

Study Protocol

Women in Science: Where We Stand?—The WHEN Protocol

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Abstract: Gender disparity in scientific fields, identified with the acronym STEM, is a complex issue whose multiple causes have distant origins in time. In the early development of scientific disciplines, women were often denied access to education and professional opportunities, and their contributions to the scientific fields were frequently not recognized. These trends of underrepresentation gave rise to the male-dominated culture in STEM that persists today, as young women often lack female role models and are less likely to pursue careers in STEM, perpetuating the gender gap and limiting women's influence and visibility in these fields. Here we present the protocol of the WHEN project, which aims to explore the perceptions that high-school students have of scientific careers and of the women in science, investigating whether gender stereotypes persist and can affect decisions about future paths. Through questionnaires, this study investigates the impact of socio-economic variables on the persistence of gender stereotypes and, most importantly, explores the potential for reducing them through direct engagement with female STEM role models.

Keywords: gender disparity; women in science; gender stereotypes; role models; socio-economic variables; career perceptions; secondary education; female representation; STEM; histology; anatomy



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1. Introduction

The term STEM is an acronym of Science, Technology, Engineering and Mathematics, used to indicate the whole of scientific subjects. The exclusion of women from STEM fields stems from deep-rooted social norms that have historically defined gender roles. In the early development of scientific disciplines, women were often denied access to education and professional opportunities, and their contributions to the scientific fields were frequently not recognized (Schiebinger, 1989). Pioneering women, whose groundbreaking discoveries reshaped the field of physics, maths, biology and medicine, were rare exceptions (Ogilvie & Harvey, 2000). These historical trends of women's underrepresentation contributed to shaping the male-dominated culture in STEM that still persists today. While the presence of female role models can play a role, broader cultural and structural factors also influence young women's likelihood of pursuing STEM careers. This, in turn, perpetuates the gender

gap in science and affects women's influence and visibility in STEM fields (Ceci & Williams, 2011; Cheryan et al., 2017).

In Italy, female participation in STEM subjects still shows significant gender disparities. According to 2022 data, although women represent the majority of the overall university student population, only one in six STEM students is a woman (ISTAT, 2023). Italian data report that 23.8% of young adults (aged 25 to 34) with a college degree have a degree in STEM fields. However, this percentage rises to 34.5% among men and drops to 16.6% among women. Despite women in STEM programs often graduating with higher grades than their male counterparts (103.4 vs. 101.8 for men), these academic achievements do not mirror career progress (De Vita & Giancola, 2017; Osservatorio Fondazione Deloitte, 2023). These data concern both biological and medical scientific fields, both basic, as in fields such as Anatomy and Histology, and clinical. According to EUROSTAT (2023), in 2022, 76 million people across Europe were employed in STEM fields, 52% of whom were women. The countries with the highest concentration of women in STEM were Lithuania and Corsica (France), where women accounted for more than 58%, whereas at the bottom of the list was Italy, with a concentration of women in STEM below 49%. In Italy, the disadvantage for women in terms of employment returns is most pronounced in STEM degrees, where the female employment rate is 10 percentage points lower than that of men (ISTAT, 2023).

De Vita and Giancola (2017) posit that labour market entry is not the main challenge, as highly marketable qualifications facilitate access. Instead, the issue lies in the quality of available professional positions. While Italy continues to generate more lower-skilled jobs (Ballarino & Scherer, 2013; De Vita & Giancola, 2017), disparities in employment conditions—qualifications, contracts, and pay—persist. Thus, labour market expansion, though uneven, has not ensured gender equality in opportunities.

Major challenges in gender equality in STEM are both structural and cultural. Structural barriers include unequal access to funding and leadership opportunities and a lack of policies supporting work-life balance (Etzkowitz et al., 2000). Cultural barriers are equally pervasive, with stereotypes portraying STEM careers as unsuitable for women, impairing their career progression (Bilimoria & Lord, 2014; Cheryan et al., 2017). De Vita and Giancola (2017) highlighted that sociological perspectives stress the role of socialization, value structures, and reinforcement systems in shaping educational choices. They outlined two main sociological approaches focusing on the gender gap in STEM careers. The first argues that families, schools, and media shape gendered educational choices by fostering different skills and behaviours in boys and girls (Sherman, 1980; Jaoul-Grammare, 2024): girls are encouraged to value cooperation, communication, and aesthetics, while boys are guided toward independence, practical activities, and formal reasoning, reinforcing societal stereotypes. The second approach suggests that female educational choices are primarily influenced by intrinsic interest or the social and cultural significance of a field, rather than its economic value, as seen in male-dominated disciplines (Beutel & Marini, 1995; Bobbitt-Zeher, 2007; Johnson, 2001; Hägglund & Leuze, 2021).

