.

C. GENDER EQUALITY IN STEM

Mathematics and computing are STEM areas with low participation of women in recent years, but this has not always been the case, as women had an essential role in the emergence of computers. Before the creation of the first mechanical computer, women often performed the job of *computers,* which consisted of manually computing data and performing calculations, tasks fundamental to the work of astronomers [34].

In the 20th century, women often operated mechanical computers to perform calculations and data processing because these activities were associated with the secretary role [35]. A review of the history of the *Electronic Numerical Integrator and Computer* (ENIAC) reveals that Computing reflects a lack of intention to put women in the spotlight [36]. According to Light [36], ''the invisibility of female contributions in technological development has promoted a reduced view of women's capabilities in this field.'' For example, NASA's Langley Research Center has hosted numerous contributions from women through work with computers, which were fundamental to the center's entire research effort. Ada Lovelace (1815-1852) was the first to publish an algorithm to be processed in a mechanical computer [37]. Yet, the relevance of women's role has remained largely invisible [38].

Concerning Brazil, from the 1970s to the mid-1980s, women's participation increased from 10% to 36% among computing professionals, and most students in the area were female. At the Institute of Mathematics and Statistics at USP in São Paulo, the first course of Computer Science, formed in 1974, had 20 students, of which 14 were women (70%) and 6 were men (30%). In recent decades, this situation has reversed. In 2016, they had 41 students, of which only six (15%) were women [35]. According to the BBC [35], society gave little value to information technology in the 1970s – machines had little processing and memory, and the work with computers was manual and repetitive, performed mainly by women.

Gender equality is also far away in Brazilian STEM education, given that only 30% of students are women. The proportion of women is even lower in courses such as Mechanical Engineering (10%) and Computer Engineering (11%) [18]. Issues in secondary education related to gender equality, particularly the inclusion of young women in STEM areas, were analyzed through a mapping of academic works between 2001 and 2015 [39]. According to Oliveira et al. [39], we need caution when comparing cultures and countries because they involve two educational systems with different needs and priorities. Overcoming gender inequalities requires social, economic, and political initiatives, especially in science and technology development. In education, we must understand how gender differences have historically developed into inequalities, often reinforced by biased narratives, practices, and behaviors that increase gender inequality in social relations.

III. METHODOLOGY

In this section, we present the research process used in this work. We based our analysis on the Rapid Review methodology [20]. This knowledge-synthesis methodology emerged in the medical field as an alternative to the Systematic Literature Review (SLR) to reduce the time for gathering evidence [40]. Questions in RR research have a broader scope than SLRs and are defined *a priori*. Clarifying questions *a priori* reduces the execution time since we can produce more assertive search keywords and use the questions to extract precise information when reading the selected papers. Like SLRs, RRs must also use a predefined protocol to assess their academic rigor. While SLRs usually take six months to two years, RRs typically occur in about five weeks. The RRs protocol are less labor-consuming in specific steps or even omit some steps when compared to SLRs. For example, RRs can search for studies in a limited number of databases, may allow only one person to select studies, and can skip the formal synthesis of results [41].

Figure 1 illustrates the process adopted, while the following subsections explain the individual steps. We used the Scopus and Scielo databases for this review work due to their relevance. While the Scopus database provides a well-curated list of scientific papers that cover STEM areas, the Scielo database provides a smaller database focused on documents in Portuguese. The review process allowed us to write and compare evaluation notes through previously constituted templates, spreadsheets, and textual code software while screening articles. This standardized approach reduces conflict resolution between reviewers during data extraction while maintaining rigor and relevance assessment. We thoroughly reviewed the article when there were discrepancies between the authors' notes.

A. DEFINITION OF RESEARCH QUESTIONS

We intend to characterize the barriers that make it difficult to achieve gender equality, the motivators, and the strategies that empower women during their higher education journey in STEM. Then, we collected evidence reported in the scientific literature to develop the analysis of the factors that affect women's journey in higher education in STEM, as well as the possibilities of improving this journey for women. Finally, we defined the following research questions:

RQ1: What barriers hinder/prevent women from entering/remaining in higher education in STEM?

RQ2: What motivators stimulate women to enter or remain in STEM higher education?

RQ3: What strategies encourage the entry/permanence of women in higher education in STEM?

In **RQ1,** we intend to obtain evidence on the barriers that make it difficult to achieve gender equality. This characterization illustrates the challenges women need to overcome and initiatives to reduce gender inequality in Brazil's higher education field. In **RQ2,** we intend to characterize the motivators found in the literature that strengthen initiatives and women, allowing researchers to identify valuable paths that can be used in strategies to combat gender inequality. In **RQ3,** we intend to identify implemented strategies, with evidence on how they support women in overcoming barriers to achieving gender parity in higher education in Brazil.

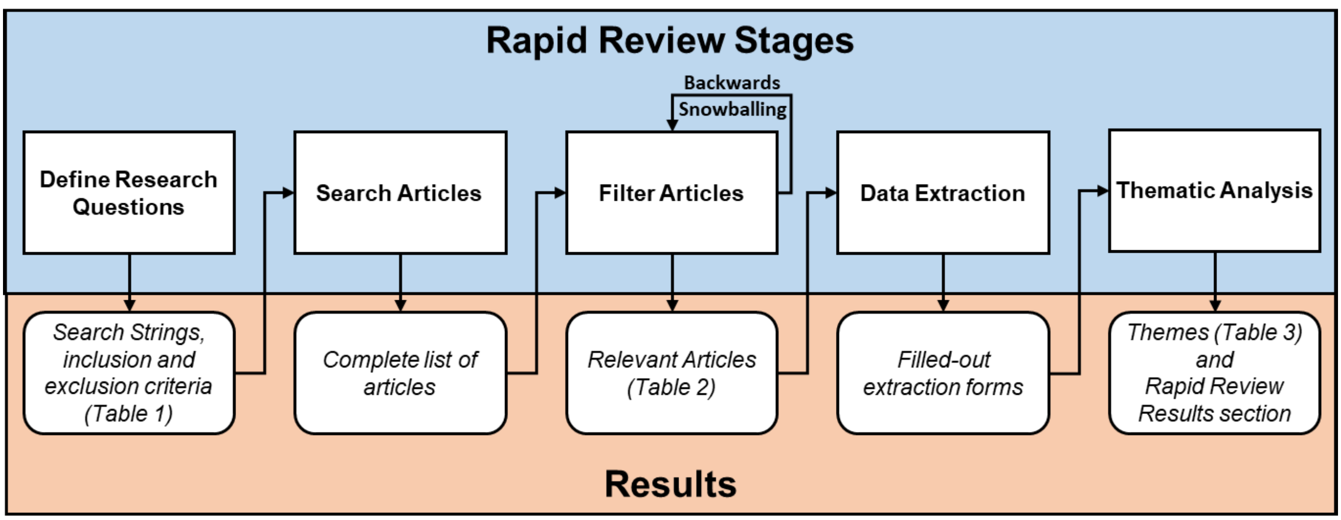

FIGURE 1. Rapid Review Stages and Results.

TABLE 1. Final search strings used in each database.

