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Analysis of Secondary School Students' Perception of Scientists and its Impact in STEM Education with a Gender Perspective

Análisis de la percepción del alumnado de secundaria de los/las científicos/científicas y su impacto en la educación STEM con perspectiva de género

Andrea Fernández-Sánchez[*1], Ana Sánchez-Bello[*] y Alicia Arias-Rodríguez[**]

*Departamento de Pedagogía y Didáctica, Universidad de A Coruña (España)

** Departamento de Didácticas Específicas y Métodos de Investigación y Diagnóstico en Educación, Universidad de A Coruña (España)

Resumen

El declive del interés del alumnado por cursar estudios postobligatorios en el ámbito STEM radica en las actitudes negativas hacia las materias de ciencia y tecnología ("CyT"), que han ido desarrollando durante la educación secundaria, y se atribuye, entre otras causas, a la imagen estereotipada de la CyT, concretamente a visión distorsionada del trabajo científico y sus profesionales. Este artículo analiza narraciones construidas por alumnado de secundaria sobre la vida de un científico y una científica para esclarecer la imagen que presentan sobre los/las profesionales del ámbito científico-tecnológico y su trabajo. Se llevó a cabo un análisis de contenido de los relatos siguiendo una perspectiva de género para determinar las similitudes y diferencias existentes entre el alumnado femenino y masculino en cuanto a la percepción sobre el trabajo científico y sus profesionales. El análisis concluyó que el alumnado percibe como cualidad principal de los/las científicos/científicas la inteligencia y el interés innato por su campo de estudio; e imaginan al trabajo científico como muy exigente, el cual requiere compromiso, dedicación y esfuerzo. En un plano personal, el alumnado concibe a estos/estas profesionales como personas sociables, lo que significa que la imagen socialmente aceptada de la ciencia "folk" está

1 **Correspondencia:** Andrea Fernández-Sánchez, andrea.fernandez.sanchez@udc.es, Facultad de CC. de la Educación, Campus de Elviña s/n · 15071 · A Coruña.

difuminándose. Finalmente, el estudio concluye que el alumnado no sólo otorga un papel central a las familias en el proceso de elección de estudios; sino que también reconocen la existencia de barreras, no relacionadas con factores internos – inteligencia, habilidad o compromiso – sino con factores sociales, que frenan el desarrollo profesional de las científicas.

Palabras clave: estereotipos de género; imagen de la ciencia y tecnología; imagen de los científicos; visiones distorsionadas ciencia y tecnología.

Abstract

Students' declining interest in pursuing a STEM education after the compulsory school years lies in their negative attitudes towards Science and Technology ("S&T") subjects developed during the lower-secondary school years and it is attributed, inter alia, to a stereotyped image of S&T and, in particular, to stereotypes about scientists and the misconceptions about their work. This article analyses students' descriptive narratives about male and female scientists in order to disclose the stereotypical representations of scientists and scientific work held by high school students. A content analysis approach with a gender perspective was chosen, as this method allows us to disclose similarities and differences between male and female students' perceptions about scientists and scientific work. The analysis revealed that students consider intellect and innate passion as the main qualities of scientists, and picture scientific work as highly demanding, requiring commitment, engagement, and endeavour. On a personal level students conceive scientists as sociable people, meaning that the socially accepted idea of "folk" science is fading. The study further concludes that students take their families into account as key players in their career decision-making process. They also acknowledge the existence of barriers that hinder the career development of female scientists, barriers unrelated to internal factors such as intelligence, ability, or commitment, but that have to do with social factors.

Keywords: gender stereotypes; image of scientists; S&T stereotypes; school science.

Introduction and objectives

Student's increasing unwillingness to take part in science and technology-related careers has been underscored in the science education community (Ulriksen et al., 2015). This matter is often aligned with the improvement of STEM areas of knowledge to reproduce the cognitive capitalism and to contribute to the reinforcement of the future workforce who with their knowledge, skills and expertise contribute to develop the financial marketplace (Torres, 2017). Nonetheless, it must be addressed as a matter of justice to reach a proportional gender representation in the STEM field and its educational programs since society is integrated by both men and women. In Spain the figures of the academic course 2020-2021 show that in the Scientific and Technological Baccalaureate 47,66% of the student body are female students (Ministerio de Educación y Formación Profesional, 2022). Although these figures are positive, this type of baccalaureate comprises health sciences studies which are still predominantly carried out by women. In this sense, whereas there are more women than men who access to university, there remain stereotypically male and female studies (Cobreros et al., 2024).

As we transition into higher education, gender disparities become more apparent. Up to 72% of new students enrolled in engineering and architecture degrees are male, while 75% registered in health sciences are female (Ministerio de Universidades, 2022). This gender bias is particularly stark in certain domains; for instance, only 14% and 16% of students in IT and Industrial Electronics and Automation engineering are female, respectively. Conversely, Architecture and Food Science Technology show more balanced female representations, at 53% and 67% respectively. Furthermore, there has been a notable decline not just in percentage but also in the absolute numbers of female students in fields like Mathematics and Physics over recent decades (Cobreros et al., 2024). This disparity is even more pronounced in postgraduate studies and vocational training (Cobreros et al., 2024).

