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STEM, a Non-Place for Women? Evidences and Transformative Initiatives

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Abstract: Numerous studies, diagnoses, and projects have been carried out in recent years to analyze the low female presence in STEM studies. However, progress has been limited, and the female presence is still low in certain degrees related to information and communication technologies, physics, and engineering. Many of the actions have been aimed at attracting women to these fields, but few have tried to change the culture of these disciplines, which make them a non-place for women. This paper analyses the measures carried out in Spanish public universities, and specifically at the University of Santiago de Compostela, to contribute to making these disciplines a place for women. Computer engineering workshops for primary and secondary education are proposed, incorporating a gender perspective. These transformative activities were highly valuated and welcomed by non-university teachers. The ideas inspiring these initiatives might help both to attract girls to STEM degrees and to generate gender equality environments, in order to change the androcentric culture of this field.

Keywords: gender equality; gender bias; gender gap; STEM; ICT; artificial intelligence; education; computational thinking

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1. Introduction

Gender equality is a fundamental human right necessary for a peaceful, prosperous, and sustainable world UN (2015). Unfortunately, the gender gap is common in our society, as Taboada (2024) pointed out in relation to the presence of women in the news of digital media; Ferran-Ferrer et al. (2023) referring to Wikipedia; Lunnemann et al. (2019) in the Nobel prize history; Goldin (2024) related to women's pay; and Queralt Jiménez (2024) in social media or in leadership of higher education Meza-Mejia et al. (2023). This gender gap is present in STEM disciplines and is detrimental for the quality of research and innovation in engineering projects.

According to Cimpian et al. (2020), some STEM fields such as physics, engineering, and computer science (PECS), continue to be underrepresented fields for women. Eurostat (2024) reported that only 32.8% of STEM graduates in the European Union were women in 2021. In science and engineering, the report "She figures" 2024[1] shows that the persistence of vertical segregation in academic career is very pronounced: women represent only 20% of the highest positions, compared to 30% in all fields. Likewise, women continue to be underrepresented as authors in engineering and technology, and represent only 9% of patent applicants; in addition, the majority of teams associated with inventions are made up solely of men. Analyzing the countries of the G20, the UNESCO (2024b) report entitled "Changing the equation: securing STEM futures for women" concludes that "no progress has been observed in the past decade in the proportion of women who study and graduate in STEM subjects". This report proposes actions closely related to the role of universities to train future professionals in this field, and teachers for non-university education. Page 27 quotes that until now universities "are more focused on measuring women's access to higher education (about four in five universities track gender in application rates) than tracking their outcomes and success rates (less than two-thirds of them track women's graduation rates and have plans aimed at closing the gap). Information about performance and the factors pushing women away from STEM choices is essential to better inform policy responses".

This paper discusses and analyzes why there are so few women in some STEM fields, despite efforts to increase their participation. To explain this situation, we will use the concept of non-place, introduced by Augé (1995) and Calvo-Iglesias (2015). Bridging this gender gap in STEM is important because, as Oreskes (2020) asserts, "Science is a collective effort, and it works best when scientific communities are diverse. The reason is simple: heterogeneous communities are more likely than homogeneous ones to be able to identify blind spots and correct them". The persistence of the gender gap in these fields has led us to review the actions promoted by Spanish universities and to ask ourselves why the initiatives developed are not being effective. Among the possible causes, Samper-Gras (2022) considers the androcentric approach that continues to permeate the STEM field, without forgetting that when scientific-technical areas are attractive from a socioeconomic point of view, men go on to occupy these fields and women are left on the margins. In this context, we present an alternative educational proposal that attempts to overcome gender stereotypes by recognizing the important contributions of women to STEM, taking into account the different motivations for using technology and trying to improve women's self-perception of their technological skills. In the remaining sections of the paper, the concept of non-place in STEM is extended in Section 2. Section 3 collects the actions in the Spanish universities to promote gender equality in STEM disciplines, customized in Section 3.1 for our University of Santiago de Compostela (USC). The Section 4 presents an alternative experience for introducing computer thinking concepts in primary and secondary schools, with the intention to create a space of belonging to girls. Section 5 showcases and discusses the experiences in USC promoting gender equality in higher education and in our outreach activities in society. Finally, conclusions are summarized in Section 6.

