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Gender Differentiation in STEM Career Choice and the Role of Education

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Abstract
This work is the product of research conducted by the project team of the Regional Directorate for Primary and Secondary Education of Attica formed under the Erasmus+Project "RoboGirls: Empowering girls in STEAM through robotics and coding». The research has focused on identifying and investigating the factors that influence and interpret the differentiation in men and women's participation in education and in their professional careers in the fields of STEM, but also on the selection of the best educational practices that enhance the participation of women in the STEM fields. The research has combined literature review with data analysis resulting from questionnaires and interviews of a selected focus group. The results of the research have contributed to understanding the factors that conduce to the creation of these differences, as well as the role that education can play in Greece and in the EU in bridging the gender gap in the STEM fields.

Keywords
STEM, gender differences, education, professional career

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Introduction

The research was carried out in the framework of the Erasmus + RoboGirls project which is implemented in five European countries by six partners (Universities, one Regional Directorate of Education, specialized Private bodies) for the period 2020-2022. The Erasmus + ROBOGIRLS aims to promote gender equality in STEM sciences at school and to maximize the positive attitude of girls and boys in these sciences. The project uses the arts as a learning tool for students to increase their motivation in Science, Technology, Engineering and Mathematics as well as to guide students' exploration, dialogue and critical thinking, based on creativity and reflection. The encouragement of girls' participation in the STEM fields will be achieved through the organization of Workshops, Lesson Plans and Thematic Days, as a pilot application in schools. Part of the project is the present research, for the validity of which the application of data triangulation was chosen (Robson, 2007). The research process includes literature review on the participation rate of women in STEM sciences and the challenges of enhancing women's participation at European level as well as a secondary data analysis, a questionnaire surveying the views of the focus group members and a structured group interview.

Literature Review

Based on relevant literature review, there are differences as to which elements characterize a STEM educational intervention, and how should be applied. According to the most recent approaches, Boon Ng, S. (2019) and Psycharis, et al., (2020) the main pillars of the STEM approach are: interconnection to the Big Ideas (made up of Cross-cutting concepts) or Core Ideas, Transdisciplinary Approach and Linking school knowledge to everyday life problems. Glancy & Moore (2013) report that the STEM approach aims to help students develop evidential thinking in mathematics, design thinking in engineering, research in science and computational thinking in technology, all of which, although distinct and inter-dependent, are systemically connected through problem solving and experiential processes.

An integrated STEM approach connects school education to the needs of the future career workplaces that students will encounter in the future. STEM approaches promote the development of collaboration and communication skills through multiple learning options and skills development opportunities, necessary for future citizens and employees (Australian

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Curriculum, Assessment and Reporting Authority (ACARA), 2015). Overall, STEM education not only helps students to better understand STEM subjects, but also contributes to the development of skills for their future careers. (Hunt, 2011; Moore & Smith, 2014).

STEM research evidence, on the one hand acknowledge the important role STEM plays in the development of academic and social capital, and, on the other hand, record gender differences. The available data show that women are under-represented worldwide in the STEM fields, both in the number of graduates (especially at doctoral level) and in research, in fields such as mathematics, engineering and computer science UNESCO (2015).

As indicated in the UNESCO report (2017), "in terms of girls' participation in STEM education, gender differences at the expense of girls are already visible in pre-school education and become more obvious in the following educational levels".

EU countries, in close cooperation with the public and private sector and the civil society, have committed to enhancing women's participation in the digital and technological sector. (European Commission 2019a; European Commission 2019b). Each Member-State should:

- have a cross-sectoral national plan for women in the digital sector (autonomous or integrated in their existing digital agenda),
- celebrate "Girls in ICT Day" across Europe,
- Promote awareness-raising activities about women's contribution to the digital economy

Contemporary EU approaches to research and development reflect a relationship between science and society which focuses on building reciprocal relations between stakeholders, in scientific research and innovation, and social groups and their representatives, from a perspective of "Science with and for the society" (Kupper et al., 2015).

This effort is attributed to the term Responsible Research and Innovation (RRI) and has been, since 2015, part of the implementation of the European Horizon 2020 Program (European Commission, 2021). Application and implementation of Programs with a relevant orientation in formal education, starting from pre-school education to the next levels, sets the conditions for strengthening school education in the fields of STEM, in order to attract more young people to science through the promotion of innovative pedagogical methods. Moreover, emphasis is placed on addressing the challenges faced by young people and on inclusion for all, breaking down gender stereotypes against women in areas such as the pursuit of careers in science and research, and undertaking roles in institutions and decision-making centers.