To further understand these dynamics, it is crucial to consider the array of factors influencing educational choices. Students' self-perception (Cobreros et al., 2024), relationships with significant individuals – such as peers, family and teachers-, and their preconceptions of scientists play significant roles (Halim et al., 2018; Holmegaard et al., 2014; Reinhold et al, 2018). Negative perceptions about science impact both students' interest in pursuing post-compulsory education in STEM studies (Mead & Métraux, 1957; She, 1998; Ulriksen et al., 2015), academic achievement in STEM classes, and self-identification with science (Cundiff et al., 2013). Declining interest and negative attitudes towards school science occur during the lower-secondary school years (Gibson & Chase, 2002; Murphy & Beggs, 2003) which is attributed, among other factors, to a stereotyped image of S&T (Chambers, 1983; She, 1998; Vázquez-Alonso & Mas, 2005), precisely due to stereotypes about scientists and their work activities (Bozzato et al., 2021).

Stereotypes are preconceived and generalized beliefs about an individual's attributes, interests, behaviours and personality so ingrained in our collective consciousness that we are no longer capable of analyzing or rationalizing them, and blinded accept and reproduce these as self-evident truths (Arias-Rodríguez & Sánchez-Bello, 2022). Stereotypes limit what we think about certain social groups, and gender stereotypes particularly limit the way we perceive men and women. Both leading to essentialists, reductionists societies and promoting segregation (Arias-Rodríguez & Sánchez-Bello, 2022). Stereotypes in general and gender stereotypes particularly are conformed through social interaction with socialization agents and observation of group members – direct observations – or mass media – indirect observations – (Koening & Eagly, 2014; Rocha, 2009). In relation to science, children form gender stereotypes unknowingly through their teachers' beliefs and attitudes and also through media sources such as books, movies, shows, magazines etc. (Miller et al., 2018).

The images of science and scientists held by students represent their perceptions of scientists and of their roles in society. In the past decades several studies to determine the stereotypical representations of scientists have been conducted (Archer et al., 2010; Bozzato et al., 2021; Chambers, 1983; Ferguson & Lezzotte, 2020; Finson, 2002; Miller et al., 2018) as the image students have of scientists is one of the influential factors of the educational choice process inasmuch as students picturing themselves in a scientific career is influenced by their representation of science and scientists (Regan & DeWitt, 2015). Mead and Métraux (1957) carried the first study to investigate students' image of scientists. With that purpose in mind, they asked high school students to complete some statements about scientists. Latter Chambers (1983) develop the Draw-a-Scientist Test to assess the scientific literacy of students by asking them to draw a scientist and analyzed the images afterwards. Various research using the DAST test have been conducted in different countries around the world, mostly in USA (e.g.: Chambers, 1983; Finson, 2002; Miller et al., 2018) and European countries (e.g.: Bernard et al., 2017; Bozzato et al., 2021; Ruiz-Mallén & Escalas, 2012). This research concluded that students hold a stereotypical image of scientists because they perceive them as a middle-aged or elderly males, wearing a white coats and glasses, working in a laboratory (Finson, 2002; Mead & Métraux, 1957) and believe they are unorganized, distracted, and even crazy people (Rodari, 2007).

Most people's image of scientists is stereotypical and seem to be pervasive and resilient over time (Chambers, 1983; Finson, 2002; Rodari, 2007). If we have a look into scientific education investigations up to seven distortions of the image of science and technology were identified, misconceptions conveyed by teachers, textbooks and mass media that perpetuate some iconographies about scientific work and scientists (Fernández et al., 2002). Two of these misconceptions are particularly relevant in the stereotypical image of scientists: the empiricist-inductivist and non-theoretical view of science and technology, in which scientific knowledge is the result of an objective inductive process of raw facts or pure data gathered through experiments (Fernández et al. 2002) and the individualistic and elitist understanding of science. According to this conception, scientific knowledge is formed by isolated male genii in their labs (Fernández et al., 2002) neglecting collective work and cooperation between teams as a pre-requisite to progress (Fernández et al. 2002). Hence, students build misconceptions about science and scientists such as scientific work as a domain of an "intellectual elite" (Masnick et al., 2010 in Regan & DeWitt, 2015). In this regard, APIRES project revealed that students perceived school science as a difficult subject which requires a "natural" ability (Archer & DeWitt, 2015). These visions are related to the socially accepted image of science, a folk or naïf science linked to the scientific method and cliché-studded which portrays scientists as wise but absent-minded males and/or IT workers as "nerds" (Fernández et al., 2002). This misconception impacts deeply on female students since science is not only presented for an intellectual elite – when girls hold a lower self-concept of ability in math's domains than boys despite having a similar academic achievement (Cobreros et al., 2024; Wang, 2013) - but is considered an activity for a male intellectual elite (Fernández et al., 2002). This gender biased association that society has of STEM to masculinity deploys the idea to students that STEM studies are for male and/or scientific work is conducted by males (Regan & DeWitt, 2015) and lead girls to not consider themselves as "a science person" (FSO, 2019 in Chauke, 2022; Regan & DeWitt, 2015).