Institutional biases also persist in STEM, especially affecting resource allocation. For example, women often face harder scrutiny and higher standards than their male counterparts when applying for grants or career advances (Ceci & Williams, 2011). This disparity, in turn, diminishes women's ability to become leaders in their fields. Implicit biases—unconscious attitudes and stereotypes that affect our actions and decisions—play a significant role in perpetuating gender disparities in STEM (Cheryan et al., 2017). Both men and women are susceptible to these biases, influencing peer review processes, as previously mentioned (Etzkowitz et al., 2000; Moss-Racusin et al., 2012).

A critical review by Cheryan et al. (2017) reports that gender disparities in STEM are not due to innate ability differences, but rather influenced by cultural and social factors, such as: field-specific stereotypes (STEM fields are perceived as more masculine, discouraging women from pursuing these careers and reinforcing gendered expectations), lack of female role models (the under-representation of women in STEM disciplines results in fewer visible role models, making it harder for young women to see themselves in these careers), unwelcoming learning and work environments (male-dominated cultures in STEM can create unwelcoming environments for women, discouraging their participation), and less early encouragement for girls (girls receive less encouragement to pursue fields like engineering or physics from a young age, influencing their academic choices later on). Regarding all the types of barriers, the COVID-19 pandemic has had a particularly dramatic impact on women's representation in STEM fields. The necessity of remote work, combined with school and childcare facility closures, disproportionately increased caregiving responsibilities for women, reducing their time for research activities. This resulted in a significant reduction in the submission of research papers led by female scientists during the pandemic, a trend not seen among their male counterparts (Viglione, 2020), despite some editorial initiatives to encourage greater female author representation in many highly competitive research fields (Bianchi & Nagelkerke, 2024). The publishing rate is a critical measure for career advancement, particularly in STEM, and the gender disparity in authorship during the pandemic, particularly in the active authorship roles, could have long-term consequences (Myers et al., 2020). Indeed, publications translate into funding and career advancement.

Policy interventions must be implemented to address the systemic barriers that women face in STEM (European Commission, 2021). To address the complex nature of gender disparities, several different but coordinated actions are required. Besides the promotion of targeted funding opportunities for women, family-friendly workplace policies, parental leave, regular monitoring and reporting on gender disparities within organizations, and balanced evaluation criteria, the literature reports that one key to overcoming gender bias is Representation. According to the Social Cognitive Career Theory (SCCT), proposed by Lent et al. (1994), personal beliefs and environmental factors are key factors influencing career decisions. SCCT suggests that self-efficacy (girls often believe themselves to be less competent in STEM than boys), outcome expectations (girls can believe that STEM careers are less welcoming or compatible with their gender), and goal-related beliefs (if girls are not encouraged to pursue STEM, they may not develop an interest in these fields) can shape self-perception and career aspirations.

Another critical framework is Stereotype Threat Theory (Steele, 1997), which describes that exposure to negative stereotypes about one's group can negatively impact performance and aspirations. The classic example is that generally "girls are not good at math", and so they tend to perform worse on these tasks. This theory is highly relevant to our study, as we investigate whether exposure to female STEM role models can counteract stereotype threat and improve students' perceptions of their own STEM potential. Role models are critical in encouraging women to pursue and persist in STEM careers: women in leadership roles can inspire young women to envision similar paths (Cheryan et al., 2017; Eagly & Wood, 2011; Lockwood, 2006). Therefore, our hypothesis is that initiatives promoting female representation in STEM can result in higher retention rates and increased confidence among female students and early-career professionals in STEM (Leblebicioglu et al., 2011; Olsson & Martiny, 2018).