Database	Research Question	Query String
Scopus **Search 1 and 2**	RQ1	TITLE-ABS-KEY ((engineering OR computer OR computing OR "information system" OR stem) AND (undergrad* OR formation OR graduat* OR college OR "high level education" OR "higher education" OR "superior education") AND (brasil OR brazil) AND (woman OR women OR girl OR gender OR female OR sex) AND (parity OR equality OR retention OR participation OR share OR gap OR inequality OR segregation OR equity) AND (challenge OR difficulty OR obstacle OR barrier))
	RQ2	TITLE-ABS-KEY ((engineering OR computer OR computing OR "information system" OR stem) AND (undergrad* OR formation OR graduat* OR college OR "high level education" OR "higher education" OR "superior education") AND (brasil OR brazil) AND (woman OR women OR girl OR gender OR female OR sex) AND (parity OR equality OR retention OR participation OR share OR gap OR inequality OR segregation OR equity) AND (factor OR influence OR cause OR motivation OR motivator OR motive OR reason))
	RQ3	TITLE-ABS-KEY ((engineering OR computer OR computing OR "information system" OR stem) AND (undergrad* OR formation OR graduat* OR college OR "high level education" OR "higher education" OR "superior education") AND (brasil OR brazil) AND (woman OR women OR girl OR gender OR female OR sex) AND (parity OR equality OR retention OR participation OR share OR gap OR inequality OR segregation OR equity) AND (strategy or action or initiative or policy or approach))
Scielo **Search 1**	RQ1, RQ2, and RQ3	(engenharia OR computação OR "sistemas de informação" OR stem OR "tecnologia da informação" OR tecnologia OR TI) AND (graduação OR formação OR universidade OR faculdade OR "nível superior" OR educação) AND (brasil OR brazil) AND (mulher OR mulheres OR gênero OR menina OR meninas OR sexo OR rapariga OR feminino) AND (paridade OR disparidade OR igualdade OR desigualdade OR retenção OR permanência OR participação OR cota OR lacuna OR gap OR segregação OR equidade OR diferença OR relação) AND (year_cluster:("2021" OR "2020" OR "2019" OR "2018" OR "2017" OR "2016" OR "2015" OR "2014" OR "2013" OR "2012"))
Scielo **Search 2**	RQ1, RQ2, and RQ3	(engenharia OR computação OR "sistemas de informação" OR stem OR "tecnologia da informação" OR tecnologia OR TI) AND (graduação OR formação OR universidade OR faculdade OR "nível superior" OR educação) AND (brasil OR brazil) AND (mulher OR mulheres OR gênero OR menina OR meninas OR sexo OR rapariga OR feminino) AND (paridade OR disparidade OR igualdade OR desigualdade OR retenção OR permanência OR participação OR cota OR lacuna OR gap OR segregação OR equidade OR diferença OR relação) AND (year_cluster:("2023" OR "2022" OR "2021" OR "2020" OR "2019" OR "2018" OR "2017" OR "2016" OR "2015" OR "2014" OR "2013" OR "2012"))

We focused on courses with lower gender parity indicators in Brazil to develop search strings: Engineering, Computer (Science), and Information Systems. We tested different versions of the search string in a refinement process based on the return of initial reference articles and the reading of newly found articles and their key terms. The Scopus and Scielo search strings are similar, but we translated the query to discover documents in Portuguese. Table 1 shows the final strings for the research questions.

B. SEARCHING FOR ARTICLES

In this work, we used the Scopus and Scielo search engines because these databases contain the most relevant digital libraries for this RR. Our initial search was conducted in the selected databases on July 14, 2021, using the final search string. The Scopus database yielded seven articles for Research Question 1 (RQ1), 13 articles for Research Question 2 (RQ2), and 18 articles for Research Question 3 (RQ3). Meanwhile, the Scielo search produced 35 articles. Therefore, this first search resulted in 61 articles.

During our preliminary analysis, we identified significant gaps in the existing literature. Therefore, on June 14, 2023, we conducted an updated search to include articles published after the first search. In this second search, the Scopus search returned five articles for RQ1, five for RQ2, and eight for RQ3. The Scielo search yielded 77 articles. This second search resulted in a total of 90 articles.

We used the same search string for both searches – exactly the same on Scopus and only included **2023** and **2022** in the cluster years to the Scielo – to ensure consistency in our approach. We analyzed all search results and meticulously removed duplicates with the search 1, since they were already thoroughly analyzed. This comprehensive analysis is essential since articles might be indexed sometime after publication. During the second search, we selected an article from 2022 and another from 2019. The article from 2019 was probably found only in the second search due to delays in the indexing process. None of the six articles from 2023 passed our filtering process, which included the inclusion and exclusion criteria.

The 2023 search results revealed only six articles, reflecting the relatively low number of publications indexed by mid-2023. The 2023 search highlighted the natural lag in indexing recent publications, as evidenced by the few articles from that year. Additionally, we found 21 articles from 2022 in the second search, with one being selected for inclusion and one needing to be retrievable. We also had issues with duplicate entries, as some articles were available in Portuguese and English (usually extended versions).

After filtering the papers from the second search, we performed a third search through backward snowballing [42]. This technique involved examining the references cited by the selected articles to identify additional relevant articles. We conducted a single iterative cycle of backward

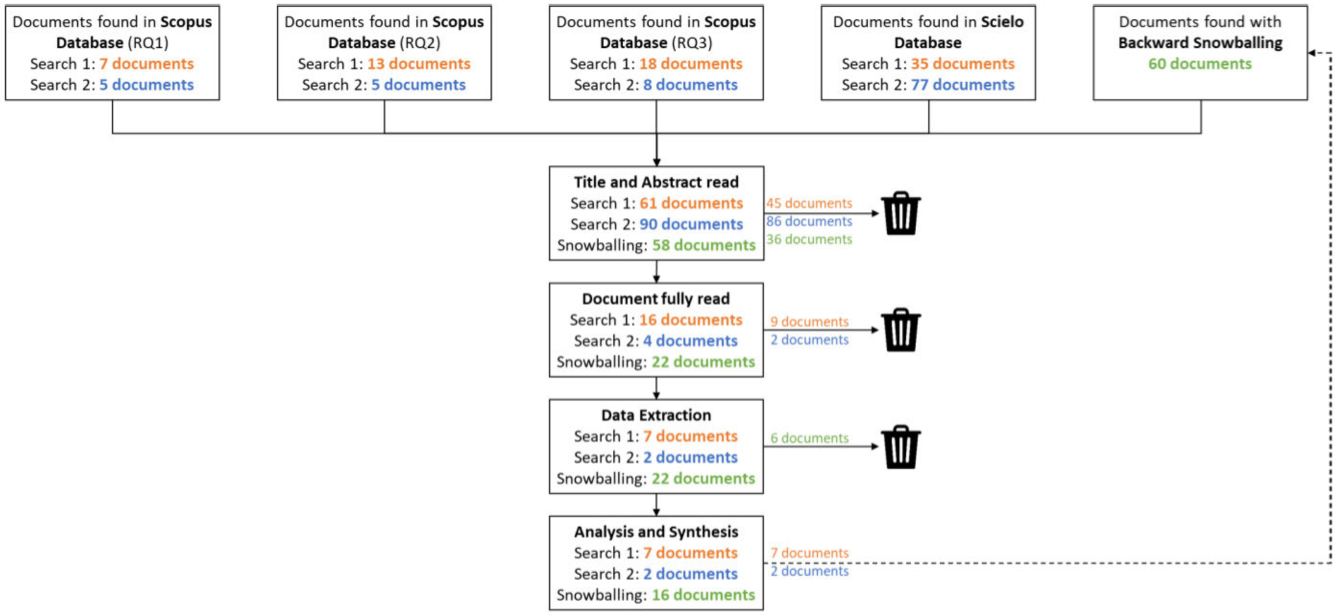

FIGURE 2. **Article analysis and filtering procedure.**

snowballing, applying our established inclusion and exclusion criteria. This process yielded 60 documents, which were then subjected to our filtering process, as detailed in the subsequent section. This review was not registered in any database for systematic reviews due to the simplifications of the Rapid Review methodology. However, to ensure transparency and accessibility, the search result data are publicly available on Zenodo [43]. Figure 2 shows the search results and the posterior filtering procedure in detail.