2. STEM, a Non-Place for Women

In 1965, Alice Rossi formulated the question "Why so few?", initiating a line of research on science, technology, and feminism. In this pioneering research work, Rossi denounced the absence of women in the production of scientific knowledge, and the gender bias in science and technology. Tomassini (2021) lists multiple investigations that have been carried out since then. This research has served to delve into the factors (influence of stereotypes, power relations, and gender models) that influence the choice of STEM vocations and the underrepresentation of women in some STEM areas that enjoy great prestige, low unemployment rates, broad career opportunities, and higher salary ratios compared to other fields. Cheryan et al. (2025) identified one of the factors influencing this underrepresentation of women: the existence of male organizational cultures in which masculinity is rooted in institutional practices and ideas. In the same line, Casad et al. (2021) point out the factors that contribute to gender inequalities and the abandonment of women in STEM academic fields: gender stereotypes present in recruitment and promotion processes, the lack of supportive social networks, and cold, if not hostile, academic climates. Msambwa et al. (2024) review the empirical evidence on the factors affecting girls' participation in STEM subjects, finding that only 10% of the studies indicated that girls' poor participation could be attributed to personal factors, and 61% to environmental factors like negative attitudes, lack of career plans, lack of collaboration, interest, poor self-concept, self-efficacy, and low motivation. Given these unwelcoming contexts, we could talk about STEM fields like a non place for women by referring to the concept introduced by the French anthropologist Marc Augé (1995) to define spaces of non-belonging and apparent transit: "If a place can be defined as a place of identity, relational and historical, a space that can be defined neither as a space of identity nor as relational or historical, will define a non-place" (pp. 77–78).

This non-place is especially marked in the field of information and communication technologies (ICT), one of the most masculinized areas within STEM disciplines according to the World Economic Forum (2022), which shows that female ICT graduates represent 1.7% of the total number of graduates compared to 8.7% of men. The Spanish organization Unidad Mujeres y Ciencia (2025) shows in its "Female Scientists in Figures 2025" report that Computer Science degrees and PhDs have a low proportion of female students (17.2%). Theses written by women comprise only 18.8%. We can also observe that, in the Spanish labor market, 46.3% of professionals are women, but if we focus on ICT, this participation[2] reduces to 29.8%. According to González Ramos et al. (2017), this raises the need for a structural change in companies. Berrío-Zapata et al. (2019) and Jaffe (2021) also suggest that ICT is a non-place for women, from which they have been excluded by erasing their historical achievements in computer science, discouraging their participation in education in computer science and in the workplace. Similarly, Collett et al. (2022) show in their report, "The Effects of AI on the Working Lifes of Women", the non-place in different aspects of AI professionals: women comprise only 7% of ICT patents, only founded 10% of start-ups in G20 countries, only 20% of academic staff in AI, and so on.

ICT also deserves special attention within STEM because technology and AI systems are increasingly interacting with our daily activities and will have an impact on shaping future society. Therefore, the UNESCO (2023) report "Harnessing the era of artificial intelligence in higher education" also expresses concern about the significantly lower participation of women than men in STEM fields and in AI-related academic research, due to its implications for the creation of fair and inclusive AI systems in relation to education. AI can be predictive, which is normally a type of machine-learning algorithm that analyses data and forecasts future events or results, or generative, which is specialized in producing new content. In both cases, computers learn and recognize patterns from examples. The diversity and characteristics of the examples used in this training shape the future behavior of AI systems, influencing their social impact. AI systems have many social implications derived from: who, how, and what data are collected to train AI systems? Criado-Pérez (2019). These implications include intellectual property of data used and generated by AI Dornis and Stober (2024); legal, ethical, and privacy issues of data collected to train AI Veliz (2021); Zuboff (2019); sustainability Crawford (2021); and cultural damage Katirai et al. (2024). Among all these implications, we mainly focus on gender bias of AI.

While AI can bring benefits to some industrial sectors, these systems pose serious risks to society when human future or well-being depends on decisions made by AI systems. In fact, there is a strong evidence of gender bias in AI systems which, together with the presence of AI systems in our lives, could perpetuate or amplify the persistent gender bias of our society. The UNESCO (2024a) report alerts about the gender bias (intersected by other bias) in three Large Language Models (LLM), OpenAI's GPT-2 and ChatGPT 3-5, and Meta's Llama 2, demanding the design of more inclusive, responsible and egalitarian AI systems. Shrestha and Das (2022) reviewed 120 academic studies on gender bias in automated decision-making systems, mainly in a widespread amount of fields like: natural language processing (NLP), automated facial analysis, advertisement, marketing, recruitment systems, robotics, medicine, and more.