This social construction of science builds student's negative feelings towards science and leads them to not consider science as an educational or career option (Archer & DeWitt, 2015). Moreover, science stereotypes are particularly problematic for females not only because both males and females are more likely to link scientific disciplines to males and believe that males are better at science (Lane et al., 2012) but also because females are more likely to perceive STEM careers as lacking of a contribution to society development and with unattractive lifestyles (Wang & Degol, 2016 in Chauke, 2022; Ferguson & Lezzotte, 2020), according to Merayo and Ayuso (2022) in Cobreros et al. (2024) among high school students, helping people and society ranks higher for girls, whereas earning money is more significant for boys when choosing STEM careers.

These dynamics, leads to an image of science with characteristics reverse to and/or far removed from girl performances of popular feminity (Archer et al., 2010) and binds girls, who want to enrol or purse STEM careers, to balance or accommodate their "masculine" science aspirations with popular discourses of science as "clever" and "masculine" (Archer & DeWitt, 2015). To incorporate this vision of science to their identity they use two strategies: drawing their identity around either the "feminine scientist" or the "bluestocking scientist". Girls who resort to the "feminine scientist" try to balance the masculine vision of science with performances of popular femininity – fashion, makeup etc. - (Archer & DeWitt, 2015). In contrast, the 'bluestocking' girls foreground their academic identity and tend to explicitly define themselves as 'not girly' (Archer & DeWitt, 2015) and end up being tagged as "geeks".

Objectives

The aim of this study is to understand students' perceptions of science and scientists. This case study of two public high schools in Galicia (Spain) that uses active teaching and learning methods in science and technology lessons tries to:

- Reveal the stereotypical representations of scientists held by Spanish secondary school students from two public schools in Galicia (Spain).
- Identify the similarities and differences between the perceptions of male and female students about scientists.

Method

A case study approach with a gender perspective is used in this study. This article, which is part of a larger case study research about two public high schools in Galicia (Spain) that uses active teaching and learning methods in science and technology lessons. Several researchers have regarded the case study approach as a valuable method of inquiry in understanding a social problem through the participants' perceptions (Denzin & Lincoln, 2011).

This article is based on a content analysis approach i.e. a flexible method for describing and interpreting written or visual productions of society or social groups, as it provides information about the informant while fulfilling the triple aim of inference, analysis and interpretation (Andréu, 2002). In this study, the descriptive narratives of 66 secondary school students about two scientists, Arkaitz Carracedo and Katie Bouman (see Figures A1 and A2), were subjected to a content analysis that considered three dimensions: the image of scientific work, the portrayal of scientists and the role of socialization agents in career choices. Narratives are one of the tools for data collection of qualitative researchers (Denzin & Lincoln, 2011). For these authors a narrative may be a short topical story about a particular event and specific characters.

Population and sample

A total number of 65.226 students were enrolled at public secondary schools in Galicia. However, our research approach was a case study in which the selection of the sample was based on criteria (Goetz & LeCompte, 1988): schools where active teaching and learning methods in science and technology lessons are used. Thus, this study was drawn on an intentional non-probabilistic approach.

This study included 66 students who chose technology-related electives—ICT and programming—at two secondary-schools in Galicia, Spain, characterized for employing project-based and cooperative learning methods in these electives. In the secondary school located in Pontevedra, 29 students (6 females and 23 males) aged 15 and 16 chose ICT (4ESO) as their elective. In the secondary school in A Coruña, 37 students (16 females and 21 males) aged 12 to 13 (1ESO) opted for programming. The unequal number of female and male students in the sample is due to the smaller number of girls who choose technology-related subjects as optional subjects since engineering is still perceived as a male domain.

Instrument

Traditionally, to collect the stereotypical views of scientists and scientific work, studies have resorted to the DAST "draw-a scientist test" and its diverse versions. DAST tests are useful tools to disclose students' - who are still developing verbal abilities - perceptions of scientists (Chambers, 1983) but some limitations have been underscored (Losh et al., 2008): stereotypes may result from students' poor artistic skills rather than biases, drawings may be reflections of societal stereotypes represented in mass media instead of the student's ideas (Bogdan et al., 2018) or even researcher's biases may influence drawings' interpretations (Bogdan et al., 2018; Ferguson & Lezotte, 2020; Losh et al., 2008).