The Women in Science: wHere wE staNd? (WHEN) project (<https://scibis.unimi.it/it/terza-missione/scuole-e-pubblico/progetto-when>, accessed on 1 January 2025) investigates the persistence of stereotypes during the pre-university years, a critical period when high-

school students are shaping their educational and career orientations. These stereotypes can generate fears that affect young women's choices in the bio-medical and scientific fields (Eagly & Wood, 2011; Santrock, 2013). Within the orientation events organized by the University of Milan (Unimi), we are conducting a survey to assess how students, both male and female, perceive the figure of the scientist, especially related to the scientist's gender, and whether this perception is influenced by their gender and familial background (Greene et al., 2013). Additionally, we will examine whether participation in orientation events can modify these initial perceptions, particularly by challenging stereotypes associated with women in science (Leblebicioglu et al., 2011; Olsson & Martiny, 2018). Here, we describe the approved protocol of the WHEN study to foster debate within the education sciences community.

2. Study Design

2.1. Objectives

The primary objective of the Women in Science: wHere wE staNd? (WHEN) project is to evaluate the perception of the scientist's figure concerning gender, addressing three fundamental questions:

1. Do gender stereotypes in the scientific field still persist among pre-university high-school students despite societal changes and inclusion policies?
2. What are the main challenges perceived by pre-university students, especially female students, regarding pursuing a scientific career?
3. Is it possible to alter already-established stereotypes?

2.2. Study Phases

Phase 1: Students in their fourth and fifth years of secondary school (age 17–18 years), regardless of gender, who participate in Unimi's orientation events, are invited to complete two surveys: an initial questionnaire (Table 1) before the event (also called pre-intervention) and a final questionnaire (Table 2) after the event (also called post-intervention). These surveys are specifically developed for the WHEN study to assess students' perceptions of scientists, the foundations of these perceptions, and the potential for change.

Phase 2: The survey results are collected and analysed anonymously. These data will contribute to understanding how orientation interventions can influence the perceptions of young people regarding careers in STEM.

End-Points: The Primary Endpoint is to determine whether the perception of the scientist's figure is influenced by the respondent's gender; the Secondary Endpoint is to assess the impact of orientation events on the perception of the scientist, specifically examining whether the ability to alter stereotypes is associated with (i) the gender of the instructor; (ii) the age of the instructor; (iii) the academic discipline (SSD) of the instructor; or (iv) the type of activity conducted during the orientation event (seminar vs. laboratory). The Additional Secondary Endpoint is to evaluate the effects of orientation events on students' perceptions of the challenges faced in pursuing a scientific career. The Ancillary Endpoint is to assess the perception of the scientist's figure in relation to (i) the geographical area of origin; (ii) the type of school or educational institution attended; and (iii) the job of the parents.

This framework is designed to provide a picture of how different factors influence students' perceptions of scientists and their potential career paths in the STEM, with a particular focus on addressing gender-related stereotypes and barriers.

Table 1. Pre-Orientation Survey. Initial questionnaire to complete pre-intervention.

Question	Response Options
Type of School	Scientific High School, Humanistic High School, Technical Institute, Other
Grade Level	4th Year, 5th Year
Geographic Area	Milan (City), Milan (Province), Other Province
Gender Identity	Woman, Man, Non-binary, Prefer not to answer
Mother's Profession	Open-ended response
Father's Profession	Open-ended response
Desired Future Profession	Open-ended response
Preferred University Field (max 2)	Mathematical and Computer Sciences, Physical Sciences, Chemical Sciences, Earth Sciences, Biological Sciences, Medical Sciences, Agricultural and Veterinary Sciences, Civil Engineering and Architecture, Industrial and Information Engineering, Humanities, Historical-Philosophical-Psychological Sciences, Legal Sciences, Economic and Statistical Sciences, Political and Social Sciences, Not Sure
How much do you think girls like STEM subjects? (1–6)	1 (Not at all)–6 (A lot)
How much do you think boys like STEM subjects? (1–6)	1 (Not at all)–6 (A lot)
How good do you think girls are at STEM subjects? (1–6)	1 (Not at all)–6 (Very good)
How good do you think boys are at STEM subjects? (1–6)	1 (Not at all)–6 (Very good)
How much do you personally like STEM subjects? (1–6)	1 (Not at all)–6 (A lot)
Future Challenges in a Scientific Career (max 2)	Work-life balance, Study commitment, Financial sustainability, Job security, Gender-related obstacles, Career obstacles, Personal interests balance, Not suitable for this path, None, Other
Perceptions on Professions (indicate whether professions are best performed “mainly by women”, “mainly by men”, or “equally by both”)	Secretary, Kindergarten Teacher, Truck Driver, Nurse, Dancer, Firefighter, Scientist, Bricklayer, Librarian, Mechanic, Doctor
Attributes of a Female Scientist (max 3)	Competence, Cheerfulness, Coldness, Kindness, Precision, Intelligence, Tenacity, Reliability, Independence, Sensitivity, Many Interests, Organization
Attributes of a Male Scientist (max 3)	Competence, Cheerfulness, Coldness, Kindness, Precision, Intelligence, Tenacity, Reliability, Independence, Sensitivity, Many Interests, Organization

