METHODOLOGICAL GUIDELINES FOR CREATING THE FRAMEWORK OF THE *FEMSTEAM MYSTERIES* PROJECT

Intellectual Output 1_A1

FemSTEAM Mysteries: A Role-Model Game-Based Approach to Gender Equality in STEAM

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Executive Summary:	*FemSTEAM Mysteries* is based on the values of gender equality and non-discrimination between men and women in the fields of Science, Technology, Engineering, Arts and Mathematics (STEAM), creativity and innovative entrepreneurship. Through the adoption of an innovative approach that integrates STEM and Arts, and combines Role-Model and Game-based methodology with a mystery story-telling digital game (escape room) that engages teenagers (age 12-15), *FemSTEAM Mysteries* aims to: (i) bring out the significant role of women in STEAM; (ii) fight stereotypes of students and teachers; (iii) inspire young girls through role-model game-based STEAM pedagogy to follow STEAM careers; (iv) enhance acquisition of key skills and competences for STEAM studies and careers of all students (boys and girls); (v) enhance teachers' skills in dealing with gender equality in STEAM. A main output of the EL-STEM project is an in-service professional development course targeting STEAM teachers of lower secondary school students (ages 12-15). The course aims at strengthening teachers' profile and competences in adopting the *FemSTEAM Mysteries* approach for the promotion of gender-equitable STEAM teaching and learning. Teachers are acquainted with ways in each they could employ serious games, game-based activities and tools, and role models to promote both all students' (females' and males') engagement and learning in STEAM education, while at the same time fighting gender stereotypes that prevent females from pursuing higher studies and careers in STEAM disciplines. The current report first describes the theoretical framework underpinning the *FemSTEAM Mysteries* in-service teacher training course, providing an overview of the five interrelated bodies of research it is grounded on: (a) Transdisciplinary STEAM Education Model, (b) Game-Based Learning, (c) Female Role Models in STEM/STEAM Education, (d) Principles of Adult Education and (e) TPACK framework. It then describes the course design: pedagogical and didactical approach, aims and objectives, content and structure.

This document is issued within the frame and for the purpose of the *FemSTEAM Mysteries: A Role-Model Game-Based Approach to Gender Equality in STEAM* project, funded by the European Commission-Erasmus+/ Key action 2, Cooperation for Innovation and the Exchange of Good Practices/ KA201 - Strategic Partnerships for school education (Ref. #: 2020-1-CY01-KA201-066058)

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List of Abbreviations/ Acronyms

Abbreviation / Acronym	Description
CY	Cyprus
DE	Deutschland (Germany)
EL	Hellas (Greece)
ES	España (Spain)
FemSTEAM Mysteries	FemSTEAM Mysteries: A Role-Model Game-Based Approach to Gender Equality in STEAM
EU	European Union
STEM	Science, Technology, Engineering, Mathematics
STEAM	Science, Technology, Engineering, Arts, Mathematics
TPACK	Technological Pedagogical Content Knowledge
4Cs	Communication, Collaboration, Critical Thinking, Creativity

FemSTEAM Mysteries Project Description

Although many women have contributed massively to the progress of science and technology, very few students as well as teachers in Europe learn and know about them. The situation is similar in visual arts education. The vast majority of the famous artists students get acquainted with, are males. The EU-funded, two-year project *FemSTEAM Mysteries* (Nov 2020-Oct 2022) *FemSTEAM Mysteries* is designed to counteract this tendency for gender inequality in the arts and sciences by bringing out the important role of women in STEAM to students' and teachers' community, in order to fight stereotypes of students and teachers of both genders and to provide role models for young girls to follow STEAM studies and careers.

The objectives of the *FemSTEAM Mysteries* project are:

- To bring out the significant role of women in STEAM (Science, Technology, Arts, Engineering and Maths)
- To fight stereotypes of students and teachers
- To inspire young girls through role-model game-based STEAM pedagogy to follow STEAM careers
- To enhance acquisition of key skills and competences for STEAM studies and careers of all students (boys and girls) through engaging game-based activities and a mystery storytelling game
- To enhance teachers' skills in dealing with gender equality in STEAM.

The project target groups are:

- Young girls (age 12-15): Empowering them through role-model game-based education in approaching STEAM, finding inspirational personalities and planning their careers without considering social stereotypes.
- Young boys (age 12-15): Empowering them to respect their female classmates and later co-workers without stereotypes by acquainting them with the importance of female contributions in STEAM.
- STEAM teachers (in secondary education): Enhancing their skills and professional development by providing them with innovative educational methods to make the role of women visible in their STEAM classroom, overcome their own stereotypes and encourage young girls and boys in STEAM.
- STEAM professionals like trainers, career coaches, science communicators, art curators, researchers, university staff.

The Intellectual Outputs of the project include:

- O1- Methodological Guidelines for creating the framework of the *FemSTEAM Mysteries* project
- O2- Instructional Guide on Role-model education for promoting gender equality in STEAM
- O3- Instructional Guide on Game-based education for promoting gender equality in STEAM
- O4- *FemSTEAM Mysteries* Digital Mystery Game
- O5- *FemSTEAM Mysteries* Library
- O6- *FemSTEAM Mysteries* Teacher Professional Development Program on promoting gender equality in STEAM.

The Main Results of *FemSTEAM Mysteries* will be:

1. 500 staff and associates of the partner organizations including teachers, educators, professors and science communicators will learn how to implement the educational tools created within the project.
2. 1500 students of both genders will participate in educational activities within the framework of the project.
3. Innovative tools and resources based on role-modeling, game-based STEAM education: Methodological Guidelines, Guides on Role-model and Game-based education for promoting gender equality in STEAM, a Storytelling Mystery Digital game, a *FemSTEAM Mysteries* Library, a blended teacher professional program.

Six partners from four EU countries (Cyprus, Germany, Greece, Spain) participate in the consortium, organized in such a way so as to cover the required competences for successful implementation of the project: European University Cyprus (CY), American Academy Nicosia (CY), Cologne Game Lab (DE), Challedu(EL), Doukas School (EL), La Salle Buen Consejo (ES).

1 INTRODUCTION

The EU-funded, two-year project *FemSTEAM Mysteries* (Nov 2020-Oct 2022) is designed to counteract gender inequalities in the arts and sciences by bringing out the important role of women in STEAM to students' and teachers' community. Through the adoption of an innovative approach, that integrates STEM and Arts, and combines Role-Model and Game-based methodology with a mystery story-telling digital game (escape room) that engages teenagers (age 12-15), *FemSTEAM Mysteries* aims to create a new culture and attitude amongst teachers and students that will: (i) bring out the important role of women in STEAM; (ii) fight stereotypes of students and teachers; (iii) inspire young girls through role-model game-based STEAM pedagogy to follow STEAM careers; (iv) enhance acquisition of key skills and competences for STEAM studies and careers of all students (boys and girls); (v) enhance teachers' skills in dealing with gender equality in STEAM.

This document is the first intellectual output of the project and aims to offer methodological guidelines for creating the framework for the rest of the activities of the project by identifying the current situation, best practices, and challenges regarding gender equality in STEAM. The report consists of three parts. In the first part, an extensive overview of the literature identifies factors that influence students' study and career-related decisions, such as gender stereotypes, role models, parents' and teachers' expectations, students' beliefs about their abilities and knowledge relating to STEM/STEAM career options.

The second part of the report examines the existing situation in each country partner (Cyprus, Germany, Greece and Spain) concerning secondary students' performance in STEAM related subjects, with emphasis on Math and Science, by overviewing various European reports such as the PISA and TIMSS assessments. In particular, this section investigates whether there are any substantial differences between girls' and boys' performances in secondary education, and whether these might relate to expectations about future careers. More so, some information is provided relevant to women's representation in tertiary education across the four partner countries, as well as women's representation in higher education and research relating to STEAM occupations and fields.

In the third and final part of the report, the results from surveys contacted with teachers are presented, in relation to teachers' perceptions about gender difference, perceived challenges and incentives regarding STEAM education, as well as about teachers' needs and expectations. Results from surveys conducted with students are also presented, in relation to students' knowledge about STEM/STEAM careers, their perceptions concerning school learning and STEAM studies and careers.

Overall, this report, which was developed in the first year of the project, attempts to outline how the data collected from the surveys, supported by the literature and the country-specific information, can offer a complete and comprehensive framework about role-mode education, teachers' professional development, game-based learning and STEAM education as a new pedagogical approach.

2 THEORETICAL FRAMEWORK

According to various international reports (EIGE, 2018; OECD, 2020) adolescent female students are less likely than males to aspire to careers in STEM (science, technology, engineering, and mathematics) fields. As undergraduate students, women tend to choose the fields of education, health, and welfare (OECD, 2020) and, at the postgraduate level, only a small proportion of them specialize in the field of information and communication technology or in the field of engineering, manufacturing, and construction (European Commission, 2019). Women's underrepresentation in STEM research and professions, which have higher pay-levels, perpetuates economic gender inequalities (EIGE, 2018; OECD, 2016). Also, it deprives STEM fields from the breadth of human resources that can support innovation and economic development (European Commission, 2019).

Adolescent girls have caught up with and, in several countries, surpassed adolescent boys in science, mathematics and ICT literacy (Mullis, Martin, Foy, Kelly, & Fishbein, 2020; OECD, 2019a; Siddiq & Scherer, 2019). However, according to PISA 2018 results (OECD, 2019b), female students who are top performers in science and mathematics are less likely than top performing male students to pursue studies in STEM fields. Over the past decades research has shown that student academic choices cannot be attributed to differences in cognitive abilities and academic achievement but are influenced by gendered psychological processes which include cultural values, stereotypes, and expectations expressed by parents and other important socialization agents (Bleeker & Jacobs, 2004; Eccles, 2007; Gunderson, Ramirez, Levine, & Beilock, 2012; Lauermann, Tsai, & Eccles, 2017; Wang & Degol, 2017). In the following sections we examine the factors that influence female as well as male students' study and career-related decisions and explain how relevant research has informed the design of the FemSTEAM Mysteries project.

2.1. The role of beliefs and cultural stereotypes in students' study choices and career aspirations

Two important predictors of students' academic and career choices are students' beliefs about their competence in relevant academic subjects and about the value of studying these subjects (Eccles, 2007; Lauermann et al.; Sáinz & Eccles, 2012; Wigfield & Eccles, 2000). To pursue a particular academic subject, students need to think that they can succeed in learning it as well as that it is interesting, important, and useful to them (Wigfield & Eccles, 2000). Ability and value perceptions are enhanced when students have enjoyable and challenging learning experiences in which they are successful. However, beliefs are influenced by students' own interpretations of their experiences and by the values and expectations communicated by parents, teachers, and other important socialization agents, which are often based on cultural stereotypes and misconceptions (Bleeker and Jacobs, 2004; Gunderson et al., 2012). Hence, female students may underestimate their math, science and ICT abilities even when they perform well academically (Sáinz & Eccles, 2012; Wach, Spengler, Gottschling, & Spinath, 2015) or they may have inaccurate understandings of the nature and scope of STEM professions and,

as a result, think that taking math and science courses at school is not useful and important to them (Eccles, 2007; Mann, Denis, Schleicher, Ekhtiari, Forsyth, Liu, & Chambers, 2020).

2.1.1. Stereotypes about gender and STEM

Gender stereotypes attribute gendered social roles to biological differences (Eagly, Nater, Miller, Kaufmann, & Sczesny, 2020). Due to their ability to bear children, women are perceived to possess high levels of communal traits and to be eligible for activities and professions that require empathy, hard work and caring for others. On the other hand, due to their physical strength men are seen as predisposed for high status roles and for professions that require agentic traits, such as leadership skills, independence, and risk taking (Ellemers, 2018). In educational contexts, STEM fields are considered "masculine", and therefore more appropriate for men, because they are supposed to require innate intellectual talent (e.g., the ability to think abstractly and systematically) and agentic traits, which are considered male characteristics (Carli, Alawa, Lee, Zhao, & Kim, 2016; Leslie, Cimpian, Meyer, & Freeland, 2015). Although research has challenged these gender stereotypes (Ellemers, 2018), they are still abundant in mass and digital media (Singh, Chayko, Inamdar, & Floegel, 2020; Sink & Mastro, 2017), and can be found even in educational materials and textbooks (Kerkhoven, Russo, Land-Zandstra, Saxena, & Rodenburg, 2016; Moser & Hannover, 2014). Their pervasiveness reinforces the stereotype that STEM fields are masculine and limits female students' exposure to female STEM role models.

Several studies (e.g., Dicke, Safavian, & Eccles, 2019; Ertl, Luttenberger, & Paechter, 2017; Flore & Wicherts, 2015) have demonstrated that gender stereotypes create psychological obstacles for women and influence their behaviors. Female students who internalize gender stereotypes about STEM tend to underestimate their ability to succeed in STEM fields and are less likely to aspire to and to pursue careers in STEM fields (Dicke et al., 2019; Ertl et al., 2017). However, even if they do not espouse gender stereotypes themselves, female students are susceptible to a phenomenon that is called "stereotype-threat": they may perform bellow their ability level in STEM tasks, especially in contexts where gender bias is salient, due to physiological stress caused by the possibility to confirm gender stereotypes (Flore & Wicherts, 2015; Smith, 2004).