To mitigate some of the aforementioned limitations and avoid biased interpretations, our study employs descriptive narratives from 66 students aged 12 to 16, discussing their perceptions of two scientists. This approach was chosen over drawings to leverage the richer detail and depth that narratives can provide. Narratives are a well-established tool in qualitative research for capturing complex personal and social dynamics (Denzin & Lincoln, 2011). This method follows in the tradition of seminal works such as by Mead and Métraux (1957), who explored the image of scientists using students' written statements, revealing nuanced insights into students' perceptions. Mérida-Serrano et al. (2021) further exemplify this approach in their INFACIENCIA program, where they combined drawings with "drawing interviews" to foster communication and respect for learners' genuine expressions, minimizing adult mediation that could alter the original construction of discourses. Similarly, Rodríguez et al. (1996) emphasize the value of artifacts, such as written documents or other materials produced for research purposes, as reliable research instruments. By utilizing narratives, our study aims to capture a more direct and undistorted representation of how students perceive scientists, thus providing richer data for analyzing contemporary student perceptions of scientific careers.

In our study, the artifacts are the stories developed by the students, as all participants had developed their writing skills. Within these narratives, the students describe the scientists' past and former lifestyles, preferences, backgrounds, and personality traits. To construct these narratives, we provided students with the photograph of two scientists (see Figures A1 and A2), their names, and areas of knowledge. To explore students' entrenched gender stereotypes beyond stereotypical representations of fields of study and physical characteristics, we selected young scientists in non-traditionally gendered scientific professions – Arkaitz Carracedo is a specialist in molecular biology and Katie Bouman is a specialist in computer science. This choice was intended to challenge the students' perceptions and provoke more thoughtful and potentially revealing responses about the roles of gender in scientific professions.

These narratives contain information comprised in three dimensions - image of scientific work, depiction of scientists, the role of socialization agents in the career decision-making process -, and a set of more specific indicators, as outlined below, analyzed by gender as a cross-sectional category.

- Image of scientific work: Declining interest and negative attitudes towards science at school are attributed, among other factors, to a stereotyped image of S&T, precisely due to stereotypes about scientists and their work activities. This impacts students' interest in pursuing post-compulsory education in STEM and self-identification with science (Cundiff et al., 2013). The main codes in this dimension are the epistemology of science and technology, contribution to society, workplace, social recognition, workload and salary (see Figure 1.)
- Depiction of scientists: Our society dictates symbolically what we are or should be as men and women. The socially constructed images and stereotypes to which we are exposed from birth shape the way we think and behave as adults (Iglesias & Sánchez-Bello, 2008). One of the factors that influence educational choices is self-perception. Science stereotypes are particularly problematic for females because scientific disciplines are usually linked to males. Archer and DeWitt (2015) point out that the masculine vision of science collides with girl performances of popular femineity that prompts girls to not consider themselves as "a scientific person". The main codes in this dimension are: scientists' personality and interests when young, and as adults, current civil-status, and their decision-making process on pursuing a scientific career (see Figure 1).
- Socialization agents in the career decision-making process: Eccles and Wigfield (2002) highlights that the socialization process plays a key role in the student's educational choices. Parental and family attitudes towards science in everyday life, career expectations and parental support play an important role in shaping children's science aspiration (Halim et al. 2018). According to Reinhold et al. (2018), teacher expectations and behaviour are also positively related to students' motivation to explore STEM careers. Relating to gender and science stereotypes science, children form through their families and teachers' beliefs and attitudes and media sources as books, movies, shows, magazines, etc. (Halim et al. 2018; Miller et al., 2018). The main codes in this dimension are: role of families, secondary school and mass media (see Figure 1).

A descriptive codification of the data was carried out based on these key concepts (Miles et al., 2014). The codification process showed the recurrence of themes, which were organized according to categories. We reach the saturation of emergent themes through the integration and density of the theory when all the data and variations within the theory is exhausted (Ardila & Arenas, 2013).

Figure 1. Descriptive codification of analysis units: categories and codes.

Procedure and data analysis

Data collection took place during lessons, i.e. students wrote their narratives during ICT or programming classes under the supervision of the researcher and the teacher. First, we projected the image of the male scientist to students and asked them "how do you think he became a scientist and how is his life nowadays? They had 15 minutes approximately to write about his lifestyle, preferences, background, and personality traits (see Figure A3) since the objective of the study is to identify both forthright and embedded students' images of scientists and scientific work. Secondly, the picture of the female scientist was shown, but, this time, students were asked to point out the differences between them in terms of lifestyle, preferences, background, and personality traits, for which they had 10 minutes. The image of the male scientist was first provided to facilitate the writing process for the students as it is easier for them to imagine and describe the lifestyle, preferences, background and personality traits of a male scientist and then compare him to a female colleague since science is usually perceived as a male domain (Regan & DeWitt, 2015; FSO, 2019 in Chauke, 2022). The aim of the comparison between the lifestyles of male and female scientists is to identify students' tacit and explicit stereotypes and perceptions about scientists, i.e. what students are able to identify as differences between male and female scientists by describing them in the stories, and which stereotypes they unconsciously perpetuate by omitting them from their comparison.

Data was analyzed using the MAXQDA program. By labelling each text fragment this software eases the search of data patterns and the establishment of classifications, thus yielding stricter, more reliable results (Hwang, 2007). The results of the codification process are displayed below in Figures 2-6.