Table 2. Post-Orientation Survey. Final questionnaire to complete post-intervention.

Question	Response Options
How much do you think girls like STEM subjects? (1–6)	1 (Not at all)–6 (A lot)
How much do you think boys like STEM subjects? (1–6)	1 (Not at all)–6 (A lot)
How good do you think girls are at STEM subjects? (1–6)	1 (Not at all)–6 (Very good)
How good do you think boys are at STEM subjects? (1–6)	1 (Not at all)–6 (Very good)
Perceptions on Professions (indicate whether professions are best performed “mainly by women”, “mainly by men”, or “equally by both”)	Secretary, Kindergarten Teacher, Truck Driver, Nurse, Dancer, Firefighter, Scientist, Bricklayer, Librarian, Mechanic, Doctor
Attributes of a Female Scientist (max 3)	Competence, Cheerfulness, Coldness, Kindness, Precision, Intelligence, Tenacity, Reliability, Independence, Sensitivity, Many Interests, Organization
Attributes of a Male Scientist (max 3)	Competence, Cheerfulness, Coldness, Kindness, Precision, Intelligence, Tenacity, Reliability, Independence, Sensitivity, Many Interests, Organization
Future Challenges in a Scientific Career (max 2)	Work-life balance, Study commitment, Financial sustainability, Job security, Gender-related obstacles, Career obstacles, Personal interests balance, Not suitable for this path, None, Other
Impact of Orientation Session	Information about university field, Study commitment required, Career prospects, Job opportunities, Expected salary, Work-life balance
Favourite Aspect of the Session	Open-ended response

2.3. Population

Inclusion Criteria: The inclusion criteria for participation in the WHEN study are: (i) Being a high school student in their fourth or fifth year; (ii) Providing informed consent for participation in the study as stated in the relevant section.

Exclusion Criteria: There are no exclusion criteria for participation in the questionnaire.

Sample Size: Based on previous experiences with similar interactive approaches in educational settings, an estimated compliance rate of approximately 80% is expected among the students involved. Moreover, during the 2022/23 academic year, approximately 100 high school students and 300 middle school students participated in orientation events organized by the Department of Biomedical Sciences for Health, with whom the WHEN researchers are affiliated. The involvement of faculty from other medical-scientific departments, and of the University Study and Career Guidance Services, is expected to increase the number of participating students. The majority of participants in the sample, having been selected on a voluntary basis, do not form a statistically representative cohort. The sample predominantly comprises students enrolled in general-track scientific high schools (*licei*), with a lesser representation from technical institutes (Corbetta, 2014).

2.4. Recruitment

Phase 1: A document explaining the WHEN study is sent to high schools with students in their fourth and fifth years participating in orientation events. This document, to be posted on the school's electronic register for parents' review, outlines:

- The study's objectives;
- The execution methods;
- The assurance of anonymity;
- The voluntary nature of participation;
- The option for parents to review the questionnaires by contacting the study researcher via email up to the day before the scheduled orientation event;
- For parents of underage students, the possibility to opt out their kid from the study by notifying the researcher via email by the day before the scheduled orientation event.

The silence-assent approach is implemented, and no response to the document is required for participation, which will proceed in Phase 2. There is no pre-selection of schools; participation is open to all schools that engage in the proposed orientation events. The protocol documents the type and the geographical area of the participating schools.

Phase 2: During orientation events at Unimi, students are collectively addressed by the researcher at the beginning of the event. The researcher explains the study's objectives and invites voluntary completion of an initial anonymous online questionnaire.

