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Why do Women Refrain from IT/ICT studies at Higher Education Institutions? A Literature Review

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ABSTRACT

Solving global and local challenges efficiently requires as many diverse, educated, and knowledge-based viewpoints as possible. Regarding diversity in science, technology, engineering, and math (STEM), especially in the Information and Communications Technology (ICT) sector, men have dominated the field for decades. Even nowadays, when the study contents have highly diversified, a more significant share of men join STEM studies paths than women. Based on a literature review, we explore and analyse reasons explaining why women choose or do not choose ICT studies at higher education institutions and what challenges they face in this path. The study collected current research-based views and extended the existing views on improving gender diversity in ICT studies. When choosing a future specialization, the society in which the child grew up, the family in which they were brought up, and the traditions they invested in are much more important than their gender. We have analysed the challenges and difficulties faced by women during the STEM pipeline based on the modern academic literature. Our recommendations can be considered and implemented in university and school organizing strategies and implementation models to achieve better gender balance. Researchers, universities, and organizations involved in ICT and STEM can apply our findings to future-proof their efforts to develop more efficient all-gender supportive operational models.

KEYWORDS

Gender balance; ICT; CS; STEM; underrepresentation of women; stereotype; diversity; complex problem; global challenge; career; equality; diversity; education; Higher Education

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Global society is constantly transitioning towards more digitalized and cross-connected economies, wherein developed countries have almost limitless access to information and knowledge (Schneider & Kokshagina, 2021). This change has taken a long time to realize through different stages of industrial and social revolutions (Popkova et al., 2019). The most recent revolution refers to cyber-physical systems (Colombo et al., 2017), where appropriate software is a core success factor. In this context, Marc Andreessen (Andreessen, 2011), an internationally recognized inventor and venture capitalist, has stated that "software is eating up the world." Current research confirms this claim (Cohen, 2018; Gobble, 2018; Paavola & Sele, 2020). Moreover, the software is not just 'eating the world'; it is modifying, changing, and even re-inventing the world we know. Since moving into this era of global development of information and communication technology (ICT), it is not easy to imagine any process or production chain without ICT-based solutions (Harris & Johns, 2021).

Digital technology-based production has been called a digital economy (Benčič et al., 2020). In a digital economy, the ubiquitous and rapidly accelerating dissemination of information leads to radically new approaches to the organization of work and training generated by digitalization: changes in the maps of professions and labor markets and the growth in demand for digital skills (Carlsson, 2004). As a result, scientists, businesspeople, and ordinary citizens are increasingly aware of the need for skills to use modern technologies and social interaction based on them. In this regard, the formation of the digital economy requires universal digital literacy of the population and leads to the emergence of new digital specialties, for example, in connection with the development of robotics or artificial intelligence (Brougham & Haar, 2018; Ionescu, 2019; Smith & Anderson, 2014). At the same time, the fast-developing field can produce feelings of being overwhelmed, but at the same time, researchers do state that software developers possess unique traits that may enable them to navigate through the storm of overwhelm (Michels et al., 2024) more effectively than their peers in other traits might be able to.

While the digital economy is creating new professions and jobs in the labor market, existing data are unambiguous about the severity of current gender gaps in the ICT market (Bokova & UNESCO (Paris), 2017; Mariscal Avilés et al., 2018; Squicciarini, 2018). UNESCO estimates men are around four times more likely than women to have advanced ICT skills, such as computer programming (Antoninis, 2017).

This research is based on an academic literature review, though studies surveyed could have personal views. The material surveyed covers only publications written in English; opinions published in native languages in national publications were not included in this article. The main contribution to literature data came from ACM, IEEE, Web of Science, and Google Scholar databases. The studies are limited by the assumed Western cultural background of the subjects. The viewpoints expressed in this study align with the existing literature. However, it is vital to acknowledge the

possibility of inaccuracies in the data extraction process compared to globally accessible materials. These limitations could have influenced our results.

This study aims to find the reasons behind women's choice to study science, technology, engineering, and mathematics (STEM), especially in the ICT sector at Higher Education Institutions (HEIs), based on the analysis of academic research. The study also aims to review and synthesize the challenges that women face in ICT and STEM studies and jobs. The research questions focus on identifying the current state of research on women in STEM, focusing on ICT, and finding why women choose or prefer not to study STEM subjects. A global shortage of STEM skills requires HEIs to recruit more students into STEM programs and produce enough STEM graduates to meet the demand. The idea is that this could be made more accessible by increasing the number of women in STEM programs. To achieve an increase in numbers, these programs need to be developed to be more appealing for women (Kovaleva, Kasurinen, et al., 2024), but at the same time, the interest in men to apply should not be negatively affected.

