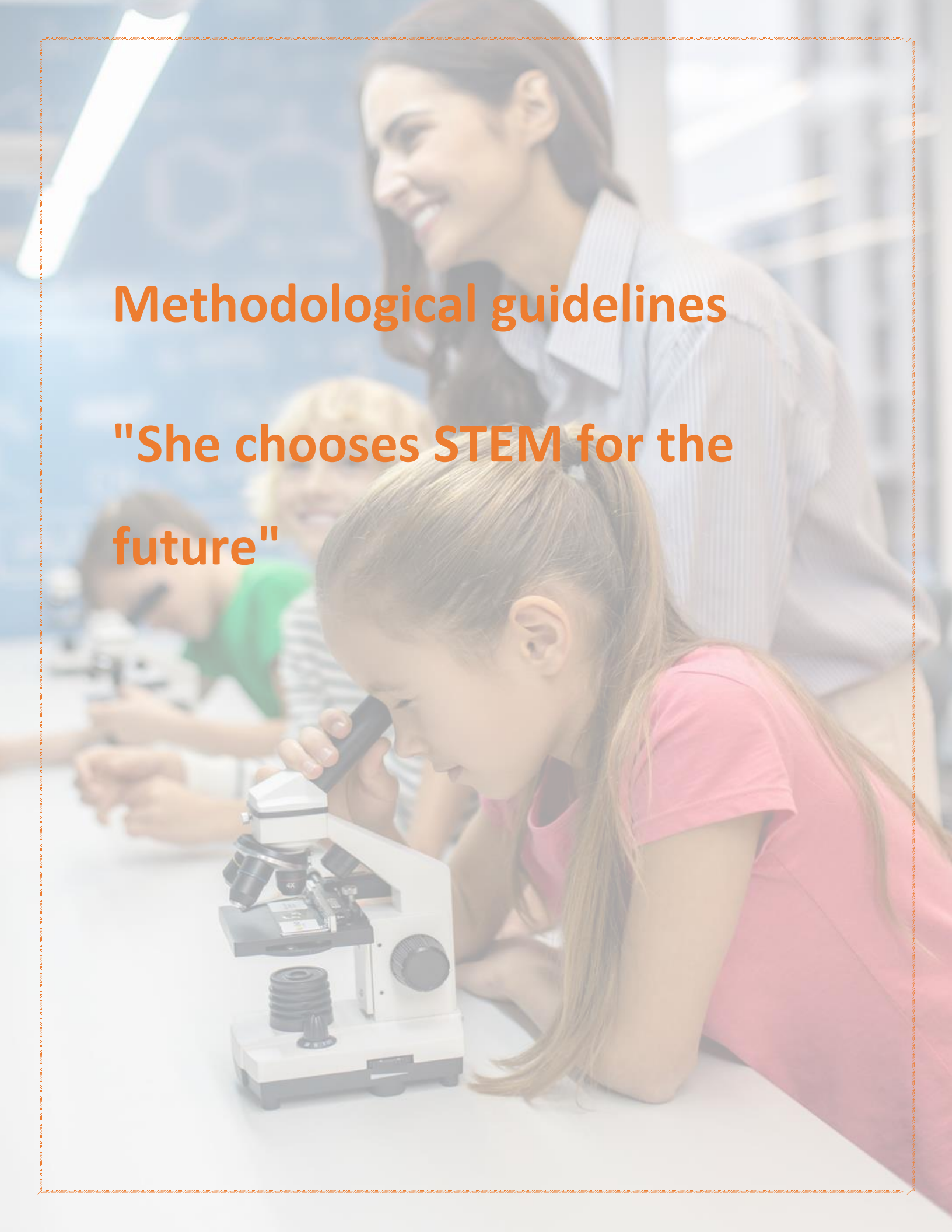

# Methodological guidelines

# "She chooses STEM for the future"

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# I. Introduction

This methodological guide has been developed within the framework of a project in Key Action 2 of the Erasmus+ Program – Cooperation Partnership for Education, Training and Youth. The project "She chooses STEM for the future" aims to promote interest in STEM disciplines, the STEAM approach, as well as to spread the values of inclusion and diversity by countering discrimination and gender stereotypes in the field of STEM. The methodology serves as a guideline for teachers in the organization of the learning process and aims to help them make STEM subjects more attractive to students, especially girls.