C. FILTERING ARTICLES

The next step was filtering the documents by applying the inclusion and exclusion criteria in three increasingly complex readings of the articles. First, we analyzed only the *title* and *abstract* and applied the inclusion and exclusion criteria listed below. Then, we performed an initial analysis by reading the introduction sections of the remaining papers. Finally, we thoroughly analyzed the documents not excluded in the previous tasks.

The *inclusion criteria* for further analysis are:

- The article discusses gender differences in STEM education in Brazil,
- The text is in English or Portuguese, and
- The article describes the results of studies that applied research strategies such as case studies, surveys, and interviews or reported an observational study [44], [45].

The *exclusion criteria* for further analysis are:

- The article is more than ten years old,
- The text has less than five pages (short papers),
- The document is not a journal or conference article, and
- The article is a literature review or an opinion.

We performed the filtering in three stages. In the first stage, all documents were analyzed by an individual researcher, who reviewed the titles and abstracts of the studies, removed duplicates, and applied the exclusion criteria.

In the second stage, we analyzed the abstract of the studies and the introduction section, reducing the number of studies within the initial analysis to 16 articles from the first search, four from the second search, and 22 from the backward snowballing.

In the third stage, we conducted a comprehensive analysis of the entire content of the articles to exclude articles that did not address the survey questions. The detailed analysis encompassed seven articles from the first search, two from the second search, and 16 from the backward snowballing technique, totaling 25 articles, as shown in Table 2.

Despite the low number of studies, we believe that the rigor established in our methodology allows the characterization of themes that answer the research questions and identify research avenues focused on female STEM barriers, motivators, and strategies.

D. DATA EXTRACTION

In the extraction procedure, shown in Table 3, a researcher filled out a form for each candidate source that required the following information in the fields: *title*, *objective*, *type of study*, *objective*, *how to respond to research questions*(three fields, for barriers, motivators, and strategies), and *reviewer's reflections*. A second researcher reviewed the data extraction to verify its quality and completeness.

E. THEMATIC ANALYSIS

In this RR step, we performed a thematic analysis of the texts. We reanalised each of the 25 selected articles considering the research questions and iteratively reading and reflecting on them. The analysis applied the inclusion and exclusion

TABLE 2. The final list of selected articles.

Ref.	Found in	Year	Short title
[46]	Search 1	2021	Permanecer ou desistir?
[47]	Search 1	2020	Female participation in hackathons
[48]	Search 1	2020	Reducing inequalities in STEM
[49]	Search 1	2020	A comparative study on the support in engineering courses
[50]	Search 1	2019	How to think about third wave HCI
[51]	Search 1	2018	Digital girls program
[52]	Search 1	2016	Encouraging women in science
[53]	Search 2	2022	Female Graduates in Mechanical Engineering: an Exploratory Approach
[54]	Search 2	2019	Factors Affecting Female Students Motivation Related to Enrollment and Retention in Information Technology Courses
[55]	Snowballing	2020	Fatores de Influência na Escolha pela Continuidade da Carreira em Computação pelas Estudantes de Ensino Médio Técnico em Informática
[56]	Snowballing	2020	Experiência com atividades desplugadas do Code.org na disciplina de Língua Estrangeira de uma Escola Estadual
[57]	Snowballing	2018	Participação feminina em game jams: um estudo sobre igualdade de gêneros em maratonas de desenvolvimento de jogos
[58]	Snowballing	2017	Percepção das Meninas do Ensino Médio sobre o Curso de Computação no Distrito Federal do Brasil
[59]	Snowballing	2017	Uma Pesquisa com Alunas do Ensino Fundamental e Médio sobre os Cursos da Área de Computação
[60]	Snowballing	2017	Percorrendo labirintos: trajetórias e desafios de estudantes de engenharias e licenciaturas
[61]	Snowballing	2017	Machismo no curso de Engenharia Mecânica: Verdade ou mito?
[62]	Snowballing	2017	Brazilian High School Girls: What Drives Their Career Choices?
[63]	Snowballing	2016	Programa Meninas Digitais: Prototipando Soluções Tecnológicas para uma Vida Melhor
[64]	Snowballing	2016	Meninas na Ciência: atraindo jovens mulheres para carreiras de Ciência e Tecnologia
[65]	Snowballing	2016	Programming contests and mobile apps development as actions for attracting and retaining Brazilian women in Computing courses
[66]	Snowballing	2016	O espaço das mulheres na área da Engenharia Mecânica: um Estudo de Caso referente às questões de gênero no Instituto Federal Sul-rio-grandense – campus Sapucaia do Sul
[67]	Snowballing	2016	Ciência da Computação também é coisa de menina!
[68]	Snowballing	2015	Introducing Computer Science to Brazilian Girls in Elementary School Through HCI Concepts
[69]	Snowballing	2014	Perfil Feminino em Computação: Análise Inicial
[70]	Snowballing	2013	HCI with chocolate: Introducing HCI concepts to Brazilian girls in elementary school

TABLE 3. The Extraction form.

Field	Description
Title	Article identification for future reference.
Description	A concise summary of the work, usually taken from its abstract.
Type	Type of study (e.g., survey, experiment, opinion, case study, etc.).
Objective	The primary goal or purpose of the study.
Barriers	The barriers identified in the study.
Motivators	The motivators identified in the study.
Strategies	The strategies identified in the study.
Observations	Additional notes or reflections from the reviewer.

criteria defined in the RR protocol. We summarize this analysis in Table 4.

IV. RESULTS

We present RR results in two parts. First, we briefly summarize the objectives and methodologies of the 25 selected articles, enhancing understanding of their content. Then, we summarize the findings in the articles to present the barriers, motivators, and strategies related to the participation of women in STEM education.

A. SUMMARY OF SELECTED ARTICLES

Klanovicz and Oliveira [46] offer a nuanced case study that intersects gender studies with science education, specifically examining the power dynamics between men and women within academic settings. Their analysis focuses on women's experiences in engineering and technology courses at the Universidade Federal do Paraná, documenting the journeys of those who either discontinued their studies or persisted through their undergraduate programs. This investigation, covering the period from 2012 to 2019, pays particular attention to the narratives of migrant and black students, highlighting the compounded challenges individuals face at the intersection of gender, race, and migration status. By delving into these personal accounts, Klanovicz & Oliveira provide valuable insights into the systemic barriers and societal pressures that influence women's decisions in the STEM fields, offering a critical lens on the broader issue of gender inequality within academic and professional spheres.

Paganini and Gama [47] analyzed the reasons for the absence of women in hackathons, even when they included the participation of multidisciplinary teams. The study seeks the motivation for the involvement of both men and women,

TABLE 4. Thematic analysis result.

