BARRIERS FOR FEMALES TO PURSUE STEM CAREERS AND STUDIES AT HIGHER EDUCATION INSTITUTIONS (HEI). A CLOSER LOOK AT ACADEMIC LITERATURE

Elizaveta Tereshchenko[1], Ari Happonen[1] and Victoria Hasheela-Mufeti[2]

[1]LUT School of Engineering Science, LUT University, Lappeenranta, Finland, Lappeenranta Campus, Yliopistonkatu 34, 53850 Lappeenranta, Finland.
[2]School of Science, University of Namibia, Windhoek, Namibia.

ABSTRACT

Background and context*: Even when the modern world is transitioning quickly into the digital age, the gender gap continues to be more acute. Social scientists note the low number of women in Science, Technology, Engineering, and Maths (STEM) as a scientific, creative, economic, and innovative potential loss. The importance of women's participation in technical sciences and technical production is also recognized as a factor for stable social development.* ***Objective and method:*** *A scoping review has been conducted to study females' reasonings and society-based explanations for females to choose STEM studies at the Higher Education Institutions (HEI) level. The goal is to understand the reasons for the low number of females in STEM careers related to education in STEM and to reveal the underlying phenomenon.* ***Results:*** *The gender attitudes and stereotypes inherent in boy and girl children's spare time and school life narrow the children's possibilities from what specific education and career direction they can choose. But only a few genetics and physical differences could postulate and explain this status quo. Humans have formed a particular social framework; in the process, we have socialized childhood and education. When choosing a future specialization, the society in which the child grew up, the family that brought him up, and what traditions they invested in are much more important than his gender.* ***Implications:*** *Based on our results, we summarise the scattered knowledge base and utilize the analyzed summary for recommendations to further the development of HEI programs to make them more fitting for both genders and help reduce the gender gap. The universities should cover the achievements of females, more often in their media channels, related to the previously mentioned interest in STEM, based on the presence of a role model. When choosing a university, girls can see a real example and be inspired to study STEM majors.*

KEYWORDS

Gender Gap, Female in STEM, Computer, Science, ICT, IT, Gender Inequality, Underrepresentation of Women, Gender Balance, Education Balance, Gender Bias, Diversity, Equal capabilities, sustainability.

1. INTRODUCTION

The world is constantly getting more gender-neutral [1], and males and females are starting to have relatively equal chances to study the most attractive education programs. At the same time, our world is getting "smaller" through digitalization, which is happening in every area of our society. Traditional companies transform from asset providers to knowledge companies [2], artificial intelligence (AI) is used to improve global sustainability efforts [3], community wisdom is utilized to improve living conditions [4], digital design and additive manufacturing [5], [6] are being utilized to produce mass customized products, and even human resources in companies are

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digitalized [7]. This global change results from more emerging technologies impacting our societies and humankind. The current world is different from the one we had ten years ago. Multiple fields are transitioning towards cyber-physical and highly connected systems, integrating physical, digital, and biological areas. Industry 4.0 [8] and rapidly changing technology, digitalization, and general electrification of our lives (e.g., electric vehicles (EV) [9], collaboratively created digital services [10]–[13] and high-level move towards platform economies [14]) highlights the importance of training the young population on coding, software, robotics, computer science, technology understanding and understanding of digitalization in general. Thus, ensuring that society has new generations of qualified workforce ready to tackle future challenges is imperative for global development. Digitalization and technology's impact can be seen in the job market, business, education, and cities. It has already led and will continue to increase the demand inside the job markets for Science, Technology, Engineering, and Math, including Computer Science (STEM) related jobs, as part of the advent of global technological progress. However, the STEM workforce is already currently perceived to be in short supply [15] of educated talents, even when more and more men and women strive to become STEM-significant students yearly [16], [17]. On the other hand, even when the number of students is enough, literature claims that STEM students exit colleges and universities, switching to other majors or dropping out of college without a degree [18], [19]. Interestingly, more female college students tend to change majors from STEM to a non-STEM field [20]–[22].

Society can benefit from diversity. Firstly, research on gender diversity has shown that diversity increases innovation efficiency [23]. Secondly, female leadership is more appropriate in a crisis [24]. Thirdly, increasing the proportion of female directors also improves financial and environmental performance. Female managers are keener on the social dimension and engage with stakeholders than female directors [25]. Finally, a positive and significant relationship exists between gender diversity and firm performance [26]. Multiple studies discuss gender inequity and imbalance in the STEM job market. Besides, many researchers discuss gender gaps, stereotypes, and biases [27]–[29]. Indeed, the current topic has been widely discussed in academia and business. However, only a few studies provide recommendations for Higher Education Institutions (HEI) to deal with the stereotypes and biases and not fall into their trap. Thus, the study aims to find academic research explaining females' reasoning for choosing and not choosing STEM studies at the HEI level, to summarise the current somewhat scattered knowledge space, and to utilize the analyzed summary for recommendations to further the development of HEI programs to make them more pleasing for both genders. In other words, the global need is to receive more STEM graduates, and the hypothesis is that this would happen easier by increasing females in STEM major study programs. These programs need to be developed to be more appealing to females, but at the same time, the male's interest in applying should not be negatively affected. The programs should be gender-neutral, inclusive, and an exciting option for late teens to pursue.