**Definitions**

In this first part, we will take a deeper look at the terms that are used in the document. One of the most popular definitions of STEM is as follows: "general term, used to group the different but related technical disciplines of Science, Technology, Engineering and Mathematics". The acronym STEM was introduced in 2001 by scientific administrators in the United States. - National Science Foundation (NSF).

The term "methodology" is associated with various meanings and is sometimes used as a synonym for the term "method". A method is a way to achieve a predetermined goal. Methodology is a set of methods, used in Certain area on teaching or activity, system from Ways for making, teaching or Studying on thing. The methodology usually involves various steps, such as Introduction to the topic, Data collection and interpreting the data. Research methodologies are broadly classified into two main categories: quantitative research methods and qualitative research methods. Quantitative studies are those based on quantitative terms and involve collecting numerical data, analyzing them and drawing conclusions using numbers. Qualitative

research, on the other hand, is one that is carried out using nonnumerical and immeasurable elements such as feelings, emotions, sound, etc.

**Objectives of this methodological guide**

The methodology aims to promote interest and achievements in STEM disciplines, to promote the STEAM approach and gender equality. It is a useful tool for teachers, providing information and ideas on how to make STEM subjects more attractive to students. The activities described in this guide could easily be implemented in upper secondary education without the need to spend financial resources.

In particular, the methodology also aims to:

- Facilitate dialogue building in a dynamic, innovative, multidisciplinary and cross-sectoral environment.

- Develop processes and pathways for capacity building and soft skills acquisition to enable exchange of experiences and practices.

- Studying and implementing inclusive approaches in school education and taking joint action to tackle inequalities, discrimination and to overcome gender stereotypes.

- Development of technical-methodological content of joint design, joint management and strengthening of digital skills applied in the process of school orientation to STEM disciplines.

- Enrich knowledge to design pedagogical strategies for engaging girls in STEM disciplines.

- Provide specific activities and practical advice on making STEM professions more attractive to students, especially girls.

**To whom is the methodology addressed?**

This methodological guide is an innovative educational model of crossSTEM education, multidisciplinary education and is applicable to the upper secondary level, including teachers, students and families. Specifically, the guidelines are addressed to STEM teachers in secondary education and members of school institutions.

## II. Analysis of the collected data

**Method of data collection**

The data presented in this part of the document was collected through online surveys created in Google Forms. Studies are a valuable tool for data collection and analysis, which in this case was used to find out more about the attitude of students towards STEM disciplines, current learning methods used by teachers, their needs, as well as the attitude of students and their families towards STEM professions.

**Data analysis: Students, STEM teachers, non-STEM teachers and families were asked to answer the questionnaires**

A total of four surveys have been developed in order to gather information on the aspirations of teachers, students and their families towards the STEM area. The information collected sets out the main aspects of this methodology. The first survey was addressed only to students in secondary education, the second – to teachers of STEM disciplines, the third – to teachers of non-STEM disciplines and the latest survey aims to collect data from students' families. The four schools that are partners in the project and collected the answers are:

"Epralima Escola Profissional do Alto Lima" - Portugal

"IES LA ZAFRA" - Spain

"IIS GANDHI" - Italy

Simeon Radev High School of Foreign Languages - Bulgaria

## A. Survey for students

A total of 163 high school students responded to the survey as follows: 92 from Italy, 33 from Bulgaria, 29 from Portugal and 9 from Spain. More than half of the students surveyed (54.7%) are girls. The majority responded that they had support from their families in pursuing a STEM career and motivated them to hear stories of girls who had succeeded in the STEM field. Marie Curie is the most famous among the famous women with success in STEM. If students were to develop a methodology that would inspire girls to pursue a career in STEM, they would include in it information about why STEM sciences are important for their personal and professional development: better decision-making abilities, better problem-solving skills, critical thinking, etc.

