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Gender equality in science, technology, engineering and mathematics: industrial vis-a-vis academic perspective

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Abstract
The aim of this study is to present the findings of a qualitative study aiming at capturing key stakeholders' perceptions with regard to: (a) gender equality in academia and the workplace; (b) challenges, needs, and experiences in academia and workplace with regard to gender. This research captures the current situation of gender equality in the fields of Science, Technology, Engineering and Mathematics (STEM) and provides a deep understanding of the needs, challenges and experiences both men and women encounter in academia vis-a-vis the industry. Forty-one interviews were conducted in Cyprus, Greece, Italy, Slovenia, and Spain. Data collected demonstrate a variety of challenges faced by all genders in the workplace and in academia, as well as the need for more concrete actions that will allow for a gender-balanced perspective to be heard in the STEM fields. Implications for practitioners, policymakers and researchers are also provided.

Keywords Gender-equality · STEM · Academia · Industry · STEM challenges · STEM experiences

1 Introduction

Despite the digitalisation benefit, low participation of women in the labour force persists [1, 2]. The main obstacles are gender bias and socio-cultural constructs, which at different life stages dissuade girls and women from taking up Science, Technology, Engineering and Mathematics (STEM) studies and careers. It is essential to integrate awareness of gender bias across all relevant sectors including in the initial and continuous training of teachers; address structural barriers such as work conditions and culture, which hinder girls and women from entering a predominantly male-dominated field; and increase the visibility of role models who are insufficiently valued, aiming to inspire women and girls [3].

The present study uses inclusive definitions of "woman" and "female" that also include trans, genderqueer, non-binary and intersex people. The use of "women" and "female" as umbrella terms is not designed to unify the unique experiences of individuals, but to reflect on a collective experience of difference defined by gender and sexuality. When citing other scholars, the article adopts the terms used in their work [4–6].

Ceci and Williams [7] provide an overall view of the main empirical evidence that currently exists on gender bias in science. An indicative example provided in their book demonstrates one study in which the same curriculum was signed

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by a man, a woman, or with initials. The curriculum signed with a male name always received the highest scores, while the one signed with a female name consistently received the lowest marks. When addressing gender inequality, things seem to worsen when women become mothers. For women of equal merit, mothers are perceived as less competent and committed than women without children, whilst men are not only not penalized by their parenthood but rather on the contrary, it has been proven to be a factor that works in their favor in some occasions. The study shows that employers discriminate against mothers and favour fathers [8]. When analysing gender biased situations within the academic world, many factors have to be considered, as these influence the different situations as well as the many levels at which the analysis would be operating. As stated by Sánchez de Madariaga, de la Rica, and Dolado [9] we should take into account different aspects such as: gender differences in diverse subject areas at 15–16 years of age, differences in university education, the transition from bachelor degree/ master's degree to doctorate, the transition from doctorate to post-doctorate and the public grants for post-graduate and postdoctoral study.

Reducing the gender gap in STEM education areas may lower labour market bottlenecks, increase women's employment and productivity, and reduce occupational segregation. Getting more women into STEM education will have a positive impact on economic growth and employment in the European Union (EU) [10]. By 2050, total EU employment would increase by 850 000 to 1 200 000. Women will become more productive as a result of higher rates of STEM qualifications, contributing to the smart growth envisioned in the Europe 2020 strategy. Likewise, the increased employment of women in STEM fields is also expected to benefit the EU economy's competitiveness [10].

1.1 Rationale

The acquisition of data about women's reality in HE and the industry is key to boosting our understanding of the status quo and to promoting equality politics that are effective for all genders in any field. Additionally, by identifying key themes and patterns that emerge across the different participants and organizations, we aim to provide a more comprehensive view of the issue of gender inequality in STEM fields, which adds significant new insights to the existing literature.

1.2 Objectives

This paper aims at capturing the current situation in gender equality in STEM by taking a snapshot on the way women and men experience and ascribe meaning to it in the field of STEM in HE and the industry in five EU countries: Cyprus, Greece, Italy, Slovenia, and Spain. Through a qualitative methodology, this study brought together both men and women from HE and the industry to voice their views regarding gender equality in STEM, barriers that they encounter as well as how they overcome them. The research questions guiding this study are:

(1) How do experiences of gender inequality in STEM differ between HE and industry?
(2) What are the specific challenges faced by men and women in the fields of STEM in achieving gender equality?
(3) In what ways do national policies can alleviate gender inequalities in the STEM fields in HE and industry?