2. METHODOLOGY

The research utilizes scoping literature review and aims to achieve an in-depth understanding of the researched phenomena through peer review academic research publications. The chosen methodology to conduct the academic publications screening, selection, and review was a scoping literature review, which was used to gain more profound knowledge in the field of gender in STEM and to get insights into the current trends and predicted/predictable possible future challenges [30].

The scoping study followed these five main steps [30], [31]:

1. Identification of the research questions.
2. Locating the relevant studies from well-established electronic academic materials databases, such as Scopus and Google Scholar.
3. Selection of studies relevant to the set research questions, with a predetermined inclusion criterion(s): focus on computer science/IT field and exclusion criteria(s): mechanical and civil engineering medicine and biology fields.
4. Extracting and organizing the data, selected from the found literature providing databases and deemed relevant for the study.
5. Summarising the findings and reporting the results.

This scoping review included a literature search in Scopus and Google Scholar, including studies from 2011 until 2021. The literature was collected using search terms in three supportive key area groups. Keywords looked for in the selected literature in the first group were: women, female, and gender. The second group, defined as an area of research, included the following keywords: computer science, STEM, technology, ICT (Information and Communication Technologies), and information technology. The third group was to focus on publications related to females in technical fields and education areas, including keywords: female students, women in computer science, women in STEM, education, and academia. The articles were included based on the titles, so this scoping study is less exhaustive than a full systematic literature review would have been. The papers were subsequently discussed as part of the selection process, and a selection consensus was made between all three authors. As per the selection rules, peer-reviewed articles that met the following inclusion criteria were identified for the review: (a) published in English; (b) during the decade from January 2011 to December 2021; and (c) with a focus on females' students in Computer science, STEM, technology, ICT (Information and Communication Technologies) and information technology limited to school students and university students. We excluded articles involving mechanical and civil engineering, medicine, and biology to focus on technology fields, where a person's physics has minimal to no effect on the ability to work in the field. Also, mainly because of the current fast-phased global digitalization [8], [32]–[39] of everything [4], [5], [40] and labour shortage in ICT fields. In addition, to have a general focus on STEM, the authors also have a more specialized look at the computer science and IT field, considering the high speed of digitalization the global economies are currently going through. Considering the topic's heterogeneity and the interconnection and influence of gender, the author reviewed papers from various fields, such as sociology, psychology, education, and cultural studies.

The study aims to scope the current research on females' experiences in STEM fields and generate literature findings-based recommendations as an output of the scoping study analysis for HEI programs to attract more female students. With this aim, the authors considered the academic literature focusing on the gender gap in computer science and IT and current researched explanations of why women are underrepresented in STEM in most societies. We studied gender stereotypical differences and different societies, cultures and studied program social biases studied as academic research. Accordingly, based on the set goals, the following research questions we formulated to guide the study:

- What are the underlying reasons for females to choose or prefer not to study STEM subjects in HEI environments?
- How can an HEI unit increase the share of applicants and the number of females in their study programs?

To answer to the first research questions, we have studied academic literature about boys' and girls' interaction with society from early childhood. It was essential to learn at which stage of the maturation the interest in STEM and stereotypes about abilities are created. Significantly, the role of parents, coaches, and teachers was analyzed in this study. The second research question explored opportunities for HEI units to increase female applicants and students. Thus, to answer it, we have explored current practices to increase students' interest in the educational offering of STEM programs. The section "Results and findings" answers the research questions. The subsection "STEM pipeline from childhood to young adults" answers in to the 1st research question as do the "World situation for women's employment in STEM". Recommendations for the HEI to increase female interest subsection continues to add depth on answering to the last research question.

The general results were summarised concerning the following gender imbalance themes: (i) An overview of the female path into the STEM field, (ii) the emergence and categories of biased attitudes and stereotypes, and (iii) the consequences and effects of stereotypes as barriers and motivational sources for STEM studies or career.

3. RESULTS AND FINDINGS

All source materials are highly academic, and all selected studies were journals, conferences, and book chapters publications, published in high-quality peer-reviewed journals. Moreover, our study used numeric statistics data from open sources for available countries [41]–[43]. All the sources describe the methodology of how the data was collected and how the analysis was performed. Besides, we have used official statistical databases as information sources, databases such as Eurostat for European countries [42], Statistics Finland for Finland [43], and Rosstat for Russia [41]. We also analyzed the numeric data to map the big picture and show the current state of gender equality. In our analysis, we looked for evidence and explanations for gender gaps in different countries, especially those connected to higher education institutions and STEM-related careers. These analyses were conducted to identify and compile the critical factors of the gender gap challenges and problems connected to HEI-level education. The findings on primary data collection are presented in chronological order.

Beyer's study tackles women's representation in computer science (CS) and explains various factors influencing choosing a CS course in the USA. Stereotypes, self-efficacy, values, interests, and predictors were investigated in data from American first-year college students. Using data, the authors answered why women are underrepresented in Computer Science [27]. The article reveals women's challenges when pursuing a career in science and shows women's retention in the USA [44]. By exploring the effects of stereotype activation and anticipated effect on women's career aspirations, the study [45] confirms that women still face stereotypes in STEM fields in Germany and Norway. It can be one of the reasons why they do not choose STEM-related fields as a future profession.