For the majority of students interviewed, technology is attractive and they would like to find out more about possible careers in STEM by visiting jobs and direct contact with professionals working at STEM.

## B. Survey for STEM teachers

A total of 45 teachers in STEM disciplines responded to the survey. Their age is on average between 31 and 50 years. 100% of the STEM teachers interviewed are women. The majority of respondents have 10+ years of experience teaching STEM sciences. Among the most used pedagogical approaches are experimentation teaching and project-based learning. A very small minority of respondents use online collaboration tools and specific software. The majority of STEM teachers would like

to find in this handbook a range of motivational techniques for engaging students in STEM activities. Almost 40% of teachers interviewed would like to attend conferences, seminars and on-site events at school or online about STEM teaching methods and new approaches.

### C. Survey for teachers who do not teach STEM sciences

A total of 42 teachers in other disciplines than STEM responded to the survey. Most of them are language teachers. Only 7% use storytelling ("storytelling") as a tool in the teaching process. The majority of respondents felt it was important to provide information on career opportunities in STEM and to invite guest speakers to class (women working in STEM). The majority of them have a positive attitude towards the products developed within ERASMUS+ projects and would use them in the teaching process. 33% of respondents believe that students are increasingly interested in a career in STEM. They all share a positive attitude about innovative teaching of STEM in their school. That said, it is essential to ensure adequate teacher training and provide real-life lessons, with practical exercises in the learning process.

### D. Survey for families of students

A total of 137 parents/families of students responded to the survey. Almost 85% agree that interest in STEM begins at an early age. Teaching lessons with real-life examples, applying as many practical exercises as possible, providing adequate training for STEM teachers, and stimulating critical thinking during classes are among the most essential activities that would lead to increased student interest in STEM according to the families surveyed.

## III. STEM teaching methods

The use of digital tools in the process of teaching STEM is important for several reasons:

- Improved engagement: Interactive simulations, virtual experiments and multimedia presentations can capture students' attention and make learning more enjoyable.
- Real-world applications: Digital tools can provide real-world applications of STEM concepts. Virtual labs and simulations allow students to explore and experiment in a controlled digital environment, making abstract concepts more tangible and applicable to real-life scenarios.
- Access to resources: Digital tools provide access to a wide range of resources, including online databases, educational websites and multimedia content. This allows students and teachers to be updated with the latest information and research in the field of STEM.
- Adaptability: These offer flexibility and adaptability in teaching methods. Teachers can tailor their lessons to cater for different learning styles and pace, allowing for personalized and differentiated learning.
- To promote collaboration: Many digital tools facilitate collaboration between students. Online platforms, virtual classrooms, and collaboration software enable students to work together on projects, share ideas, and solve problems collectively, fostering teamwork and communication skills.
- Data analysis: STEM topics often include data analysis. Digital tools can help students collect, analyze and interpret data more effectively. This hands-on experience with data improves their quantitative and analytical skills.

- Preparing for the future: In today's digital age, knowledge of technology is crucial. The integration of digital tools into STEM education prepares students for future careers that increasingly rely on technology and digital skills. This helps them develop the technical skills needed in various areas of STEM.
- To foster innovation and creativity: By coding, programming, and using technology, students can develop critical thinking skills and learn to approach challenges in innovative ways.
- Efficiency and time management: Digital tools can streamline administrative tasks, automate assessments, and provide immediate feedback, allowing educators to focus more on teaching and facilitating student learning.

By incorporating digital tools, educators can create a dynamic and engaging learning environment that better prepares students for the demands of the 21st century job market. It could also encourage the active participation of girls in classes.

Here is a list of some of the digital tools that can be applied in the teaching process:

I. **Google Workspace for Education** - Offers collaboration tools like Google Docs, Sheets, and Slides that facilitate real-time collaboration between students.
II. **Padlet** - A collaborative platform to create an online board where students and teachers can share resources, ideas and collaborate.
III. **Kahoot** - An interactive quiz platform that engages students through game-based learning.
IV. **Mentimeter -** An interactive presentation and polling tool that allows presenters, educators, and speakers to engage their audience in real time.