Research Methods and Findings

The research was carried out in the framework of the RoboGirls project, implemented in five European countries by six partners, (Universities, one Regional Directorate of Education and specialized Private bodies) focusing on strengthening the teachers' skills to organize and implement innovative STEAM practical activities and events (such as lesson plans, workshops, thematic activities in schools) using robotics and coding. The goal is to reduce the gender gap, empower, encourage and energetically involve girls in digital technology activities, so that they are able to operate and play an active role in the digital age. In order to establish a link between real needs and the results of the project, it was deemed necessary to investigate, using valid methodological tools, the situation both in the partner countries and in the European Union as a whole. The Regional Directorate of Attica undertook the coordination of the relevant research and formulated the research questions and the proposal for the research methodology.

To ensure the validity of the research, triangulation of the data was applied (Robson, 2007), the collection of which was carried out using different methodological approaches. The research process includes: a literature review and secondary data analysis; a questionnaire to explore the views of the focus group members; and a structured interview of the focus group members.

Concerning the literature review and data analysis, predefined axis took place.

In the **STEM Education and Career** axis, it is clearly reflected that women are a minority in scientific researchers (UNESCO, 2020). In Greece and in the countries of the project partners, the respective participation rates of women range between 36.3% and 48.4%. There is also a difference in the type of career that women choose to pursue, with the largest percentage of women researchers ending up in an academic career in education, while for men researchers we have an almost equal distribution between an academic career and the business sector. Under-representation of women is also observed in the total workforce; women are fewer in the fields of science and engineering, but they outnumber men in higher education degrees in these fields. According to European Commission data presenting the "proportions of male and female scientists and engineers in the total workforce, by gender" in 2017, in all 28 EU countries the percentages are 4.5% men and 3.1% women. The highest difference in favor of men is found in Finland (8% men, 3.3% women) with Norway at the opposite side, with 6.7% women and 5.7% men. Differences of less than 0.5% are observed in the project partner countries, Croatia, Ireland and Spain, while in Cyprus the difference is 0.6% (European Commission, 2018; UNESCO, 2020). At the same time, women across Europe have less specialized digital skills - only 18% of IT specialists are women (European Commission, 2020). UNESCO agrees that women are fewer than men in the STEM fields worldwide, and that differences from country to country are due to sociocultural factors (UNESCO, 2015; UNESCO, 2017).

In the **Current situation in Greece in STEM / STEAM - School curricula** axis, it is reflected that STEM education has not been formally introduced in the curricula, while the efforts recorded so far are made mainly through pilot programs. Several studies have highlighted the effectiveness of the STEM approach in improving the educational process (Smyrnaiou, Petropoulou, Sotiriou, 2015; IEP, 2017; Kotsifakos, Kostis, Douligeris, 2017; Psyharis, 2018; Patrinopoulos, Iatrou, 2019; Psycharis, Kotzampasaki).

In the **Educational Policy in Greece** axis, it is recorded that the enhancement of students' digital skills is of "vital priority". The National Digital Strategy (ΥΠΨΗΠΤΕ, 2016) also includes the development of STEM. The report of the Eurydice Network sets the promotion and acquisition of skills and competencies (addressing low performance in mathematics, science and literacy through effective and innovative teaching and assessment, promoting entrepreneurship education, promoting critical thinking through STEM-related subjects, as well as science in an environmental and / or cultural context) as a school priority (Eurydice, 2021).

In the axis **National Initiatives that promote STEM education in Greece**, the current situation was recorded. Pilot programs, groups in Model and Experimental schools, Educational Priority Zones, Robotics and Science teams that operate in the context of extracurricular activities, Robotics Competitions, Skills Workshops etc. are some of what was studied (Patrinopoulos, 2017; Patrinopoulos, Kefalis, 2017; IEP, 2017; EELLAK, 2021). However, despite the increasing dynamics in the introduction of STEM in the educational process, it is found that the implementation of activities is fragmented and isolated, without systematic and long-term implementation in schools (Patrinopoulos, Iatrou, 2019).