BACKGROUND

According to the level of economic growth and social development, the leading countries are those where women’s potential for contribution is optimized (Cuberes & Teignier, 2014; Moorhouse, 2017). When all genders have maximum chances to educate themselves and achieve their peak output for society, the country flourishes, as most of the intellectual capacity to innovate novel means of progress and prosperity is well utilized. More resources mean more potential (Herring, 2009; Joseph et al., 2021; Pearl-Martinez & Stephens, 2016). It should not surprise anyone that competition in the global knowledge economy will be won by countries, organizations, and coalitions that can maximize the balanced utilization of intellectual resources by people of all genders in the most ingenious and inspiring way.

The world is getting more job competitive. Students understand that the competition at Higher Education Institutions (HEI) is not about gender but competencies (Deloitte, 2017; UNESCO International Institute for Higher Education, 2021). At the same time, the world is getting "smaller" through the digitalization happening in every area of our society. Traditional companies transform from asset providers to knowledge companies (Kortelainen et al., 2019); artificial intelligence (AI) is used to improve global sustainability efforts (Ghoreishi & Happonen, 2020); and community wisdom is utilized to improve living conditions (Palacin et al., 2020). Digital design and additive manufacturing (Piili et al., 2013) are being used to mass-produce customized products, and even companies' human resources are being digitalized (Vatousios & Happonen, 2022). This global change results from more emerging technologies impacting our societies and humankind.

The current world is different from ten years ago. Multiple fields are transitioning towards cyber-physical and highly connected, even fleet-level systems, integrating physical, digital, and biological spheres. In this transition, industry 4.0 (Ghoreishi & Happonen, 2022) and rapidly changing technology and digitalization of our lives

have changed the industry and everyday life (Gradillas & Thomas, 2023). At the same time, the electrification of "everything" has, for example, changed our transportation system through electric vehicles (EVs) (Metso et al., 2020). These transitions go hand in hand with collaboratively created digital services, such as through University-Industry collaboration activities (Happonen et al., 2020). At the same time, new higher-level platform economies are built on previous generations' efforts in asset production (Metso et al., 2019). Overall, this transition highlights the importance of training the young population in coding (Ikonen et al., 2007), software, robotics, computer science, technology understanding, the role of social media in employment (Happonen et al., 2022), and digitalization in general. Thus, ensuring that society has new generations of qualified workforce ready to tackle future challenges is imperative for global development, not forgetting to train this new generation to understand the influence of digital transformation on technical career aspirations (Subasman & Aliyyah, 2023). Demand for software engineers is not slowing down; companies increasingly need a new workforce for digital transformations (Brenner, 2022). Statista predicts continued demand rise to persist in 2024 (Evans Data, 2022).

Digitalization and technological impact can be seen in the job market, business, education, and cities. The demand for STEM-related skills has already increased due to the advent of global technological progress (International Labour Organization, 2021; World Economic Forum, 2023). However, the ICT and STEM workforce is already currently projected to fall short (Deming & Noray, 2018) of educated talent, even when, year after year, increasing numbers of men and women strive to become STEM students (Leshner & Scherer, 2018; Masterson, 2021). On the other hand, even when enough students enter STEM programs, studies show that many switch to other majors (Arcidiacono et al., 2016; Griffith, 2010). Interestingly, more female than male college students tend to switch between STEM and non-STEM majors, both in and out (Chen, 2013; Ellis et al., 2016; Maltese & Cooper, 2017).

The study of the specifics of the professional trajectories for young people is based on a gender-based approach. Professional training and promotion of women on the career ladder should be carried out without discrimination based on gender. It should be based on providing boys and girls with equal rights and opportunities for their implementation in all professional fields.