This study was carried out following the principles of credibility for qualitative research pointed out by Flick (2012). To guarantee the reliability of data and results, we conducted this study with clear objectives and stuck to research standards and the principle of literality. The validity of our study was built on its adherence to the self-critical principle in both the research process and its results (Creswell, 2013), as well as the validity transmitted by the participants. Validation is the process through which we assess the credibility of observations, interpretations, and generalizations (Flick, 2012). The essential criterion is the degree to which we can draw on the concepts, methods, and inferences of a study (such as Bogdan et al., 2018; Chambers, 1983; Ferguson & Lezotte, 2019; Losh et al., 2013) as a basis for our theorizing and empirical research. With this reformulation, the essential question of validity depends on the scientific community (Sandín, 2003).

Qualitative research faces ethical issues that arise not only during data collection in the field but also in the analysis and dissemination of qualitative reports (Creswell, 2013; Sandín, 2003). Therefore, to ensure an ethical study, we followed the main ethical principles of research, such as integrity and honesty, upholding informed consent, beneficence, confidentiality, and privacy (Sandín, 2003). To be more specific, the families of students were informed about the aims, methods and data processing of the study, and their consent was requested. Also, data was anonymized by assigning an alias to each student.

Results and discussion

Image of scientific work

The analysis of the image of scientific work was carried out using the following codes: Epistemology of science and technology (e.g., finding cures, researching, doing experiments, creating, making discoveries), contribution to society, workplace, social recognition, workload, and salary (see Figure 2).

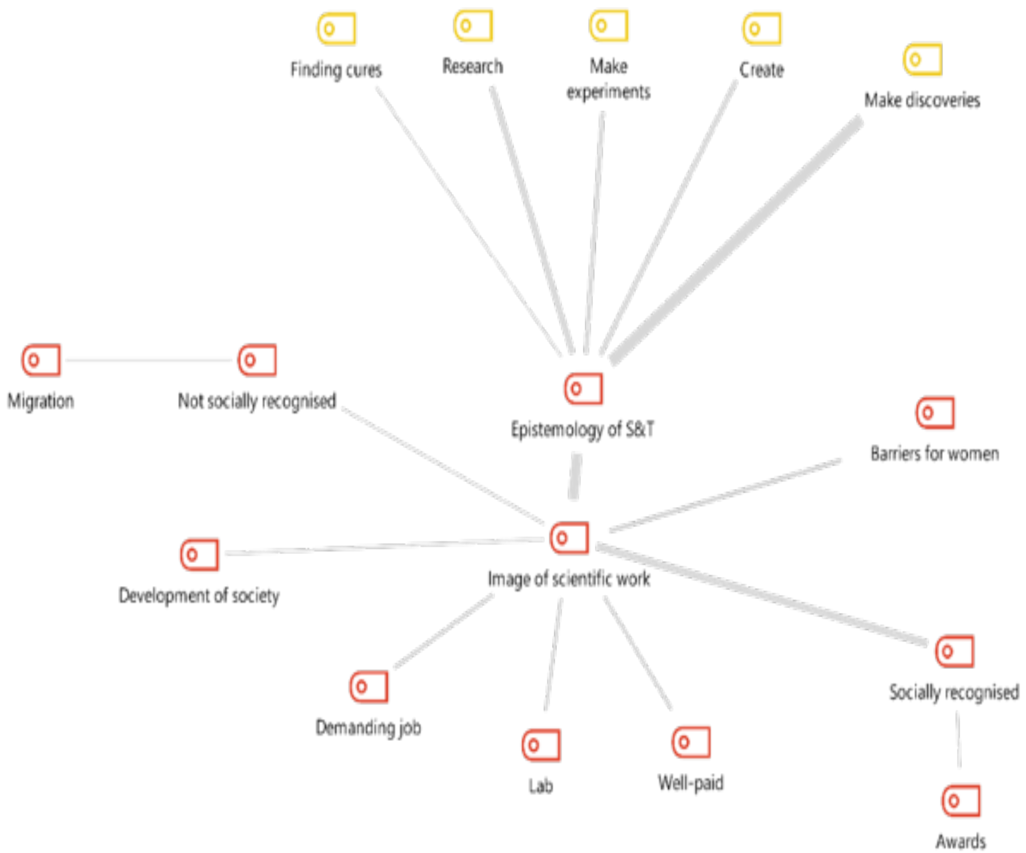

Figure 2. Categories and codes: Scientific work.

Figure 2 shows that students perceive scientific work as "doing experiments", "making discoveries," or "creating things" when technology takes place (e.g. male student: *"He got a science degree and, nowadays, he works as a scientist doing experiments"*; e.g. male student: *"he discovered the medicine to cure lung cancer"*; e.g. female student: *"Afterwards he started to create things resulting from his experiments such as cures for diseases*"). Few students have a narrower image of scientific work, perceiving it as "research." However, the Spanish language uses the same term for "research" and "inquiry," implying that some of these students also have an empirical view of scientific work. Only some students imagine laboratories as scientists' workplaces in their narratives, but the rest of them do not allude to workplaces in their stories. Thus, we cannot argue that they have a more accurate picture of scientific work.