Phase 3: Upon completion of the questionnaires, anonymized data are analysed in line with the study objectives. Initial exploratory analysis will examine questionnaire responses. Further analysis will assess variations in responses based on the respondents' gender, school type, and familial background (parents' occupations). Pre- and post-intervention questionnaires will be compared to evaluate the impact of the orientation events, including the influence of the instructor conducting the session.

Recruitment started in November 2023.

3. Evaluations

3.1. Questionnaires

The initial, pre-intervention questionnaire (Table 1) and the post-intervention questionnaire (Table 2), used for assessment in Phase 2, are completed on a voluntary basis. Both questionnaires are entirely anonymous (refer to the section on informed consent) and are adaptations of scales previously employed in various research protocols (see [Ashby & Wittmaier, 1978](#); [Hertz et al., 2018](#); [Mastera et al., 2021](#); clinical validation bibliography).

The questionnaires investigate the following areas:

- The type of school the student attends;
- The student's gender identity, including options beyond male/female, such as non-binary or a choice not to disclose;
- The occupational status of the student's parents ([Greene et al., 2013](#));
- The student's current desired fields of study and career aspirations;
- Gender stereotypes associated with scientific subjects (adapted from the questionnaire by [Mastera et al., 2021](#));
- Gender stereotypes linked to specific occupations (adapted from the Occupational Stereotype Measure by [Hertz et al., 2018](#));
- Gender stereotypes related to the idea of scientists (adapted from the Adjective Checklist by [Ashby & Wittmaier, 1978](#));
- Beliefs about the challenges that might be encountered when pursuing a scientific career.

The questionnaire (Table 2) administered at the conclusion of the orientation event using the same method as the initial questionnaire partially replicates the questions from

the initial questionnaire (including scales on gender stereotypes related to scientific subjects, occupations, and the image of scientists). Additionally, it includes new questions specific to evaluating the classroom intervention, such as:

- Satisfaction with the intervention;
- Interest in the topic;
- Changes in beliefs regarding the challenges of pursuing a scientific career.

This comprehensive approach will allow for a robust assessment of the impact of orientation events on students' perceptions and attitudes toward careers in science, with a particular focus on identifying and addressing gender-based stereotypes.

The questionnaires are administered online using MForms, with the option to collect usernames disabled in the settings: <https://support.microsoft.com/it-it/office/configurare-il-sondaggio-in-modo-che-i-nomi-non-siano-registrati-nella-raccolta-delle-risposte-25dd8442-f6ba-4934-9319-99f9f867f239> (accessed on 1 January 2025), ensuring that the tool is GDPR-compliant (also refer to the section on the collection and storage of data obtained). Participants who decide to complete the initial questionnaire (Table 1) can access the questionnaire using their personal electronic device (mobile phone or tablet) via a QR code given by the researcher. In the first screen visible to participants, the informed consent form appears, and the agreement is voluntary but necessary to proceed with the completion of the questionnaire. In the second screen visible to participants, there is the possibility to independently generate a code, consisting of two letters and two numbers chosen by the participant, which will link the pre- and post-intervention questionnaires and will not contain any information that would allow the participant to be identified. The expected time for completing the initial questionnaire is under 10 min.

After completion, the scheduled orientation event will continue. Subsequently, at the end of the orientation meeting, participants are invited, using the same procedure described above, to complete a final questionnaire that does not repeat some of the questions already administered but includes some new ones regarding their satisfaction with the orientation event (Table 2). Participants are asked to access the final questionnaire using the same code generated for the initial questionnaire. The expected time for completing the final questionnaire is under 10 min.

Additional information:

- No data from the questionnaires will be discussed or released to the participants.
- Compliance with the questionnaire completion will be recorded.
- The teachers who conducted the orientation event are invited to fill out an information sheet and a notice to collect some data (gender, age, SSD), and the type of activity carried out by the teacher with the students (seminar or laboratory activity), are recorded.

3.2. Analysis

All data will be presented in tables used for statistical analysis in an anonymized format to preserve privacy. Firstly, an exploratory analysis of the questionnaire responses will be conducted. Subsequently, ANOVA and Chi-square tests will be used to analyse whether responses differ according to the gender of the respondents, the type of school attended, and family background (parents' occupation). Lastly, a paired sample T-test analysis will be conducted to compare the pre- and post-intervention questionnaires to assess the effectiveness of the event, using an alphanumeric code that allows the student to be identified anonymously.