The paper is structured as follows: in the next section we provide an overview of the state-of-the art of gender equality in the STEM industry and HE and the methodology adopted follows. The article then provides the findings extracted and concludes by connecting the empirical findings to the existing literature.

2 Literature review

2.1 Women in the STEM industry

Gender equality in industry is an important issue that has economic and social implications. Women are overrepresented in some industries and underrepresented in others [11]. Research has highlighted the persistent gender inequality in STEM fields, particularly, where women continue to be underrepresented in leadership positions and technical roles (e.g., Charlesworth & Banaji [12]; Wang & Degol [13]; UNESCO [14]; Women in Digital Scoreboard, 2019 [15–18]). Even though the number of women enrolled in STEM fields at universities has increased, there are still not enough job opportunities for women in this field, which adds to the general decline in women's employment [19]. Studies have shown that gender biases in recruitment, performance evaluations, and networking continue to be major barriers for women in STEM fields

in the Industry (e.g., Moss-Racusin, et al. [20]). There is also a significant number of women that quit from technological job positions [21]. This happens due to parenthood [22, 23], unfriendly work environments and microaggressions [24, 25] as well as due to dissatisfaction with management and a desire for greater advancement opportunities [26]. According to the study of Friedmann [27], the most significant factors influencing women's career decisions in STEM were salary and the capacity to balance work and family responsibilities. It is recommended that women's entry into the STEM fields be facilitated by concentrating on these aspects. Additionally, research has highlighted the important role of organizational culture, work-life balance policies, and mentorship programs in shaping gender inequalities in STEM fields in the Private Industry (e.g., Moser and Branscombe [28]; Christou and Parmaxi [29]; Christou, et al. [30]). Recent studies have also shown that intersectional factors such as race, ethnicity, and sexual orientation, interact with gender to further exacerbate the inequalities faced by women in STEM fields in Private Industry (e.g., Alfred, et al. [31]). Women that work in STEM and technological fields face several barriers that prevent them from starting or progressing in their professional career [32]. These barriers include gender bias and stereotypes [26, 32–34], sexual harassment [16, 33] and lack of personal life and work balance [21, 32–34], as well as the insufficient opportunities for employment for women in the STEM fields and the socio-cultural obstacles hindering their career advancement [19].

2.2 Women in STEM in HE

Recent research has highlighted the persistent gender inequality in STEM fields, particularly in HE, where women continue to be underrepresented in science and engineering disciplines (e.g. [35]). Even though the number of women enrolled in STEM fields at universities is now higher [19], s.tudies have shown that gender biases are prevalent in academia specifically in recruitment, promotion, and pay. While more women are obtaining postgraduate degrees now than in the past, the proportion of women holding STEM faculty positions has not changed significantly. Negative and widespread gender stereotypes could be a contributing factor in the lack of progress toward gender parity, as they can encourage discrimination in hiring practices and limit women's career advancement opportunities [36]. A recent review demonstrates the issues that women encounter as members of faculty, such as gendered teaching loads, tenure and promotion, work–family balance, departmental policies and diverse hiring practices [37]. The same review also notes improvement in achieving equality in the status of women in STEM in HE, yet more work is needed for the situation to be considered significantly improved and stable.

Additionally, research has highlighted the important role of implicit biases, gender stereotypes, and lack of role models in shaping gender inequalities in STEM fields (e.g. [38–41]). Recent studies have also shown that intersectional factors such as race, ethnicity, and social class, interact with gender to further exacerbate the inequalities faced by women in STEM fields (e.g. Kricorian, et al. [40]). Organizational change interventions that focus on recruiting diverse applicants (e.g., training search committees), mentoring, networking, and professional development (e.g., promoting women faculty networks), and improving academic climate (e.g., educating male faculty on gender bias) are potential solutions for these issues [36]. Overall, these findings suggest that there is a need for targeted interventions that address the systemic barriers faced by women in STEM fields, particularly in HE.

2.3 Intersectionality

Crenshaw [42] coined the term "intersectionality" to describe how Black women experience dual oppression based on both their race and gender, which has historically resulted in their marginalization in feminist movements and social justice efforts. Intersectionality is an approach that recognizes that individuals are not defined by just one identity category, but rather, are shaped by multiple intersecting identities such as race, ethnicity, gender, sexuality, class, and ability. This means that experiences of oppression and privilege are not additive, but rather, are interconnected and mutually reinforcing. Crenshaw [43] emphasized that intersectionality is not merely a theory of multiple identities, but that some identities can make individuals more vulnerable to discrimination, exclusion, marginalization, and invisibility. Intersectional feminism is about giving voice to people who experience both concurrent and intersecting forms of oppression. The intention is to learn more about the complex relationships between disparities within a particular setting and the intricacies of inequalities themselves [42, 44].