Although students consider scientific work to be prestigious, only a few of them can recognize its contribution to society through 'finding cures for diseases' (see Figure 2). More than half of the students associate social recognition of scientific work to winning prizes and/or being famous.

Figure 3. Differences and similarities between the male and female scientist.

However, the fact of being socially recognized, and the way it is expressed, seems to be linked to the sex of the scientist, as this code is mostly found in the stories about the male scientist (see Figure 3). Moreover, winning awards is only mentioned in the male scientist descriptions (see Figure 3).

Figure 4. Differences and similarities between the male and female students' stories.

Similarly, students imagine scientific work as an extremely demanding profession. However, male students consider it to be well-paid, as opposed to their female peers (see Figure 4). This image contributes significantly to the notion of an unattractive lifestyle, even more for female students.

Finally, students report obstacles that hinder women scientists in their career development. These difficulties in accessing and developing a scientific career are not related to intelligence or commitment (e.g. female student: *"she also stood out for her grades at school and in the test to access to college, but unfortunately, I believe that she may have had more difficulties despite having the same capabilities due to being a woman"*), but to social barriers such as having to make greater efforts to achieve a work position in the science and technology field (e.g. male student: *"Nowadays, she works in a scientific career, but she had to study much more to have a career in this field."*) and the salary gap (e.g. female student: *"They have the same opportunities to access to scientific work, but she has suffered more difficulties finding a job position which was in accordance to her expertise and with a good salary"*). From these findings, we can conclude that students still consider science as a male domain and female scientists are and have been systematically excluded.

Depiction of scientists

The analysis of the image of scientists focused on the following codes: personal characteristics (e.g. curiosity, intelligence, ambition), civil status, characteristics as young students (e.g. sociability, grades), and the development of their interest for their field of study (see Figure 5).

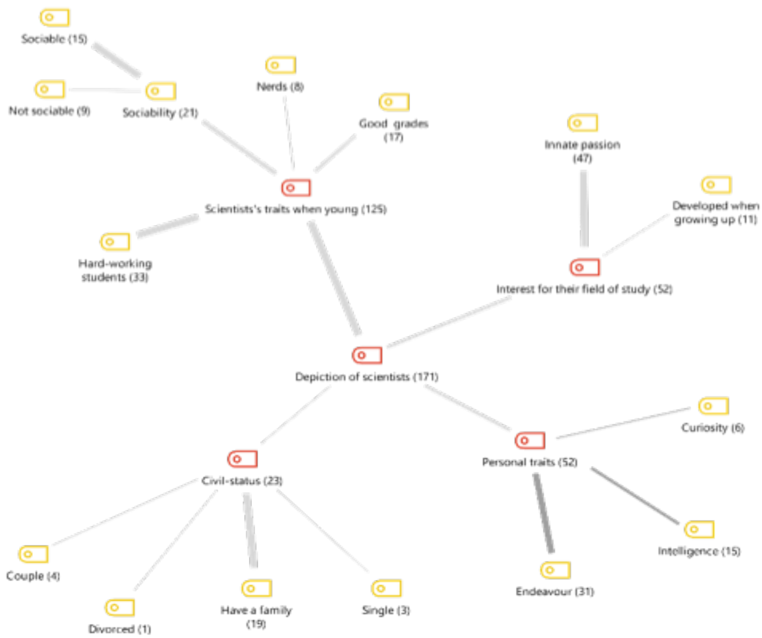

Figure 5. Categories and codes: Depiction of scientists.

The analysis of the scientists' features shows that students perceive engagement as the most relevant trait, ahead of intelligence (see Figure 5). As Figure 5 shows, most students believe that scientists have an inner passion for their field of knowledge since childhood (e.g. male student.: *"From a young age science and experiments drew his attention. In his free time, he liked to spend time with animals and insects"*; e.g. female student: *"The main passion of this scientist from a very early age was space, stars, galaxies, planets..."*; e.g. female student: *"When he was little he liked science very much and all sort of things related to it. I am sure that when he was a 12-year-old boy he did many experiments, and he was super smart*"), and half of them believe that scientists work and have studied very hard since childhood to pursue a career in science. This view can lead students to flee science if they do not perceive themselves as committed to their studies or "naturally gifted" in science.

In lower secondary school years, female students allude to the "intelligence" of male scientists in their narratives, while their male peers make no reference to it, neither for the male or the female scientist. In upper secondary, however, both female and male students consider scientists to be intelligent and eager. Nevertheless, while male students consider scientists to be hardworking since childhood, female students emphasize the scientist' grades at school or whether they excelled in a particular subject (e.g. female students: *"She stood out for her high grades at school and in the test to access to college"; "she was very smart and got good grades at school mainly in science"*). Such an unequal image might be related to the higher achievement value of girls (Eccles & Wigfield, 2002).