RQ	Theme	Sub-theme	Articles
RQ1	Barrier	Segregation, Isolation, feeling as a minority without support from colleagues and teachers	[46], [47], [55], [58], [61], [67]
RQ1	Barrier	Fears, lack of confidence, and issues of housing and children	[46]
RQ1	Barrier	Gender stereotypes	[43], [44], [45]
RQ1	Barrier	Lack of support from family and friends	[54], [60], [61], [66], [67]
RQ1	Barrier	Discrimination through comments, anecdotes, and persistent jokes	[46], [47], [53], [60], [61]
RQ1	Barrier	Women tracking men's skills	[46], [53], [54], [59], [61]
RQ1	Barrier	Girls lacking exposure to STEM areas	[59]
RQ1	Barrier	Previous negative experiences	[55]
RQ1	Barrier	Fear of mathematics or exact sciences subjects	[46], [60], [61], [67]
RQ1	Barrier	Colleague's judgment of the women capacity	[46], [53], [60]
RQ1	Barrier	Lack of opportunities	[53], [60]
RQ1	Barrier	Interruptions, mansplaining, having ideas ignored	[47], [57]
RQ1	Barrier	General lack of awareness by men	[60]
RQ2	Motivator	Institutional support (including teachers)	[49], [50]
RQ2	Motivator	Exposure to the STEM area during high school	[49], [54], [55]
RQ2	Motivator	Role Models	[49]
RQ2	Motivator	Girls being good at STEM and problem-solving	[53], [54], [55], [58], [62], [66]
RQ2	Motivator	Support from family, friends, and classmates	[46], [49], [53], [54], [58], [59], [62]
RQ2	Motivator	Good salaries and job opportunities	[53], [55], [58], [62], [69]
RQ3	Strategy	Expose girls to STEM topics and computers	[48], [51], [52], [54], [63], [64], [68], [70]
RQ3	Strategy	Teach girls teamwork and problem-solving skills	[56]
RQ3	Strategy	Involve teachers in encouraging and training actions	[48], [52], [64]
RQ3	Strategy	Usage of role models	[48], [51]
RQ3	Strategy	Participation in technology competitions	[47], [51], [52], [65]

seeking to find motivational differences between the groups. The authors developed a female-focused hackathon, Hack Grrrl, using suggestions from previous studies to make hackathons more inclusive and attract more women.

Moreira et al. [48] presented data on inequalities in STEM worldwide, reporting social consequences for women and initiatives to combat them. The study also shows a project developed in Brazil by *Meninas na Computação*(Girls in Computing) of the Universidade Federal da Paraíba. The authors focused on quantitative data to answer questions like "If women tend to be prevalent in the educational system, what kind of effects keep them away from STEM areas?". Finally, the study presents an initiative from the Universidade da Beira Interior to create a gender equality plan.

Castelini and Amaral [50] highlighted plural approaches in the Brazilian Computing Society and Computer Science and Information Systems courses. The study aims to understand the normative culture in Computer Science, specifically in the third wave of the Human-Computer Interface. The authors analyzed documents from the Computer Engineering course at Universidade Federal do Paraná.

García-Holgado et al. [49] searched for factors of low female representation in engineering careers in Brazil and Spain by analyzing the support received during different career stages – from before entering university to the labor market. The authors compared the perception of support received in Brazil and Spain by surveying 208 students of both genders. Among their findings, we highlight that the support received in their academic institutions is low in both countries.

Maciel et al. [51] introduce the *Meninas Digitais* (Digital Girls) program, underlining the significance of male involvement in advocating for female participation in computer science. Building on this foundation, Maciel et al. [70] implement successful strategies to engage teenage girls in Human-Computer Interaction (HCI) concepts through tailored activities, showcasing the effectiveness of interdisciplinary approaches. Lastly, Bim and Maciel [63] discuss the impact of the Women in Information Technology (WIT) event, examining a decade of endeavors to boost female representation in Computing. Their analysis underscores the pivotal role of private companies in these initiatives. They provide valuable strategies for mitigating gender disparities in the field, contributing to the ongoing effort of fostering female interest and participation in computing.

Sacchelli et al. [52] evaluated the project *Meninas na Ciência* (Girls in Science), which encourages high school students to pursue a career in Science & Technology. The authors perform practical experiences, such as workshops and research projects, which can arouse interest in STEM. Their empirical study included workshops on Sustainable Energies, Educational Games, and Satellites for four girls between 15 and 17 years old. These workshops occurred in parallel with two courses – Basic Robotics and Sustainable Manufacturing – each with ten classes.

Holanda et al. [59] provide an in-depth view of the perceptions of middle and elementary school students in Brazil, specifically in the Federal District, regarding computer science courses. The study was conducted from 2011 to 2014 and collected responses from 3707 participants using printed forms during the National Week of Science and Technology. The research revealed that actions aimed at elementary school students might have a more significant impact than those directed at high school students. In a second study by Holanda et al. [58], the perception of high school girls in the Federal District about computer science courses, particularly in the Computer Science Department of the University of Brasília, was investigated. With less than 10% of the student body being female, the authors sought to understand the lack of interest among girls in computing-related courses. The results indicated a significant influence of family approval on the girls' decisions to pursue computer science. Most girls interested in computer science had their families' approval. However, they also perceived computer science courses as predominantly male, which could discourage them from choosing this area for their education and career.

Freitas et al. [65] discuss initiatives by the Institute of Computing at the Federal University of Amazonas to bridge the gender gap in STEM, focusing on computer science. Through the SciTechGirls project, they aimed to engage female students in programming contests and mobile app development with women-relevant themes, leading to notable outcomes like publications, awards, and heightened awareness in Amazon. This success spurred the Cunhantã Digital program, extending efforts to younger students and addressing challenges like disengagement among women in computing. The projects empowered participants and attracted attention from entities like Microsoft Research, promoting female inclusion in STEM within the Brazilian Amazon.

Mochetti et al. [67] address women's low participation in Computing and IT, underscoring its negative impact on diversity and problem-solving. Their project at the Fluminense Federal University started with discussions among Computer Science newcomers about the deterrents for women entering tech fields. Despite efforts to improve diversity, women's representation in IT remains low, with significant historical challenges in integrating women into male-dominated sectors. The paper highlights efforts like the Grace Hopper Celebration and the Meninas Digitais program to counteract these trends. It also points out the importance of addressing societal biases and the role of male allies in discussions about gender inequality. Advocating for inclusive initiatives, the authors stress the need for dialogue among students of all genders to mitigate gender disparities and encourage more women to stay in Computer Science programs.

Nakamura et al. [62] try to answer why high school girls in Brazil are steering away from IT careers despite the field's need for greater gender diversity. Their study, conducted during a career event, indicates a paradox where girls enjoy mathematics but feel deterred by a perceived lack of aptitude and interest in IT. Highlighting initiatives like the U.S.-based GETSMART Project and Brazil's Cunhantã Digital Movement, the authors advocate for more efforts to encourage women's participation in STEM and initiate gender discussions within education and the IT sector. The survey shows that while technological innovation and job prospects in IT are attractive, misconceptions about vocational suitability and mathematical requirements often dissuade girls from considering IT careers, pointing to broader issues of gender bias and educational outreach in STEM fields.

Brito et al. [64] outline the objectives and accomplishments of the *Meninas na Ciência* (Girls in Science) project, aimed at encouraging young women to pursue careers in science and technology and empowering those already engaged in such fields. Through the training of graduate students in science and technology dissemination, along with teaching astronomy, physics, and robotics in public schools, the project seeks to solidify its position as a reference in scientific and gender education. By challenging gender stereotypes and promoting awareness of women's roles in society within academic and vulnerable communities, the project strives to establish science and technology as inclusive spaces for women. Reflecting on their efforts over the past two years, the authors believe the project's foundations are stronger, focusing on continual expansion and improvement to further advocate for gender equality in S&T fields.