According to research by Wang and Degol (2013) and the Global Gender Gap Report 2021 ordered by the World Economic Forum, despite the trend to increase the involvement of women in STEM, the share of women is still significantly less than men (Schneider, 2013; Wang & Degol, 2013). This situation is associated with many factors, both external and internal. For example, women still face biased attitudes and stereotypes about women in technology, for instance, biased recruiting processes favoring male candidates over equally or more qualified women (Carlsson et al., 2021; Reuben et al., 2014). On the other hand, some women have personal restrictions against applying to the field, e.g., internal fear of failing in STEM topics, since they view these fields as "hard" and "complicated" (Kennedy et al., 2018; Makarem & Wang, 2020).

Overall, the current significant men's dominance in ICT and STEM indicates that shifting the focus to women is more promising. To achieve a substantial increase in STEM graduates, more effort should go into recruiting female students into STEM programs, as pursuing male students to the same degree, who already dominate STEM studies, presents less of an opportunity for growth. Also, research on gender diversity has already shown that 1) added diversity increases innovation efficiency (Sulik et al., 2021; Xie et al., 2020); 2) female leadership is more appropriate in times of crisis (Comi et al., 2020; Fernando et al., 2020); 3) increasing the proportion of female directors also improves financial and environmental performance; women managers are keener on the social dimension and in engaging with stakeholders than male managers (Galletta et al., 2021); and 4) there is a positive and significant relationship between gender diversity and firm performance (Brahma et al., 2021; Wynn, 2020).

DATA COLLECTION & METHODOLOGY

Our literature analysis concentrates on the status of women in STEM in higher education based on the theory of gender norms embedded in the world, in institutions, and reproduced by people's actions (Cislaghi & Heise, 2020). The gender norms broadcast people’s beliefs and expectations (Kovaleva, Kasurinen, et al., 2024) of men and women in society. We have reviewed and analyzed the literature to discover reasons why women choose STEM studies at higher education institutions following a gender-based approach. The gender-based approach in the analysis of any activity assumes that the differences in the behavior of men and women are determined by sociocultural norms rather than their physiological or biological characteristics (Cislaghi & Heise, 2020; Taasoobshirazi & Carr, 2008). The following objectives were formulated based on the gender-based approach: What is the current state of research on women in STEM focusing on ICT? Why do women choose or prefer not to study STEM subjects? What are the challenges women face when deciding to pursue a STEM major?

Our review is primarily determined by methodology and orientation to selecting and analyzing theoretical sources. The review aims to identify the state of academic studies and research about women in STEM focusing on ICT, provide a general schematic description of ICT and gender imbalance, and synthesize the findings. The review is based on a methodology with a higher degree of elaboration of the search, analysis, and structuring of information than the narrative review, allowing for expanding the coverage of sources and introducing some consistency. The procedure is straightforward and does not have a multi-stage algorithm as a systematic literature review. The general steps of the review are presented in Figure 1.