In the axis **Correlation between school education in the STEM fields and the selection of STEM disciplines by women**, researchers record a strong correlation. Both the students' involvement in STEM and the age at which this happens are important (Freeman et al., 2014; Bottia et al., 2018). It is suggested that school activities should be based on daily life and play, offering experiences that enhance self-confidence, collaboration and communication skills, and experiential learning (Campbell et al., 2018). In an extensive survey that took place in Greece (in 123 General Lyceums/Upper Secondary Schools with the participation of 70,000 students,), Goulas, Griselda, & Megalokonomou (2020) recorded as a prevailing trend for educational and professional aspirations the fact that girls who, within their school class, have a comparative advantage in STEM courses, are more likely to choose the specific disciplines for their studies or careers. The results of this research, amongst other things, help us identify which points can be improved by a project such as "RoboGirls", so that girls choose their professional careers on equal terms in the future. Based on the literature data, the differences in the remuneration of men and women in STEM professions are pointed out, but also the fact that women do not wish to choose professions with high competition. In OECD countries, on average in the year 2017, only 30% of new entrants to STEM undergraduate programs were women (OECD, 2019).

Regarding investigation of the **Relationship between STEM school education and women's participation in STEM career fields**, studies show that girls are less likely to study in the STEM fields than boys. In IT, for example, despite the fact that the jobs offered have increased and there is a shortage of professionals in the field, women's participation in the industry is declining. The distorted views that alienate women from IT are: IT does not suit women, IT is just programming, IT is very difficult, a career in IT requires many hours of computer use without significant human interaction. Lack of female role models, less computer experience and lower self-confidence in their capabilities in the field are also significant barriers. At home, boys are more encouraged to focus on computer science by tech-savvy fathers. Over time, some of the above data may change, but women's participation in IT remains low (Papastergiou, 2008). Research by Delaney & Devereux shows that women prefer certain types of study or certain types of work directly related to the field of study. There are a number of recent surveys in various countries, which show that: a. women tend to choose professions oriented to working with other individuals (people), while men tend to choose professions which involve working with objects (things) (Kuhn & Wolter, 2020), b. women seem to have a comparative advantage in jobs that require social and interpersonal skills (Cortes, Jaimovich, & Siu, 2018), c. male-dominated professions are better paid, with women having lower wage expectations (Osikominu & Pfeifer, 2018). At the same time, it is found that gender differences in wage expectations are not the only way to interpret the choice of studies in STEM fields, as their investigation points to characteristics, like flexibility at work, which affect women. An additional motivation for women's choices is the capability to support the creation of a family through their profession. Some of their suggestions for improving the female position in STEM professions are that women's self-confidence in mathematics should be boosted and that the form of their admission to higher education institutions should be modified (for example, Cambridge University secures a number of STEM positions for female students) (Delaney & Devereux, 2021).

In the axis **Record of EU surveys / projects aiming to reduce the gender gap in STEM**, the study of García-Holgado et.al (2019) shows that the EU invested € 30,825,921.54 in the period 2014 -2019 for the gender gap in STEM. Most of the projects were combined with interventions aimed at increasing the number of women in STEM and achieving gender equality or balance within STEM.

Concerning the Questionnaire on the views of the focus group members and the subsequent interviews with them aimed to answer the research questions:

- Which factors contribute to encouraging or discouraging women's participation in STEM professions?
- Which educational practices can promote girls' participation in STEM?

To investigate the views of the members of the focus group, a structured questionnaire was used, which, after formative evaluation and review, was sent, completed, and returned. After elaboration of the questionnaires, for the joint interview to be carried out, there were joint teleconferences between the project research team and the focus group members. During these meetings clarifications were made, there was a deepening and highlighting of additional data which had not been pointed out in the questionnaires. The overall process of the meetings was structured in such a way that, despite the flexibility of the discussion, the necessary answers to the research questions were given. The methodological instructions and the questionnaire form were translated and used by the other project partners, so that a similar research process would be followed in their countries as well.

The participants in the focus group were all women (n = 9). They all come either from the field of education or pursue a profession and / or studies related to the STEM disciplines. What they have in common, therefore, is either their interest in promoting science because of their studies and their profession and also the way they view themselves and other women in the field, or their desire to introduce their students to processes that will open up new avenues for them in the STEM disciplines. The focus group team have enhanced academic and professional qualifications – they all have a basic degree and postgraduate studies; one holds a PhD and two are PhD candidates. All participants completed the questionnaire before the focus group meetings.

The factors that shaped the participants' study and career choices were:

- inclination / love for specific subjects (e.g., Mathematics, Physics, Chemistry),
- creative curiosity,
- inspiration or encouragement/incitement from teachers (the phenomenon of the encouraging and charismatic teacher -role model- who supported them but was also a model for their educational and professional decisions),
- participation in innovative programs and groups,
- the strong belief that these disciplines can offer good professional rehabilitation and
- the catalytic effect of the family environment (either by offering them a model or with the continuous encouragement of their choices).