2.1.2. Stereotypes about STEM fields and professionals

Students' educational and occupational choices may also be influenced by negative stereotypes about the nature of STEM fields (Cheryan, Master, & Meltzoff, 2015; Ehlinger, Plant, Hartwig, Vossen, Columb, & Brewer, 2018). Non-specialists, including teachers, parents, and students, often have inaccurate understandings of the types, settings, and ethics of STEM research and professional activities. They may perceive math, science, and computing as solitary, non-creative and mechanistic activities, or even as morally ambiguous activities motivated by self-interest, and they may view STEM researchers and professionals as eccentric geniuses who have no social skills and personal lives (Cheryan, Plaut, Handron, & Hudson, 2013; Christidou, Hatzinikita, & Samaras, 2012; Critchley, 2008; DeWitt, Archer, & Osborn, 2013; Sáinz, Pálmen, & García-Cuesta, 2012).

Students who endorse such negative stereotypes may consider STEM fields and professions as incompatible with their values and identities (Erlinger et al., 2018; Zarrett & Malanchuk, 2005), especially if they are interested in jobs that are creative, provide opportunities for social interaction and enable them to benefit society. This is particularly important for female students who, due to their socialization, are more likely than males to place importance on humanistic job characteristics (Guzdial, Ericson, McKlin, & Engleman, 2012; Weisgram, Dinella, & Fulcher, 2011). Also, many female and male students may find it difficult to identify with the "nerdy" or "genius" STEM professional prototype and, therefore, to feel that they do not belong in STEM (Erlinger et al., 2018). On the other hand, research has shown that students who hold non-stereotypical images of STEM professionals tend to have more positive ability perceptions and higher perceived identity compatibility between self and STEM, as well as to be more likely to intend to major in a STEM field (Nguyen & Riegle-Crumb, 2021; Shin, Levy, & London, 2016). These research findings indicate that students need exposure to images and role models that present STEM researchers and professionals as ordinary individuals who are successful because they work hard and enjoy their work and who make significant contributions to society by tackling complex problems (Cheryan et al., 2015; DeWitt et al., 2013).

2.1.3. Understanding of STEM career options

Finally, adolescents' career aspirations are influenced by their understanding of possible career options and their respective educational requirements (Kashefpakdel & Percy, 2017). In the PISA 2018 assessment, significant percentages of students expressed high interest in occupations that are likely to become automated and low interest in jobs with positive prospects for the future, which shows that students were not aware of how the labour market is likely to change and what they need to do to prepare for this change (Mann, et al., 2020). Considering also that, on average across OECD countries, only 13.1% of top performers in science and mathematics expect to work in related fields (26% of the boys and 14% of the girls) and that many other students do not have a clear idea about their future jobs (OECD, 2019), these findings indicate that students may not know what professions and working environments are part of STEM as well as that science- and math-related jobs have a promising future.

2.2. The influence of parents, teachers, and role models

Parents and teachers can influence adolescents' academic beliefs and choices in several ways. Parents may inspire their children's interest in STEM academic subjects by discussing their value and usefulness for their children's future, by providing learning experiences, and by monitoring and supporting their children's learning (DeWitt, Archer, & Mau, 2016; Šimunović & Babarović, 2020). Parents and teachers may also influence students' aspirations by communicating expectations about their academic achievement and future accomplishments (Pinquart & Ebeling, 2020) as well as by communicating stereotypes about the abilities of boys and girls in particular domains, the nature of these domains, and their appropriateness for boys and girls (Bleeker and Jacobs, 2004; Eccles, 2007; Gunderson et al., 2012).

Parents and teachers may espouse stereotypes about STEM fields and their suitability for women (DeWitt et al., 2013; Sáinz et al., 2012; Vekiri, 2012), which are communicated to students through their pedagogical practices and the values and expectations they express. Several studies have shown that parents tend to provide their sons with more opportunities and encouragement to develop skills and interests in STEM (Bhanot & Jovanovic, 2009; Vekiri & Chronaki, 2008) and that they are more likely to expect their sons, rather than their daughters, to work in a STEM field (OECD, 2015). Similarly, teachers tend to provide boys with more opportunities for class participation and interaction (Jones & Dindia, 2004; Smith, Hardman, & Higgins, 2007), which subtly conveys the message that their learning is more important. Also, both teachers and parents tend to attribute girls' accomplishments to effort and self-discipline and boys' achievement to "masculine" personality traits (Gunderson et al., 2012; Perander, Londen, & Holm, 2020). Studies have shown that children's views about STEM are related to parents' and teachers' views about STEM fields (Gunderson et al., 2012; Keller, 2001; Šimunović, Ercegovac, & Burušić, 2018) and that parental and teacher stereotypes and expectations influence girls' ability perceptions and academic choices (Bleeker and Jacobs, 2004; Gunderson et al., 2012).

Finally, parents, teachers and other adults can influence young people's aspirations and study choices by acting as role models. According to social role theory (Eagly & Wood, 2016), when children observe men and women in gender-stereotypical roles, they are likely to develop gender stereotypes which in turn promote aspirations and behaviors that are considered appropriate for their gender. Finding that only a few women have STEM professions and leadership roles may signal to adolescent girls that they do not have the traits to succeed in these domains or that these domains are not appropriate for them. Research has shown that students who are exposed to STEM-related stereotypical role models are likely to endorse gender stereotypes (Beilock, Gunderson, Ramirez, & Levine, 2010), while, on the other hand, exposure to counter-sterotypical role models, such as successful female scientists, can influence females' aspirations and gender-related views in a positive way, even if this exposure is brief (Olson & Martiny, 2018).

2.3. Gender-equitable practices and the FemSTEAM approach

Based on the literature reviewed in the previous sections, stereotypes about the nature of STEM fields and professions and their suitability for women have a negative impact on female students' career aspirations and study choices. Therefore, educational programs that aim at increasing the number of women in STEM fields need to question gender stereotypes and to present diverse images and role models of STEM fields and professionals, both male and female, so that students do not feel that they need to fit a particular prototype to be successful in these fields (Cheryan et al., 2015; Olson & Martiny, 2018; Wang & Degol, 2017). Also, it is essential that parents and teachers become aware of their own role in shaping young people's academic interests and career aspirations so as to provide students with access to accurate information and appropriate learning experiences (DeWitt et al., 2013; Sáinz et al., 2012; Vekiri, 2012).

In addition, students need to gain a better understanding of the nature of STEM research and professional activities, to appreciate their relevance to everyday life, their creative and collaborative nature, and their contribution to society. Inquiry-oriented, problem solving or construction activities that are personally relevant and highlight the social benefits and applications of STEM fields in real-life situations are pedagogical approaches that can improve students' interest in STEM and their understanding of the nature of STEM fields (Carbonaro, Szafron, Cutumisu, & Schaeffer, 2010; Chi, Wang, & Liu, 2021; Goldstein & Putnambekar, 2004; Hazari, Sonnert, Saddler, Shanahan, 2010) as well as their intention to pursue STEM studies and careers (Hazari et al., 2010; Sharma, Torrado, Gómez, & Jaccheri, 2021).

STEAM education is a new pedagogical approach that combines various art forms, including dance, theater, music, visual and media arts, with STEM subjects (Martinez, 2017). It is expected that integrating the arts in STEM learning will help students develop a unique set of diverse skills and abilities, such as design and problem-solving skills, creativity, and trans-disciplinary thinking, which are considered important in 21st century (Henriksen, 2014; Perignat & Katz-Buonincontro, 2019) and are expected to facilitate the development of thinking processes that support innovation in STEM (Henriksen, 2014; Wajnkurt & Sloan, 2019).

STEAM education is expected to attract more students to STEM/STEAM fields and to be particularly effective for female students (Wajnkurt & Sloan, 2019), because it employs inquiry-oriented, problem-based or project-based approaches to learning (Martinez, 2017; Roehring, Dare, Ring-Whalen, & Wieselmann, 2021) which have been found to have a positive influence on students' motivation (Carbonaro et al., 2010; Hazari et al., 2010; Sharma et al., 2021). Also, in STEAM education projects students engage in investigations about complex problems that relate to the real world and their everyday lives, and this may help them gain a better understanding of the nature of STEAM fields and professional activities and to appreciate the creative and socially relevant aspects of STEM fields (Cairns, 2019; Chi et a., 2021).

FemSTEAM Mysteries is a two-year (Nov 2020-Oct 2022) EU funded project that integrates STEM with the Arts and aims at (i) bringing out the significant role of women in STEAM; (ii) fighting stereotypes of students and teachers; (iii) inspiring young girls through role-model game-based STEAM pedagogy to follow STEAM careers; (iv) enhancing acquisition of key skills and competences for STEAM studies and careers of all students (boys and girls); (v) enhancing teachers' skills in dealing with gender equality in STEAM. The project targets secondary school students (age 12-15) because during adolescence students begin to think about their future and to formulate their career plans and aspirations. *FemSTEAM Mysteries* combines Role-Model and Game-based pedagogy with a mystery story-telling digital game (serious game) which is designed to challenge stereotypes about women and STEAM and about the characteristics of STEAM professionals and the nature of their work. The game will include 8 escape rooms, each dedicated to an important (female or male) scientist or artist, and players will be able to solve each mystery by exploring various resources providing information on the lives and contributions of these personalities. Research has shown that serious games can be more effective than other forms of instruction in supporting student learning and motivation (Clark, Tanner-Smith, & Killingsworth, 2016; Lamb et al., 2018). Also, serious games can be easily

integrated in STEAM curricula and projects because they are compatible with STEAM pedagogy and may advance several STEAM goals, including the development of interest in STEAM fields (Gao, Li, & Sun, 2020). The game will be available in English as well as in three other languages (Greek, Spanish, and German), the languages of the four project partner countries (Cyprus, Greece, Spain, and Germany).

Given the important role of teachers in the enactment of STEAM pedagogy and in the development of students' beliefs and academic aspirations, teacher professional development is a key priority of the *FemSTEAM Mysteries* project. A blended professional development course on promoting gender equality in STEAM through serious games, game-based activities and tools, and role-models will be developed, and pilot tested within the project lifetime. The course will initially target secondary school STEAM teachers of partner schools in Cyprus, Greece, and Spain. Teachers will be familiarized with role-model, game-based approach to STEAM education by using the prototype *FemSTEAM Mysteries* game and by creating accompanying educational scenarios to use in their STEAM classrooms. Also, a transnational online community will be created for the exchange of experiences, ideas, and resources. The course material and resources will be revised, based upon feedback received from the pilot testing and follow-up experimentations in participating teachers' classrooms, and will be released for independent use by any interested stakeholder across Europe and internationally.

3 NATIONAL REPORTS

3.1. Existing situation concerning female participation in STEAM studies and careers

This section examines the existing situation in each country partner (Cyprus, Germany, Greece and Spain) concerning secondary students' performance in STEAM related subjects, with emphasis on Math and Science, by overviewing various European reports such as the PISA and TIMSS assessments. In particular, this section investigates whether there are any substantial differences between girls' and boys' performances in secondary education, and whether these might relate to expectations about future careers. More so, some information is provided relevant to women's representation in tertiary education across the four partner countries, as well as women's representation in higher education and research relating to STEAM occupations and fields. The figures presented in the following sections showcase a gender imbalance both in terms of representation in research, high-paid occupations, and higher-level positions, as well as in a sense of job security (precarious contracts).

3.1.1 Girls' and boys' performance in Math and Science

CYPRUS

According to the TIMSS 2019 Mathematics and Science Results Report (Mullis, Martin, Foy, Kelly, & Fishbein, 2020), Cypriot students' average achievement in math and science has improved significantly since Cyprus' previous TIMSS assessment in 2007, and this applies to both the primary (4th grade) and the secondary (8th grade) education levels. Findings are better for the primary students whose performance in the 2019 assessment was higher than the centerpoint[1] for both math (Cyprus average score = 532 points) and science (Cyprus average score = 511 points). At the secondary level, average math achievement climbed just above the centerpoint (501 points in 2019 compared with 465 points in the 2007 assessment), but average science achievement was still under the centerpoint (484 points in 2019 and 452 in 2007). Similarly, according to the recent PISA evaluation in 2018 (OECD, 2019a), the average score of adolescent Cypriot students was higher in mathematics (451 points) than in science (439 points), however, both scores were below the OECD mean (which was 489 for both science and mathematics).

The TIMSS 2019 report indicated that Cypriot students maintain consistently positive views (slightly above the TIMSS international average) about the enjoyment and value of math and about their ability to succeed in mathematics, both at the primary and at the secondary level (Mullis et al., 2020). Regarding science, students expressed positive views (above international average) at 4th grade. However, 8th grade students' attitudes were above international average only in biology, while their scores on the enjoyment of and confidence in physics, earth science and chemistry were below the centerpoint. Based on the above data regarding primary and secondary Cypriot students, achievement and motivation appears to be higher for math than for science, however there is a need to improve not only science but also math achievement scores at the secondary school level.

In Cyprus, there is a narrow gender gap in math and science achievement favoring adolescent girls, and this is supported by both PISA and TIMSS recent data. Specifically, the TIMSS 2019 report (Mullis et al., 2020) shows that in 2019 there was an advantage of girls in 6 out of 7 domains (algebra, geometry, data and probability, knowing, applying, and reasoning) and this gender difference was significant in algebra and mathematical reasoning. Also, in 2019 8th grade female students performed significantly higher than boys in science (and, more specifically, in biology and chemistry and in the cognitive domains of knowledge application and reasoning), a finding that was also observed in the previous TIMSS assessment in 2007. Similarly, according to the PISA 2018 report (OECD, 2019a), 15-year-old girls outperformed 15-year-old boys in reading (448 compared with 401), math (455 compared with 447) and science (450 compared with 429) and the difference was statistically significant in all three subjects.