2.4 Intersectionality and STEM

In the context of STEM fields, intersectionality can help to illuminate the complex and often overlapping barriers that women and underrepresented groups face in these fields. For example, research has shown that women experience a unique set of challenges in STEM fields, including racial discrimination, gender bias, and stereotype threat [45–47]. According to the study of Smith et al. [48], black women in STEM fields may face discrimination and exclusion due to the intersection of their race and gender. A review of racialized experiences in STEM entrepreneurship has underscored the significance of intersectionality by pointing out the underrepresentation of racially minoritized populations in STEM fields, entrepreneurship, and innovation [49]. By taking an intersectional approach, researchers can more fully understand how these different forms of oppression intersect and compound to shape experiences of inequality and exclusion.

3 Methodology

3.1 Research design

To capture a thorough understanding of participants' views of the role of women in the fields of STEM in HE and the industry, a qualitative methodology was adopted. To analyze the data in our study on gender equality in STEM fields, we draw on an intersectional feminist framework that highlights the ways in which gender intersects with other forms of social stratification. The intersectional feminist framework guided the data analysis by providing a lens through which to examine the experiences of individuals in STEM fields. The intersectional feminist framework acknowledges that individuals are not defined by a single identity (e.g., gender) but are shaped by the intersections of various identities (e.g., gender, race, class) (Crenshaw [42]). In our study, we recognized the participants' multifaceted identities and how these intersected to influence their experiences in STEM. The framework helped us identify power dynamics within the experiences shared by participants. By considering how various identities intersect, we could discern patterns of privilege and disadvantage, shedding light on the structural inequalities present in both higher education and industry settings. Moreover, by acknowledging the connections between different types of discrimination, we were able to make more focused and inclusive policy recommendations that cater to the unique needs of people with a variety of intersectional identities. This approach is informed by numerous studies on gender inequality in STEM fields that have used an intersectional feminist lens, including work on the experiences of black immigrant women in STEM [50] and the impact of intersectionality on STEM career choices [51].

3.2 Sampling

Forty one (41) interviews were conducted, as the literature indicates anywhere from 5 to 50 participants as adequate for qualitative studies [52–54]. The interviews involved all genders in senior and junior positions in the fields of STEM industry as well as students and academics in the fields of STEM in HE. More specifically we involved 13 participants from the industry and 28 participants from HE from five different EU countries: Cyprus, Greece, Italy, Slovenia, and Spain. The aim was to capture a wide range of experiences and to represent both senior and junior participants from the fields of STEM.

A convenience sampling was employed. Participants were recruited through the research team's professional contacts with key stakeholders in these fields. Participants' age varied (18–53) and career stage varied. The inclusion criteria were the participants to belong in the fields of STEM, either in HE or in the industry. With regards to the industry, we aimed at interviewing stakeholders with more than 3 years of experience. A breakdown of the participants appears in Table 1.

3.3 Tool

The interview protocol employed in this study was carefully developed, drawing directly from the insights gained from the literature review on gender inequality in STEM. The literature review offered a thorough comprehension of the body of research, major themes, and obstacles encountered by individuals in academic and industrial settings. Acknowledging the significance of capturing nuanced viewpoints, the review also emphasized the intersectionality of gender experiences. This plethora of information directly influenced the development of the interview questions and prompts,

Table 1 Break down of participants in the interviews

Country	Students in HE	Researchers in HE	Instructors in HE	Junior industrial stakeholders	Senior industrial stakeholders
Cyprus	3F; 1 M	1F	1 M; 2F	5F	4F
Spain	2F; 3 M	1F			
Slovenia	1F	1F	3F; 3 M		
Greece	1F;	1F	1F		
Italy	1F		2F	3F;	1F;

ensuring that our investigation was purposefully in line with the gaps in the literature. Therefore, an interview protocol was designed focusing on the following thematic areas: (a) experiences and needs at workplace/studies with regard to gender; (b) perceptions of equality/inequality; (c) challenges encountered at workplace/studies with regard to gender; (d) expectations and practices and (e) recommendations/suggestions for overcoming challenges at workplace/studies with regard to gender.