The authors studied current knowledge, implications for practice, policy, and future directions for the gender gap. Females are striving to occupy biology, medic, and health fields. They continue to be underrepresented in the most mathematically intensive STEM fields. This article reasons that females are underrepresented and highlights factors affecting their STEM share in the USA [46]. The authors conducted a gender analysis of the occupational pathways of STEM graduates in Canada [47]. They studied the situation of women in STEM in Canada. Generally, male STEM graduates were more likely than female STEM graduates to be employed in a STEM occupation. Research confirms that the occupational pathways of male and female STEM graduates also differed. The authors studied how gender diversity in STEM can positively influence and create a more sustainable future [48]. Evidence from Spain from the paper shows that women enroll in

STEM disciplines in a smaller percentage than men, especially in Engineering-related fields. The authors suggest increasing the number of women studying and working in STEM fields to achieve better solutions to global challenges.

Although some available data show a high proportion of women in Latin American university education, they are still a minority in STEM programs. García-Holgado et al. studies ways to engage more women in STEM in Latin America. The study on gender equality in STEM programs [49] aims to provide a proposal to analyze the situation of a university regarding the gender gap as a first step to defining gender equality action plans focused on processes of attraction, access, retention, and guidance in STEM programs.

The authors qualitatively explored women's experiences studying computer science at university in the UK [50]. The research conducted in 8 universities in the UK shows that early exposure to computers and the culture can affect female engagement and confidence. Besides, competition, mastery, and self-directed learning do not always appeal to students. The most recent paper published by Speer claims is no single stage to focus on in understanding the gender gap in STEM [51]. Therefore, our study aims to focus on and systematize the female path from early childhood to entering the job market.

These studies show evidence that the studies reflect the relevance of the topic and that research on this topic has been carried out in several countries. Thus, it can prove the theory of the multinational and international foundation of the gender gap problem. We have found more research from the USA; it can be explained either by many universities presented there or the awareness of the topic. Also, our results indicate an apparent gender inequity in STEM. To solve this problem, the studies mentioned above highlight that it is necessary to create equal conditions for men and women when entering university or holding positions, including top management positions. These conditions should allow the possibility of occupying a particular place based only on the applicant's professional qualities, which directly determine the effectiveness of their future activities.

This study is based on an academic literature review, and personal views from large-scale surveys are not reflected in this research publication. The materials processed cover only publications written in English; opinions published in the native language in national publication forums were not processed in this article. An assumed Western cultural background in the paper can limit the studies.

3.1. STEM Pipeline from Childhood to Young Adults

As a term, STEM pipeline describes a journey from an early interest in STEM to pursuing the desired field of study and career path in STEM [52], [53]. In the following section, we will present the academic research-based explanation of gender stereotypes and social biases' formation from early childhood to the start of HEI studies, which could explain the reasons and roadblocks for entering to STEM pipeline.

Nowadays, countries that have had the ideology to limit the role of women in society to motherhood and family responsibilities are a rarity, which means the education environment has men and females alike in their education programs [54], [55]. There are workshops, hackathons, scholarships, and meetings for women, like males, to support both genders' progress in many social and work-life areas. According to the level of economic growth and social development, the leading countries are those where the human potential of women has the most opportunities for disclosure [56], [57]. When both 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 new novel means of progress and prosperity is well utilized. Everyone can master any profession they want if their physical attributes and previous success in studies grant them the study place. Several countries concentrate their efforts on expanding the competencies of young people in STEM) by creating engaging projects, such as “Choice” and “My World of Work Live!” [48, p. 4], [58]–[61]. The need to “pull up” women are no more at the discussion level; specific programs and implementations are ongoing. There has been a shortage of students in STEM compared to how much and how far our society is constantly going in digitalization, robotization, automatization, and technology utilization. Software is seen every day, everywhere, and in everything nowadays. Humans use devices every day, both in private and business life. Also, automatization and robotization (both software and hardware robotics) are rising [62], [63], so we need more developers, machine builders, and maintenance specialists with technical skills and installation processes. More resources mean more potential [64]–[66], so it should not be a surprise to anyone that the competition in the global knowledge economy will be won by the countries/organizations/coalitions which can maximize balanced utilization of both genders' intellectual resources in most ingenious and inspiring ways.

The problem of the gender gap in the STEM field is a real concern for scientists in multiple countries [27]–[29]. According to a study by Wang and Degol (2013) and the Global Gender Gap Report 2021 performed by the World Economic Forum, despite the trend to increase the involvement of women in STEM, the share of females is significantly less than males [67], [68]. This situation is associated with external and internal factors. For example, women still face biased attitudes and stereotypes about females in technology. On the other hand, some women fear that they will fail in STEM because these fields are positioned as “hard” and “complicated” [69], [70].

Currently, we still have many STEM studies areas in education, which are male-dominated zones, and these are male-dominant not because of apparent physical strength [71], [72]. For instance, it can be educational paths aimed at intellectually based careers: politics, management, leadership, finance, banking, insurance, architecture, and medicine. It applies some requirements for applicants and students in the related programs. In the case of highly physically demanding traditional occupations, gender-based differences are expected to be visible based on male and female genetics-based physical differences. However, gender bias is present in STEM, where physical advantages are irrelevant. Women are not seen as professionals due to the stereotypes with more masculine attitudes in STEM, in contrast with feminine professions, for example, helping people or caring for children (Yang & Barth, 2015).