GERMANY

According to the TIMSS 2019 (Schwippert, 2020) the average performance of German students in Mathematics is significantly higher (521 points) than the international average (501 points) but lower than the average values of the participants in EU (527) and OECD (529 points) countries. This only applies to the primary education (4th grade) level. Students' overall performance for Mathematics in TIMSS 2019 (521 points) is on par with the performances in TIMSS 2007 (525 points) and TIMSS 2015 (522 points), however significantly lower than TIMSS 2011 (528 points). In addition, TIMSS 2019 shows that significantly fewer students have a high positive attitude towards Mathematics compared to TIMSS 2007. Moreover, similar results were reported in PISA 2015, where the 9th graders scored an average of 506 which is higher than the average score in OECD countries (490 points). The average performance for Mathematics did not have a significant improvement since 2003. Additionally, in the recent PISA 2018 report, German students' average performance was 500, compared to the average score of 489 points in OECD countries. Therefore, the results may suggest that many school children, including secondary school students in Germany, are motivated and confident with Mathematics.

In Germany, almost three-quarters of students who graduated from primary school have a positive attitude towards Natural Sciences. The average performance in Germany (518 points) is higher than the international average (491 points) and at a comparable level to the average of the participating EU (522 points) countries. The difference to the mean of the participating OECD (526 points) countries is lower but still statistically significant. Nevertheless, this trend is rather unfavorable. Students' overall performance for Natural Sciences in TIMSS 2019 has declined by 10 points, significantly below the performance level in TIMSS 2007, 2011, and 2015. However, in PISA 2015, different results were reported, where the students in Germany scored a higher average score points (509) than the average score points in OECD countries (493 points). Similar outcomes were reported in PISA 2018, where students in Germany also scored a higher average score points (503) than the average score points in OECD countries. Germany's average performance in Natural Sciences has remained unchanged since 2006 when science

[1] The centerpoint refers to the mean of the combined achievement distribution of all participating countries, which was 500 for both math and science at the primary and at the secondary level.

was the major domain, with an average decline of 1.7 points every three years, not a significant change. However, since 2012 when science was one of the minor domains, the country's average score has dropped significantly.

In the last ten years, the gender gap in the performance between boys and girls declines. While more than ten years ago a large performance gap could be observed, which was partly due to different motivations, interests, cultural aspects, many initiatives have been proposed and performed to change this situation (Kröll, 2010).

However, even based on the recent PISA 2018 report, gender gap is observed in relation to girls' and boys' performances. Boys outperform girls in Mathematics by 7 points in Germany, which is slightly bigger than the average gender gap in mathematics across the OECD countries (5 score points). However, more recently girls and boys performed similarly in science due to a decline in boys' performance.

GREECE

Greek students scored lower than the OECD countries' average in Mathematics and Natural Sciences, as shown in the PISA survey for 2018. In particular, the performance of 15-year-old Greek students was 451 in mathematics (489 average) and 452 in science (489 average). The percentage of Greek students with high performance (high achievers) in at least one subject was 6.2% (average 15.7%) and that with low performance in all three subjects (low achievers) was 19.9% (average 13.4%).

In mathematics and science, PISA 2018 suggests that gender differences in Greece among 15-year old students are huge in reading skills (479 girls vs 437 boys), with girls outperforming boys by 42 points, which is one of the biggest gaps compared to the rest of OECD countries. This is not the case with mathematics, in which case girls and boys perform equally (451-452). In science though, girls again outperform boys by 11 points (457 girls vs 436 boys). The average performance in Sciences declined steadily in Greece since 2006, by an average of 5.9 score points per 3-year period, even though changes from one round to the next were not always statistically significant. Performance in mathematics can be described as hump-shaped, mainly due to a spike in performance in PISA 2009; performance in other years was stable. Greece performed below the OECD average in all subjects in every year it participated in PISA. The decline in science performance over the 2006-2018 period was observed across the performance distribution. Performance amongst the highest-achieving students declined by 6.4 percentage points and that amongst the lowest-achieving students fell by 5.3 percentage points per 3-year period.

SPAIN

Based on the TIMSS 2019 Mathematics and Science Report (Mullis, Martin, Foy, Kelly & Fishbein, 2020), the Spanish report on the results of TIMSS (MEFP, 2002a), PISA 2018 report (OECD, 2019) and the Spanish PISA 2018 report there is an observed decrease on the 4th and 10th grade students' average achievement in math and science in comparison with the results of

2015. Substantial differences exist between mathematics and science subjects. In the case of mathematics, boys have better results than girls. There is a gap of 14 points among the average scale of 4th grade boys and girls scores. Meanwhile this gap is only seven points in the case of 10th grade students. Although non-significant differences can be found when considering the mathematical content domain (numbers, measures and geometry and data), there exist significant differences in relation with the mathematical cognitive domain. The biggest gap between girls' and boys' performance is in the domain of reasoning. In the case of science, there is almost no gap between boys' and girls' performance in the global assessment for students of grade 4th and 10th. Girls have a better achievement in Life Sciences than in Earth and Physical science. The biggest gap in scoring is in Physical Science.

Most of the students are clustered in the levels three and four in the scale of performance. There is only a 4% of students in the level six of performance for both subjects, mathematics and science. Furthermore, there is a deficit in the representation of girls among the students with highest levels of achievement in science and mathematics. Due to its idiosyncratic nature, Spain has cultural, social and political differences that affect the regional laws of education. There are regions with almost no gap between the scores of both genders; meanwhile, there are others with almost a gap of 10 points in favor of boys, so it seems that there might be a correlation.

3.1.2. Career Expectations in STEM/STEAM

CYPRUS

Despite performing better than their male counterparts, adolescent female students who are top performers in math and/or science are less likely to pursue a career in science and engineering (21.6%) compared to top performing teenage boys (26.3%). They are also more likely to work in a health profession (26.7% of girls as opposed to 22.2% of boys), which is a pattern that was observed in many other European and OECD countries (OECD, 2019a). Besides gender differences in student career choices, it is interesting to note that less than half of high-achieving adolescent students, both male and female, are interested in pursuing studies and professions where they can utilize their high-level math and science skills. Another important finding about students' future career plans and aspirations is that approximately one fifth of 15-year-olds in Cyprus do not have a clear idea about their future job at that age (OECD, 2019a). Also, based on OECD data (Mann et al., 2020) a large percentage of both boys (45%) and girls (43%) at this age expect to work at jobs which by the time they become 30 years old are likely to be automated[2]. The above findings show that many Cypriot students, including high performing ones, are most likely not adequately informed of the availability of current jobs and, more particularly, of jobs with good prospects that are in line with their abilities.

[2] According to the 2020 report "The Future of Jobs" by the World Economy Forum: "... by 2025, 85 million jobs may be displaced by a shift in the division of labour between humans and machines, while 97 million new roles may emerge that are more adapted to the new division of labour between humans, machines and algorithm" (p. 5)

GERMANY

The gender gap identified above relating to performance in math and the natural science not only leads to fewer girls than boys performing at or above Level 5 in Natural Sciences, but also makes girls – even top-performing girls – less likely than boys to work in a science-related occupation. As this situation cannot be explained by performance related differences of boys and girls, other aspects like job attractiveness, image, interest, gender-related role models need to be considered.

Amongst high-performing students in mathematics or science, about one in four boys in Germany will typically work as an engineer or science professional at the age of 30, while only one in eight girls will do so. About one in four high-performing girls will work in health-related professions, while fewer than one in ten high-performing boys will do so. Only 7% of boys and 1% of girls in Germany plan to work in ICT-related professions.

GREECE

Girls in Greece tend to follow more humanitarian professions (medicine, nursery, teaching, law, veterinarians), while boys seem to prefer careers in engineering, athletics, police and armed forces. Professions of science and engineering are the expectation for almost an equal number of boys and girls (23.1% to 23.4% respectively). On the other hand, health professions are far more popular among girls (27%) than boys (15.4%). According to the Hellenic Authority for Higher education (HAHE, 2019) boys are more likely to choose Engineering and Technology (17%, versus 6% of girls) as a field of interest, and they are also less likely to follow a career in Computer Science (2%), health and bio sciences (3%). Girls tend to choose Art and Humanities (9% vs 5% of boys), and are less likely to follow Computer Science (1%) or Physics and Math (4% versus 6% of boys).

Moreover, the results from OECD (PISA 2018) show that students from disadvantaged backgrounds tend to hold lower ambitions than would be expected, regardless of their academic achievements and performance. More than 30% of high-achieving disadvantaged students did not expect to complete tertiary education.

SPAIN

In the 2018 PISA survey, only 49% of 15-year old boys and 56% of 15-year-old-girls had clear expectations relating to a future career. This changed to a small extent since the first PISA survey in 2000. PISA 2018 Spanish report (MEFP, 2019) informs that students' expectations for their academic and professional future are not only conditioned by gender. They are also conditioned by the socioeconomic status, parents' expectations, or their ethnic group. Most of the students have great job expectations; however, their academic aspirations are several levels below what is usually required in order to reach the positions to which they aspire. Meanwhile in the OCDE there is a 35% of socio-economically disadvantaged students who expect to enter high skilled jobs without completing their tertiary education; in Spain this percentage decreases to almost 18%. The percentage of students (advantaged and

disadvantaged) who expect to complete tertiary education in both groups are higher than the OECD average or the EU total. Again, there are differences at a regional level with the highest one of 33% points. The percentage of boys who expect to work in science and engineering is almost 10 percentage points higher than that of girls who think they will work as health professionals (around 10 percentage points). Five of the nine most cited career expectations named by girls are related to the field of health sciences (doctor, specialist, nurse, psychologist etc.), and other four can be related to community services (lawyer, teaching professional, policy manager, etc.), while those cited by boys are more varied: engineering, sports, politics, or teaching.

3.1.3. Representation in tertiary education

CYPRUS

As far as tertiary education in Cyprus is concerned, female students are overrepresented in university education and more specifically in postgraduate programs of study. Cyprus is one of the few European countries where women are overrepresented among doctoral students. The number of women pursuing doctoral studies has increased steadily since 2012, when there were equal numbers of men and women doctoral candidates, and according to a recent report by the European Commission (2019) Cyprus has currently one of the highest percentages of female PhD students (60%) among EU countries. According to another recent Eurostat data (Eurostat, 2020), in 2018 about 53% of students in Cyprus were female. Women accounted for 46.6% of all bachelor's degree students but constituted 65,8% of the students studying for a master's degree and 60% of those studying for a PhD.

Gender imbalance characterizing students' participation in bachelor programs of study can also be observed at the doctoral level, as female doctoral graduates are underrepresented in the field of ICTs as well as in the field of engineering, manufacturing, and construction. In 2016 there were 0% and 35% female doctoral graduates, respectively, in these two fields (European Commission, 2019). Women doctoral students are overrepresented in education, arts, humanities, and social sciences as well as in natural science (particularly, in biological sciences), mathematics and statistics. The latter (that is, natural science, mathematics, and statistics) constitutes the most popular research field for women, while engineering, manufacturing, and construction, on the other hand, is the most popular field of study for male doctoral students.

Also, female bachelor students have higher graduation rates than their male counterparts in all but 3 fields (agriculture-forestry-fisheries and veterinary, health and welfare, and services). However, female students are underrepresented in STEM fields. Eurostat data on tertiary education graduates by field of study show that in 2018 there were almost twice as many male than female students graduating in a STEM field (Eurostat, 2020). More specifically, while the field of "natural sciences, mathematics and statistics" has been rather women-dominated in recent years, female students are underrepresented in the field of information and communication technologies (ICTs) and in the fields of engineering, manufacturing, and construction (EIGE, 2018). Although there was an increase in female students' share of these fields since 2003, in 2013-2015 women in Cyprus represented less than 20% of students in ICTs

and approximately 35% of students in engineering, manufacturing and construction (EIGE, 2018). Further, gender segregation is even higher in STEM vocational education where women represent approximately 5% of the student population and their share tends to decrease.

GERMANY

According to the report of the German Ministry for Education and Research (BMBF, 2019), in no other OECD country is the STEM degree as popular as in Germany. More than a third (36%) of all graduates obtained a tertiary degree in 2017, i.e. a university degree or a job-oriented tertiary educational degree in a STEM subject. The percentage of STEM graduates in Germany in 2018 is 46,7% higher than in the EU (35,2%). According to the German Government, the total number of first-year students (1st semester) – including the number of women – increased between 2008 and 2017 in the domains of electrical engineering, mechanical engineering/process. At the same time, the gender gap in tertiary education in STEM is bigger than the EU in general. In Germany, women in STEAM education tend to choose natural sciences, mathematics and statistics significantly more than engineering or ICT. In 2012 the number of women graduating from ICT decreased slightly and increased in natural sciences, mathematics and statistics in comparison to 2006. Within EU-28, Germany had the largest increase of females in STEM in tertiary education from 2004-2012, but it also had a slight decrease in vocational training. The percentage of females in STEM careers is lower than in all other academic fields. However, the percentage increased in all fields over the last 10 years, including STEM (Statistisches Bundesamt, 2019). In 2019 the participation of females in Math and Science degrees was nearly 50%, but in engineering it was a lot lower (23,6%). Of the women in Math and Science 35,4% are graduating with a Bachelor, 29,6% with a Master degree and 15% graduate with a PhD. In Engineering however 56,1% are graduating with a Bachelor, 36,3% with a Master, and just 3,6% graduate with a PHD.