3.4 Data collection

The interviews were conducted in five different EU countries—Cyprus, Greece, Italy, Slovenia and Spain. Interview facilitators informed the participants on the aim of the interview and sought written consent. Each interview lasted approximately 15–25 min. The facilitators followed the interview protocols with the thematic areas mentioned above.

3.5 Data analysis

The interviews' transcriptions (henceforth the interview dataset) were then imported in the qualitative software Nvivo 12 (Nvivo, 2012) for organizing, analyzing and visualizing qualitative data [55]. Data was then coded and categorized according to the participants' sayings. Thematic analysis was undertaken in order to generate key themes and patterns related to the areas mentioned earlier. Thematic analysis was undertaken as we aimed at interpreting "meanings and perceptions created and shared during a conversation" [56]. The analysis involved an iterative process which encompassed reading and rereading of the interview dataset and generation of initial codes that were then refined further upon further coding and discussion among the research team. The analysis followed six steps (see Fig. 1): familiarisation with the data; code generation; classification of codes in categories; reviewing of categories and subcategories; definition of themes and production of report [57].

3.6 Ethical considerations

All participants were informed about the aim and context of the research study verbally and in writing. They were also informed on their right to withdraw at any time. Each participant signed a consent form. The principles of confidentiality, anonymity and personal data were also applied.

4 Findings

The dataset revealed similarities as well as differences in the various areas explored. Overall, participants expressed similar views regarding gender equality elaborating on equal opportunities and challenges in HE. On the other hand, participants from the industry had a different view of gender equality at the workplace. In the following sections, we present the analysis of the data classified in the five areas mentioned earlier:

(a) experiences and needs at workplace/studies with regards to gender; (b) perceptions of equality/inequality; (c) challenges encountered at workplace/studies with regard to gender; (d) expectations and practices and (e) recommendations/ suggestions for overcoming challenges at workplace/studies with regard to gender.

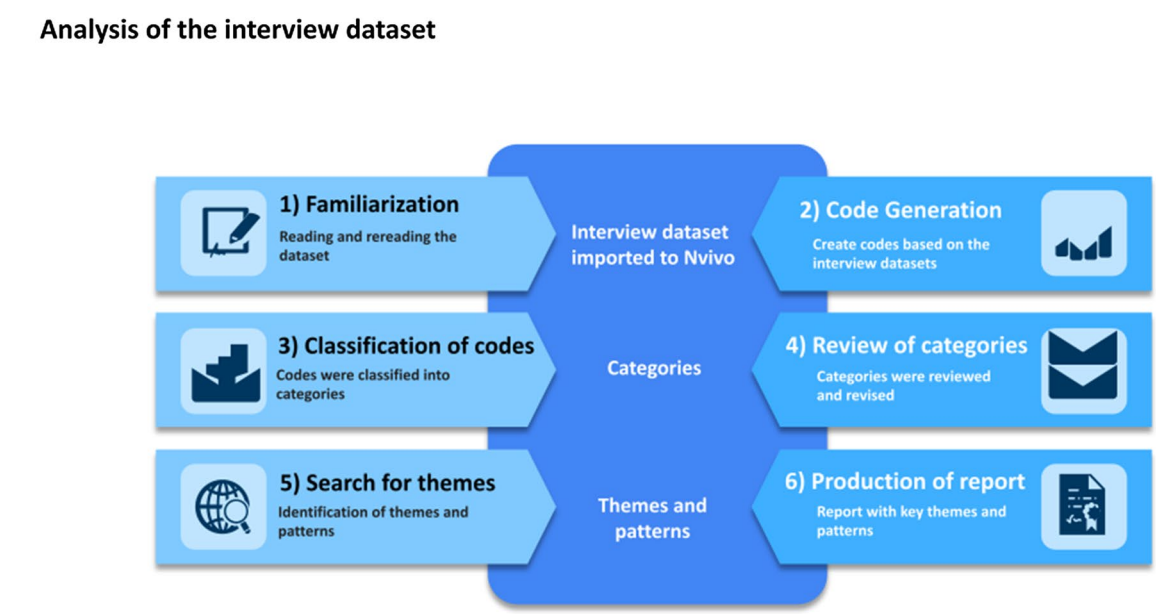

Fig. 1 Six-step followed for the analysis of the interview dataset

4.1 Experiences and needs with regard to gender in HE vis-a-vis the industry

Participants in both HE and the Industry recognized the lack of women in the fields of STEM and often characterized the field as men-driven.