Gender bias emerges in the text generated by LLMs, being propagated through other AI systems that use internally the LLMs to analyse text. Other recent studies found more gender biases: Simon et al. (2023) in recruitment systems from social networks like LinkedIn and Facebook, which affects the professional development of women; Schiebinger (2021) in machine translators, like Google Translate, where Farkas and Németh (2022) found gender bias even for a language with gendered neutral pronouns such as Hungarian; Zack et al. (2024), Ayoub et al. (2024), and Desai et al. (2024) in AI systems based on LLM, such as ChatGPT, in the health care field; Buolamwini and Gebru (2018) in face recognition systems; Wu et al. (2025) also found gender differences in text-to-image generation models, even when neutral prompts are used, both in the object presence and image layout. Since these comercial systems, such as DALL-E, Midjourney, Stable Diffusion, and Adobe Firefly, present a sexualization of women and stereotypical children's representations, Sandoval-Martin and Martínez-Sanzo (2024) suggested that they can be reinforcing traditional stereotypes associated with gender roles from childhood, which can impact their future decisions regarding studies and occupations. Another impact of generative AI systems is pointed out by Engel-Hermann and Skulmowski (2024), who warn about the naive realism of AI image generators and their impact in scientific and educational contexts, due to their lack of accuracy and precision.

In the educational context, Jarquín-Ramírez et al. (2024) carries out a critical analysis about the use of generative AI, such as ChatGPT, exposing technooptimistic opinions and warning about their use Chomsky (2025), which can discourage the development of critical thinking in students. For example, in the clinical context, Vicente and Matute (2023) warn that human overreliance on AI advice could lead humans to accept the recommendations of AI algorithms, even when they are noticeably biased or erroneous. As stated by Avraamidou (2024), science education needs human-centered feminist AI that provide the frameworks and "tools to prioritize algorithmic literacy and understanding of how AI perpetuates existing biases, racism, and systems of oppression" for the design of socially just, AI-based curricula that foreground the identities, subjectivities, values, and cultures of all learners. Beltrán (2023) states that women and girls suffer discrimination and violence in technology-related tasks, such as using social networks Tortajada and Vera (2021), unlocking their cell phones, or playing video games Mihura López et al. (2023). For example, De la Torre-Sierra and Guichot-Reina (2025) examined gender representation in mainstream videogames, concluding that women are significantly underrepresented, relegated to secondary roles, and depicted with submissive attitudes, unrealistic body types, and subjected to various forms of violence, perpetuating the tendency to masculinize female figures. On other hand, Lavalle et al. (2025) show that women who play video games feel more integrated into STEM degrees and have similar hobbies to classmates, and Hosein (2019) also shows that girls who were heavy gamers at 13–14 years were found to be more likely to pursue a STEM degree, although this was influenced by their socio-economic status. However, Butcher et al. (2023) suggest that women who experience hostile sexism in geek culture and continue to participate might have a general tolerance of toxic geek masculinity. In addition, Machado and Ishitani (2024) identified a set of recommendations to be included in games to stimulate women's interest in computing. So, there is a controversy surrounding the use of technology and video games to attract girls to STEM careers. Therefore, it is necessary to rethink how we teach engineering, what examples we use, and how we assess competencies, in order to build a place for girls and not consider them just as guests.

3. The Role of Spanish Universities Promoting Gender Equality in STEM

The process of institutionalization of equality in Spanish universities is based on Organic Law 3/2007 for Effective Equality between Women and Men and Organic Law 4/2007 on the Modification of the Organic Law on Universities (LOMLOU), complemented by regional regulations. This framework regulates the mandatory implementation of equality plans and units as key elements. Organic Law 2/2023 of the University System consolidates the presence of equality units to ensure compliance with current legislation on equality between men and women. Also, the Network of Gender Equality Units for University Excellence (RUIGEU[3] for its acronym in Spanish) was created in 2009, at the third annual meeting of equality units of Spanish universities. Currently, 50 public universities and 4 private universities are members of RUIGEU, which constitutes a space for sharing knowledge, experiences, resources, and good practices, as well as generating synergies and joint initiatives in the face of the challenges associated with the implementation of equality policies in the university environment.