GREECE

According to HAHE (2019), 43% of the population between the age of 25-34 in Greece has a first degree in higher education, which is almost the same as OECD and EU average. Among them, the majority are women (51%), while men are less by 16%, reaching 35% in this age range. It is crucial to highlight that Greece is reported to have raised its percentage of people between the age of 25-34 who have a first degree in higher education by 15% since 2008. In Greece, most students choose engineering, construction, and building as well as business administration and legal studies. Arts and humanities are among the popular choices, followed by: social sciences, journalism and information, natural sciences, mathematics and statistics and then computer science and communication systems. The biggest deviation from the European average is that Greek graduates do not show as much preference to the health sciences and social welfare, contrary to the rest of Europe.

Among all enrolled higher education students in Greece (766,874), women outnumber men in four out of ten categories based on the subject of study as follows: arts and humanities, education, health and social sciences, social sciences, journalism and information. Men outnumber women especially in engineering and construction sciences, science, math and

statistics and information and communication systems. The presence of women among doctoral graduates increased between 2007 and 2016 both at the EU-28 level and at country level. The proportion of women among doctoral graduates for 2018 was 49,2%, with preferences towards fields of study such as: education, arts and humanities, social sciences journalism and information, health and welfare, mathematics, natural sciences and statistics. Women tend to avoid careers in business administration and law, engineering or informatics.

SPAIN

In 2018, women represented a 53% of tertiary education students in Spain (Eurostat, 2020). Short-cycle tertiary courses, however, which represent the 20% of tertiary education, had a higher participation of men. Most of the Spanish students (59%) were studying for a Bachelors' or equivalent, among of which 54% were women. The highest gap between males and females concerns their presence in tertiary education at the Master's level where 58% of students were females. Only 4% of all students studied for a doctoral degree with a balanced proportion between men and women. In 2018, there were only 5,2% of graduates in natural sciences, mathematics and statistics, 3,9% in information and communication technologies and 13,1% in engineering, manufacturing and construction. This represents a total of a 22,2% of graduates in STEM fields. There is a gender gap of over 13 points that favours males graduates in natural sciences, mathematics, and statistics, information and communication technologies, engineering, manufacturing and construction (Eurostat, 2000).

Gender segregation in STEM is much stronger in vocational than in tertiary education with a difference of almost 18%. In Spain, gender segregation in STEM vocation training remained stable in women's engagement in this sector during the last decade (data from 2004-2012) with a difference smaller than a 5%. In particular, there was a non-significant positive increase in STEM tertiary education and a negative one in vocational one (EIGE, 2018). Considering gender segregation in education across study fields and time (2013-2015), there are around 23% of female graduates in the STEM field in comparison among graduates. Less than 4% of females graduated in natural sciences, mathematics and statistics. Almost another 4% of girls graduated in information and communication technologies, and over 15% of femine graduated in engineering, manufacturing and construction (EIGE, 2018).

3.1.4. Female representation in STEM/STEAM research and professions

CYPRUS

Although the number of women pursuing doctoral degrees has increased in recent years, women are under-represented among academic staff. In 2016 women made up 47% of academic staff in Grade D positions (which do not require a PhD) but their percentage declined rapidly in higher positions. Specifically, women constituted 39,7% of Grade C staff (staff holding entry-level academic positions after obtaining a PhD) but only 31,6% and 13% of Grade B and Grade A staff, respectively. Women academics in Grade A positions are more likely to be found in social science and medical science fields (SHE Figures, 2019).

In Cyprus the percentage of researchers among R&D personnel is high in higher education but low (the lowest in Europe) in the government sector. In 2015 the proportion of women researchers in Cyprus was 37,9%, which was higher than the EU mean (33,4%) and also characterized by higher annual growth than that of Cypriot men researchers (European Commission, 2019). Women researchers are concentrated mostly in higher education. They are slightly overrepresented in the government sector (where their proportion is 55,9%) but are underrepresented in higher education (where they make up only 37,6% of the research staff), in most activities and fields in the business enterprise sector (32,4%) and in the private non-profit sector (30.3%) (European Commission, 2019). In the higher education sector, the proportion of women among researchers is higher in the humanities, in medical and health sciences and in social sciences (where in 2015 it was 47%, 42% and 41%, respectively) compared to natural sciences, agricultural sciences and engineering and technology (where in 2015 it was 33%, 30% and 30%, respectively). The percentage of researchers working with "precarious" (that is, with non-permanent) contracts is higher for women (14,2%) than for men (9,4%) and women earn less than men researchers (the pay gap was 18,9% in 2014) (European Commission, 2019).

In Cyprus men with tertiary education are more likely to be employed and, also, to be employed as professionals or technicians (49,7%), compared to women (46%) (European Commission, 2019). The proportion of women is higher than that of men in knowledge-intensive jobs, such as jobs related to education, healthcare and social work, where women traditionally have had higher shares than men, both in the public sector and in the business industries. There is also a gender imbalance in the opposite direction regarding men and women scientists and engineers who make up 3,7% and 3,1% of the labor force, respectively (European Commission, 2019).

The most popular undergraduate field of study in Cyprus is business (Ministry of Finance, 2020). In 2018, 39% of tertiary education students had graduated in business and only 15.2% graduates in STEM field (Eurostat, 2020). This is related to the fact that the percentage of all employees working in STEM occupations in Cyprus has been relatively low compared to the EU average. Specifically, in 2013-14 only 10% of all employees in Cyprus worked in STEM occupations and this percentage was lower than the EU average which was approximately 13.5% (EIGE, 2018). The share of women in STEM occupations was 12%, also lower than the EU average, and was characterized by a significant decrease (more than 5 points) in the percentage of science and engineering professionals. The percentage of women working as science and engineering professionals, ICT technicians or ICT professionals was below 30%, 30% and 20% respectively, but still above the EU mean (EIGE, 2018). Gender segregation was much higher in vocational education STEM occupations (such as electrical and electronic trade workers and stationary pant and machine operators) where the share of women was much lower than the EU mean, which was approximately 5%.

Women's under-representation in STEM professions, which have higher pay levels, can be a factor that contributes to the gender pay gap in Cyprus (EIGE, 2018; OECD, 2020) which is currently 13.9% (Pavlou 2020). However, besides overall differences in earnings between men

and women, statistics show that there are gender gaps within specific sectors, which may reflect the role of vertical gender segregation and the glass-ceiling effect (EIGE, 2018). The pay gap for STEM occupations is approximately 13% in Cyprus, which is much lower than the gender pay gap in the business economy.

In a 2019 forum organized by the Ministry of Labor, the equality body and the Committee on Gender Equality in Employment and Vocational Training, it was pointed out that even though the right to equal pay is now enshrined in legislation, there is gender bias in perceptions of the abilities and roles of men and women (Pavlou 2020). This accounts for the persistently high gender pay gap. During the forum it was also highlighted that women are underrepresented in high-pay positions and they are often responsible for the unpaid domestic and care work in their households, which consequently leads to difficulties participating in the labor market or competing for senior positions (Pavlou 2020). In addition, the lack of affordable and reliable care facilities for children and other members of the family, as well as the lack of flexible employment - comparably lower than other European countries - enhance gender inequalities in employment and the gender pay gap.

GERMANY

In general, the percentage of female academics in Math, Science, Engineering is lower than their participation in the study programmes. The gap is highest on the level of professors.

In majority of EU-28 countries including Germany, fewer women than men are employed as scientists and engineers (S&E), according to the SHE Figures 2018. The proportion of female scientists and engineers in Germany was 2.7%, which is lower than the EU-28 countries (3.1%). Despite a number of strategies aimed at encouraging more women to opt for technical and engineering jobs, these categories do not feature in the list of 20 most popular professions among women. The old favorites remain to be office administrator, doctor's receptionist and sales assistant.

The total number of female STEM workers was reduced by 5 percent to just over 1 million from 2011 to 2016, compared with 8 million men in such jobs. The shortage of skilled STEM workers widened to 338,000 in October, up 42,000 from 2017, which emphasize the lack of female interest in the domains of engineering and IT, which are more popular among men (Gillmann et al., 2018). According to the Eurostat (2020), the number of females' employment in technology and knowledge-intensive sectors has a significant improvement from 2010 (538.8) to 2019 (605.4) and contributed the highest number within the EU-28 countries.

The average gender pay gap in Germany for 2020 is 18% across all sectors. The gender pay gap in 2020 varied greatly by sector. The highest were in arts, entertainment and recreation (31%), professional, scientific and technical activities (27%), followed by health and social work (24%), banking and insurance, and information and communication (both 23%). The earnings gap was also relatively high in manufacturing (22 %) and trade; repair of motor vehicles and motorcycles (21 %), where men are traditionally more represented than women. (Statistisches Bundesamt,

2021b). Even though the gender pay gap has been decreasing in Germany over the past years, it is still among the highest in Europe (Statistisches Bundesamt, 2021c).

GREECE

In general, Greece has very low shares of both women and men working in STEM occupations, compared to the rest of the EU Member States. Women in Greece are more likely to work in private non-profit organizations (46%) and state universities (44%) when it comes to research. Private for-profit enterprises are largely male-dominated. The study of SHE FIGURES (2018) showed that women are under-represented, in comparison to men, in the population of scientists and engineers although they are over-represented among the tertiary-educated who are employed as professionals or technicians. Greece has one of the lowest proportions of part-time employment among women researchers (2.1%) (SHE FIGURES, 2018). In the higher education sector, women researchers are more likely than men to be employed under 'precarious' contracts (8.1% vs 1.7% respectively) (SHE FIGURES, 2018). The existence and increase of precarious employment is subject to debate throughout the EU (European Parliament, 2016). Researchers with 'precarious working contracts' are those without contract, with fixed term contracts of up to one year, or with other non-fixed term, non-permanent contracts.

According to the Unesco Science Report (UNESCO 2015) in Greece, women are 48% of students (university-PhD) in STEM fields. They fall to 37% of researchers in science while 21% of A level researchers. The proportion of women among grade A staff, in engineering and technology was 12,3% for 2016 (SHE FIGURES, 2018). Finally, less than 10% of the professors at the University are women. This already signifies a great inequality that women face during their career. It is difficult to maintain a top researcher career as a woman in Greece. Furthermore 11% of women have unstable jobs in research (compared to 3% of men). Moreover, women are paid 18% less than men in science and research in the private sector. In general, women with a higher education degree are paid less than their male colleagues, earning 79% of their salary (HAHE, 2020).

SPAIN

During the last ten years, the proportion of PhD holders who were females has been higher in Spain than in the average in the European Countries. In 2018, this increment rose to 50,8% of women, almost three points over the European average (Eurostats, 2020). At the same time, based on the 2016 figures of approved doctoral theses by field of study in public universities, there is an observed horizontal gender segregation for the field of Engineering, Industry and Construction (37% female). In the other fields, including those of Mathematics, Science, Statistics, Technology and Information Communication, there is a gender balance with no significant changes overtime (MCIYU, 2018)

The proportion of women among all research staff (in full-time equivalence) in Spain in 2016 remains stable at 39% (a figure already reached in 2009). The representation of women in research careers at university remains low in the highest rank category (Grade A), while there is a gender balance in the other research categories (Grades B, C and D), which indicates a glass ceiling effect. The distribution of researchers according to age groups continues to call into question the generational factor as the main explanation for the vertical segregation in the research career and in governing bodies: women make up 31-32% of senior research staff over 54 years of age in private and public universities. In all other groups there is a gender balance.

In terms of the horizontal gender segregation, the evolution of the distribution of female and male researchers in each of the scientific-technological areas of public universities shows that in 2016, women continued to be under-represented among the research staff in the areas of Engineering and Technology (24%), Natural Sciences (34%) and Agricultural Sciences (36%) (MCIYU, 2018). Engineering and Technology, together with Natural Sciences are the two primary areas that show an under-representation of female researchers (28% and 35% respectively) when analyzing the staff of both public and private universities.

Male researchers (7%) have a higher share of part-time employment than women (4%) in Spain. In higher education contracting sector, women researchers are more likely than men to be employed under precarious contracts.

In the recent decades, there has been a notable increase in women's participation in the labor market, but one of the characteristics of this market is the concentration of men and women in different economic sectors and occupations, as well as gender-differentiated working conditions (INE, 2020). According to 2018 data, the gender gap in hourly wages increases with age, with a percentage of 18,7% in the sector of technicians and scientific and intellectual professions.

3.2. Promoting Gender Equality in STEAM

This section examines the ways in which gender equality is secured and/or safeguarded at a governmental level or otherwise, with regard to research and innovation as this is defined in the priorities of the European Research Area and Horizon 2020 Regulations on gender equality and gender mainstreaming. Information is also presented in relation to entrepreneurship and other available opportunities to support women's initiatives in the business and private sector.