V. **Edmodo** - Learning Management System (LMS) designed for K-12 schools and educators. It provides a secure and collaborative online platform for teachers, students and parents to communicate, share resources and manage tasks.

VI. **Socrative -** Socrative is commonly used for assessments, quizzes, and surveys, providing educators with immediate feedback on students' understanding and progress.

VII. **TED - ed -** Educational platform related to TED Talks. It is designed to facilitate the creation and sharing of lessons.

VIII. **Code.org** - Provides resources for teaching coding and computer science, including interactive lessons and coding exercises.

IX. **Elementari -** An online platform designed to enable students to create and publish interactive stories. It combines storytelling with coding, allowing students to integrate programming into their narratives.

X. **Ozobot -** A small programmable robot designed to present students with concepts of coding and robotics.

XI. **Lego Education -** Lego Education offers a range of educational solutions that use the familiar building blocks of Lego to promote hands-on learning in a variety of subjects, including STEM.

XII. **Google Earth -** Teachers can use Google Earth to create interactive lessons, explore historical images, and take students on virtual tours.

XIII. **Desmos** - A digital calculator and graphical tool that is especially useful for math and science classes.

XIV. **GeoGebra** - Integrates geometry, algebra, spreadsheets, graphs, statistics and calculus into a dynamic platform.

XV. **Labster** - Virtual labs that allow students to conduct experiments in a simulated environment spanning a variety of scientific disciplines.

XVI. **Cospaces Edu** - Enables students to create a 3D virtual reality environment, supporting creativity and exploration in STEM subjects

XVII. **Flipgrid** - A video discussion platform that encourages students to share their thoughts and ideas through short videos.

**Innovative teaching and learning methods**

Innovative and attractive teaching methods in STEM can significantly improve the learning process and engage female students more effectively. Here are some ideas:

1. PROBLEM-BASED LEARNING Students should solve problems in the real world or context.
2. RESEARCH-BASED LEARNING – Students engage in mathematical and scientific forms of research.
3. GAMIFICATION - Introducing elements of the game into the learning process to make it more engaging. Educational games and simulations can help strengthen concepts, promote healthy competition, and provide immediate feedback.
4. STORYTELLING - Weave narratives and stories into STEM tutorials to make abstract concepts more relevant and interesting. Storytelling can help students see the practical applications and importance of knowledge of STEM in different contexts.
5. DESIGN BASED LEARNING - Students should identify the problem, look for a solution strategy, design a product and evaluate it. Solving the problem sometimes involves designing a prototype, evaluating a model, or building an artefact. Design-based learning especially facilitates the incorporation of engineering and technology.

6. COLLABORATIVE LEARNING - Students need to work together to achieve a common goal.
7. VIRTUAL AND AUGMENTED REALITY Immersive technologies such as VR and AR can transport students to virtual environments, allowing them to explore concepts in three dimensions. This improves understanding and makes learning more interactive and memorable.

By incorporating these innovative and attractive teaching methods, educators can create a dynamic learning environment that arouses curiosity and fosters a deeper understanding of the subjects.

## IV. Engaging Girls in STEM Disciplines

**Women in STEM**

According to a World Bank report, women make up less than a third of the global workforce in technology-related fields. Women hold 28% of all jobs in computing and math occupations and 15.9% of jobs in the engineering and architectural professions. The U.S. science, technology, engineering and mathematics (STEM) workforce represents only 23% of the total U.S. workforce. In the European Union, women make up only 19.1% from the information and communication technology (ICT) sector.

It is hard to believe that about 60 years ago women represented only 1% of the engineering workforce. Fortunately, we are now living in different times, and there is no doubt that the number of women in STEM has increased since the 1960s and continues to rise. Many sources prove that computer science, engineering, and technology demonstrate the largest gender differences among current students, graduates, and workers. Although there is some progression, there are still

disproportions, and not so many women decide to choose STEM for their career. Some of the disciplines are more popular than others and women tend to choose subjects focused on the biological sciences over engineering and computing.