In terms of personality, students perceive scientists as friendly people who enjoy spending time with their friends (see Figure 5). Moreover, few male students see them as nerds or withdrawn people (e.g. male student: "*When he was young, he liked to play Dungeons and Dragons due to which he had become a socially rejected nerd*"). On the contrary, the female scientist is perceived as shy, introverted, friendless, and even bullied (e.g. male student: *"None of her classmates liked her because she was a bookworm and had trouble with her classmates but she never minded and kept working to become a scientist*") (see Figures 3 and 4).

Regarding the scientist' civil status, it is mostly the male students who mention it. They believe male scientists are married and have children (see Figures 4 & 5), while female scientists are sometimes described as single, in a partnership, or even divorced (see Figure 3). Nonetheless, the fact that some students did not mention the female scientists 'civil status cannot be interpreted as them not imagining her as having a family, since the aim of the activity was to compare the lives of the male and female scientists.

This image may be a result of the identified barriers hindering women's career advancement; specifically, the difficulty of balancing family and a successful career.

Role of socialization agents in career decision-making process

The results related to the role of socialization agents in the process of career decision-making are based on the following codes: Role of the family (e.g. encouraging interest in science, family income, supportive family/non-supportive family), mass media, and decision-making in secondary school (see Figure 6).

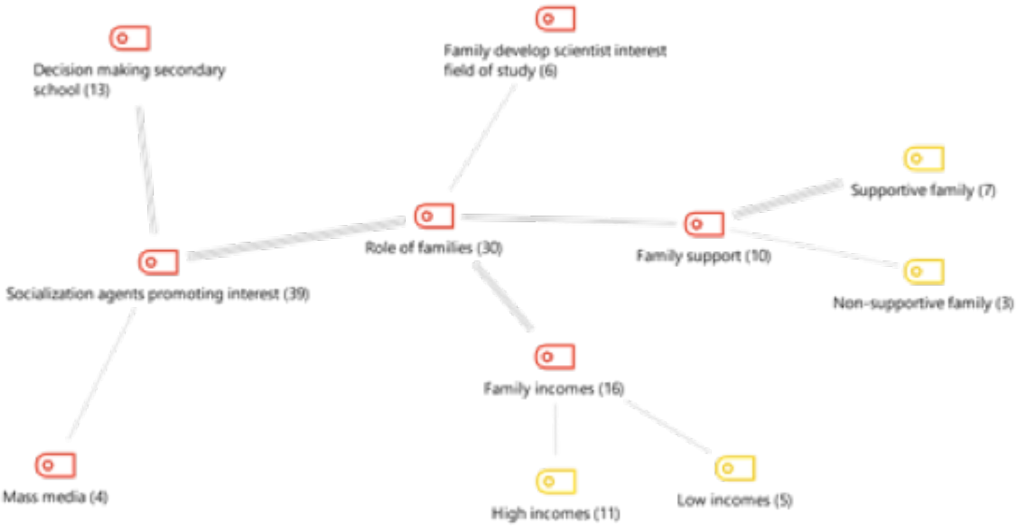

Figure 6. Categories and codes: Role of socialization agents in career decision-making process.

Families play a key role in the career choice process, whether by acting as referents (e.g. male students: *"She became interested in planets because her dad liked them very much"; "I think he became a scientist because when he was young he liked science, and because his dad is a scientist*") or by supporting them when the decision has already been made (see Figure 6). Although students believe that families support their children's career choices, the few students who describe a limited support from families, or even deterrence, were in the narratives of the female scientist (e.g. male students: "*Her parents encouraged her to choose another career, but she didn't want to*"; "*Her family was less supportive than what she would have liked them to be*") (see Figure 3). This perception may be related to the socially accepted idea that science is still a male domain.

A quarter of the students refer in their narratives to the financial status of scientists' families, most of whom have high incomes (e.g. male student: *"To become what he is nowadays, I believe he came from a wealthy family. This helped him study in an excellent school and to be able to achieve the goal he had set when he was young";* e.g. male student: *"Katie Bouman was born in a different country with a very different education. She was always oriented to science and came from a family with better socioeconomic status and more inclined toward education"*) (see Figure 6). This characteristic seems to follow a gendered pattern, as only two female students allude to it in their narratives (see Figure 4). Male students are also more likely to believe that the female scientist comes from a wealthy family, as opposed to male scientists (see Figure 3).

The mass media appears to have little influence on the career-choice process or to spark scientists' interest in science during childhood, as only 4 (all male) out of 66 students mention this code (see Figures 4 & 6). Finally, a quarter of students-both male and female-believe that the male scientist decided his university degree during secondary school (e.g. female student: *"During secondary school, he realized he liked science. He* *changed his mind and decided to be a scientist as a career"*) (see Figures 4 and 6), in contrast to the female scientist (e.g. female student: *"In the last year of secondary education, she didn't know what she would like to be when she grew up"*) (see Figure 3).

Conclusions

This study substantiates that students persist in embracing an empiricist-inductivist and non-theoretical view of science and technology, where scientific knowledge is seen primarily as the result of hands-on experimentation (Fernández et al., 2002). This perspective suggests that popular cultural portrayals of scientific 'discovery' heavily influence student perceptions. This outdated view may prevent students from appreciating the full scope of scientific inquiry, including its theoretical underpinnings and the collaborative effort required in scientific research.