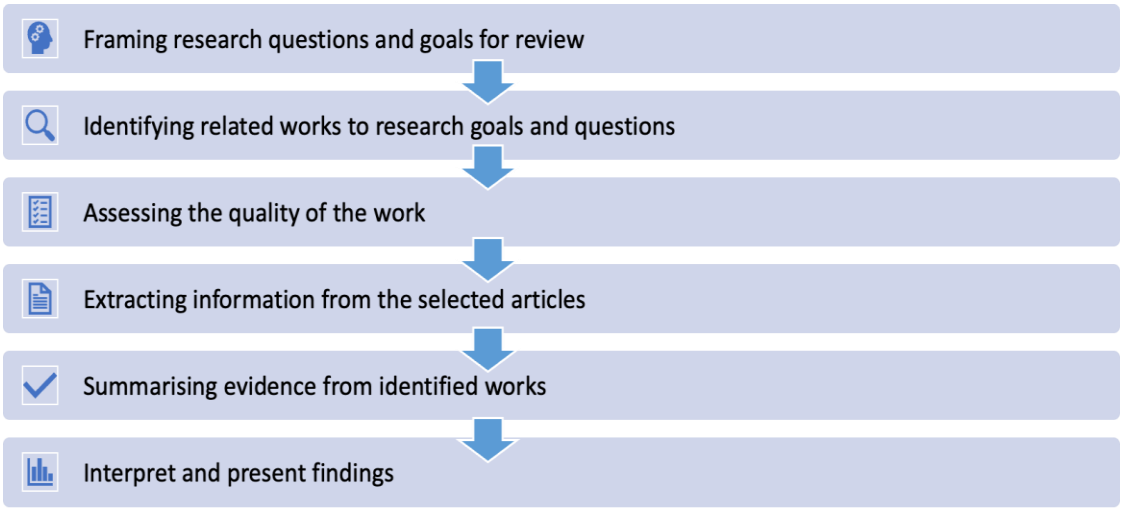

Figure 1. General steps of review

This paper provides an overview of how this topic is currently treated by researchers concerned with the status of women in ICT and STEM in higher education. To understand the interconnection and influence of the topic, papers from various fields, such as psychology, gender studies, cultural studies, education, science, technology, engineering, and mathematics, were selected. The paper aims to find the reasons behind women's choice to study in ICT, raise questions, bring problems to the fore, synthesize them, and illustrate how the field is developing. The study utilized ACM, IEEE, Web of Science, and Google Scholar databases for the focused literature review process. Academic peer-reviewed journals publishing English articles from 2010 to 2021 were considered. The year range was chosen due to the development in the ICT field, the effects of digitalization, and how it is reshaping ICT and STEM studies and considering how rapidly STEM, particularly computer science, is changing. Knowledge in this area needs to be updated quite fast. Master's theses and dissertations were used for information retrieval. Keywords we used for the search are STEM, women in STEM, computer science, gender, and gender imbalance. Themes also emerged around gender diversity, gender equality, challenges, bias, and women in science. Career choices, women in computing, stereotypes, family, identity, and self-esteem were also reflected in the literature.

Other literature reviews consider women in ICT and STEM in higher education, used for data analysis and as a foundation for the study conducted (Blackburn, 2017; Holanda & Da Silva, 2021; Kovaleva, Happonen, et al., 2024; Makarem & Wang, 2020). Literature search and analysis were used to understand women's reasoning in choosing ICT and STEM and to synthesize the challenges that are faced by women in ICT and STEM-related studies and jobs.

FACTORS THAT AFFECT WOMEN'S CHOICE OF STEM STUDY AND CAREER PIPELINE

The existing literature discusses different phases where the differences between women and men in STEMs could become (Speer, 2023) and points out three central

pillars that affect the number of women who choose to pursue ICT and STEM majors, namely: family, school or university, and culture (Alawi & Al Mubarak, 2019; Beyer, 2014; Bian et al., 2017; Cheryan et al., 2015; Griffith, 2010). In one example of an early childhood study, an experiment about toys targeted at either girls or boys was conducted in the UK (BBC News, 2017). The idea was to prove how much gender differences created by society affect how children are treated. The study swapped the clothing of boys and girls and invited adult volunteers to play with the children on the playground, where different toys were available. When volunteers were playing with a girl in a boy's outfit, they suggested and proposed toys that could be rotated to different orientations, such as cars, constructor toys, and dice. These toys develop children's spatial relations and motor skills (Casey et al., 2008). In turn, the dolls and soft toys were shown to the boy in a girl's outfit. Playing with these toys, girls develop social abilities when they style dolls' hair and put different dresses on them, pretending to make and serve tea. Therefore, volunteers showed vulnerability to gender-typed toys based on the perceived sex of the child. The studies claim this can be seen as a clear sex bias, starting in early childhood (Cherney & Dempsey, 2010; Davis & Hines, 2020; Hassett et al., 2008; Musto, 2019; Spinner et al., 2018; Todd et al., 2017).

Literature also mentioned the presence of role models, for instance, parents who inspire the development of their children and teachers who arouse interest in the child (Nugent et al., 2015; Thomas, 2017). Previous studies claim that a real world-famous woman example or close relatives with ICT and STEM field success increase women's chances of pursuing a degree in the same field (Black et al., 2011; Canaan & Mouganie, 2021; Cheryan et al., 2011). Generally, any role model the child looks up to, speaks well of, and respects has significant influence. This is further exemplified by the modern phenomenon of "social media influencers." Girls on Instagram and YouTube promote STEM studies and careers by their example[1]. They can become role models for some children, and children see that it is possible to pursue ICT and STEM studies. Nevertheless, there are influencers with millions of followers who disseminate their ideas to their viewers and provide recommendations. One tricky part of that phenomenon is that some of these influencers have strong opinions and points on some selected things, with little knowledge and life experience to support those views. We should remember that being an influencer is definitely not the same as being neutral and expert on some topic (Belanche et al., 2021).