It can be noted from the existing literature that three giant pillars affect the number of women who choose to pursue STEM majors, namely: family, school/university, and culture [19], [74]–[76]. As an example of early childhood, we would like to introduce the experiment about girl and boy toys conducted in the UK [77]. The idea was to prove how much gender differences created by society affect how we treat kids. They changed the boy and girl outfits and invited the volunteers to play with them on the playground, where different toys were available. When volunteers played with a girl in a boy outfit, they suggested developing toys such as cars and constructors and playing dice. The dolls and plush toys were shown for the boy in a girl outfit. The studies claim that it can be accepted as gender bias which starts from early childhood [78]–[81]. One of the most extensive effects of overcoming such bias could be separating boys and girls from each other. The study by Park, Behrman, and Choi has revealed that single-sex schools or classrooms excel in STEM students’ outcomes, particularly for female STEM students [82]–[84]. They do not get much exposure to subtle behavioral differences and social distractions, and females do not need to compete and be compared with males [85].

Another factor that we found in the literature is the presence of role models. It can be parents who inspire the development of the children or a teacher who raises interest in the child. Previous studies claim that real-life examples of famous women or close relatives who succeeded in STEM increase females' chances of pursuing a degree in the same field [86]. Generally, any role model the child looks up to and who speaks well about anything has significant influence. One good example is the recent phenomenon of “social media influencers”. They have millions of followers and dope in their ideologies for those who watch what they do and recommend. One tricky part of that phenomenon is that some influencers have strong opinions and points on selected topics, with little knowledge and life experience to support those views. Young people who follow them do not have enough neutral data to consider what has been presented and decide whether it is a) proper, b) correct in their living and cultural context, and c) even correct and sound in the society they live in. Nevertheless, there are examples of successful women in STEM promoting the STEM industry with their example [87].

The unpopularity of STEM among girls could primarily be due to the cliches of mass consciousness. “Boring”, “too complicated, “obscure” are what the commoner says about these disciplines [88]–[91]. Moreover, schoolteachers have varying levels of expertise, experience, tools, and resources to captivate teenagers towards STEM studies, which might not be as “sexy” as, e.g. musicians' career and rock stars, or athlete and word class player status in NHL or an author and status as a world-class influencer.

The summarization of the findings regarding the age group of the children highlights the influence of stereotypes or social interaction in Table 1. Socialization or social interaction is the process of personality formation and assimilation by an individual of values, norms, attitudes, and behavior patterns inherent in each social group. Socialization occurs when a child meets other people and gradually learns the rules (spoken and unspoken) adopted in this community. The summary of the children’s age group and gender stereotypes is shown in Table 1.

Table 1. Summary of the children’s age group and gender stereotypes

Age group, years	Place/Influencer	Findings
Toddlers or babies aged 0-3	Nursery, nursery teachers, and parents	Most often, when parents find out the sex of their unborn child, they start buying things of a specific color. Our society has established that a boy must grow up in something of blue shades, and a girl, like a little princess, should be dressed up in all pink. As presented in the BBC experiment, in early childhood age, adults tend to give children gendered toys [77]. Therefore, our closest surroundings create social norms and rules as children explore and learn about the world.
Young children aged 4-8	Kindergarten, kindergarten teachers, sports coaches and art mentors, parents, cartoons	Children start to visit the kindergarten and first year of school. They begin to socialize and interact a lot with peers. At this age, the influence of the children is still quite significant, as they are the closest adults to a child and become role models. The stereotypes are the same as in the previous stage; the difference is the child has more socialization with peers.
Early teens aged 9-12	School, art and sports schools, teachers, sports coaches and art mentors, parents, friends	This age is about growing, school, and teacher influence. The presence of role models is identified around those ages [92]. For example, the boys look at the brave firefighters and want to become the same fearless, stern, and restrained individuals. The girls will admire the Disney princesses from cartoons that promote gender-stereotypical behavior [93]. At this age, children attend clubs and explore new hobbies. The views and social norms of the hobby or club mentor start influencing the children’s values.

Teenagers aged 13-17	School, art and sports schools, teachers, sport coaches and art mentors, parents, friends Social media, famous people	The stereotype that “STEM is not for women” can be expressed at school [68], [94]. Teachers should not focus on the best abilities of boys compared to girls in mathematics or physics. Teachers who did not represent this stereotype but, on the contrary, showed gender neutrality played an essential role in the girls’ choice of a technical educational trajectory. Communication with teachers who influenced children’s choices when entering the institute is crucial, as a teacher is a role model for a child. The influence of parents, teachers, and peers’ attitudes could strengthen or debunk the stereotypes of teenagers, as the presence of role models is still significant.
Young adults aged 18-21	University, work, professors, colleagues, friends	Young adults' have settled opinions and views on various aspects of their life and future. They are often subjected to move, to study in a new city with a university. A new environment can bring unique views and no bias, shaping their established opinion. On the other hand, socialization is an ongoing process, and at this stage in life, young adults meet new friends, professors, and colleagues. It can be other beneficial communication to mitigate views on gender stereotypes or, on the contrary, strengthen them.

A person has been socializing all his life to a certain degree. Significantly, when he changes his environment, he faces new normality, but the basic norms and guidelines are laid down in our childhood [95]. For example, when he moves to another city or country or gets admitted to a new school or university, he is vulnerable to a new culture and social norms. He acknowledges that some “good” standards from previous times are not accepted in the new environment. Parents and other adults deem different sources of biases essential to the child, such as teachers and mentors in sports teams. Stereotypes are broadcasted in books, cartoons, and the media [93]. They are always present in the information field where the child grows [96]. Thus, tracking bias in the person's everyday life helps create a neutral and unequivocal environment. From all points above, we should highlight that we should engage females and parents and not fall into biased opinions. Everything starts with parents who significantly influence their children and the society and culture they interact with.