Despite significant strides toward gender equality in STEM fields, the student narratives analyzed reveal a continuing view of science as a male-dominated field. This aligns with findings from Regan and DeWitt (2015), indicating that female scientists have historically been marginalized, with their achievements receiving less recognition—a factor that likely deters young women from entering these fields. The reinforcement of such gender biases not only limits the diversity within scientific communities but also restricts the variety of perspectives that are crucial for innovative and comprehensive scientific inquiry.

The portrayal of scientific careers by students as highly demanding, requiring immense dedication and effort, yet well-compensated and prestigious, might seem attractive to some. However, as suggested by Archer and DeWitt (2015), this perception could also serve as a barrier to those who do not inherently see themselves as 'hard-working' or 'passionate' about science from an early age. The belief that a successful scientist must possess an innate passion and ability for their field could discourage broader participation, effectively gating entry to the field to those who fit a specific stereotype. Moreover, the study highlights a significant shift in how students perceive personal traits of scientists. Moving away from the 'mad genius' stereotype described by Fernández et al. (2002), most students view scientists as sociable and relatable, which could encourage a more diverse group of students to consider a scientific career. However, the persistence of some traditional stereotypes – lab work - among younger students suggests the need for more proactive educational interventions to dismantle these outdated images fully.

The influence of family on career decisions in science and technology is profound, shaped by socio-economic and gender norms. This study shows that students perceive that, while families generally support their children's career choices, the level of encouragement varies with gender, as a few students described the limited support that the female scientist received from her family, perpetuating the idea that science is only meant for males (Regan & DeWitt, 2015). Additionally, for male students, the socio-economic status of the family is an important factor when it comes to pursuing a career in science or engineering.

The consequences of conditional support are significant, reinforcing the broader systemic barriers that female scientists encounter. These obstacles are rooted not in the intelligence or commitment but in entrenched social constructs that obstruct women's access to and recognition in scientific fields (Ferguson & Lezzotte, 2020). Students are aware of these barriers, recognizing the disproportionate effort required by women to secure equivalent research positions or gain similar recognition as their male counterparts. This acknowledgment reflects a deep understanding that the path for women in science is beset with both visible and invisible hurdles, such as biases in hiring, promotions, and the allocation of essential resources. Critically, the persistent belief that science is predominantly a male domain (FSO, 2019 in Chauke, 2022; Regan & DeWitt, 2015) perpetuates a cycle that may discourage young women from entering STEM fields due to inadequate familial encouragement and a lack of visible role models.

This study exhibits limitations related to its methodology and sample size. Firstly, the research instrument used to collect student perceptions could introduce bias, as it varied the questions based on the gender of the depicted scientist. Moreover, some students' perceptions might be more influenced by normative beliefs and conventional knowledge, acquired through media, rather than direct experiences. A proposed alternative would involve alternating the presentation order of male and female scientists to each participant group, aiming for a more neutral and equitable comparison.

The study's findings are based on a small sample size of only 66 participants, limiting the ability to generalize the results to the entire student population in Galicia, Spain. This small cohort consisted solely of students enrolled in technology-related elective subjects at schools that utilize active teaching-learning methods. To understand the broader impact of teaching methods on student perceptions of scientists, a comparative study including students from schools with traditional teaching approaches is necessary.

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Appendix

Figure A1. Arkaitz Carracedo material.

*Figure A2***.** Katie Bouman material.

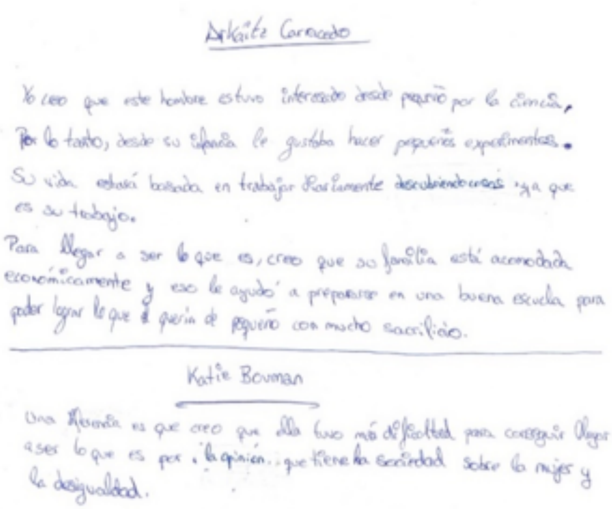

Figure A3. Sample of student descriptive narratives of male and female scientists².

Notes

1. The students' original narratives are written in their mother tongue in Spanish or Galician. The extracts from the narratives in the Results section have been translated for this article. They have been reproduced as literally as possible. Please note, therefore, that some linguistic nuances may be lost in translation.

2. This figure is in the original language of the narratives to illustrate the instrument of the study.