3.3. Other Considerations

3.3.1. Study Costs

The project does not foresee any funding.

3.3.2. Withdrawal from the Study

Participants may leave the study (stop completing the questionnaires) at any time for any reason without any consequences and without needing to provide any explanation.

3.3.3. Ethical Considerations

- Informed Consent for Students

In the introduction of the initial questionnaire (Table 1), which appears on the first screen, there is the Informed Consent for Students, in which the purpose of the study and its impact are described. It is also specified that:

- The questionnaire is completely anonymous;
- The data will only be used for research purposes in an aggregated format;
- To proceed with completing the questionnaire, participants must accept the proposed conditions and sign the informed consent form;
- It is possible to interrupt the questionnaire at any time without any consequences.

Participation in the consent is voluntary and necessary to proceed to the following screens.

Participants will independently generate a code consisting of two letters and two numbers to pair the data from the two questionnaires.

Considering the possibility that underage students may participate, the study notification will be sent to the participating school, allowing parents to review the study, request to view the questionnaires, and have the option to object to their child's participation.

- Informed Consent for Teachers

Teachers who have planned an orientation event will be contacted by email and/or phone and will be invited to participate in the WHEN study. Teachers who agree to participate in the study, before conducting their orientation event, will be invited to review and sign the information consent and the privacy notice. The collected data will include the teacher's age, gender, SSD, and the type of activity conducted (seminar or laboratory activity).

3.3.4. Incentives

No incentives will be provided to those who participate in the study.

4. Discussion

The WHEN project—Women in Science: Where Do We Stand?—is an initiative aimed at exploring young students' perceptions of scientific careers and scientists, particularly in relation to gender. It investigates the basis of these perceptions and examines whether educators and researchers, as role models, can influence them at a crucial point in their life, such as the end of high school when students have to make decisions about their academic and professional future paths. This project stems from the need to determine if gender stereotypes that limit women's participation in science, technology, engineering, and mathematics (STEM) fields persist among younger generations. The idea originated from the personal experiences of the authors, who include researchers in Histology and Human Anatomy, key subjects for medical studies; experimental oncology, where basic and clinical research intersect; and Sociology of inequalities and educational policies.

The authors have been actively involved in scientific outreach activities, particularly in schools, also holding institutional roles dedicated to this mission. Through several orientation and education events with students, they observed that, despite inclusive policies, gender stereotypes still influence perceptions of women in science, limiting young women's choices in pursuing scientific studies, especially in STEM fields.

As scientists, the authors approached this issue scientifically; following observation and documentation phases, they found that published data and reports consistently indicate that young women are still underrepresented in scientific careers. Recent statistics reveal that only 16.6% of girls in Italy choose university courses in STEM, leading to fewer opportunities in related careers (ISTAT, 2023). The hypothesis is that multiple factors contribute to this disparity, with a critical issue being the persistence of gender stereotypes among secondary-school students.

To experimentally verify this hypothesis, the project benefits from the expertise of organizations like She is a Scientist (<https://sheisascientist.com/>, accessed on 1 January 2025), which monitors gender dynamics in science, and the University of Milan's Center for Study and Professional Orientation (COSP) (<https://www.unimi.it/en/education/university-guidance/cosp-university-study-and-career-guidance-service>, accessed on 1 January 2025), which integrated the WHEN study into its numerous STEM orientation events for secondary schools (Figure 1).

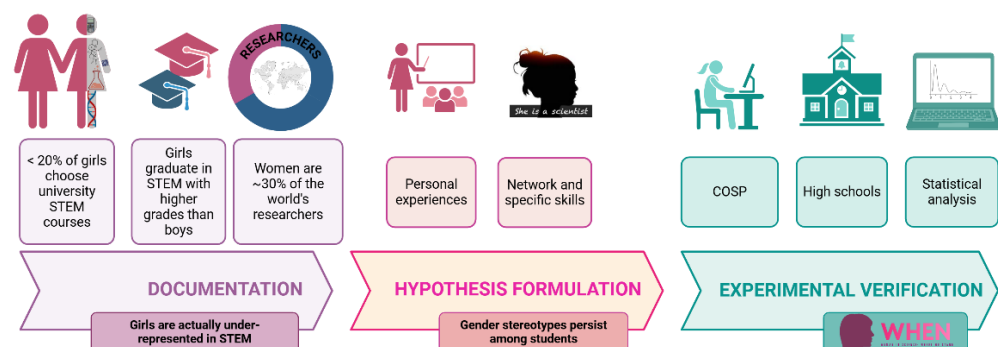


Figure 1. Scheme of WHEN generation. Created with Biorender.com.