Casagrande and Souza [60] explore the varied experiences of engineering and teaching students at UTFPR and UFBA, revealing gender-based challenges and disparities. Their qualitative study, through interviews, highlights the discrimination faced by women in engineering and men in teaching, influenced heavily by family opinions and societal stereotypes. Women in engineering are drawn by their love for mathematics and promising career prospects, yet face sexism and objectification. Despite the pervasive gender bias, the resilience shown by students emphasizes the need for ongoing action to combat gender inequality and foster inclusivity in academia.

Huff and Koppe [66] challenge traditional gender stereotypes in Mechanical Engineering, revealing that women identify with technical disciplines even more than men. Contradicting that Mechanical Engineering aligns with a specific gender, the research demonstrates a shift toward recognizing women's capabilities in this traditionally male-dominated field. The low female representation is attributed to societal biases and stereotypes rather than inherent gender unsuitability. Kohler and Ioshiura [61] address the persistent gender gap in Mechanical Engineering, with women comprising less than 10% of students at the Federal University of Santa Catarina. Their survey uncovers discouraging factors such as poor teaching practices and gender-based discomfort, including sexist remarks and differential treatment. Carvalho and Freitas [53] provide an exploratory study on the experiences of female Mechanical Engineering graduates at a Northeastern Brazilian university, outlining obstacles such as cultural norms and adverse work conditions. Despite these challenges, the students displayed resilience against stereotypes, although post-graduation, they encountered further hurdles in the workforce, with only one finding employment in engineering shortly after graduation.

Ribeiro and Maciel [55] tried to identify the factors influencing the decision of 78 female high school students in technical informatics to pursue a career in computing. Using the Socio-cognitive Career Theory, the research reveals that only 27% of the students consider computing as a career option, and they predominantly consider personal factors when making this choice. While the number of women in the computing field in Brazil is low, the numbers of girls in technical informatics courses show a smaller gender gap. The study highlights the need for a multidisciplinary effort to understand and address the numerical narrowing of women in computing as they progress in their careers.

Sassi et al. [56] present integrating unplugged computer activities from Code.org into English classes at a full-time school in Mato Grosso. They aimed to describe the teacher's perspective on their use. They implemented two activities, Happy Maps and Move It, showing high student engagement and teacher acceptance. Unplugged Computer Science, which involves problem-solving activities without computers, is recognized as fundamental for contemporary society. They also analyzed the English teacher's perception of using unplugged activities to teach Computer Science concepts, questioning their effectiveness in basic education.

Oliveira et al. [69] investigate the women's profile in Computer Science in Brazil, aiming to define strategies to attract and retain more women. The study used a questionnaire with over 1700 women in Brazil, revealing insights into their preferences and experiences. Results indicate a strong preference for Mathematics and Physics during school years, with motivations for entering the field driven by a liking for mathematical and reasoning activities. Interestingly, few participants reported preconceived biases against Computer Science before exploring it further, suggesting that bias might not be a significant deterrent for female students. However, the study raises questions about other factors influencing their decision-making process. Analysis by age group reveals differences in perceptions of prejudice and discrimination, with older professionals reporting less frequent experiences compared to younger counterparts.

Dutra and Gama [57] investigate the extent of female involvement in game jams, focusing on the *Game Jam das Minas* (Women's Game Jam) event aimed at the female audience. Despite the potential for female participation, the research reveals a significant gender gap in such events, with traditional game jams attracting disproportionately fewer women. However, events like the Game Jam das Minas demonstrate a strong interest among women in game development, evidenced by a higher number of female registrations than mainstream game jams. The study aims to elucidate gender equality issues in game development marathons and understand the motivations and deterrents for female participation. Interviews with participants highlight the importance of creating inclusive spaces, with many women expressing intimidation and inadequacy in male-dominated environments.

Amaral et al. [68] conducted an experiment to introduce elementary school girls in Brazil to Computer Science through HCI activities, addressing the gender gap in the field. Utilizing the Computer Science Unplugged Project's resources, they engaged fifty-two girls from four public schools in activities to demystify Computing beyond programming. A notable component is *Emíli@s – Armação em Bits*(Emíli@s – Plotting in Bits), which combined Database and HCI tasks with programming to offer a broad perspective on Computing – drawing inspiration from the character Emília in Monteiro Lobato's children's books.

Avelino et al. [54] explore the motivations and barriers for female students in IT courses at the Fluminense Federal University to understand their experiences in Computer Science and Information Systems. Using qualitative research, they examine the factors affecting women's enrollment and retention, acknowledging the challenges in a male-dominated field. Despite efforts to increase female presence in IT, disparities persist at UFF. The study points to the need for targeted interventions, such as *include<meninas.uff> Project*, which promotes IT careers among women through high school talks, university projects, and programming classes for younger students. Highlighting the role of family, school, and societal support, the authors call for increased efforts to encourage women's participation in IT.

B. FINDINGS

In our research on gender equality in STEM education in Brazil, we identified an opportunity: despite the global discourse on the topic, there's a need for more localized evidence specific to Brazil regarding female participation in STEM fields. To fill this gap, we analyzed female involvement in STEM from three perspectives: Barriers, Motivators, and Strategies. In this context, previous investigations identified one or more of these themes without establishing a relationship between them and their authors.

1) BARRIERS

The analysis of barriers women face in STEM reveals a complex array of challenges from educational environments to professional contexts. Our study identified thirteen barriers impacting women's participation and success in these areas. These barriers, named as documented by research, include segregation, isolation, feeling like a minority without support from colleagues and teachers; fears, lack of confidence, and issues related to housing and children; gender stereotypes; lack of support from family and friends; discrimination through comments, anecdotes, and persistent jokes; women tracking men's skills; girls lacking exposure to STEM areas; previous negative experiences; fear of mathematics or exact sciences subjects; colleague's judgment of women's capacity; lack of opportunities; interruptions, mansplaining, and having ideas ignored; and general lack of awareness by men. When examined collectively, these barriers paint a challenging picture that requires holistic and inclusive approaches to promote gender equality and effective female participation in STEM education and professions.

In the remainder of this section, we explore each barrier found in the different studies and briefly indicate the authors discussing these barriers. Such barriers may exist at different stages, such as in secondary education or universities. They also deal with different environments like home, school, or work.

Among existing oppressions against women, we can mention segregation, isolation, and lack of support from colleagues and teachers [46], [55], [67]. Moreira et al. [48] raise the question, "If women are prevalent in the educational system, what effects keep them from STEM fields?" During engineering studies, for example, it is verified that there are oppressions in the structural, political, and representational dimensions by institutions, teachers, and society [46]. Klanovicz and Oliveira [46] analyzed the personal trajectory of permanence of women in undergraduate courses in engineering and technologies based on reports from students' experiences. The authors consider that the judgment and oppression of men hinder adaptation, a sense of belonging, and the academic experience in general – contributing to segregation. Segregation is defined as difference or indifference, motivated by racial or gender issues, interpreted as symbolic violence, and reported as one of the barriers women face [46], [47], [61], [67]. Isolation, conversely, is characterized by the feeling that women are always an underrepresented group [46], [67], causing academic and social integration difficulties. Mochetti et al. [67] found similar results when interviewing women from a Computer Science undergraduate course. Women reported that as they are a minority, they feel classmates and professors are always observing them. Feeling uncomfortable interacting with their male classmates, the women bond as a group since their first days in college. Being a minority can be a barrier even before taking a graduate course. In their study with High School girls regarding their beliefs about Computer Science, Holanda et al. [58] found out that girls can feel discouraged from choosing the area because they will be the minority in a Computer Science course.