Quantifying the view of the focus group that men in Greece, compared to women, are favored in their study or career choice in the STEM fields, the percentage in favor of this view is very high. With few exceptions, women believe that they face barriers due to a number of factors: gender stereotypes, lack of vocational guidance, reduced engagement in the STEM disciplines (toys - computers - constructions), discouragement from the family and broader social environment, barriers to women's careers (delay in promotions, sidelining at work or exclusion from projects because of their gender), lack of support by networks or groups of female peers with whom they would share common experiences.

Despite the fact that most of the focus group members had been involved in STEM projects in the past, the team decided almost unanimously that the Greek education system does not sufficiently support introduction of the STEM approach. The positive elements that were recorded from the implementation of the activities include: students' training in scientific methodology, the development of critical thinking, the connection of school knowledge to everyday life, personal participation of students in exploration / discovery and problem solving processes with the use of scientific practices, increase in students' interest and cooperation, increase in the participation of students with learning difficulties, a change of attitude towards science, attraction of children's interest due to the constructive nature of several activities which allows direct hypotheses testing, promotion of interdisciplinarity.

There was a consensus of the group members in considering the school culture and particularly supportive school administration as factors that favor and facilitate the STEM approach. If we wanted to single out one of the many suggestions made for the promotion of girls' participation in STEM, this would be the existence of a role model.

Conclusions

The first conclusions of this project-study, both from primary investigation and from current literature, lead to convergent findings about the encouragement of girls' participation in STEM activities and projects from as early as pre-school education to the end of secondary education. Such experiences and skills can help to better assess the potential of young girls and boost their self-confidence by helping them shape their educational and professional aspirations and make well-considered decisions about their studies and professional careers.

Bridging the gender gap in the STEM field and encouraging women to choose it and remain in the field requires further reforms in education, teacher guidance and training, academic programs and improved working conditions and opportunities.

Inclusion of the social dimension of STEM in the philosophy of the curricula, adoption of a digital policy, prioritizing the development of digital skills and implementation of STEM programs and activities included in the official curricula of different subjects, both in primary and secondary education, but also additional organized activities aimed at groups outside school can help reduce the gender gap in this field.

School girls who feel that they have a comparative advantage in STEM subjects are more likely to continue to choose specific subjects but also to continue their education in the relevant fields. Disseminating STEM activities and good practices to more and more schools as well as

training and mentoring teachers in digital and STEM skills is paramount. Enhancement of girls' participation, according to primary research data, is provided by a stimulus-rich family and school environment, cultivation of creative curiosity and reinforcement of skills in STEM-related school subjects. Even more so, when inquiry-based / exploratory learning is methodologically adopted, experimentation and the use of logical correlations and not sterile memorization. Moreover, participation in mathematics, robotics and physics student competitions, as well as the imitation of motivational models of charismatic teachers (role models) are evaluated positively.

All of these, as recorded in the literature and highlighted by the present research/study, are favorable factors that can influence the course of individuals in relation to their choice of studies and profession.

The state needs to establish the systematic integration of STEM disciplines in all levels of education, as well as the implementation of actions aimed at reinforcing girls' engagement in the STEM fields (Patrinopoulos, Iatrou, 2019; Psycharis, Kotzampasaki, 2019).

The university should be a supporter of strategies and mechanisms to reduce the gender gap and implement gender equality action plans based on the existing situation.

The EU has sought to improve the under-representation of women in STEM through programs of organizations such as the European Platform of Women Scientists (EPWS) and WITEC; projects like The European Scenery on Gender and STEM (SESTEM), the Gender Equality Network in the European Research Area (GENERA) and GenSET have focused on action plans to bridge gender differences in science. The implementation of such programs inspires, encourages and strengthens the professional and social commitment of women engineers and scientists around the world by promoting women in the workplace through various activities and by supporting them in their professional development.

The empowerment of women through continuous training and the promotion of female role models, as well as employees' training on issues of sexism, prejudice and gender bias contribute to awareness and change of attitude.

At institutional level, it is necessary that the state follow policies and procedures which produce equal results for women and men, as proposed by the Convey Project https://conveyproject.eu, and proceed with the enactment of measures such as parental leave and incentives for companies that implement effective equality policies. Adoption of such practices by companies and organizations for the empowerment of women in the workplace and for balance between their professional and social live, development and implementation of policies and programs that encourage the representation of women and facilitate flexible forms of work can contribute to increasing women's access to STEM professions and to creating a society of equal opportunities.

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Conflict of interest

The authors declare that they have no conflict of interest.

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