HE participants' experiences concerned pay gap, receiving sexist comments or hostile behavior due to gender, struggling with work-life balance, being downgraded because of being a woman, suffering from the scissors effect, i.e. while the participation of men increases, that of women decreases as the academic levels move towards the top ranks [58]. Moreover, participants also voiced the need for women in academia to work harder than men in order to reach recognition and the tendency to allocate unimportant or administrative tasks to women. "*Generally, they have to demonstrate their capacity and skills for the position in a way in which men don't need to*" (Male, Spain, HE student). Inequalities were particularly voiced in terms of maternity, promotion and reaching the upper-ranks of the academic ladder. With regard to maternity, participants in HE voiced the need to take maternity leave into consideration when dealing with evaluation and meeting specific Key Performance Indicators (KPIs). Regarding promotion and participation of women in the upper ranks of the academic ladder, participants noted improvement in the last decades, yet 'double standards' still exist. As noted by one participant, "*it is not officially forbidden for a woman to be in a higher position, but there is a groundbreaking event, when a woman has children, then falls out of the competition for prestigious positions because it is harder to meet the criteria of scientific excellence which are written only for persons who have time just for a career, not necessarily just for men, it's also a matter of social status, not just sexual. Those who are socially privileged, regardless of gender, reach the highest positions*" (Female, Slovenia, Researcher). Another participant also voiced "*I don't know any company with women in the higher positions, to be honest*" (Male, Spain, HE student). It is worth noting though, that there were also participants noting less discriminative behavior and no or minimum differentiated behavior due to gender "*If someone is ambitious and works in this direction to have a higher position and is committed to it, that position can occur regardless of gender.*" (Male, Slovenia, HE lecturer).

On the same line, participants from the industry noted discrimination prominently-either at the position they hold now or in previous employment. The following experiences were highlighted by participants from the industry: sexual harassment, sexist jokes, gender segregation (i.e. the idea that jobs in STEM are overwhelmingly done by men), the need for women to prove themselves, dealing with misogynist employers, lack of women in upper ranks positions, exclusion of women from conversations and limiting women to administrative/unimportant tasks because of their gender.

4.2 Perceptions of equality/inequality in HE vis-a-vis the industry

When coming to perceptions of equality/inequality, participants in HE noted inequality as an issue that emerges specifically in terms of workload as they highlighted that women tend to work harder in order to move higher in the academic hierarchy. Moreover, one of the participants voiced the gender equality paradox. The gender-equality paradox, suggests that countries with a higher level of gender equality (e.g., Scandinavian countries) tend to have less gender balance in fields such as STEM, than less equal countries [59]. Despite the increasing number of women in STEM, women still indicate that they are excluded from opportunities and being discriminated against. As voiced by one participant: "*Gender bias definitely exists […] men are always the first ones to be invited to speak at more prestigious conferences*" (Female, Researcher, Italy). However, there seems to be an optimistic tendency indicating change of this discriminatory behaviour by women by advocating equality in terms of gender in academic conferences and between generations "*I think gender bias is no longer a thing, at least when speaking with my generation […] I think in the recent years slowly the STEM industry increases the numbers of women but there are still more males. I do know some enterprises with women in leading positions*" (Male, Cyprus, HE student). When it comes to celebrations (e.g. International Women's Day, International Day of Women and Girls in Science), participants noted that these types of events are important as women's achievements gain visibility and recognition, providing role models of prominent women; however, these events need to be linked with action: "*these international days are good for a start, to trigger discussions and remind some things to the people, but after that, we need something aligned deeper with everyday life aspects*" (Female, HE student, Greece).

With regard to perceptions of equality/inequality in the industry, participants noted that STEM is a male dominated field and often cultural norms drive inequality, as the field was male dominated from school years until university. Lack of trust, confidence and role models were also noted by participants as an impeder for women in leadership roles. As voiced by one participant: "*I never heard of any enterprises with women in leading positions. Sometimes women can be associate members or something, but not leaders or Chief Executive Officers (CEOs) unfortunately. I think women underestimate themselves quite a lot as well. […] My male colleagues take more risks than me—we all studied together, but they have already opened their own firms and I haven't even thought about doing it on my own*" (Female, Junior professional, Italy).