3.2. World Situation for Women's Employment in STEM

According to the International Labor Organization, the share of women employed in STEM is highly variable, from 10% to 56% of total STEM employment. For instance, in Georgia, women make up over half of those employed in STEM – 56%. In the US (United States), they make up around 48% of the category. The proportion is 40% in the UK – close to the median of 38% – while 35% in Austria. The worldwide map can be seen in Figure 1. It shows the share of women working in STEM fields in 2020. Data was collected in February by the International Labour Organization. The legend read as follows: green is 46%-56%, light green is 41%-45%, yellow is 36%-40%, orange is 31%-35%, light red is 21%-30%, and red is 10-20% of female share in STEM. The data source [97] describes the methodology for deriving data, but the authors did not collect it. The information was used for interpretations and analysis.

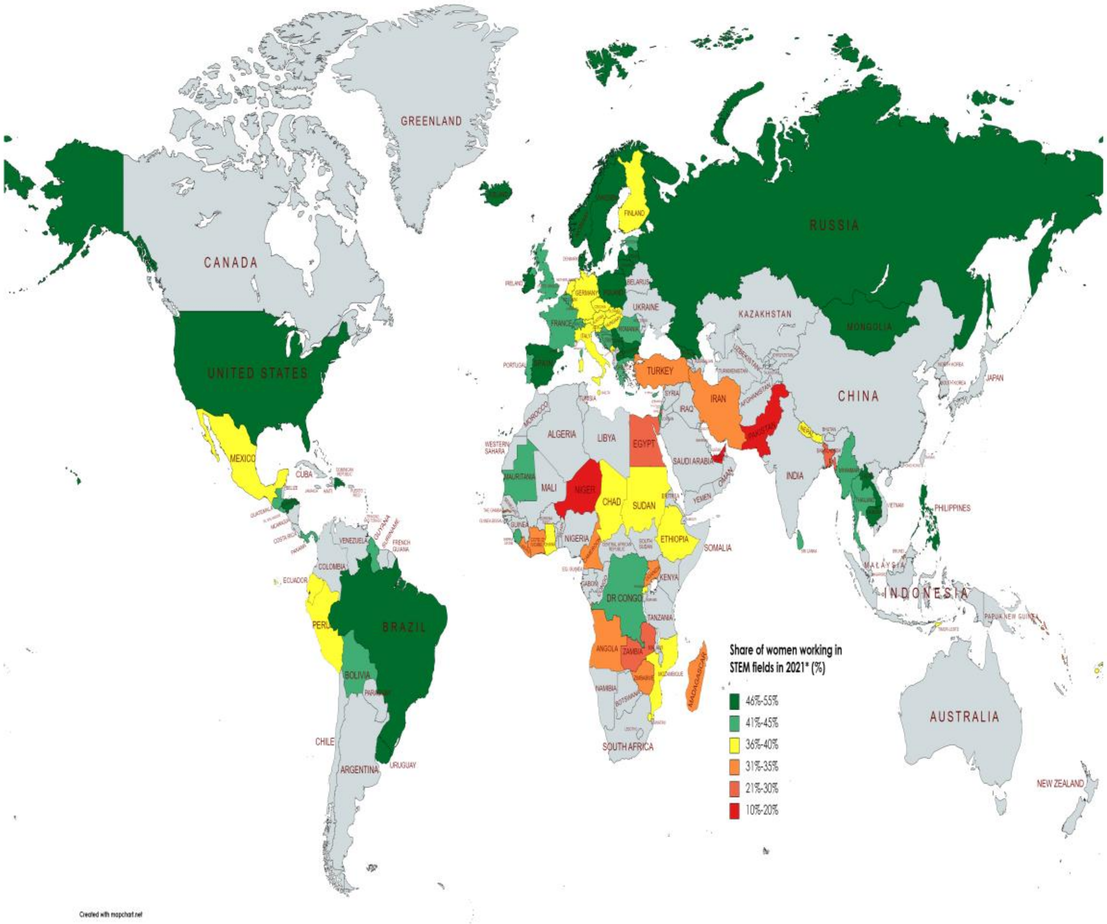

Figure 1. Share of women (as a share of total STEM employment) working in STEM fields in 2020 or the nearest years for which data are available [41], [42], [97], [98].

Some countries, such as Iceland, Norway, and Finland, closed 80% of the gender gap [99]. However, the number of females in STEM is still less than 30% in those countries. Also, Figure 2 shows the Female share of STEM tertiary graduates and how there is more female students in Brunei, Peru, North Macedonia, Bosnia and Herzegovina, Uruguay, and Panama.