3.2.1. Gender Equality and Integration of the Gender Dimension in R&I

CYPRUS

The Cyprus Research and Innovation Foundation (RIF), as the national research and innovation funding agency of Cyprus, actively supports the promotion of gender equality in Research and Innovation (R&I) and fully adopts the priorities of the European Research Area and Horizon 2020 Regulations on gender equality and gender mainstreaming. In addition, RIF has prepared and adopted the "RIF Gender Equality Plan 2018-2020", which addresses three dimensions of the issue: (a) Human Resource management, (b) Decision-making, and (c) Research content. The present Gender Equality Plan addresses all programmes, activities and functions that fall under the remit of the Foundation. To instigate the integration of gender dimension into R&I, this is targeted through a number of measures, such as:

- Including a gender-sensitive statement in all Calls and Programmes, to encourage more women to apply as Coordinators;
- Ensure gender-balanced formation of research teams by explicitly mentioning in all Calls that "Research teams should be as far as possible gender–balanced";
- Raise awareness and competence for applicants to identify whether or not a gender analysis is necessary in research content;
- Introduce a special section in order for applicants to indicate if and how sex/gender analysis was integrated in the research proposal and if not, to outline why it was not relevant to the proposed research;
- Encourage the selection of both women and men evaluators, while making available to them informative material on how to assess sex and gender integration in proposals and encouraging them to integrate gender analysis into research when evaluating proposals.

Importantly, the Foundation included the "GENDER-NET Plus" call under the RESTART 2016-2020 Work Programme, which aimed to strengthen transnational collaboration and to provide support for the promotion of gender equality through institutional change.

Finally, the Cyprus University of Technology developed a Gender Equality Plan for 2014-2020, under a Rector's Council's decision. The plan concerns all departments and the administration of the University. The working group includes members of the academic and administrative staff, as well as students. The gender equality plan was launched at a dedicated event 'Gender Equality: Vision 2020' and among its actions, which are mainly promoted and targeted at students, academic and administrative staff, is the development of quotas on higher positions, committees and key positions for women at the University.

GERMANY

The European Research Area Report 2018 for Germany states that Germany continues to have a strong overall performance in making optimal use of public investments in research infrastructures, in knowledge transfer, developing more effective national research systems and international collaborations. By contrast, Germany's performance in gender equality and gender mainstreaming in research has been somewhat weaker, falling just below the ERA benchmark on all three indicators. Germany nevertheless improved its scores at a greater speed than the EU-28 for two of these indicators. Thus, although there still appears to be room for improvement on this priority, Germany did make progress since the 2016 ERA Progress Report. During the period 01.10.2016 - 31.10.2020, Germany funded several programmes aiming to support female participation in STEM education and careers nationally.

Related to the specific goals of the FemSTEAM project, Germany also funds game-based learning activites such as the Serena Supergreen game: The Serena Project was produced in cooperation with Wissenschaftsladen Bonn, the Game studio The Good Evil and Technische Universität Dresden, and first published in 2017. Since then it is complemented with the Project "MitEffect" that is focussing on evaluating the effects of the project. "The project Serena aims at developing and evaluating a serious game providing individualized feedback to female adolescents (13-15 years) regarding their vocational competencies in the innovative field of renewable energy technologies. The serious game will use a point and click adventure to provide the girls with opportunities to explore the exciting working areas of technological vocations, and in doing so, to master typical challenges technicians are faced with when working in the renewable energy sector. The serious game is expected to contribute to (a) the acquisition of knowledge and competencies regarding technological vocations, in particular their typical tasks and challenges, (b) the development of interest in this vocational field, and (c) the increase of confidence in their abilities."

GREECE

The National Documentation Centre (EKT) is a public organization that promotes knowledge, research, innovation and digital transformation. Since 2007, the EKT has been actively supporting the enhancement of women's participation in the European Research Area through specific actions taken in national and European projects. In particular, in the framework of the PERIKTIONI Network and the project "Mapping of the Scientific Area of the Greek Women Research Potential" (2007), the EKT carried out an extensive census of Greek researchers. On June 20, 2019, the EKT organized the event entitled "Enhancing Gender Equality and the Gender Dimension in Research and Innovation" in the framework of the European project GENDERACTION, which aimed to strengthen gender equality and integrate the gender dimension in research at European level. The event addressed representatives of universities, research centers and research funders, gender equality and research executives, gender experts and young researchers. According to EKT (2019), the new law 4604/2019, which focuses on the prevention and elimination of discrimination and sexual abuse and on the promotion of issues related to gender equality, will further contribute and reinforce women's empowerment and gender equality in research and innovation.

The National Action Plan (NAP) for Gender Equality in Greece also lists several measures in the sector of studies and careers (ESDIF, 2017), including research activity for the recording of gender characteristics of education in all its levels and forms; undertaking actions to increase the percentage of women researchers in academia while increasing positions and providing incentives for women researchers; and supporting existing - and further enhancing - academic action and research on gender issues. More so, the NAP outlines actions that attempt to: maintain and strengthen undergraduate and postgraduate Gender Programs; sensitize the Academic and Research Communities (faculty members and researchers) to gender issues, sexism, discrimination and violence; establish a competent office for monitoring the implementation and promotion of gender equality within the structures of the Ministry of Education and the universities.

SPAIN

Spain's legal framework fully adopts the priorities of the European Research Area and Horizon 2020. As a whole, the Equality Law of 2007, the Law of Universities (LOMLOU) of 2007 and the Law of Science, Technology and Innovation (2011), constitute the basic elements on which to develop supporting specific measures aimed at suppressing those biases and barriers that allow highly qualified human capital to be wasted (Sánchez de Madariaga, 2011). The Woman and Science Unit, created by Agreement of the Council of Ministers in March 2005, is the Spanish body in charge of gender mainstreaming policies or mainstreaming in science, technology and innovation. It proposes the integration of gender perspective in scientific, technologic and innovative policies by promoting the following:

a. the presence of women in all areas of science, technology and innovation system, according to their merits and capabilities,

b. the structural transformation of scientific institutions for the modernization of the management resources considering the gender dimension and

c. the gender analysis in scientific research, in technological developments and innovation, as well as research specific in the field of gender and women's studies.

The Unit is involved in the publication of the third edition of statistics and science in Spain, "Scientists in data", the construction of an ERA-net about gender, in supporting the Public Research Bodies that depend on the Ministry, as well as in the elaboration of the Equality Plan of the General Administration of the State and the Equality Plan for the Information Society (MH, 2020). As examples of good practices in Europe, Gender Equality plans are mandatory in Spain for those private organizations that have more than 250 workers (European Commission, 2020a). New indicators have been adopted to ensure effective gender equality in recruitment and promotion procedures through the evaluation process, and in the composition of evaluation committees, and the management and dissemination of sex-disaggregated data.

3.2.2. Entrepreneurship

CYPRUS

One of the major initiatives to support entrepreneurship for women in Cyprus is the “Scheme for the Enhancement of Women’s Entrepreneurship”, introduced by the Ministry of Energy, Commerce, Industry and Tourism and co-financed by the European Regional Development Fund in 2007. It constitutes the central programme in terms of access to finance for female entrepreneurs. The aim of the Scheme is to develop, support and encourage entrepreneurship by women between the ages of 18 – 55, who wish to establish an enterprise, specifically in the sectors of manufacturing, services, tourist activities and e-commerce. Other initiatives include the “Women in Business Programme in Cyprus” (2018) and actions (e.g. seminars, workshops, training programmes and conferences) organized by the Cyprus Chamber of Commerce and Industry in close cooperation with BPW (Business and Professional Women) Cyprus.

GERMANY

Professional self-employment by women is becoming increasingly important in Germany. According to the microcensus, 34 percent of all self-employed persons in Germany were women in 2019. The Start-up Monitor of the Kreditanstalt für Wiederaufbau (KfW) 2020 also recorded a high number of business start-ups by women in 2019, at 36 percent (BMFSFJ, 2021). According to the Statistical Yearbook 2019, the proportion of professionally self-employed women in 2018, at seven percent of the workforce, was nevertheless only about half as high as that of employed men, of whom twelve percent were self-employed. A central concern of the Federal Government is therefore to support women in starting their own businesses (BMFSFJ, 2021).

To make it easier for women entrepreneurs to start their own businesses, the Federal Ministry for Women's Affairs, together with the Federal Ministry of Education and Research and the Federal Ministry for Economic Affairs and Energy, has set up the national agency for women entrepreneurs (bga). The bga bundles activities for women's entrepreneurial self-employment in Germany and offers cross-sector information and services on business start-ups, consolidation, growth and business succession (bga, 2021a).

The Federal Ministry for Women's Affairs also supports the bga project "Women in Business for the Future". In three project modules, recommendations for action are being developed on relevant future fields for women entrepreneurs, such as digitalisation or future models of female self-employment. The project will run until the end of 2021 (bga, 2021b).

The Federal Ministry for Women's Affairs is also funding the bga's "KITE - KI Thinktank female Entrepreneurship" project. As part of this project, an AI (artificial intelligence) tool is being designed to sensitise and train female entrepreneurs to deal resiliently with discrimination and gender-based disadvantage. The project will run until the end of 2021 (KITE, 2021).

GREECE

Although Greece has the highest percentage of self-employment (33.9%), well above the European average (15.5%) (World Bank, 2019), only one fourth of the active businesses in Greece are run by women (OECD, 2018; FEIR, 2020). The following national or EU-funded programmes aim to promote female entrepreneurship in Greece:

- The Women's Entrepreneurship Program is implemented under the Operational Program "Competitiveness and Entrepreneurship" and forms part of Priority Axis 2, which seeks to create and expand in-house entrepreneurship. The program aims to facilitate - through financial support - the launch of new businesses by women in almost all sectors of economic activity. A more specific objective of the program is to turn need entrepreneurship into opportunity entrepreneurship.

- The EQUAL Community Initiative is part of the operational program "Women's Entrepreneurship and the Interregional Support System for Social Economy - DIONI II", which is co-funded by the European Fund and the Ministry of Labor and Social Insurance (Equal-greece.gr, n.d.). The EQUAL Community Initiative is a tool of the European Employment Strategy aiming to implement and disseminate new ways of fighting discrimination and employment inequality.

- The 100MIRRORS program offers a website, where female entrepreneurs can present their experiences, skills, abilities, limitations and difficulties.

- The Community Initiative NOW "New Opportunities for Women" is a tool for vocational training for women. It encourages women to exploit their existing skills into businesses (individual or cooperatives).

Many of them, though, are considered inadequate since they have low rates of absorption and implementation, due to the unstable domestic business environment, high taxation, bureaucracy, uncertainty, lack of infrastructure, etc. As a result, despite the different programmes and initiatives in the country and at the European level, female entrepreneurship has not improved significantly in recent years in Greece.

SPAIN

Funds are available in Spain for promoting entrepreneurship (MH, 2020). These include the following:

- Business Support Program for Women - PAEM, a program launched by the national Chamber of Commerce and funded by the European Social Fund and the Institute for Women and Equal Opportunities (Programa de apoyo empresarial a las mujeres-PAEM).

- Innovatia 8.3, a project implemented between the University of Santiago de Compostela and the Ministry of Equality, which aims to introduce the gender perspective into the processes of knowledge generation and business creation, particularly committed to the scientific and technological sectors.

- Rural Women's Challenge Program. This program is aimed at women who want to start a bussines in the rural world in order to promote self-employment and business creation within this segment of the population.

In addition to these programs, there are a series of bonuses in the Social Security quotas for women entrepreneurs that work as an incentive to female entrepreneurship. From March 2020 it is mandatory for Spanish companies with 151 to 250 workers to have equality plans. For the following years this obligation will be applied according to an increasing scale.

3.2.3. National methods and/or tools for monitoring gender equality

CYPRUS

There is currently no specific legislation for monitoring gender equality, or adequate constitutional provisions on equality between men and women in Cyprus, but there is some legislation in place for implementing the directives of equality, mostly concerning cases of filing a complaint. More so, despite the Law 177(I)/2002 on equal pay between men and women for equal work or work of equal value, which implements EU equal pay provisions, a recent study by the Committee on Gender Equality in Employment and Vocational Training of the Ministry of Labour (2018) suggests that legal definitions are limited and the practical implementation of gender equality remains inadequate in national law (Pavlou 2020). In addition, legislation is in place for developing positive action measures for the promotion of gender equality in employment, but to date, no specific positive action measures in employment, or any other field, have been developed by any public or private law entity in Cyprus. Equally, little attention is paid to the effective implementation of the framework put in place to comply with EU law, particularly reflected in the lack of positive action measures implemented (Pavlou 2020).

The National Machinery for Women's Rights (NMWR) under the Ministry of Justice and Public Order is the main coordinating body for the monitoring and promotion of gender equality in Cyprus. It advises the Council of Ministers on policies, programmes and laws promoting women's rights, and it monitors, coordinates and evaluates the implementation and effectiveness of these programmes and laws, carries out information, education and training programmes on relevant issues, contributes to the mobilization and sensitization of the public sector on equality issues. It also serves as a cooperation channel between the Government and women's organisations and NGOs working on gender equality and women's rights. Among the most significant policy documents produced by NMWR is the "National Action Plan on Equality between Women and Men" (2007-2013) and later the "National Action Plan for Gender Equality 2019-2023". The objective of the latter in particular, is to ensure the implementation of the gender equality principle in the context of national Research and Innovation programs.

GERMANY

German constitutional law implies a commitment by the state to an active and effective equality policy. Article 3(2) of the Basic Law not only states 'Men and women are equal', but expressly obliges the state to enforce equal rights for women and men and to work towards eliminating existing disadvantages. The Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (Bundesministerium für Familie, Senioren, Frauen und Jugend – BMFSFJ) states that this is the basis for gender mainstreaming and for the establishment of gender equality as an integral part of political action by the federal government in all policy areas.