4.3 Challenges encountered at HE and industry with regard to gender

Both participants from academia and industry highlighted discrimination, stereotypes, the glass ceiling and lack of role models as the key challenges in the fields of STEM. Participants from the HE highlighted that gender has greatly affected their career path and employment potential. STEM is often characterized as a "*male-dominated, change resistant*" (Female, HE instructor, Greece) domain with few female role-models which is reported to have a great influence on women's recognition. Lack of trust and confidence were voiced as inhibitors of women's successes, as noted by one HE instructor "*the STEM world is seen as difficult, with only male references, so it feels like if you are not Marie Curie you don't make it*" (Female, HE instructor, Spain). Participants in HE also highlighted career instability for women which has a disproportionate effect on them, as well as suffering subtle and overt discrimination and sexism which leaves many women feeling unwelcome, undermining their value and recognition. Work-life balance, glass-ceiling and impostor syndrome were highlighted as key issues for women in academia. When it comes to technical skills, all participants agreed that both men and women have the same capabilities, yet it was highlighted that especially in the field of STEM technical experimentation takes time (needs trial and error) and "*the lack of time that comes with starting a family falls on women. So maybe men have a stronger advantage in technical skills because they have more time to experiment and become better*" (Female, Cyprus, HE instructor). To this end, stable funding is often sought so that women overcome the specific precariousness.

Reconciliation of work and family obligations appeared to be a demanding issue in the industry, especially because "*STEM industry demands long working hours and forces many women to choose between a successful career and a family*" (Female, Greece, HE instructor). Women are also often excluded from decision making bodies and need to work harder than men to demonstrate their value.

4.4 Expectations and practices: women in STEM in HE vis-a-vis the Industry

Unequal expectations were highlighted as a demanding issue that women in HE need to deal with. Women often deal with uncertainty and distrust, and need to work harder to prove themselves and promote their achievements in a prominent way in order to gain attention, validation and recognition. With respect to practices, participants in HE highlighted

the importance of bringing more women in the STEM fields, and setting forward equity and equality strategies: "*I have experienced differentiated attitudes/behaviour towards women. For instance, in the past few months I was away from my work due to maternity leave. My absence of 4 months, but also the last 1–2 months before leaving for maternity, did not allow me to perform at the same levels as before getting pregnant. … [However], the KPIs remained the same. This is an experience that a man does not have. Everyone is being assessed with the same criteria, with the same numbers (KPIs) at the end of the year. And it is not the same when being a mother vs being a father*" (Female, Cyprus, HE researcher).

When it comes to the industry, participants noted the expectations that women encounter beyond their work environments, as well as the cultural norm of a woman being excellent in handling family but average in work-related tasks. Gender segregation as a prominent expectation in the STEM industry -that is women are good in keeping notes, cleaning etc. Participants also noted that the lack of trust and confidence is often lagging women behind the upper ranks of the ladder.

4.5 Recommendations and suggestions for overcoming challenges with regard to gender in HE

Participants voiced the need for action in order to tackle the aforementioned challenges. The recommendations provided involve both high level changes such as adopting a systemic approach "*from kindergarten onwards to the promotion of women [in jobs and professional community]*" (Female, Slovenia, HE instructor) and low-level changes in employers' mentality. Almost all participants noted that both society, European and governmental bodies should focus on educational capabilities to tackle gender bias by overturning the dominant gender-related stereotypes through actively informing parents and students and promoting equality in STEM from a very young age "*they have to give more visibility to women in science since the school years. With this, the basis of the problem would be solved*" (Male, Spain, HE student). Education has a crucial role in this endeavour, as schools need to promote further STEM education (in school and outside of school) "*giving equal opportunities to men and women to participate, so they would gain more knowledge regarding STEM and decide whether it fits them or not*" (Female, Cyprus, HE student). Overcoming gender-related stereotypes is also a challenge that the education system needs to address, primarily by training teachers to put forward a culture of equality. Incentives are also needed in order to keep women active in STEM in HE. These incentives could include encouragement of women students in STEM competitions, and gender quotas in research proposals. Since STEM education does not attract or does not retain the interest of many women, a rewarding plan could be adopted by the EU for benefiting organizations which have a balanced number of employees in STEM jobs. Supporting women to reconcile career and family is also considered. More specifically, participants suggest longer maternity leave for women without any pay cut, as well as economic support to women who return from maternity and financial incentives for incorporating family-friendly practices. Gender action plans along with the monitoring of gender equality practices are also recommended. Such practices take place in Scandinavian countries, for example the Research Council of Norway has actively sought a central role in the advancement of gender equality in Norwegian research in STEM. According to the Norwegian Gender Equality Act, all employers, both private and public, are obliged to promote gender equality and to prevent discrimination through active, targeted, planned work. The Ministry of Education and Research requires that all universities and university colleges adopt a gender action plan to fulfill these legal duties. Participants also noted that raising awareness through public events and promoting or taking compulsory measures for supporting diverse hiring.