This part of our review has focused on the theoretical background and has demonstrated the complexity of the phenomena that influence the preliminary professional choice of young people. In most cases, the decision about the future career direction is due not to one predictor alone but to their combination. According to the literature studied (Makarova et al., 2016; Olmedo-Torre et al., 2018; Salmi et al., 2016; Simon et al., 2017), girls choose STEM specialties based on the assessment of their abilities in mathematical sciences (made by them or others) (Ayuso et al., 2021; Ellis et al., 2016), the popularity of the program and possible prospects, or how relevant and complex the program is. In addition, an

[1] For instance, some STEM influencers on Instagram and YouTube are @nmpanek, @astronautabbyofficial, and @misstechqueen.

essential factor in planning was the presence of an "example" or someone who has already worked or is working in the professional technical field (Cheryan et al., 2015). It is also worth mentioning how the availability of training or partial funding grants can influence the decision-making process (Olmedo-Torre et al., 2018), for example, when the family does not have a sufficient budget to cover the desired education in the ICT field.

In light of the existing research reviewed, it is clear that their parents are key actors in engaging girls. Parents significantly influence their children, and this influence grows through interactions between parents and children in society and culture (Nugent et al., 2015).

Challenges faced by women in considering ICT and STEM studies.

Women are more prone to face career challenges due to the acute shortage of time when combining family and work (Abele & Spurk, 2011; Squicciarini, 2018). They are often given administrative and services work in academia, leaving little time for research, which is crucial to promotion (Ashencaen Crabtree & Shiel, 2019; Guarino & Borden, 2017).

Analyzing indirect factors influencing women in ICT and STEM education and employment is necessary. This includes the strength of the impact of gender stereotypes, which can be called the degree of gender climate, and some specific "features" that generate stereotypes.

It is worth noting that stereotypes can sometimes be helpful, not just threats. This concept applies not only to gender stereotypes but also to any other. For example, stereotypes can be beneficial when we need to assess how unknown people may behave quickly or when we are trying to study how large groups of people, in general, differ from each other. This function helps to assess an unknown situation quickly. However, this is the paradox of stereotypes and gender stereotypes in particular. Stereotypes are harmful when we must accurately assess a person's potential or the characteristics of some specific group of people.

The main impact of gender stereotypes is the limitation of human potential. When a man is socialized in the so-called man's box, a set of defined "manly" expectations, perceptions, and behaviors, he has few opportunities in life and options for further development (Alsawalqa et al., 2021). If we imagine the following case, a boy wanted to become a manicure specialist from childhood, but messages were sent to him from all surroundings, saying that this was not normal and was not a man's job. However, normality was based only on social stereotypes about what a man should be (Hentschel et al., 2019).

Stereotypes perform a double function. On the one hand, they make it easier for us to understand social reality; on the other hand, they limit our potential. Following social prejudice, we see the uneven participation of men and women in the development of technical sectors; representatives of different social sciences call such phenomena the prevailing gender stereotypes (Cech, 2014; Miller et al., 2015). In some countries, despite the centuries-old presence of women in technical

sciences, women are perceived as incapable of mathematics and exact sciences. Public opinion remains popular that working in engineering/technical industries is not a woman's business. There are several well-known expressions, such as "women lack ability in spatial thinking" and "female logic," which represent stereotypes about the impossibility of the entire presence of women in STEM (Alfrey & Twine, 2017; Beasley & Fischer, 2012; Cheryan et al., 2009; Leslie et al., 2015). Stereotypes play a role in forming self-esteem and developing an interest in STEM when choosing a field of education (Casad et al., 2019). Studies have shown that stereotypes about women's inability to do mathematics can reduce women's interest in studying computing-related disciplines (Cheryan et al., 2015; Simpkins et al., 2006).