These events are a valuable opportunity for educators and researchers to engage with hundreds of students who are considering scientific pathways for their futures. By providing direct, personal interactions between students and researchers, these experiences help overcome barriers often due to technological media interfaces, fostering questions on future careers (Figure 2).

Our data analysis considers factors such as student gender, type of school, geographic area, and family background. The literature in the sociology of education highlights that the decision-making process for university studies is the result of a complex interplay of factors, including prior academic performance (Giancola & Salmieri, 2023), socio-economic background (Bourdieu & Passeron, 1964), family expectations, peer influence, perceived prestige of the profession (Jaoul-Grammare, 2024), individual interests, and the availability of information (Giancola & Piromalli, 2024) on tertiary education options (Heathcote et al., 2020). It is essential to note that the concept of professional prestige is a social construct (Jaoul-Grammare, 2024) influenced by the socio-economic and cultural value attributed to various occupations within specific contexts. This varies significantly depending on social environments and their evolution (Hughes et al., 2024).

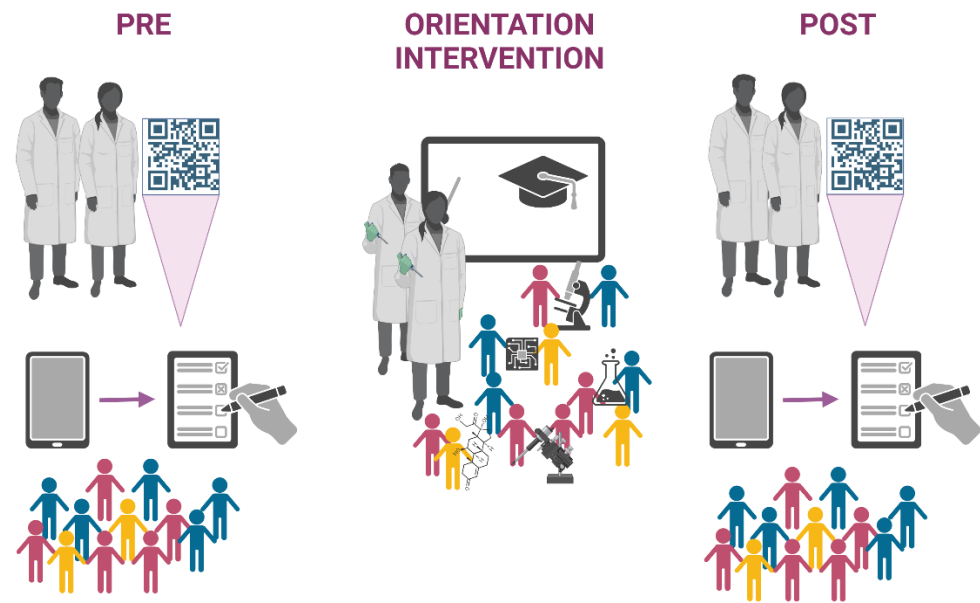


Figure 2. WHEN insert in orientation events. Created with Biorender.com.