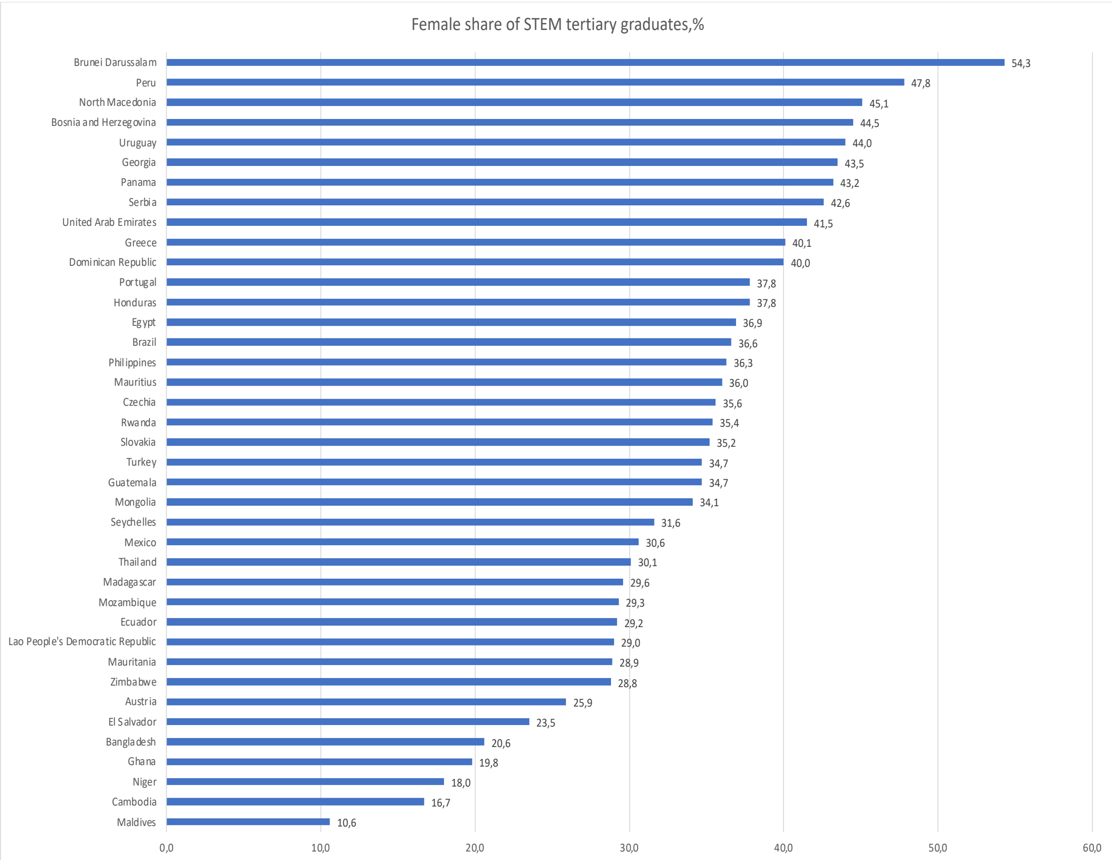

Figure 2. Female share of STEM tertiary graduates, %

In recent years, the share of female tertiary graduates in STEM has been almost the same as that of women currently working in STEM occupations in countries. E.G., in Greece, the share is the same at 40% and the same at 35% in Turkey. Nevertheless, some countries show that the percentage of women working in STEM fields in 2020 statistics is more petite than women in STEM education. This indicates that we are witnessing an inefficient use of human capital. Educated women do not work in their STEM speciality, or they do not work at all. In countries where the gender gap in STEM education and STEM employment is large, we can assume a combination of gender-friendly education policies and an unfriendly environment in state and non-state job markets concerning women professionals. It can be, for instance, a short pay gap or career prospects. Secondly, there is the presence of indirect motivation in getting an education. The reason to get a STEM education may be related to women finding a husband: young men predominate in natural sciences faculties. Or it can be prestigious to study STEM majors; however, the woman is not interested in the future profession [100], and later she chooses another field of interest or does not work using her major [21], [22].

With almost proportional rates of women's presence in STEM university fields globally, countries outside Europe demonstrate gender equality [101]. The myth that gender equality in science is more clearly represented in Europe is easy to refute. More and more women are working in STEM today — for example, 55.6% in Georgia, around 52% in Mongolia, Dominican Republic, Cambodia, and North Macedonia, approximately 47% - in Serbia, the United States, the Philippines, Brazil, and Lao People's Democratic Republic [97]. The regional averages for the share of female researchers (based on available data only) for 2016 are Central Asia (48.2%), Latin America and the Caribbean (45.1%), the Arab States (41.5%), and Central and Eastern

Europe (39.3%). These are the only regions where women represent over a third of the research and development workforce [102].

In those countries where the presence of women in science is minimal, government programs are beginning to unfold. Sustainable development, economic growth, and scientific leadership are associated with the presence of women in science. For example, in Japan (only 17% of women in science), such a criterion has been introduced for receiving the most significant university grants as the proportion of women among teachers and researchers [103]. Studying the experience of different countries that have already reached parity and have just embarked on this path is helpful. For instance, in several Arab countries, women predominate in natural sciences, medicine, and agriculture, including in response to the reluctance to depend on foreign labor [104].

Thus, we must separate gender imbalance in STEM education and employment, realizing that today's labor market is still more closed to women in STEM fields than education in some countries.

3.3. Reason to/not to pursue education in STEM and Computer science

Since women are more dependent on social and economic institutions due to the acute shortage of time in a combination of family and work, it is necessary to analyze indirect factors influencing women in STEM education. These factors include the strength of the influence of gender stereotypes, which can be called the degree of gender climate, and some specific "features" that generate stereotypes.