Information relevant to gender mainstreaming can be obtained from the website of the BMFSFJ. The Gender Competence Centre (GenderKompetenzZentrum) publishes vital information regarding the implementation, tools and strategies for gender mainstreaming. It was financed between 2003 and 2010 by the Ministry but is no longer updated. The Agency for Gender Equality within the ESF (Agentur für Querschnittsziele im ESF, 2007–2013) also provided a useful platform in this regard, which is funded by the Federal Ministry for Labour and Social Affairs, including recommendations for the implementation of initiatives under the ESF+ for 2021–2027 (Agentur für Querschnittsziele im ESF, 2018) but this, too, has been abandoned. Nevertheless, gender mainstreaming is expected to continue to be promoted, particularly within the framework of the ESF.

Training and awareness-raising is one of the methods used, in which many non-profit organizations (NGOs) and private operators provide gender equality and diversity training; however, there is no consistent national structure or program. In addition, the BMFSFJ publishes relevant studies, including the annual equality index and the gender equality report. The collected data is based on the 2015 equality statistics regulation. The gender equality report takes a more intersectional view and examines inequality categories including age, disability, citizenship and migration status.

The Federal Office of Statistics uses data from the 'microcensus'. Almost all studies/surveys and publications are gender-disaggregated. Although the data are, in principle, available and accessible, there is no intersectional analysis of different groups of women and men. Gender-related discrimination is monitored on a regular basis (e.g. gender pay gap, education, leadership).

GREECE

The General Secretariat for Gender Equality (GSF) of the Ministry of Interior is the competent government body for the planning, implementation and monitoring of the implementation of policies for equality between women and men in all areas. It addresses a wide range of gender equality bodies, such as Public Administration, Local Government, Educational Institutions, Research Institutes, Feminist and Women's Organizations and includes:

- Website-node -paratiritirio.isotita.gr: An easy-to-use integrated information system that enables the collection, analysis, processing and dissemination of statistical data, metadata and indicators related to gender equality. Its purpose is to capture gender differences between men and women (gender gap) in key policy areas and the long-term monitoring of trends, developments and critical figures for gender inequality in Greece.

- Special applications: pososto si.isotita.gr, an easy-to-use electronic application, which guides the organs of the Administration in the formation and registration of the established or under establishment collective bodies and facilitates both the observance of the quota and their monitoring by the General Secretariat of Equality.

The General Secretariat for Equality in the proposed Draft Law on Substantial Gender Equality promotes the establishment of the National Council for Gender Equality (ESIF), as an advisory body composed of representatives of the most representative women's and feminist organizations, movements and public and private sector bodies of representatives of the local government of first and second degree and independent authorities. Occasionally, academics, experts, scientists, women and men from Greece or abroad are invited, with recognized prestige and specialization in specific issues of Gender Equality. The ESIF discusses, evaluates, evaluates existing Equality policies or proposes to the GSIF policies and actions promote Gender Equality.

SPAIN

The organization in charge of monitoring the actions done in Spain to promote equality in gender according to the Law of Equality 2007 is the “Observatory for Equal Opportunities between Women and Men” launched in 2011. It is a body managed by the “Instituto de la Mujer” (Womens’ Institute), which aims to build an information system with the capacity to know the situation of women with respect to that of men, and the effect of institutional policies implemented to promote the participation of women, in all areas, on a plane of equality. Ten categories of thematic indicators intend to analyze gender differences (Instituto de la Mujer, 2020). Two of these categories are important for this study: education, and science and technology. Education indicators include information on the Level of Studies, Students and Teachers, Educational results, which has to shed light on the differences that may occur, between women and men, at different educational levels as well as differences in the performance of both sexes from a gender perspective. Science and Technology indicators refer to measurements on uses and patterns of use of new technologies disaggregated by sex, the incorporation of women to training itineraries in technological specialties at all levels, a battery of indicators related to the participation of women and men in science and technology professions, as well as in the world of research, in all its aspects, indicators on access to research resources (scholarships, project concessions) based on gender, as well as the occupation of positions of responsibility in all the fields of the scientific world.

3.3. Educational National Policies that address gender disparities in STEAM

This section provides a brief overview of the existing national policies in each partner country (Cyprus, Germany, Greece and Spain) as well as of other related activities that are funded by governmental bodies and which take place at a national level, addressing gender disparities in STEM/STEAM education. These policies and other initiatives also reflect existing issues relevant to the gender gap in education, employment and pay in later career paths.

CYPRUS

The National Action Plan (NAP) on Gender Equality, developed in collaboration with all relevant government departments, women's organizations and NGOs, is significant for it addresses six priority areas, namely: employment, decision-making, education, gender stereotypes, social rights and violence against women (Pavlou & Christodoulou, 2012). In its Chapter on Education, it puts particular emphasis on the elimination of stereotypes and this is being pursued within the framework of a wider educational reform. More specifically, the Policy on Gender Equality in Cyprus states that the "NMWR has pursued a number of initiatives aiming at challenging stereotyped traditional gender roles. In particular, two projects were implemented: the first aiming at encouraging girls to pursue new career paths and the other aimed at encouraging boys to become more involved in family and private life" (2012, p.14.) This only affirms the wide acknowledgement of the gender gap between boys and girls, as it is also proven by data presented above.

One of the most recent policy documents dealing with gender mainstreaming in education and research is the *Strategic Planning for the Equality of Men and Women 2014-2017 in Education*. This strategy was developed by the Pedagogical Institute and identifies several targets. Under Target III, action 13 Education Institutions (including Universities and Research institutions) are encouraged to create Gender Equality Plans, including a legal framework for gender issues and policies for inclusion (EIGE, 2021).

The Ministry of Education, Culture, Youth and Sports in Cyprus has formed an inter-departmental committee that monitors the NAP and is composed of representatives from all Ministry of Education directorates and all levels of educational institutions (primary, secondary, technical and vocational, and higher education). This Committee oversees and co-ordinates all gender equality issues related to actions taken by the Ministry of Education, Culture, Youth and Sports. There is also a website dedicated to Gender Equality (Pedagogical Institute), which includes useful information, bibliography, and teaching material for promoting equal opportunities of both genders and gender mainstreaming in the educational process. The relevant "Code of Conduct Against Racism & Guide for Managing and Reporting Racist Incidents" was prepared and is currently implemented in schools, while trainings of educators also take place. The code makes references to gender stereotypes in education. Finally, collaboration of the Interdepartmental Committee with the Gender Equality in Employment and Vocational Training Committee and various NGOs is taking place.

A national policy addressing gender disparities particularly for STEAM related fields, where stereotypical perceptions about girls seem to be persistent, does not exist. More so, the fact that female representation in STEAM-related careers later in life remains low, regardless of girls' high achievement in math and science at a younger age, equally poses a crucial question regarding the reasons for such gender disparities.

According to the report about the Cyprus National Reform Programme (2020) the Department of Labour Relations (DLR) currently engages in activities contributing to raising public awareness on the gender pay gap (including in ICT) and its detrimental consequences on women's economic and social life (Directorate General: European Programmes, Coordination and Development, 2020). In the same report, the various obstacles, difficulties and challenges faced by women in their effort to enter and become familiar with digital technology is also acknowledged. The report states that several actions have been included in the third "Action Plan on Gender Equality 2019-2023" that aim to tackle the issue by focusing on the education and training of Women in Information and Communication Technologies. The plan is to increase the number of women in the field of computer studies and to develop their professional technological skills. Finally, under the thematic area "Eradication of Stereotypes and Social Prejudices" several actions aim at encouraging the increase of female participation in technical directions. In this regard, the Minister for Transport, Communication and Works, among other European Ministers, signed on 05.04.2019 the Declaration on the "Commitment on Women in Digital Technology" and provided to the European Commission information on relevant actions implemented and promoted at national level (European Commission, 2020b).

GERMANY

Generally, German policies aim at increasing female participation in the academic fields related to STEM (Best, 2013). This is visible in existing policies and programmes aiming to strengthen female participation in STEM (MINT) in Germany (Deutscher Bundestag, 2019). The non-profit foundation "House of Little Researchers'' funded by the BMBF (German Federal Ministry of Education and Research) is committed to good early education in the STEM areas nationwide with the aim of making girls and boys strong for the future and empowering them to act sustainably (Haus der kleinen Forscher, 2021; Ansari et al., 2012). The "initiative free of clichés - national cooperation for career and study choice" was launched so that young women and girls, as well as young men and boys, have the opportunity to make their career and study choices not only freely, but also informed. The "National Pact for Women in STEM Professions" ("Come on, do STEM."), initiated together with partners from politics, business and science, social partners, the media and associations, aims to convey a realistic picture of engineering and scientific professions, show opportunities for women in these fields and thus inspire significantly more young women for the future careers in STEM and win university graduates for careers in technical companies and research institutions

The Federal Government emphasizes that the "National Pact for Women in STEM Professions" and the guideline "Success with STEM - New Opportunities for Women" promote projects and specialist events in the funding area. The funding programme "Strategies for implementing equal

opportunities for women in education and research" also aims to promote measures to support young women in their (academic) career and study choice in favor of a STEM subject. In addition, the Federal Government gives in its answer a long list of programs at various universities in Germany where young women are promoted in STEM subjects. The total funding amount for the reported projects is around 17.8 million euros. The Federal Government emphasizes that no projects are funded in this context that aim to exclusively motivate boys and young men for STEM professions or courses of study.

The BMBF's STEM action plan "With STEM into the future!" (BMBF, 2019) identifies four fields of action that result from the current challenge of attracting more highly qualified young professionals to promote science, research and innovation in Germany: STEM education for Children and young people, STEM specialists, opportunities for girls and women in STEM, and STEM in society. The field of activity "Opportunities for girls and women in STEM" is based on the following findings (MINT-Aktionsplan, 2019): The choice of profession is often influenced by clichéd role models and cultural ideas of "typically male" and "typically female" professions, girls often underestimate their skills in STEM Subjects, women are underrepresented in many STEM areas. Concrete recommendations for action are provided by the inventory "Attracting young women to STEM occupational fields", which systematically summarizes scientific findings on the recruitment of young women from STEM as well as evaluation results from practical projects and derives optimization potential from them. Further suggestions can be found in the results of the projects "Cyber MINTCommunities" and "Light up your Life". Recommended among others, is an early address at the beginning of the educational chain, the dissemination of role models and active engagement with STEM.

GREECE

The National Action Plan (NAP) for Gender Equality lists several measures in the sector of studies and careers (ESDIF, 2017), including the examination and evaluation of the Curricula (APS) and the Interdisciplinary Unified Curriculum Framework (DEPPS) with emphasis on language and content; the formulation of modern educational material for primary / secondary education and updating existing educational material, so that they incorporate the gender dimension as an analytical category in order to promote through education the principles of gender equality and respect for diversity, as key pillars of democratic societies. More so, NAP aims to design, implement and monitor strategies for the promotion of women executives in positions of responsibility, participation in collective bodies in all areas and levels of education.

In the sector of art, the NAP for Gender Equality lists the following measures (ESDIF, 2017):

- Organizing educational programs aimed at removing patriarchal prejudices and stereotypes, in museums, libraries and other places of cultural promotion;

- Announcing competitions for artistic expression and creation in the context of the educational process and at all educational levels in order to raise the awareness of young people on issues related to gender equality;

- Organizing events and joint actions in Greece in collaboration with the Cultural bodies of different countries;

- Establishment of an Award for Gender Equality in the context of the state film, short film and documentary festivals, among others.

SPAIN

According to the Spanish State System of Education Indicators (MEFP, 2020b), the Spanish educational system is inspired by the principle of equity, which guarantees equality of opportunities, educational inclusion and non-discriminatory approaches and acts as a compensation element for the personal, cultural, economic and social inequalities. To achieve equality, teaching is adapted to guarantee access, permanence and progression of girls in the educational system.

The UNESCO 2030 Agenda for a Sustainable development, whose commitments are assumed by the Spanish government, recognizes through the SDG 4 and SDG 5 targets the digital gender gap in Spain. SDG 4 refers to the aim "To guarantee an inclusive and equitable education of quality and promote lifelong learning opportunities for all" and SDG 5 of the Agenda refers to the aim of "Achieving gender equality and empowering all women and girls". These also recognize the significant digital divide in women's access to STEM careers. The 2018-2021 Equal Opportunities Plan developed measures aiming at promoting the education of girls and women in science, technology, engineering, and math careers.

The new Spanish reformed education law states that the regional educational administrations will encourage the increase in the presence of female students in studies in the fields of science, technology, engineering, arts and mathematics, as well as in vocational training courses with a lower demand for female students. Likewise, the educational administrations shall also promote the presence of male students in those studies in which there is a notoriously higher enrollment of women than men. The educational administrations shall ensure that curricula and textbooks and other educational materials promote the equal value of women and men and do not contain sexist or discriminatory stereotypes (MEFP, 2020c). These strategies for inclusion have been a product of the involvement of the reformed national government with gender issues and of the acknowledgment that education has a significant role in changing the gender educational gap.

3.4. Extent of adoption of STEAM pedagogical models by national school systems

3.4.1. Relation between STEAM and formal education

This section presents the relationship between STEAM and formal education in all four partner countries. From the data gathered it seems that despite increased interest in STEAM, there are no official guidelines for the adoption of STEAM pedagogical models in the national school systems and STEAM related actions or initiatives remain an extracurricular activity. The following sections serve as indications of the sporadic inclusion of STEM/STEAM approaches in the school curriculum as well as the emphasis mainly on Sciences and robotics.