Additionally, the typical length of the working day can be problematic for women due to the stereotypical idea that all household chores, especially caring for children and their upbringing, should be on women's shoulders and double the burden (professional and domestic work) — this is the tradition for many women (Jackson, 2017). For example, studies show that women with children work fewer hours in STEM fields than men, as they must return home and do household chores (Rhoton, 2011). Women tend to take breaks in the academic pipeline for similar reasons: caring for children and doing chores (Mavriplis et al., 2010). According to the studies of Baxter et al., the families analyzed in their paper are shifting to the more traditional division of chores and work related to the home and child (Baxter et al., 2015). In this regard, a woman’s excessive employment at work negatively affects the time spent at home and the performance of duties regarding family and children (Fatima et al., 2019). Most women are willing to leave their jobs in STEM fields for family (Barth et al., 2016). It is difficult for women who work in STEM fields and take care of the family to achieve the same level of productivity as men, as women are expected to care for children (Barth et al., 2016; Cech & Blair-Loy, 2019; González Ramos & Bosch, 2013). In addition, areas that are constantly developing, like technology, require constant improvement in employees’ skills, which is problematic for women when they go on parental leave or take sick leave to care for children. In a UK government study, 26% of men versus 13% of women were promoted or upgraded their jobs within five years of having a child. They found that women were likelier to change a full-time working pattern to part-time or not employed within five years of giving birth (Harkness et al., 2019; Landais et al., 2021). These reasons slow down their promotions and career paths; therefore, women might not have the same chance to work more if they wish.

On the other hand, Kate White, in her book, highlights that more fluid roles for women and men are emerging, and both younger women and men reject overt gender discrimination (White, 2014). Anyway, working more hours should not be the goal in society; we should work intelligently and automate more tasks. The challenges discussed above are summarized in the following Table 1.

Table 1. Identified stereotypes that create challenges for women in considering ICT and STEM studies and jobs.

ID#	Challenge	Explanation of Formation
1	STEM is not a woman's business (Alawi & Al Mubarak, 2019; Kretschmer & Kretschmer, 2013)	Perhaps the most substantial prejudice has been hammered into our heads for centuries. Society has long believed that the purpose of women is in the birth and upbringing of children and the maintenance of everyday family life.
2	Women are likely not to finish STEM studies (Beasley & Fischer, 2012; Maltese & Cooper, 2017)	Recent research shows that girls are less likely to complete an engineering program (Griffith, 2010). Nevertheless, boys are determined to take an entire course in computer science.
3	The trap of social bias (Blackburn, 2017; Nugent et al., 2015; Reuben et al., 2014; Thomas, 2017)	Long-term progressive uncertainty of women's mathematical abilities can be explained by analogy with poisoning – it enters the body and slowly starts to kill human cells. The most important institutions of society - family, school, work, and profession - are highly gendered. Constantly hearing derogatory judgments addressed to them, representatives of these groups begin to experience a complex set of feelings. On the one hand, they are hurt. On the other hand, they are afraid to confirm stereotypical ideas with their example.
4	School disappointment (Ellis et al., 2016; Sahin & Waxman, 2021; Thomas, 2017)	Mathematical thinking in children of both sexes develops similarly. Moreover, it is appropriate to speak not about differences but the similarities in children's mathematics comprehension. Women can lose interest and confidence in mathematics. There can be many reasons for disappointment in the exact sciences: the program's complexity, poor teaching of the subject, fatigue from school, and the reputation of mathematics as a "boring" subject. It can lead to fewer women in ICT and STEM studies (Ellis et al., 2016; Sahin & Waxman, 2021).
5	Expectations from women to take care of children (Barth et al., 2016; Cech & Blair-Loy, 2019)	In a more traditional division of household chores, the woman is seen as a housekeeper and primary child carer. It leads to less work time due to these home-related activities. She cannot stay late at work or work on weekends, so it becomes difficult to achieve the same level of productivity as men.

DISCUSSION

This study focused on two main aims: 1) to identify specific reasons for women to refrain from choosing STEM, especially ICT sector-related study lines at HEIs, and 2) to synthesize the challenges women face in their studies and career paths. Several studies (*CHOICE Project*, 2021; McKinney et al., 2021) have already analyzed why women choose and do not choose ICT studies in STEM and how gender bias affects their future lives. As noted in the experiment about the 'girl' and 'boy' toys conducted in the UK (BBC News, 2017), women can easily face stereotypes from childhood and then in school or college. The literature we reviewed states that factors such as opinions and mindset-related views from teachers and study counselors about a woman's skills can lead to unfavorable circumstances that will negatively influence her decision to select further educational paths from the technical field. For future studies, it would be important to look further into modern sustainability development, creative technologies, and the diversification of ICT and STEM jobs connected to gender balance levels. The landscape of job skills (Happonen, Manninen, et al., 2021), knowledge, and client interests are changing simultaneously. The world is experiencing global crisis, wastefulness, (Zaikova et al., 2022) and environmental impacts, (Tereshchenko et al., 2023) sustainability problems (Happonen, Osta, et al., 2021), which will change the socio-technical, skill-bias and political economy perspectives related job descriptions in these fields. Studies have shown that sustainability, social contribution, and jobs are essential for female engineering field students, which could indicate a rising number of applicants in the near future if these developments toward Employment 5.0 (Kolade & Owoseni, 2022) continue.