4.6 Recommendations and suggestions for overcoming challenges with regard to gender in the industry

Participants from the industry focused on the need to put forward gender equality as an aspect in the educational system and the need to optimise existing policies and establish new ones for supporting women in STEM. Pertaining to existing policies, participants highlighted the need to incorporate work-from-home as an established practice for working mothers as well as supporting family-friendly companies. With regard to new policies, participants noted the need for an innovative ecosystem to grow and new employment opportunities for women as well as further support of women start-ups in STEM. This is also in-line with IGNITE (2014) who noted that women's business ideas receive less start-up investment although they adopt creative and innovative approaches (Table 2).

Table 2 Summary of recommendations and suggestions for overcoming challenges with regard to gender in HE and the Industry

	Females (everywhere)	Parents (at home)	Students (at school)	Teachers (at school)	Employees & supervisors (at work)
Raise awareness	✓✓	✓	✓	✓✓	✓✓
Training	✓✓	ϕ	✓	✓✓	✓✓
Incentives: -Awards -Funding	✓✓	✗✗	✓	✓✓	✓✓
Policies & Legislation: -Family support -Employment Support -Promoting Role Models -Salary Protection -Harassment Prevention -Balanced Participation -Monitoring -Evaluation	✓✓	✓	✓	✓✓	✓✓

The symbols in the table have the following meaning: ✓✓fully recommended, ✓ well recommended, ϕ somewhat recommended, ✗✗ not recommended at all

5 Discussion

Despite the strong efforts and the promotion of social and political measures to establish gender equality, women in STEM both in HE and the industry still experience inequality. The intersectional framework adopted in this study provided a powerful tool for understanding the complex and interconnected factors that shape experiences of inequality and exclusion in STEM fields. Through this lens, the research community can more fully capture the experiences of diverse groups and develop more effective strategies for promoting gender equality in these fields. The participants of the study referred to common barriers that especially women face in STEM fields, in both HE and the industry. The barriers include sexual harassment, bias, stereotypes, discrimination, need to prove ones self and exclusion from decision making. While women in academia face obstacles related to maternity, promotions, and reaching upper ranks, industry participants focused on discrimination, sexual harassment, and gender segregation, with women frequently facing barriers to leadership positions. Notably, the gender equality paradox surfaced, indicating that even in countries with high gender equality, disparities persist in STEM fields. These barriers are very common in the STEM field and are ascertained by previous research [26, 32–34]. Our findings are also aligned with the attitudes and the overall statistical picture of the specific countries. In the survey of the European Commision about European citizens' knowledge and attitudes towards science and technology that was published in September 2021, respondents from Cyprus (47%), Greece (45%) and Slovenia (38%) were least likely to agree with the statement "Science and technology pay sufficient attention to differences between women's and men's needs". Spain (53%) and Italy (51%) had the majority of the participants agree to that statement [60].

Male respondents from the academia were more likely to take an optimistic stance or believe that gender equality may not be a major issue. This tendency could be attributed to differences in the perspectives or experiences that men and women have had. It is important to note that a variety of factors could contribute to the variation in respondents' perceptions, such as institutional structures, systemic biases, and societal conditioning. An interesting pattern of support and recognition of the difficulties women may encounter in academia in comparison to men is evident in the views of male respondents in the context of gender dynamics in STEM.

In HE, women recognize a paradox of gender equality and the need for more integration of women in STEM, whereas industry participants emphasize the predominance of men in STEM fields. Despite this difference in perspective, both groups emphasize the significance of events such as International Women's Day in honoring and promoting women's accomplishments. Another research conducted involving participants from the academia and the industry, highlights efficacious methodologies for propelling female empowerment such as offering female role models, recruiting women specifically, mentorship programs, support systems, workshops geared toward women, and equal opportunity for women [61]. The research also emphasizes the value of developing soft skills such as critical thinking, problem-solving, communication and teamwork in addition to technical expertise [61]. Amongst the challenges in effective pursuit of gender

equality policies include limited plans and monitoring mechanisms, lack of awareness on gender equality systems as well as a lack of an effective monitoring system in evaluating gender equality initiatives and actions [18, 62]. In this study, there are similarities but also differences in the views amongst participants from HE and the industry. However, in principle there is an agreement that gender inequality exists in many aspects of the STEM fields. Reconciling family and work is an issue that has been put forward by all participants and it is of high importance to put forward policies that will allow mothers to remain active in STEM. Research findings often set forward the dilemmas that women encounter across different cultures to choose between their job and having a child [63]. Possible suggestions for reconciling family and working life include longer maternity leaves and the support of family-friendly companies. Previous studies also support the provision of flexible work arrangements for STEM positions, such as extensive parental leave, that will encourage women to remain active in the field [22, 23, 32, 33].