CYPRUS

Through extensive review of the Cypriot school curriculum, it is observed that there is no official STEM/STEAM related curriculum applied in terms of the official national curriculum taught in public schools. However, it is noted that policy makers acknowledge the potential of STEM education, therefore in the academic year 2019-2020, a pilot STEM program was introduced for primary schools as part of an optional after school program. In the secondary sector there has not been an official STEM/STEAM related program similar to this yet. Secondary schools are mostly introduced to STEM/STEAM through extra-curricular activities, mainly involving robotic competitions. It is worth mentioning that it is substantially easier to include STEM/STEAM in the curriculum of private schools as policies, organization and curricula reflect the individual management of one single school unit and are characterized by flexibility. Therefore, it is easier for private schools to develop their own scheme for STEM/STEAM education. Nonetheless, there are some official programs and competitions that promote STEM/STEAM education on a Pancyprian basis, such as the Pancyprian Educational Robotics Olympiad – World Robot Olympiad (WRO), the Cypriot Robotex Challenge, Youth Makerspace Larnaca etc.

GERMANY

The main focus of the German educational system, when it comes to STEAM lies on its STEM subset (MINT in German). However, due to the federal structure of Germany, the German educational system is decentrally organised and it is mainly in the responsibility of the individual German states, where the federal government plays a minor role. On a national level, the German educational system is tripartite, where only the highest track (Gymnasium) directly prepares students for higher education. Within this track, students can choose among topics to study in the final years, where usually a minimum coverage of STEM topics is required (Jacob et al., 2020). In most German states this specifically means that at least mathematics and one further science topic (chemistry, physics, biology) are mandatory. As a consequence of the federal system, school curricula and programmes are defined on the level of the individual states. Likewise, the responsibility of including STEM pedagogical models into the school system lies with these states. This leads to the situation that no overarching, consistent way of adopting STEM pedagogical models exists in Germany. Instead, we see a range of individual, regional, or state-wide initiatives, programmes and resources to be available.

GREECE

In Greece, specific STEM or STEAM programs complement the curriculum and are not taught at any level of compulsory education. STEM is taught only indirectly through the specific learning fields (physics, math, technology, chemistry, biology, geology, geography, art). On the other hand, numerous private initiatives like STEM Education (Organization of Educational Robotics, Science, Technology & Mathematics) develop comprehensive annual training programs for all levels of education. Also, robotics is very popular in private schools as an extra-curricular activity beyond the school program. Other initiatives include events that promote robotics, like international WRO (World Robot Olympiad) and FLL competitions, Panhellenic Festivals and local exhibitions of robotics. WRO Hellas organizes annually two separate competitions for all educational levels: the Panhellenic Educational Robotics Competition (October – March) and the WRO National Competition (March-July). The two competitions, aimed at the educational community as a whole, at primary and secondary education, starting from the Regions and ending in Athens for the final.

SPAIN

From 1990, the Spanish curriculum at the school level has undergone six major reforms in an effort to guarantee the universality, comprehensibility and equity of the Spanish educational system (López et. al, 2020). Two of these laws, LOE 2006 (MEC, 2006) and its modification LOMLOE (MEFP, 2020c) considered the construction of open learning environments and the equality of opportunities through the integration of subjects, as a step towards the integration of STEM disciplines.

What should also be noted are the efforts done by the regional administrations, the schools and the didactical departments of the schools that, individually, have considered the TIMSS and PISA results, described in the first section, as an opportunity to improve the current curricular proposals) (López et. al, 2020). The Spanish National Institute of Educational Technologies and Teacher Training recognizes the importance of scientific knowledge to raise the attractiveness of science education and scientific careers and boost the interest of young people in STEM. As well as, encourage teachers, researchers and students to participate in European projects, such as: Scientix, STEM Alliance, STEM Discovery week, Girls 4 Stem in Europe, MaSDiV, STEM PD Net. The main objective of these strategies is to give visibility to those initiatives related to the promotion of scientific and technological vocations among girls and to join efforts to ensure that girls have more information and references when choosing their studies and career.

3.4.2. Professional development opportunities on STEAM pedagogy

CYPRUS

Even though STEM/STEAM education is not embedded in the Cypriot official curricula, especially in public schools, there are several professional development opportunities that focus on STEM/STEAM pedagogy. During the academic year 2019-20, the Ministry of Education organized a specified training program via the Pedagogical Institute of Cyprus, the official institute that provides a variety of professional development activities for teachers. This training aimed to equip teachers of primary education with the necessary tools to succeed in the pilot STEM program. The Pedagogical Institute additionally released an announcement at the beginning of the year (Michaelidou, 2020) where a training activity related to STEM/STEAM was introduced through an Erasmus+ KA3 program entitled Assessment of Transversal Skills in STEM (ATS STEM) involving 10 public primary schools and 10 public secondary schools (gymnasium level). It is worth mentioning that most professional development opportunities relating to STEM/STEAM pedagogy are offered from EU-funded programs aiming at promoting STEM/STEAM Education. Examples of ongoing or recently concluded projects coordinated by Cypriot institutions include the Erasmus+ KA2 programs EL-STEM – Enlivened Laboratories within STEM Education (2017-2020), FA-ST: Fast prototyping and entrepreneurial skills to promote female founded start-ups in STEM (2019-2022), and STEAME: Guidelines for Developing and Implementing STEAME Schools (2019-2021).

GERMANY

From the range of individual, regional, or state-wide initiatives, across the country, we also see resources emerging promoting the nation-wide reuse of educational resources and supporting overarching development of programmes for school education and teacher education towards STEM. One such example is “Deutscher Bildungsserver”, an openly accessible meta-resource for educational resources. Bildungsserver offers collections of resources for STEM education in schools as well as information and resources for teacher education towards applying STEM education in their own teaching.

GREECE

Greek public schools have a considerable gap in curriculum when STE(A)M is concerned. However, in recent years, the Ministry of Education in Greece has undertaken certain initiatives and collaborations towards the integration of STE(A)M in the public educational system. One of these examples refers to the approval of a project to be implemented in public pilot junior high schools in collaboration with the organisation ‘STEM Education’ and which refers to the implementation of educational robotics in workshops of competences in junior high schools. Moreover, in 2016, the Stavros Niarchos Foundation donated support to the organization WRO Hellas. Specifically, the donation included the provision of EV3 Robotics kits to more than 100 public secondary schools throughout Greece, as well as teacher training.

SPAIN

The inclusion of STEM/STEAM in the Primary and Secondary Education has not been a priority in the Spanish policies of education that have been constricted by a traditional content driven curricula, being a conditionat for the professional development opportunities of the teachers in this field. This professional development is part of a training strategy for continuous, professional lifelong learning. Teachers can acquire this professional lifelong learning through different forms. Those offered by the regional administrations, other entities and professional networks. Due to its importance in the implementation of STEAM professional lifelong learning courses, we present the results of the analysis of this teacher training in the period of 2015 to 2018. Only 8 of the 19 Spanish regions mention the inclusion STEAM teacher training in their plans of action (López et al., 2020). The Spanish National Institute of Educational Technologies and Teacher Training (intef) implemented a teacher training course in 2014 under the epigraph of "Computational thinking" and in 2020 under the title "Classroom of the Future: STEM scenarios and activities for Classroom of the Future learning spaces".

Advances in these professional opportunities on STEAM pedagogy have been announced in the first documents of the new Organic Law of Education with the inclusion of these pedagogies in the pre-service teacher training (MEFP, 2020c). And, a line of action has been designed for STEM education in the field of in-service teacher training (INTEF, 2021), particularly aiming – among others – to address innovation in learning, teaching and assessment methods, the use of digital resources in teaching, the development of resources, and the continuous professional development of educators.

4. SURVEY RESULTS

As part of the Erasmus+ Programme "FemSTEAM Mysteries: A Role-Model Game-Based Approach to Gender Equality in STEAM" we carried out two surveys involving the teachers and students of the 3 project partner schools in Cyprus, Spain, and Greece. The purpose of the surveys was to better understand the backgrounds, experiences, and views of our target populations and to gather information that would help us develop the methodological guidelines of the FemSTEAM Mysteries project. In the next sections we present the methodology and the main findings of the teacher and student surveys.

4.4. Teacher survey

4.4.1. Teacher survey methodology

An instrument was developed and posted electronically via Google forms to collect information on teachers' current perspectives and experiences regarding STEM/STEAM education, gender issues, and game-based learning. The instrument was developed in English and contained one section on demographics and 8 other sections that focused on the following: past experience and beliefs on STEM/STEAM education, gender and education, and game-based learning; gender differences in STEM/STEAM; current teaching practices and STEM/STEAM related teaching practices; current teaching practices and gender; instructional use of games; needs and recommendations. Nearly all questions were Likert-type or multiple-choice, to make it easy for teachers to complete the survey and respond to all questions.

The questionnaire was administered to teachers in the three partner schools in Cyprus, Spain, and Greece. Teachers were informed that their participation was completely voluntary and anonymous. A total of *39* teachers (28 female and 11 males) completed the survey: *16* teachers from American Academy Nicosia in Cyprus (*41.0%)*; *13* teachers from La Salle Buen Consejo in Spain (*33.3%)*; and *10* teachers from Doukas School in Greece (*25.6%)*. The majority were aged between 30-49 (*n=32, 82.1%*) and had been teaching for more than 5 years (*n=32, 82.1%*). Also, the large majority (*n=30, 76.9%*) had a Master's degree and many of them (*n=10, 25.6%*) had worked in the industry.

In the next sections we present the main findings of this survey. Data on teacher responses to questions addressing their practices and views about gender and education as well as about game-based learning are excluded from this Intellectual Output because they are presented in Intellectual Outputs 2 and 3, respectively. Also, due to the small number of participants no comparisons between institutions/countries were carried out.

4.4.2. Teacher experiences and perceptions on STEM/STEAM education

Teachers had studied and taught disciplines ranging from STEM fields, to languages, social studies and the arts. Only a few had a formal academic background (*n= 7, 17.9%*) or teaching

experience (*n=9, 23.1%*) in STEM/STEAM Education. Two-thirds of the participants (n=27; 69.2%) stated that they did not currently have any involvement/professional role in STEM/STEAM education. The remaining 12 teachers had been involved in various types of STEM/STEAM education initiatives, such as conferences, training courses or workshops, and international projects.

The majority expressed a high or very high level of familiarity with the STEM approach (*n=30, 76.9%*) and confidence in implementing STEM activities in their classrooms (*n= 25, 64.1%*). However, the many teachers (*n=22, 56.4%*) were also wondering as to whether they had the necessary skills to teach STEM effectively.

The vast majority appreciated the importance of STEAM education and its potential to improve educational practice and student learning. Respondents stated that they understood the importance of integrating content from different subject areas and disciplines (*n=33*, *84.6%*) and that STEAM education can enhance students' learning by connecting different subjects within an authentic, real-world context (*n=35*, *89.7%*). Also, the vast majority (*n=32, 82.1%*) acknowledged the need for teachers of arts/humanities to plan and work closely with teachers in STEM disciplines to deliver STEAM courses. However, less than half felt confident to incorporate STEAM activities into their classroom (*n=18, 46.2%*), to facilitate the transdisciplinary, inquiry-based learning process in STEAM education (*n=17, 43.6%*), or to find resources for teaching students about STEAM careers (*n=12, 30.8%*). Teacher responses are indicative of their need to engage in professional development activities focused on STEAM pedagogy.

4.4.3. Teacher perceptions on gender differences in STEM/STEAM education

Based on their responses to the survey, teachers did not seem to endorse stereotypes regarding the abilities of men and women in STEM/STEAM. For example, the majority (*n=33, 85%*) agreed that "boys and girls are equally smart in science" and that "women and men can be equally successful in STEM careers" (*n=34, 87.2%*). Also, no teacher agreed with the statement that "learning science, technology, engineering and math is more important for boys than for girls". However, many teachers did not seem to recognize that there are problems with the representation of women in school textbooks and instructional materials, and, therefore, to acknowledge the role of the "hidden curriculum" in the reproduction of gender stereotypes. For example, only about half of them agreed with the statements that "girls and women are underrepresented in school curricula and textbooks" (*n=20, 51.3%*) and that "there is often gender-biased language in textbooks that influences the way students think and speak" (*n=18, 46.1%*).

4.4.4. Teacher general and STEM/STEAM related teaching practices

Teachers were asked to report the frequency with which they employed various instructional strategies and activities that promoted student active learning and the development of 21st century skills. At least half of the teachers indicated that their students engaged in various complex, creative, and higher order thinking activities. For example, based on their responses,

teachers always or very often asked their students to create an original product or performance to express their ideas (51.3%), to try to solve complex problems or answer questions that have no single correct solution or answer (*n=21, 53.8%*) and to use technology to share information (71.8%), to solve real-world problems (66.7%) and to support teamwork or collaboration (66.7%) However, only a small number of teachers (n=9, 23.1%) frequently asked their students to choose their own learning topics or questions to pursue.

In addition, teachers reported that they used various types of technology on a regular basis. Examples of the most frequently used technologies include "traditional" tools such as presentation software (*n=32, 82%*) word processors (*n=31, 79.4%*) and email (*n=30, 76.9%*) but also mobile devices (*n=26, 66.7%*), podcasts/videos (*n=22, 56.4%*) and game-based platforms such as Kahoot (*n=22, 56.4%*). Less than half used technologies that can promote more inquiry-oriented and problem-solving pedagogical approaches, such as serious games (*n=16, 41%*), subject-specific software (*n=17, 43.6%*), and simulations (*n=16, 41%*).