On the part of women, there are fears, lack of confidence, and instability for the female gender, in addition to issues of housing and children presenting themselves as important dilemmas in women's lives [46]. Klanovicz and Oliveira [46] present reports from migrant and black students who demonstrate the challenge of persisting in graduation, such as: "a very difficult experience at the beginning, with most students being men and I being the only woman. In the first month I thought several times about giving up".

Despite girls performing similarly or better than boys on generic scientific literacy tests worldwide, women acquire fewer university degrees in STEM fields than men [48]. The gender stereotype comes from social construction since childhood in the family context and also in elementary and high school [46], [47], [48]. School is a space for constructing gender identity and establishing social relations because, as an institution, schools have rules, requirements, and expectations for boys and girls [46]. In the context of family and social relations, gender stereotypes frequently affect whether the girls' relatives and friends support their interest in taking an undergraduate course in STEM. The lack of support from family and friends poses a barrier for girls to choose and persist in the area [54], [60], [61], [66], [67]. Another barrier to women's participation in STEM teamwork is gender stereotypes in the division of labor. In this barrier, women do not have the same freedom as men in choosing their tasks and are often placed in roles related to design or business [47].

Race and gender discrimination through comments, anecdotes, and persistent jokes disqualifying nature regarding women's abilities, appearance, and sexuality [46], [47], [53], [60], [61] is based on the reinforcement of a perception of superiority of one person over the other. Such kind of discrimination is practiced even by professors, aggravating embarrassment and intimidating women. Having their intellectual ability and belonging to a STEM course questioned, as well as their aesthetics and way of dressing being judged, is a barrier that impacts the low rates of women in STEM areas [53], [60], [61]. For those women with high-level performance, another barrier arises from achievement devaluation due to gender stereotypes and sexualization of women's presence in a STEM course, as reported by Carvalho and Freitas [53]. Women's achievements are constantly not recognized by male classmates, who attribute female success to them being favored by male professors due to sexual interests or by female professors due to the feminist movement.

Tracking men's skills due to previous exposure in STEM areas can also become a barrier [46], [53], [54], [59], [61]. Keeping up with men's skills requires much effort, demanding that women give their best to keep up and reach the needed level for men [46]. In Computer Science courses, for instance, women face challenges in the initial modules when unfamiliar with computing concepts, mainly programming [54]. Although such difficulties can be the same for men with no previous exposure to computing, the lack of exposure is more frequent for girls.

The lack of exposure to STEM areas can play a role earlier in women's career choices. According to Holanda et al. [59], in their study about High School girls and Computer Science, the lack of exposure to STEM areas can be a barrier to girls choosing Computer Science as an undergraduate course. The authors suggest that exposing Primary School girls to Computer Science topics can be more effective than with High School girls.

In the case of a girl who studied computing before her undergraduate studies, barriers can arise from negative experiences. Due to an integrated course, Ribeiro and Maciel [55] interviewed girls exposed to computing topics in High School. They concluded that it is crucial to actively avoid experiences that result in fear, lack of self-confidence, and lack of self-efficacy. Besides, it is necessary to clarify the career possibilities since the need for more knowledge of the profession can be a barrier for girls to continue their studies in STEM.

Fear of mathematics or exact sciences subjects can cause women to feel repulsed by these topics, linked to the schooling process and socialization of girls and boys that help create stereotypes about boys and girls' abilities in elementary school environments [46]. The *fear of mathematics* is built in the school education process, in everyday and family relationships [60], [61], [67], and in the lack of opportunities to access resources, leading to despair for this knowledge [46].

Some actions of apparent kindness, such as carrying something for a woman during practical classes, were felt as capacity subjugation [46]. These actions judge the colleague's capacity, placing the woman in an inferior, minor, incapable condition. This judgment shows a trace of an understanding of gender relations from the perspective of complementarity, in which the man considered physically stronger will have the conditions to help the woman who, in this case, is incapable. In areas such as mechanical engineering [53], [60], women often are told they should not damage their nails and overall physical appearance and should not get dirt from grease while working.

Thus, discrimination against women is based on stereotypes, and it gives rise to a significant barrier: the lack of opportunities. With women being rejected for intern positions due to gender discrimination, they fear the same will happen after graduation. Women become demotivated to pursue a STEM professional career [53], [60], suspecting their challenges will last or even increase professionally. Women face barriers to gender equality in STEM after starting their careers and during their professional activities, which begin even before the students graduate. We must pay attention to these factors that affect professional performance in the area because, in addition to constituting problems in themselves, they can also represent barriers to women's interest, entry, and participation in STEM education.

Within a work environment where collaboration occurs in teams with women and men, the effective participation of women in teamwork can suffer from a series of barriers. Interruptions and mansplaining are significant barriers for women to have a voice in the discussion and decision-making process in work environments in any field, including STEM. Interruptions occur when a woman is interrupted by a man. Mansplaining is the unnecessary explanation made by a man of something a woman says. Paganini and Gama [47] found an example of these phenomena at Hack Grrrl, a hackathon event held in 2019. Hackathons are attractive spaces for analyzing gender equality in STEM education because they provide situations that could take longer in a more traditional work environment due to the time pressure to deliver a result in a highly competitive scenario. The questionnaire used by the researchers allowed the participants to describe in a free field the different treatments or uncomfortable situations they suffered during the event because they were women. The results show that six of the twelve women who completed the form reported being interrupted by a man, mansplaining, having their ideas ignored, or seeing men repeating ideas given initially by women. In addition to these situations that constitute barriers to female participation in working on STEM teams, some women also reported having suffered moral and sexual harassment during the hackathon in question [47]. Dutra & Gama [57] found similar barriers to women's participation in game jams, which are events like Hackathons except for focusing on game development. Knowing they will be a minority in the event, women feel insecure due to unequal treatment and fear of reliving experiences from past attempts to participate in competitions, such as being isolated and not being heard. These barriers and their lack of confidence in their technical abilities contribute to the women's preference for not participating in game jams.

Overcoming these barriers involves making men aware of their existence. The lack of awareness is one more barrier to the effective participation of women in STEM undergraduate courses and teams [60]. Researchers also observed the same barrier in some of the hackathons they analyzed. The researchers report greater confidence among men when compared to women, even when women are treated equally. The numbers vary from one event to another, showing that this barrier is closely related to the environment [47].

2) MOTIVATORS

Motivators are elements that have evidence of a positive influence on increasing gender equality in the STEM field, meaning that they have been recognized as such by women in the STEM field. In our study, we identified five motivators. These motivators, documented by research, include Support from family, friends, and classmates, Exposure to the STEM area during high school, Girls being good at STEM and problem-solving, and Good salaries and job opportunities.

In the remainder of this section, we explore each motivator found in the different studies and briefly indicate the authors discussing these motivators. Such motivators may exist at two periods: before enrolling in a STEM course and during the STEM course.