Over the past ten years, the total number and share of women in engineering professions has increased and Europe had almost 7 million women scientists in 2021, 369,800 more than in 2020, accounting for 41% of all science and engineering jobs. This is encouraging information, but in the statistical classification of economic activities in the EU, women are underrepresented in all sectors of activity.

Eurostat's 2023 article proves that although there was a better representation of women in the service sector (46% of scientists and engineers were women), men outnumbered women. Taking other areas into account, there are only 28% women scientists and engineers in the air transport sector, but only 21% of those in the industrial sector. In the least popular areas, only 8% of water transport workers are women, compared to 12% in the manufacture of transport equipment and 13% in the automobile industry.

To complement Eurostat's data, we looked at a January 2023 McKinsey report that focused on European companies, showing that the average share of women in technology roles in European companies is only 22%. McKinsey analysed specific roles in the technology industry and the highest participation rate of women in product design and management was 46% (e.g. product manager), while only 15% in computing and operational roles (e.g. systems engineer, incident manager) and 8% in DevOps and cloud roles (e.g. cloud, DevOps or site reliability engineer).

Taking into account women who work in technology companies, the statistics are only slightly more positive. 37% are women employees in European technology and technology enterprises, with the highest percentage in social networking organisations (50%) and e-commerce companies (46%). However, the total number of women in technology roles is only 25% (McKinsey, 2023).

There is a wide range of female scientists and engineers in Europe. According to Eurostat, in 2021 there were 6.9 million female scientists in the EU, compared to around 6.6 million women scientists and engineers in 2020. In 2021, Lithuania again recorded the highest shares with 52% and then Bulgaria, Latvia and Portugal, while the countries with the lowest proportions were Luxembourg, Germany, Italy, Hungary and Finland.

**Bridging the gender gap in STEM disciplines. Stereotypes.**

Gender stereotypes at different levels of organizations act as a vicious circle that maintains a male-dominated image of STEM. This constitutes a barrier to career interest, choice and perseverance of women in STEM. A multilevel approach is needed to debunk gender stereotypes about the culture, work and abilities of women in STEM and to create a more inclusive image of the importance of being a STEM professional.

The gender gap in the field of STEM is particularly worrying when it comes to the specific academic disciplines. "The notion that boys are more interested in computer science and engineering girls begins as early as age six," according to a new study published in the Proceedings of the National Academy of Sciences. Women represent only 16% of those who obtained a bachelor's degree in computer and

information science, 21% of engineering and engineering technology graduates, 27% with an economic background and 38%, recipients of degrees in physical sciences.

According to the U.S. Bureau of Labor Statistics, STEM occupations have seen remarkable growth of 79% over the past three decades and are expected to increase further by 11% from 2020-2030.

How to overcome this challenge in the learning process?

- Teachers should focus on the individual development of each student.
- Providing support and confidence throughout the learning process: teacher support is a great tool to bridge the gender gap in STEM, as educators can inspire students to pursue future careers in the field.
- Teach with inclusiveness in the classroom: talk to students as equals, providing equal opportunities for all genders. Teachers should accept that everyone would be interested in STEM and structure the lessons accordingly. During classroom activities and projects, give your students the leadership role to help them believe in their capabilities. Gender-neutral learning environments are not necessarily the ones which is free of gender. Rather, it is an environment where teachers and learners avoid gender stereotypes and aim to ensure that all learners are valued, respected and treated equally.
- Cultivate a culture of thinking about growth : encourage students to adopt a growth mindset where effort and learning lead to success. This mindset reduces the fear of failure and enables students to continue facing challenges.
- Create personal relationships with students: sometimes external activities can further strengthen the relationship between teachers and students. Girls are often more shy, with a lack of confidence regarding their performance in STEM

disciplines. Organizing an outdoor lesson at a STEM center, visiting a factory/workplace, or elsewhere outside the school can help girls participate more in STEM school classes.