Let us give an example: In the 1960s and 70s in the USA, the share of women in the Information Technology (IT) field was growing, and the growth rate often outpaced the pace of mastering the industry by men. But from the mid-1980s to the mid-2010s, it dropped from 35% to 17%. While in other fields (medicine, physical sciences, law), the proportion of women continued to grow to 40-50% [105]. Why have women started programming much less? The answer may be that in the 1980s, the first personal computers appeared in households, but since they were expensive, they were bought primarily for boys, as they were seen as future providers for the family. At universities, boys did not waste time mastering basic operations, causing an inferiority complex in girls. The girls dropped out of the race [106], and the industry has become promising and highly paid, which has led to its masculinization. Besides, the National Science Foundation (NSF) study from 1961 [107] showed a significant population of women and national and ethnic minorities in the Soviet Union's scientific and technological workforce. Women constituted 50% of the science and engineering professionals in the Soviet Union [108]. The NSF's analyses of the Soviet situation [107] revealed a significant diversity among Soviet scientists and engineers. An urgent need for human resources can exist due to the lack of men after the war.

Currently, one of the reasons for the uneven participation of men and women in the development of technical sectors of the economy, representatives of different social sciences call the prevailing gender stereotypes [109]. In some countries, despite the almost century-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 stable expressions, such as "female inability to spatial thinking" and "female logic", which represent stereotypes about the impossibility of the entire presence of women in STEM [110]–[112]. Stereotypes play a role in forming self-esteem and developing an interest in STEM when choosing a field of education [113]. Studies have shown that stereotypes about women's inability to do mathematics can reduce women's interest in studying computing-related disciplines [114], [115].

Also, the length of the working day turns out to be very sensitive for women due to the stereotypical idea that all household chores, especially caring for children and their upbringing, should be on women’s shoulders. The existing tradition for many women doubles the burden of professional and domestic work [116]. For example, studies show that women with children work fewer hours in STEM fields than men, as they must return home and take care of house chores. According to studies by Baxter, families are shifting to the more traditional division of chores and work related to the home and child [117]. In this regard, women's excessive employment at work negatively affects the performance of duties in the family and children. Most women are willing to leave their jobs in STEM fields for family [118]. 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. In addition, constantly developing areas requires improving the skills of employees, which is problematic for women when they go on maternity leave or take sick leave to care for a child. The challenges that women and females face are summarized in Table 2.

Table 2. The found research pointed out challenges females face in STEM-related studies and job areas.

№	Challenge	Explanation of Formation
1	STEM is not a woman’s business [74]	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 life.
2	Not completing studies at university [21]	According to research, girls are more likely not to complete an engineering program [19], when males instead tend to graduate and pass the full programme.
3	The trap of social bias [119], [120]	Over the years, the progressive uncertainty of women's mathematical abilities can only be explained by analogy with poisoning – it enters the body and slowly starts to kill human cells. The essential society institutions - 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 [121]	Mathematical thinking develops similarly for all children. It is inappropriate to speak about gender differences rather than the similarity in children’s mathematics comprehension. There can be many reasons for disappointment in the exact sciences: new hobbies, the program's complexity, poor teaching of the subject, fatigue from school, and the reputation of mathematics as a “boring” discipline. But the demotivation of girls can also be explained by the fact that mathematics is not considered a socially significant field in the mass consciousness. For girls, the need for people is a weighty argument when choosing a profession.
5	Poorly designed tech/STEM curricula in schools and universities [92], [122]	Not enough opportunities to try tech/STEM activities outside of school, no real-world example for the child
6	Lack of confidence in their abilities [22]	Barriers were created during the whole process of socialization and social interactions with adults.
7	Lack of financial resources (funding or scholarships) [123]	The family does not have enough budget to cover desired education in the STEM field.
8	Expectations from females to take care of children [118]	In a traditional division of chores, a female is seen as a housekeeper. Home-related activities then limit work time. She cannot stay late at work or on weekends, limiting her to achieve the same level of productivity as men.

4. RECOMMENDATIONS FOR THE HEI TO INCREASE FEMALE INTEREST

The first thing that should be mentioned is that digitalization impacts and aligns gender inequality. Digitalization makes equal opportunities available for men and women [124]. If we go back to our era of hunters and gatherers, the difference in favor of men was that men had greater physical endurance. They could travel longer distances, stay at work longer, and be away from home longer. Nowadays, these advantages become less significant when everyone works wherever they want, including online.

The bright side of digitalization is that students can study from home; they need a laptop. Students can learn or work when convenient. Besides, it allows females to combine studies and household chores or care for a child at home. The university can offer training, workshops, and studies for students from other countries without a permanent presence on campus. On the other hand, digitalization has a dark side: anyone can study or work online, including those who did not apply for studies.

Secondly, positive discrimination, attracting more women to STEM by providing more scholarships and financial aid, will help out the centuries-old imbalance that otherwise will not align. [125], [126] state that the STEM gender gap won't close and vanish without further educational reforms. Therefore, society needs to make efforts: slightly skew the structure in the other direction to give it at least the appearance of balance.

Diversity is the healthiest way for the development of society and science. In addition, research confirms that it is also cost-effective. For example, if there are 15 elderly white boys on the board of directors, in this case, the company has one director for the price of 15. They have a standard angle of view and the same opinions, and they always agree, and there are no conflicts between them. But if a company among these 15 people has people with different backgrounds, experiences, and education, some are women, non-binary, or some have disabilities. At the same time, some of them are migrant workers who have risen high in management and have diverse experiences. The company has an eclectic vision; it looks at 180 degrees at once and presents an opportunity to make more effective decisions [127].