Castelini and Amaral [50] and García-Holgado et al. [49] also point to the institution's support as a crucial motivator to avoid women dropping out of STEM courses, as the institution is responsible for promoting practices and creating spaces for inclusion and support for women. According to García-Holgado et al. [49], school support is a determining factor for girls to study engineering. Nearly 70% of study participants decided on a STEM career at the end of high school or in a vocational education activity. Several studies cite the school as an environmental factor that affects children's and young people's interest in STEM careers when they include actions that support scientific activities or other STEM areas in the school curriculum.

The implementation of strategies by the school contributes to the occurrence of another motivator: exposure to the STEM area during high school, which favors the empowerment of girls by increasing self-confidence about their abilities to work in the STEM areas [49], [54], [55]. Such exposure also helps reduce the fear of subjects considered suitable for men due to gender stereotypes, such as mathematics and physics. Such initiatives increase the career possibilities they believe they can choose beyond those culturally considered feminine, such as education and health.

Another motivating element in the school context is the support of teachers [49], role models, or mentors, who can awaken and encourage girls' interest in STEM careers. Teachers' educational level, as well as their social connections and confidence, strongly influence how they communicate with their students regarding their preferences for higher education.

Nugent et al. [71] further argue that a teacher's quality as an educator and their teaching practices impact their students' interest and achievement in STEM subjects beyond their background, such as poverty or being part of a minority. While fear of math is a barrier, realizing their math, problem-solving skills, and related STEM subjects is a motivator for girls to choose a STEM career, as reported in [53], [54], [55], [58], [62], and [66]. Contradicting stereotypes, girls can be driven by a curiosity about how machines work, how things such as buildings and devices are built, and by an interest in games and creating or fixing things.

In addition to school and teacher strategies, other motivators cited as necessary when choosing a STEM career are elements of the social context: support from family, friends, and classmates [49], [53], [54], [58], [59], [62]. This motivator is helpful for women to adapt to the university space [46], [49].

Prospects for good salaries and job opportunities also play as motivators in the decision for a career in STEM, as well as the expectations for professional stability due to a shortage of STEM professionals [53], [55], [58], [62], [69]. Particularly in the computing area, the possibility of developing software applications and working with technologies was cited as a motivator in the study of Nakamura et al. [62].

3) STRATEGIES

Strategies are elements whose main objective is to change the perception and increase the confidence of young students to awaken their interest in the STEM area. In our study, we identify five strategies. As documented by research, these strategies include exposure to girls to STEM topics and computers, teamwork and problem-solving skills, teachers encouraging and training actions, usage of role models, and participation in technology competitions.

In the remainder of this section, we explore each strategy in the different studies and briefly indicate the authors discussing these strategies. Such strategies can exist in different scenarios, such as visiting universities and participating in conferences.

We found most strategies aimed at changing the perception of STEM and increasing the confidence of young female students to awaken their interest in the STEM area. Several actions include exposure to STEM topics, including regarding human aspects in the interaction with computers [48], [51], [52], [54], [63], [64], [68], [70].

Initiatives to teach teamwork and problem-solving skills needed for software development were also considered strategic in introducing computing topics to elementary and high school students [56].

Strategies to deconstruct gender stereotypes embrace stimulating young female students to visit spaces dedicated to university STEM activities, such as information technology, robotics, and other engineering academic laboratories, and developing STEM skills through courses, workshops, and practical challenges. Additionally, a strategy related to motivators is the inclusion of teachers in encouraging and training actions [48], [52], [64].

Using a strategy focusing on role models in [48] and [51] also follows this change in perception strategy. Moreira et al. [48] report girls' contact with women in the STEM area through lectures and conversation circles, in which they discuss their routines and challenges. Researchers found that the connection with women in the area encouraged girls to participate in programming workshops. On the other hand, sharing their experiences with high school girls positively affected challenges faced by women as undergraduate students in STEM, such as the feeling of belonging and being encouraged to continue in the course and career.

Participation in technological competitions – observed in [47], [51], [52], and [65] – is another strategy that changes girls' perceptions. In addition, competitions empower girls by encouraging them to practice knowledge in the area and have space for developing ideas, which can bring benefits such as those mentioned above to reduce barriers encountered during graduation. For undergraduate students, participating in competitors focused on female participants helps them to get in contact with more women in the area, besides being an opportunity to develop technology. In this context, forming a friendly environment, with space for dialogue, and with women being part of the technical evaluators are also strategies with evidence of contributing to encouraging girls in the STEM area.

V. DISCUSSION

We identified the barriers presented by the selected articles, such as stereotypes, oppression, patriarchal relations, prejudice, segregation, isolation, lack of support from colleagues and teachers, judgment, fear of mathematics, and mansplaining. We can minimize or even overcome such barriers through motivators, such as support from the school and teachers, exposure to the STEM area during high school, support from family, friends, and classmates, and teamwork. Strategies to overcome barriers women face in STEM education include exposure to STEM topics, the inclusion of teachers in encouraging and training, role models, participation in technological competitions, a friendly environment, and women participating in technical evaluators' work.

Our findings are comparable to some of the factors presented in the UNESCO report *Cracking the code: girls'* *and women's education in science, technology, engineering and mathematics (STEM)* [22], which proposes a framework of factors influencing girls' and women's participation, achievement, and progression in STEM studies. The factors are organized as an Ecological structure encompassing the Learner, Family, School, and Society layers. Although the UNESCO framework is based on worldwide data about girls in educational stages before undergraduate studies, some of its factors relate to our research findings. In Figure 3, the dotted lines highlight the UNESCO factors related to the barriers, motivators, or strategies we found in our research. When comparing our results to the ones reported in the UNESCO framework, it is important to notice that although some factors are unrelated to our findings, it does not mean they are not present in the context of Brazilian girls and women. It shows evidence of the need for more research in Brazil covering different aspects or layers, such as proposed by the UNESCO framework [22].

Regarding the Learner, our findings relate to *self-perception, stereotypes, and STEM identities*; *self-efficacy*; and *interest, engagement, motivation and enjoyment*.

The women's lack of confidence in their performance and the worry about spending more effort to keep up with men's skills are directly related to self-efficacy, self-perception, stereotypes, and STEM identity factors. They are individual beliefs resulting from the context and experiences women have lived since early ages and affect their performance in STEM subjects [22]. Our findings show that such factors remain for girls who choose a STEM undergraduate education. More than affecting women's performance, these factors become barriers to women graduating in the area.

Stereotypes created several decades ago and institutionalized in relevant organizations, both in Brazil and around the world, were responsible for delaying and hindering the entry of women into technology. Popular beliefs maintain stereotyped traits and temperaments, indicating that men and women are suitable for different occupations [72]. They explain that people acquire stereotypes, in part, through personal experience. However, stereotypes become shared beliefs and assumptions that society has about different types of people and groups. Why are men – and not women – who are low performers more attracted to these areas? According to Cimpian et al. [73], the masculine culture of these fields and the gender stereotypes attached to the fields of physics, engineering, and computer science can lead to the retention of less qualified men instead of more qualified women.

Regarding the Family and Peers, our findings relate to *peer-relationship*; and *parent beliefs and expectations*.

Our findings present, for example, the student-student interaction factor aggregates the ''support from classmates'' motivator and barriers such as segregation, isolation, judgment, and oppression. The family exposes children to the professions by sharing information and motivating skills development. Besides financial support, parents are essential for encouraging interest in science and mathematics in early school life, playing a crucial role in students' future job possibilities [74].