**Effective Strategies for Engaging Girls in STEM**

Teachers aren't the only ones who are able to motivate girls to have an interest in STEM science. Parental encouragement and support is also extremely important. More than half of those surveyed said they felt encouraged by their families. Parental encouragement has a positive impact on girls' interest and likelihood of learning STEM in the future.

How can we support all girls in developing a growth mindset?

It is essential that classrooms become a safe place for questions and vulnerability**.** Often, students feel uncomfortable asking questions in STEM and computer science classes because they feel like the only ones who do not understand the material. Not surprisingly, this trend is more prevalent among girls who are not encouraged by their parents and teachers and do not participate in STEM clubs and activities. The fear of exposing themselves is indicative of a "fixed mindset". Students with this way of thinking doubt their knowledge, as well as in their ability to build.

With the help of the data and information collected, we know that there are immediate and practical steps that schools, parents, teachers, NGOs and professionals can take today to improve girls' engagement with STEM and computer science.

Some of them include:

• Provide greater visibility of positive role models and mentors with whom students can associate and aspire to be. You can enrich the classroom with printed posters containing information about the women in STEM and their achievements.

• Support extracurricular STEM activities that teach girls how to build their confidence.

• Provide real-world practical experience and examples. You can do this through case studies or storytelling videos illustrating successful women in the field.

• Highlight the creative aspects of STEM and computer science.

• Demonstrate the enormous impact that STEM and computer science have on the world and the labour market in particular.

• Encourage parents to support and encourage the interest of students, in particular girls, in STEM and computer science.

• Work on developing strategies to engage students who are afraid to ask questions, be wrong, or ask for additional help.

• Listen to what girls say about their challenges and desires.

We know that some girls and young women thrive in STEM and computer science and careers, while others are hampered and choose not to continue in this direction. As we continue to look for the reasons why this happens and how to work on them, we need to keep our focus on students and act taking into account what they tell us they need.

**STEM labour market**

**Role models in recent years**

**Catalin Carrico (2022, Lifetime Achievement)**

Hungarian biochemist Katalin Carrico has developed a way to modify ribonucleic acid for safe use in the human body, paving the way for its use in COVID-19 and other vaccines, as well as promising therapies for cancer and heart disease.

**Claude Grison (2022, Research)**

Researcher Claude Grison has developed a method of using plants to extract metal elements from contaminated soil and then uses these elements as "ecocatalysts" to make new molecules for the chemical, pharmaceutical and cosmetic industries.

**Madiha Derouazi, Elodie Belnue and Team (2022, SMEs)**

Together with their team, Madiha Derouazi and Elodie Belnue have come up with a platform for the development of therapeutic cancer vaccines that help the immune system recognize and destroy cancer cells in the body.

**Elena Garcia Armada (2022, Popular Prize)**

Elena Garcia has developed an adaptive robotic exoskeleton for children who use wheelchairs. The exoskeleton allows children to walk during muscle rehabilitation therapy, improving their well-being and prolonging their life expectancy.

**Sumita Mitra (2021)**

Sumita Mitra has developed a nanomaterial-based dental filler that offers improved strength, wear resistance and aesthetics. Mithras was the first to use nanotechnology to create fillings, and today dental products based on her invention are used in over 1 billion restoration procedures worldwide.

**Gordana Vunjak-Novakovic (2021, Popular Prize)**

Gordana Vunjak-Novakovic has opened new horizons in regenerative medicine by developing a way to grow new tissue ex vivo (outside the body) using the patient's own cells. Vuniak-Novakovic's innovative approach offers a safer, more precise and less intrusive method of facial reconstruction and promises to replace damaged lung and heart tissue.

**Margarita Salas Falgueras (2019, lifetime and popular award)**

Margarita Salas Falgueras invented a faster, simpler and more reliable way to reproduce traces of DNA in quantities large enough for full genomic testing. Her invention, based on phi29 DNA polymerase, is now widely used in oncology, forensic medicine and archaeology.