The same example can be transferred to the university environment. Student teams that have a diverse composition of participants come to more successful decisions in studies or hackathons. Diversity helps to consider the problem from non-standard sides and come to the most sustainable solution [128], [129]. Overall, transparent mechanisms for admission and future promotion of students should partially solve the problem of discrimination (not only gender but also other types). Also, designing and operating intensive educative events [130][131] and study programs in gender neutral way will definitely help too [132]. Additionally, students' achievements and educational advancement tend to depend on the observed performance indicators, with properly organized, can reduce discrimination opportunities.

Universities should cover the achievements of females, e.g. promoting them more often in their media channels, related to the previously mentioned interest in STEM, and based on the presence of a positive role model. One good example are female entrepreneurs in technology industry sector [133] and their stories how they become e.g. CEOs of their own found company. When choosing a university, girls can see a real example and be inspired to study STEM majors. Also, with more coverage of women in science, it is possible to reduce the discussion about gender inequality, as awareness will increase.

5. CONCLUSIONS

The Results and Findings section identified and interpreted critical themes in STEM careers and studies at HEI. This study was driven by two main research questions: Why do females choose or prefer not to study STEM subjects in HEI environments? And how can an HEI unit increase the share of applicants and the number of females in their study programs?

The study found that gender attitudes and stereotypes inherent in everyday children's private and school life narrow the possibilities of choosing the direction of education and profession for girls and boys. If the behavior or idea does not fit into the "normality" existing in society and the educational program, then it limits the future choices of teenagers in their future careers. We can conclude that the stereotypes expressed in the remarks of teachers, professors, colleagues, and bosses who met at different stages of the biographical path played an essential role in choosing a career and educational trajectory in STEM.

Women can face stereotypes from birth, as noted in the gender reveal experiment conducted by BBC and at the school level. This can lead to a harmful combination of circumstances that will influence a decision about further higher education in the technical field, such as opinions from the teachers about their skills. Then, while studying at universities, students who choose STEM fields can begin to feel discriminatory attitudes towards themselves and their chosen field of study. Teachers' opinions can be different: 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. When applying for employment and interviewing a male supervisor, women are more likely to be rejected than men. For a successful STEM career, women need to put more effort into being evaluated as professionals and promoted up the career ladder.

Thus, we saw that the stereotypical statements of significant others appearing in biographies are associated with increased doubts about choosing a further career path in STEM, with a decrease in professional self-esteem and the search to justify leaving this professional sphere and acquiring others, more "feminine" professions. When choosing a future specialization, the society in which the child grew up, the family that brought him up, and what traditions they invested in are much more important than child's gender.

To sum up, studies have already shown that men's and women's joint and collaborative work on scientific and engineering projects adds to productivity, novelty and insightfulness. Also, mixed teams offer more innovative ideas, and gender-balanced companies are significantly more successful than their counterparts. Still, there is much space to expand the field of research and consider how gender-balanced HEI programs should be formed and how to promote STEM studies with tangible benefits for both genders equally. One potential approach is to connect STEM studies to globally meaningful development targets, which both genders would find valuable and good objective to be able to contribute into. For example success of SMEs and sustainability [134] trough digitalization, digital and real-life robotization for corporations work force acquiring problem and work safety issues solving capabilities [135][136], Digital citizen science solution development [137][138], Industry 4.0 and circularity and [139] and University-Industry collaboration for sustainability purposes [140]. Also, based on our findings, studies on the role of parental support in forming boys' and girls' subjective assessments of their achievements using interviews with STEM students and women working in STEM would be essential to be continued. Future studies could, e.g., contribute more widely to cross analysis of different approaches' efficiency and how they stack up on top of each other and full fill gaps different solutions generate/leave out to be solved.

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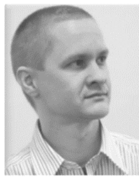
AUTHORS

ELIZAVETA TERESHCHENKO received a B.S. degree in business informatics from Peter the Great St. Petersburg Polytechnic University, Saint Petersburg, Russia, in 2019 and M.S. degree in science from LUT University, Lappeenranta, Finland, in 2021. She is currently pursuing a Ph.D. degree in software engineering at LUT University, Lappeenranta, Finland. Her research studies small and medium enterprises in digitalization and their success and failure factors.



ARI HAPPONEN is a project manager/principal investigator and University-Industry collaborator at LUT School of Engineering Science in Lappeenranta University of Technology, Finland. Assoc. Prof. Ari Happonen's research interests include Digitalization, ICT for Sustainability, Robotization, Hackathons, Code Camps, Digital transformation, Experimental innovation, Design Thinking, and Modern waste reduction methodologies. His research focuses mainly on practical and efficient industrial-related applied research collaboration activities in B2B and B2C contexts. He contributes to software engineering, ICT & sustainability, AI solutions, hackathon & education-related research areas there. He also actively participates in education and teaching development efforts with 20 years of experience. He works as an intermediary in multiple research projects between universities and innovative front-line companies.

VICTORIA HASHEELA-MUFETI is a senior lecturer in the School of Science, under the department of Computing, Mathematical and Statistical Sciences. She has over 12 years of experience in the IT industry. She holds a Doctor of Science in Technology, a Master of Science in Business Informatics, as well a Bachelor of Science in Computer Science. Her research focuses on Digital transformation, ICT for Development, Software Practices and Educational Technologies.