Then, while studying at university, female students who do choose ICT and STEM studies begin to experience a discriminatory attitude towards themselves and their choice of studies (Wang & Degol, 2013). When a young person builds their future career and professional self-image at the university level, teachers' feedback, support, and guidance are important to healthy and positively progressing development (Thomas, 2017). Currently, a wide range of different sorts of teacher opinions seem to be visible in daily university life. Teachers' opinions fluctuate from side to side (Thomas, 2017). Some can be condescending, supporting the desire of girls to study complex "male" disciplines. On the contrary, others do not hide their stereotypes regarding female professions. For a successful ICT and STEM career, women often have to put more effort into tasks and show outputs to be evaluated as professionals and promoted up the career ladder (Barth et al., 2016; Cech & Blair-Loy, 2019; González Ramos & Bosch, 2013).

Our analysis of previous research shows that the stereotypes expressed in the remarks of teachers, professors, colleagues, and bosses whose paths crossed a woman played a significant role in her choosing a career and educational trajectory in STEM. As shown in Table 1, the five most common stereotypes faced by women are "STEM is not a woman's business (Alawi & Al Mubarak, 2019; Kretschmer & Kretschmer, 2013)," "women are likely not to finish STEM studies (Beasley & Fischer, 2012; Maltese & Cooper, 2017)," "the social bias's trap (Blackburn, 2017; Nugent et al., 2015; Reuben et al., 2014; Thomas, 2017)," "school disappointment (Ellis et al., 2016; Sahin & Waxman, 2021; Thomas, 2017)," and "expectations

from women to take care of children (Barth et al., 2016; Cech & Blair-Loy, 2019).” These stereotypes will play their part later when justifying women's accepted career paths. However, when selecting a future specialization, the child's upbringing, the family that brought them up, and the traditions they inculcated in that child are much more important than their gender.

CONCLUSION

This review article has outlined the different aspects of the multifaceted gender challenge and has brought issues and debates to the fore. We have emphasized the reasons and difficulties women face when choosing an ICT and STEM major. However, there are still many open questions and research areas about how to deal with these stereotypes regarding HEIs, for example, what sort of solutions can be provided, especially when looking at different cultures and traditions.

Our work adds to the discussion on the challenge of the low involvement of women in knowledge-intensive and technological professions. The importance of this specific challenge is underscored, e.g., by the fact that UNESCO prioritizes solving the matter and levitating the level of related issues, as seen in UNESCO for the EQUALS Skills Coalition (West et al., 2019). Also, as part of the bigger picture, women's involvement in science, technology, engineering, and mathematics (Miller et al., 2015; Wang & Degol, 2017) could be higher because diversity matters. To effectively address global crises that threaten the future of humanity, including population growth and climate change, it should be evident that we need as many culturally, educationally, gender-based, and experience-based diverse lines of thought and viewpoints as possible. We must invite and train new generations of diverse and qualified specialists capable of responding to these environmental and technological challenges. We have a better than ever chance to solve our complex global challenges through comprehensive and diverse insight, discussion, and resource focus in the right direction. Recognizing the principles of a sustainable technological transition to a new digital society, we have focused on the problem of how to enable active, involved participation of female students in HEI in choosing and studying STEM. As a plan for future studies, we seek to have the opportunity to give recommendations for HEI on how to attract women for STEM majors and explore other gender biases specific to location and ethnicity. We also suggest future research to explore challenges combining demanding careers and parenthood. Research could be extended to consider the analysis of gender biases based on location, ethnicity, and geographical affiliation and what can be done by the HEIs to overcome stereotypes.

To sum up, many studies have shown that the joint work of men and women on scientific and engineering projects is much more productive than a single-sex team. Mixed teams offer a field for more innovative ideas, and gender-balanced companies are significantly more successful than their peers (Thompson, 2015). Diversity can become the key to a successful future and a strong economy with adequate and proper education, and the current state of ICT education lays the foundation for that future.

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