**STEM job market – a great opportunity for women**

The unemployment rate for skilled STEM labour is very low and well below the overall unemployment rate of the early 2000s in the EU. Also, STEM workers have higher average wages than their non-STEM counterparts. Students often don't know what the future career path of the STEM discipline might be. For example, if a student likes the subject of biology, there are at least 42 professions (yes, 42) related to biology.

Teachers can use free websites that show possible career paths by subject. Using a free online in-class quiz like "The Gist" shows you the areas of study and STEM careers that suit your interests.

Link: https://www.thegist.edu.au/students/careers-in-stem/quiz-and-careers/the-gist-quiz/

Attending STEM events with students and seeing at first sight what a career in STEM looks like in real life can also enable girls to choose a career in the field. Teachers and mentors should keep in mind that STEM skills are crucial for students' professional development, regardless of the path they have chosen next. As the quote says: *"STEM skills and knowledge will be key to unlocking future jobs not only in STEM but in all industries" (Deloitte 2014).*

In conclusion, the STEM job market represents a great opportunity for women to embark on a rewarding and impactful career. As the world continues to rely on technological advances, the demand for diverse and talented people in the STEM field will only grow, making it an ideal time for women to explore and excel in these exciting and dynamic career paths. With the right support systems, women can make significant contributions to the ever-evolving world of science, technology, engineering and mathematics.

## V. Conclusion

The methodology provides valuable information on factors influencing women's decisions to pursue STEM areas. Through a comprehensive approach covering surveys, interviews and qualitative analysis, we have revealed the multifaceted aspects that contribute to girls' choices.

Our findings confirm the importance of early access to STEM education, work on eliminating stereotypes, and fostering supportive environments in class and in the family. Mentoring has emerged as a major factor, highlighting the importance of positive role models in guiding and inspiring girls. In addition, other factors such as race, socioeconomic background, and cultural influences highlight the need for inclusive strategies in class.

Unfortunately, although the proportion of women graduates with basic STEM degrees is steadily rising, in the EU only approximately 35% of graduates in this field are women. Basically what prevents girls from pursuing careers in the field of STEM is:

- Lack of support
- Lack of mentoring
- Lack of information on women, role models, in the field
- Difficulty balancing work and other responsibilities
- Gender bias and behaviour influenced by stereotypes in the workplace
- Unequal opportunities for growth compared to male colleagues
- Lower salary for the same position

This shows that efforts should be made to encourage women to pursue these areas of training and make the transition to the workforce. We hope that in future the figures will differ less than they do now. Encouraging educational institutions, policymakers and industries to collaborate in creating inclusive and equitable STEM ecosystems is key. By providing mentoring opportunities and fostering a culture of

inclusion in education, we can empower more women to confidently choose and thrive in STEM areas, contributing to a more diverse and innovative future.

We can say that it is essential to combine the strength of girls, parents, teachers, mentors and professionals to build trust in young girls and support their future in the field of STEM!

# VI. Sources

1. https://en.wikipedia.org/wiki/Science,_technology,_engineering,_and_mathematics
2. https://dictionary.cambridge.org/dictionary/english/methodology
3. https://www.britannica.com/topic/STEM-education
4. https://doi.org/10.26822/iejee.201843814
5. https://www.womentech.net/en-us/women-technology-statistics
6. https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE1UMWz
7. https://www.oecd-forum.org/posts/optimizing-labor-market-potential-of-women-in-stem-from-surface-level-to-deep-level-diversity-and-inclusion-beb2963a-41e1-4008-9f7f-c01a4098f1cd
8. https://careerswithstem.com.au/science-careers-list/?utm_source=Refraction+Media&utm_campaign=360915014a-EMAIL_CAMPAIGN_2018_04_04_COPY_01&utm_medium=email&utm_term=0_20dc88b9ea-360915014a-148847429&mc_cid=360915014a&mc_eid=bc9cebdb3e#featured&gsc.tab=0
9. https://www.thegist.edu.au/educators/stem-career-advice/career-resources-for-stem-teachers/