Teachers reported making very frequent use of "conventional" means of student assessment, such as worksheets (*n=31, 79.4%*), exams (*n=25, 64.1%*), quizzes (*n=21, 53.8%*), and essays (*n=21, 53.8%*). At the same time, a considerable proportion employed alternative forms of assessment such as authentic problem-based tasks and projects (*n=23, 59.0%*), self-evaluation (*n=21, 53.8%*), group assignments (*n=20, 51.2%*), and peer evaluation (*n=18, 46.1%*).

When questioned about their current STEM/STEAM related teaching practices, only 7 teachers reported teaching STEM/STEAM integrated courses. The rest were teaching Individual disciplines (e.g., science, arts, mathematics). The approach employed by 4 out of the 7 teachers who taught integrated STEM/STEAM courses was multidisciplinary, with no attempt to cross the boundaries and generate integrated knowledge. Two teachers adopted an interdisciplinary approach, and only one teacher reported adopting a transdisciplinary approach in line with STEAM pedagogy. Most of these 7 teachers reported that they shared ideas and resources with their colleagues, they co-designed and co-taught STEM/STEAM learning activities, and that they knew where to find resources for STEM/STEAM education.

4.4.5. Teacher needs and recommendations

Teachers were also asked to report their biggest challenges and incentives regarding the adoption of the STEAM pedagogical approach as well as to explain whether they would be interested to receive professional development. Based on their responses, the most important barrier for adopting the STEAM approach was the lack of time to coordinate course content with other teachers (*n=27, 69.3%*), the need to to cover certain topics in their subject-matter so that students are prepared for future courses in their discipline (*n=25, 64.1%*), and planning and preparing STEAM lessons (*n=24, 61.5%*). Teachers stated several other barriers, such as insufficient infrastructure (*n=21, 53.9%*) and their own limited knowledge of strategies for implementing STEAM into the curriculum (*n=17, 43.6%*).

Important stated incentives for adopting STEAM education include the will to incorporate more student-centred strategies (*n=36, 92.3%*) and innovative pedagogical approaches (*n=35, 89.8%*)

as well as the beliefs that STEAM education relates better to the real world (*n=34, 87.2%*), can improve students' communication and collaboration skills (*n=35, 89.8%*) and prepares students better for their future studies and careers (*n=33, 84.6%*).

Finally, most of the teachers (*n=22*) would like to receive professional development that would focus on STEAM education, to help them become familiar with the approach and able to use it in their classroom, while only a few teachers expressed an interest in professional development on gender and education (*n=3*) or on game-based learning (*n=1*).

4.2. Student Survey

4.2.1. Student survey methodology

To understand the background and beliefs as well as the school and out-of-school experiences of adolescent students (ages 12-15), a survey was carried out in the three partner schools of the FemSTEAM Mysteries project, located in Cyprus, Spain, and Greece. An instrument was developed in English which, in addition to demographics, addressed the following topics: knowledge on STEM/STEAM studies and careers; after-school activities; school practices on STEAM; perceptions about STEAM studies and careers and of men and women in STEM/STEAM; use of games in daily life and at school. Nearly all questions were Likert-type or multiple-choice, to enable students to complete the survey in about 20 minutes and without leaving unanswered items. The instrument was developed and posted electronically via Google forms. Invitation messages explaining the purpose of the study, and providing a link to the survey, were sent via email to all teachers in the three institutions. Participation was completely voluntary and anonymous. No identifying information was collected from participants.

A total of 361 students responded to the survey from the three partner institutions: 102 students from American Academy Nicosia in Cyprus (*27.98%)*; 165 students from La Salle Buen Consejo in Spain (*45.7%)*; and 94 students from Doukas School in Greece (*26.04%)*. Fifty-three percent of the respondents (*n=190*) were male, 42 percent female (*n=152*), while the remaining 5 percent either identified themselves as "Other" (*n=8*) or selected "I prefer not to respond" (*n=11*).

In the next sections we present the main findings of this survey. Data on student responses to questions addressing their views about teacher classroom practices relative to gender as well as about the use of games in daily life are excluded from this Intellectual Output because they are presented in Intellectual Outputs 2 and 3, respectively.

4.2.2. Student knowledge regarding STEM/STEAM studies and careers

In the survey students were asked whether they had adequate knowledge of the types of activities that are involved in STEAM careers, whether they had family members or family friends who had worked in a STEAM field, and whether they received support to attend higher-level math and science courses. Finally, students were also questioned about the sources they use to get career advice.

Based on their responses, most students knew a family member or a family friend who had worked in a math or science-related field (*n= 243, 69.5%*) or who had worked as an engineer or in an ICT field (*n=242, 67%*). Also, many students knew someone who had worked in an arts-related field, although their proportion was smaller (*n=198, 54.8%*). Despite that, only about half of the students reported knowing about STEAM careers (*n=146, 40.5%*), how to find information about them (*n=161, 44.7%*), and what kind of classes they need to take in order to have a career in STEAM (*n=183, 50,9%*). Students stated that they seek career advice mainly from family members (*n=268, 74.2%*) and teachers (*n=100, 27.7%*). However, they also seem to rely a lot on the media, and mostly on the internet (*n=310, 85.9%*) and on social media (*n=105, 29.1%*) which provide access to information sources that are not always trustworthy and reliable.

Based on their responses, students are being encouraged to take higher-level math or science courses by their family (*n=240, 66.7%*) and by their teachers (*n=235, 65.1%*), and, overall, this encouragement is higher than the encouragement they get for art-related courses both by their family (*n=130, 36%*) and by their teachers (*n=155, 42.9%*). It is interesting also to note that the percentages of boys and girls who receive encouragement to take higher-level math or science courses are quite similar (e.g. 68.9% of boys and 65.1% of girls receive encouragement by their parents), however, the percentage of boys agreeing/strongly agreeing that their parents and teachers encourage them to take art-related courses is much lower than that of girls (32.1% of boys vs. 41.4% of girls receive encouragement by their parents).

4.2.3. Student after-school activities and school learning

Students were also asked to provide information about their after-school activities as well as to present their views about school practices relative to STEM/STEAM. Based on their answers, the three most common after-school activities were participation in sports/athletic teams (*n=164, 45.4%*), learning extra languages (*n=129, 35.7%*), and doing performance arts (*n=80, 22.2%*). The most common home activities (which students said that they did at least once a week) were social networking (*n=311, 86.1%*), playing video games (*n=235, 65.1%*), and reading books (*n=182, 50.4%*). Many students also reported that they engage in photo (*n=170, 47.1%*) and video editing (*n=156, 43.2%*) as well as in arts/crafts or design activities (*n= 168, 46.5%*). It is interesting that there were important gender differences regarding the frequency of playing games between the two genders: 70% of the boys vs. only 33 percent of the girls played video games every day or 2-3 times a week. Also, although half of the girls (49.3%) stated that they never or rarely played video games at home, the corresponding percentage for boys was only 12.6%.

Students' responses about their school experiences relative to STEM/STEAM show that about one-third of them (*n=130, 36%*) have taken a STEM/STEAM integrated course. Student answers regarding their experiences of general classroom pedagogical practices indicate that they engaged in several types of inquiry-oriented and collaboration activities quite frequently (always or very often), such as collecting and analysing information (*n=219, 60.9%*), working in

small groups to find answers to problems (*n=190, 52.7%*), and using technology to communicate with others (*n=241, 66.7%*). Smaller percentages of students, however, stated that their teachers very often or always asked them to engage in creative activities, such as doing experiments and creating things (*n=107, 29.6%*), communicating ideas using art-related means and techniques (*n=106, 29.3%*), using digital games to learn (*n=104, 28.8%*), and choosing their own topics of inquiry (*n=102, 28.3%*).

4.2.4. Student perceptions of STEAM studies and careers and of men and women in STEM/STEAM

More than half of the students reported that they enjoyed learning about math (*58.2%*), science (*65.7%*), arts (*54.8%*), and technology (*71.4%*). Also, more than half felt confident in their ability in math (*60.9%*), science (*54.6%*), and technology (*65.1%*), and *41%* expressed confidence in their ability in arts. However, less than one third of the students thought that they had what it takes to become mathematicians (*28.9%*), scientists (*31.9%*), and artists (*24.9%*), and only *33%* and *37.6%* thought so about becoming engineers and IT professionals, respectively. An interesting finding was that the percentages of girls were smaller than the percentages of boys who thought that they were qualified to become mathematicians (*23.7%* of girls vs. *35.2%* of boys), scientists (*27.6%* vs. *35.3%*), engineers (*22.4%* of girls vs. *42.1%* of boys) and IT professionals (*30.9%* of girls vs. *42.6%* of boys). On the other hand, one-third of the girls (*33.5%*), in contrast to only *17%* of the boys, agreed that they "have what it takes to become an artist".

Overall, students did not endorse stereotypes about women's ability to succeed in STEM careers. For example, most students agreed or strongly agreed with the statement "women and men can be equally successful as men in STEM careers" (73.7% of male vs. 82.5% of female students) and few students agreed with statements expressing stereotyped views about the abilities of boys and girls in STEM, such as "boys are more talented in mathematics than girls" (*12.1%*), "learning science, technology, engineering and math is more important for boys than for girls" (*10.5%*), or "girls are more inclined and better suited for the arts and humanities and boys for science and technology" (*13.8%*). However, it is particularly interesting to note that a considerable proportion of male students have conservative views regarding the role of women in STEM careers and the impact these might have on their family responsibilities. For example, around one-third (*31.1%*) of male students (vs. *17.7%* of female students) agreed with the statement that "a woman who is really dedicated to a career in science, technology, or engineering would not be able to devote much time or energy to her family" and only half of male students (*52.6%* vs. *73.0%* of female students) agreed/strongly agreed with the statement that "most women having a STEM career find that, with a little ingenuity and support, they can happily combine their career with having a family".

Also, significant proportions of students expressed stereotypes about the nature STEM professions and provided responses showing that they were not aware of the job prospects in STEM. For example, several students agreed or strongly agreed that "science, technology, or engineering related jobs are monotonous" (*28%* of boys and *23%* of girls) and that "science,

technology, or engineering related jobs are rather solitary" (*33%* of boys and *26%* of girls). Also, only a little more than half of the students thought that "science, technology, or engineering related jobs pay higher wages" (*58.8%* of all students) and that "there are many interesting STEM related jobs" (*59.8%* of all students).

5. CONCLUSIONS

Although STEM/STEAM jobs are going to be in great demand in the future, only small percentages of math and science top performing girls and boys are interested in pursuing careers in STEM/STEAM fields. In fact, adolescent female students are less likely than males to aspire to careers and to pursue studies in STEM/STEAM (science, technology, engineering, arts, and mathematics) fields, and this perpetuates already existing gender inequalities. Such inequalities are observed at national level (all partner countries), especially in relation to the low proportion of women among grade A staff in tertiary education, their under-representation in STEM related degrees, research jobs and academic positions.

Gender inequalities are often the result of many factors including but not limited to students' beliefs about their abilities, the value of STEM subjects, or the nature of the profession and those working in these fields; the latter often perceived as impersonal, solitary and mechanistic activities that are deprived from creativity and imagination, while professionals in STEM subjects are viewed as eccentric and socially inept geniuses who have no personal life. These are misconceptions that along with perceived cultural stereotypes and social expectations about the place or nature of women, discourage students from pursuing relevant studies and careers.

More so, parental expectations, pedagogical approaches, and role models seem to play a significant role in students' decisions about their career paths – much more than students' actual performance. In fact, it seems that exposure to role models that challenge stereotypes can change students' perceptions (Shin et al., 2016; Van Camp, Gilbert, O'Brien, 2019). Interventions targeting women's underrepresentation in male-typed academic fields using exposure to counter-stereotypical role models – such as successful female scientists – can also influence female aspirations and gender-related views, even if the duration of these interventions is brief (Oslo & Martiny, 2018).

In addition, students need to gain a better understanding of the nature of STEM research and professional activities, to appreciate their relevance to everyday life, their creative and collaborative nature, and their contribution to society. Students' interest in STEM and their understanding of the nature of STEM fields, can improve through inquiry-oriented, problem solving, creativity and trans-disciplinary thinking or activities that are personally relevant and highlight the social benefits and applications of STEM fields in real-life situations. Finally, the integration of the arts in STEM, as a new pedagogical approach, is expected to facilitated the development of thinking processes that support innovation.

Since, there are currently no official guidelines for the adoption of STEAM pedagogical models at national level in the different partner countries, while there are also no plans in place that target inequalities and monitor the implementation of actions that address gender disparities for the creation of equal opportunities to both male and female students, the *Fem*STEAM project comes to offer guidelines for the future. Finally, given the important role of teachers in the enactment of STEAM pedagogy and in the development of students' beliefs and academic aspirations, as well as the fact that teachers are often unfamiliar or uncomfortable with

incorporating STEAM activities, professional development becomes a key priority of the *FemSTEAM Mysteries* project. In combining Role-Model and Game-based pedagogy with a mystery story-telling digital game (serious game) *FemSTEAM* aims to challenge stereotypes about women and STEAM and about the characteristics of STEAM professionals and the nature of their work.

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