Support from friends and classmates is also a motivator because of something essential for people, especially during youth: the feeling of belonging to a group [75] and receiving motivation from that group. Support from friends and classmates occurs during conversations about careers and their possibilities, even when choosing similar areas, given the common interests in topics that friends are exposed to and can share experiences [71]. The feeling of belonging, one of the essential human motivators [75], [76], [77], may be threatened in environments where there are negative stereotypes about the minority group and where the majority group has more valued characteristics.

Regarding the School, our findings have elements related to *STEM equipments, materials and resources*; *student-student interaction*; *teacher' perceptions*; *teaching quality and subject expertise;* and *textbooks and learning materials.*

We found several studies concerning the barriers women face in STEM education. The teacher-student interactions factor encompasses the ''support from teachers'' motivator and the ''discrimination practices from teachers'' barrier. In most cases, universities try to recruit but not retain female students [78], [79]. Corbett and Hill [79] state that this recruitment of women will only be successful if these women remain in these areas.

We found literature reviews on the subject that also point to the problems faced by women in entering and remaining in undergraduate courses [39], [78], [80], [81]. Despite this, we identified a gap given that the literature only talks about changing the perception of girls without paying much attention to what other actors – such as men, family, teachers, and Universities – could do to reduce gender inequality in STEM. García-Holgado et al. [49] present some possibilities in their study but focus on the factors that influence women before entering and during engineering studies, including practices in the labor market and comparing data from Brazil with Spain. Thus, there is the possibility of carrying out several studies that observe gender equality from the perspective of other social actors involved.

Regarding Society, we found elements related to *societal and cultural norms*; and *gender equality.*

In a case study conducted at the University of Valencia in Spain, Botella et al. [82] argue that Information Theory is predominantly male, citing a lack of visibility for women already working in the field who could serve as role models for others. They attribute this to several barriers, including gender bias in the workplace and the gender pay gap experienced by women in STEM careers [83].

Moreover, their review highlights challenges women face in the job market, such as work-life balance issues and a lack of encouragement from educational institutions to prepare girls for careers in STEM [83]. Other studies discuss motivators that can promote women's entry and retention in these

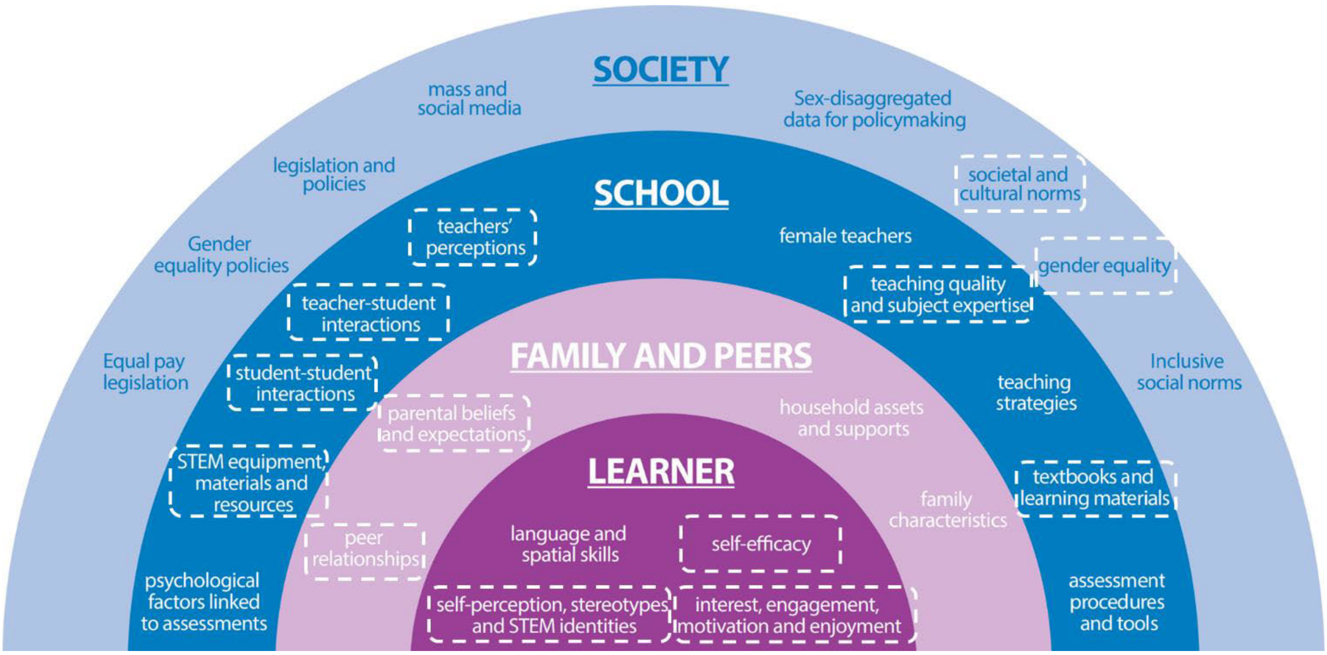

FIGURE 3. Findings on barriers, motivators, and strategies for gender parity in STEM compared to factors in UNESCO's framework [22].

fields and propose strategies to address the existing gender gap in STEM participation.

We argue that to bring about a fundamental change in this scenario, we recommend that the relationship between these three elements – barriers, motivators, and strategies – be well understood, studied, and applied in the context of higher education.

VI. CONCLUSION

This work aims to present the factors that affect women's journey in STEM education in Brazil, mainly in engineering and computer science. We performed a Rapid Review of the literature to understand the barriers women face, the motivators that increase their participation in STEM, and strategies to improve the situation and achieve gender equality.

We interpret that the relationships between the evidence found, referring to the barriers, motivations, and strategies, are fundamental to reducing women's low participation in higher education in STEM. Our review identified initial conjectures about the relationship between themes that need further investigation. For example, STEM training relates to barriers found in other studies in the phases before and during college, such as gender stereotypes and lack of confidence in their performance.

Our findings can support companies in discussing the role of women within their organizations, assisting in strategic decision-making, hiring processes, and internal training. Additionally, these results can contribute to deepening the understanding and relevance of this topic in a general sense.

Furthermore, the findings can also help educators develop relationship-building skills with their students and gain access to relevant information on effective strategies to address the low participation of women in STEM education. These findings include the use of inspiring role models, both in primary and higher education. Universities can leverage these results to implement policies aimed at improving gender equality in STEM education, such as actions that promote more balanced gender recruitment in higher education and the reduction of barriers that hinder the advancement of women in academic, research, or administrative careers.

As future work, we believe that developing a set of conjectures establishing relationships between barriers, motivators, and strategies and the reasons for these relationships is relevant to research opportunities identified in the area. In addition, another scientific contribution is the possibility of reusing our research framework (RR protocol and organization in theme and subthemes) by other researchers, enabling the direct comparison of the results.

As a limitation, we can indicate that focusing only on Scopus and Scielo research bases increases the quality of the studies while reducing the range of studies available for analysis. Another limitation of our research concerns the exclusion criteria, which are limited to primary studies published in the last ten years.

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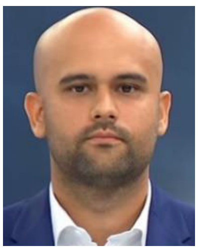

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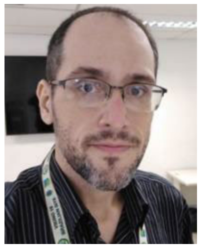

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