It seems that the participants would like to see high-level and low-level policies to be implemented for reinforcing the participation of women in STEM. Small changes from early childhood education can have big achievements that could impact remarkably on the beliefs and understanding of women in STEM. This is in line with previous studies that support that effective interventions for increasing girls' interest in STEM should be implemented at an early stage, because their decisions at high school will determine their future education, career and salary [39].

Further, there is a need to establish gender equality action plans both in HE and in the industry as well as monitoring mechanisms for supporting equal opportunities are given to women. The first step towards this direction is already in action as Horizon Europe has set official criteria for HE and Research Organisations to have a gender equality plan (GEP) in place [64].

6 Conclusion

Our findings highlight the ongoing obstacles that women face in spite of significant efforts and policy initiatives. Women face similar challenges in STEM in both the industry and HE such as a pay gap, sexist comments, struggling with work-life balance and a lack of females in leading positions. Moreover, they usually need to work harder to reach the same recognition as men and some inequalities were noted regarding maternity. Nonetheless, there have been some improvements in the last years regarding the promotion and participation of women and discrimination is not a generalized experience for all women. Our study adds valuable insights to the existing literature, offering nuanced perspectives that pave the way for informed interventions and systemic changes to promote gender equality in STEM. The gender equality paradox, workplace expectations, and the need for comprehensive policies are critical considerations for fostering an inclusive STEM landscape. The findings highlight the urgency of targeted interventions to address specific issues in each setting, from discriminatory practices to the lack of women in leadership roles. Our research not only points out enduring problems, but it also offers a path forward for future action. It advances the more general objective of establishing inclusive and equitable STEM environments by providing a thorough understanding of the experiences of women and men in STEM and supporting focused, evidence-based interventions.

6.1 Implications for practitioners, policymakers and researchers

Several recommendations and suggestions have been voiced for overcoming challenges with regard to gender in HE and the industry, such as:

Providing training. Continuous training of females, teachers and employees can help overcome gender-related stereotypes and put forward a culture of equality.

Offering incentives. Incentives such as encouragement of female students in STEM competitions, gender quotas in research proposals and financial incentives for incorporating family-friendly practices are needed to keep women active in STEM in HE.

Raising awareness. Raising awareness on gender inequality through public events and promotion can help mitigate the challenges and stereotypes for women in STEM in HE and the industry.

Empowering and supporting. Empowering and supporting women to participate and remain active in all fields of STEM can lead to improvement of the quality of life for women, men, families and consequently communities.

Establishing gender equality policies. Local and EU policies and strategies both for HE and the industry need to be revisited and enhanced to tackle gender bias. More specifically, there seems to be an urgent need for strengthening gender-sensitive approaches in education and incorporating gender-sensitive plans in industry and HE. Policies for mitigating gender biases, sexual harassment and gender discrimination should be also employed in institutions and the industry.

Acknowledging women's achievements. The successes of women in all STEM fields need to be promoted and act as examples for young women to follow and remain active, despite the numerous challenges and obstacles encountered.

7 Limitations

The findings are not generalizable. The convenience sample used in selecting the interviewees and the fact that participants represented STEM fields only consist a limitation. Additionally, as a limited number of male participants from academia and no male participants from the industry took place in this study, we draw attention to the necessity of conducting more gender-balanced research in the future to offer a thorough understanding of the experiences in STEM fields.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to particiate Ethical issues were taken into consideration according to the General Data Protection Regulation, and all interviewees participated voluntarily. All participants were informed about the anonymity of the interviews and about the utilization of data for research purposes ensuring privacy and confidentiality issues. Informed consent was obtained from all subjects. The study participants were informed they could withdraw at any time without any consequences. Participants' data were stored securely and anonymously. There was no harm or discomfort experienced by the participants, and their rights were fully protected. All procedures performed in studies involving human participants were in accordance with the ethical standards of the national research committee.

Competing interests The authors have no potential competing interests.

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