Despite the presence of various educational and labour policies that mention career guidance, in Italy today, it takes the form of a quasi-educational market (Giancola & Piromalli, 2024). In this context, career guidance assumes quasi-market characteristics, delegating to schools and universities, as service providers, the responsibility of identifying student consumers and directing them toward their educational offerings (Giancola & Piromalli, 2024). Building on this perspective, our study results can not only provide insight into the current Italian situation regarding gender stereotypes in STEM but also aim to enhance future guidance initiatives, making them more effective in promoting gender equality in scientific careers. Indeed, the questionnaire proposed at the conclusion of the guidance events assesses changes in student perceptions, particularly regarding gender stereotypes, evaluating the impact of different types of orientation events and the role of the gender of the presenting educators or researchers in altering stereotyped perceptions. According to previous research in this field, interventions that offer direct exposure to female scientists and counter stereotypical role models are important in shaping perceptions of STEM (Leblebicioglu et al., 2011; Olsson & Martiny, 2018). Interventions such as ours, with female scientists talking about their experiences, can help students to develop a more accurate image of scientists, and the exposure to female role models in STEM can reduce gender stereotypes and encourage women's participation in scientific careers. For example, after our intervention, female students reported that they were less afraid that a scientific career would be incompatible with having a family and children, and also that they were less worried that their gender could be an obstacle to their academic and work careers in STEM. Our results are also aligned with the main theoretical framework of the Social Cognitive Career Theory (SCCT) (Lent et al., 1994), showing how gender stereotypes can influence career choices through mechanisms like self-efficacy and outcome expectations. Moreover, according to the Stereotype Threat Theory (Steele, 1997), interventions such as exposure to female role models may help mitigate the effects of gender stereotypes which may suppress STEM engagement.

These results further confirm that counter stereotypical role models—women succeeding in male-dominated fields—can positively impact girls' self-perceptions, career aspirations, and motivation (Olsson & Martiny, 2018). However, in defining and promoting female role models in STEM, it is essential to consider not only their representation but also the message they convey. Rather than solely presenting women who testify to the

challenges of being in science, role models should also emphasize the importance of free choice in following one's passions as a path to both personal and professional fulfilment. This approach can help inspire students by framing STEM careers as an open and rewarding pursuit, rather than one defined primarily by obstacles.

The results of this study therefore highlight, once again, how gender stereotypes are socially constructed, and therefore how these can also be socially overcome. Therefore, interventions like the present one could start before stereotypes become deeply internalized, also in primary and secondary education. For example, schools can: develop specific programs with successful women in STEM fields; ensure gender-balanced classroom environments, promoting active participation of girls in STEM-related activities; and train teachers to recognize gender stereotypes educate for gender equality. Governments also play a crucial role in removing structural barriers and incentivizing female participation in STEM: policy measures could include scholarships and financial incentives targeted at women pursuing STEM degrees, but the legislation can also promote workplace equity, such as policies ensuring equal pay and parental leave, which are critical for retaining women in STEM careers. In this regard, the world of work also plays a crucial role in supporting gender equality in STEM careers, for example, hiring more women in decision-making roles (which can create a more inclusive work culture) and develop workplace policies that support work–life balance to ensure career sustainability for women in STEM.

The WHEN protocol also has some limitations. First of all, the current study was conducted within the specific socio-cultural context of Italy, where gender stereotypes regarding STEM fields remain influential. Studies have shown that gendered perceptions of STEM careers are different in various countries depending on the specific cultural context ([Cheryan et al., 2017](#); [Stephens et al., 2012](#)); therefore, interventions like the presented one can have different results depending on macrolevel cultural factor such as role models, social values, perceived power and status, the labour market, and peer support ([Stephens et al., 2012](#)).

Another limitation concerns the response mode: self-reported data collected by individual questionnaires may be subject to social desirability bias, which might influence our findings. To mitigate this concern, we ensured anonymity and confidentiality in the questionnaire responses, a strategy that has been shown to reduce response bias ([Krumpal, 2013](#)).

Additionally, other limitations concern the short-term nature of the intervention and the reliance on self-reported attitudes rather than long-term behavioural outcomes. Future research could explore longitudinal effects and employ experimental designs to better isolate causal effects.

In conclusion, the WHEN project represents a significant step towards understanding and overcoming the barriers that still limit young women's access to scientific careers. It is an initiative that looks to the future with the goal of building a more equitable and inclusive society, where career choices are driven by individual passions and abilities rather than gender prejudices.

NOTE: With the term "Gender Disparity" in the manuscript, we indicate a measurable difference in outcomes, opportunities, or treatment between male and female genders in science, often indicating an imbalance in access to resources, rights, or societal benefits. With the term "Gender Gap" in the manuscript, we indicate the difference between genders in specific indicators, such as the rate of enrolment and frequency in STEM university courses and leadership positions. With the term "Gender Stereotypes" in the manuscript, we indicate ideas and socially constructed beliefs about the characteristics, roles, and behaviours deemed appropriate for individuals based on their gender in the STEM fields.

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