In 2021, RUIGEU elected an Executive Committee to implement the operating regulations and established six specific working groups: (1) equality units and plans; (2) teaching and training with a gender perspective; (3) research and transfer with a gender perspective; (4) prevention and action against harassment; (5) conciliation and co-responsibility; and (6) communication. One of the first activities undertaken was the diagnosis in RUIGEU (2022) about "University equality policies" in the universities that make up the network. To this end, each RUIGEU thematic working group was responsible for designing a questionnaire and the subsequent analysis of the responses of all the member equality units. In this diagnosis, there are several specific references to the promotion of gender equality in STEM areas. Firstly, the promotion of women's access to STEM degrees is mentioned as one of the lines of action. In the chapter focused on the mainstreaming of the gender perspective in research and transfer, several initiatives were related to mentoring programs for young female researchers such as: Excellence Mentoring, for the development of STEM talent; Inspira STEAM; Alumni Mentoring; FEMenGin, for the accompaniment and creation of women networks in engineering and architecture; and FELISE. Likewise, the chapter focused on mainstreaming the gender perspective in training and teaching highlights the difficulties to implement gender perspective in university teaching, especially in STEM degrees.

The studies of Castaño-Collado and Vázquez-Cupeiro (2023) and Ascencio Cortés et al. (2025) about gender equality in higher education show that, despite the implementation of equality policies and plans, institutional and cultural resistance persists and limits their effectiveness. Alcalde-González and Belli (2024) state that motherhood continues to penalise women in academia, because the academic career maintains an androcentric vision, a linear path that, according Reverter (2024), does not allow for breaks due to care. In particular, in the STEM field, Epifanio and Calvo-Iglesias (2024) note the lack of measures to address the structural factors at the root of inequality, and recommend to promote actions to: (1) fight against gender stereotypes before accessing university; and (2) favor the access and permanence of female students in STEM areas, where their presence is in the minority. Thus, they proposed to recognize the work of students, teachers, and researchers carried out using a gender perspective, and to make visible the excellence of female researchers in the STEM area.

Initiatives to promote gender mainstreaming in Spanish higher education can be planned and promoted by public institutions, or be individual initiatives carried out by one or more university teachers. Within the first type, Rodríguez-Jaume and Gil-González (2024) present the collection "Guides for gender mainstreaming in university teaching", developed by Gender Equality Policies working group of the Vives Network of Universities and translated to different languages. These guides provide recommendations to introduce the gender perspective in both visible and hidden curriculums, including objectives, contents, methodologies, teaching resources, instruments to evaluate, and competences to be achieved by the students, among other skills. They suggest to reflect on sex-gender inequalities in the professional field of each discipline, as well as their impact on both professional practice and research. In addition, they also provide guidelines for conducting gender-sensitive research. Likewise, Peña et al. (2021) and Lusa et al. (2024), at the Universitat Politècnica de Catalunya, and Marco-Simó et al. (2023), at the Universitat Oberta de Catalunya, show the introduction of gender-related competencies in these universities to meet the requirements of the Catalan Agency for University Quality Assurance. Higher Polytechnic School of Zamora also developed an engineering with a Gender Perspective project González-Rogado et al. (2025).

Regarding individual teaching experiences to promote gender equally in STEM degrees, González-González and García-Holgado (2021) organized a workshop with teachers about strategies to gender mainstreaming in engineering studies; Rueda-Pascual et al. (2021) introduces gender perspective in a computer engineering degree in the University of Valencia; and Pérez-Sánchez and Sánchez-Maroño (2023) carry out a pilot experience in a machine-learning subject for a master's degree at the University of Coruña. In relation to the AI field, Cernadas and Calvo-Iglesias (2020) and Cernadas and Calvo-Iglesias (2022) propose to include transversally the gender perspective in the majority of subjects of the degrees and masters on AI. Calvo-Iglesias et al. (2022) visualizes female models related to each theme in any STEM course. Cernadas et al. (2023) use cooperative learning to promote equality in basic computing programming courses. Prendes-Espinosa et al. (2020) point out the scarce existence of scientific literature on gender equality education through technologies in a review of educational practices in formal contexts that work on gender equality and ICT (early childhood, primary, secondary, and higher education). Calvo-Iglesias and Aguayo-Lorenzo (2023b) compiled various initiatives developed by research centers and universities to promote the visibility of women in scientific and technological disciplines and to serve as a pole of attraction for girls and young women to science and engineering. Particularly in Galicia, we can mention the activities carried out in the framework of the European project ICT-Go-Girls; the program "Exxperimenta en femenino" in the campus of Ourense Carballo et al. (2020), University of Vigo; mentoring activities in the Faculty of Computer Science of the University of Coruña carried out by the association "Hello Sisters"; or the work carried out by the "Chair of Feminisms 4.0" of the University of Vigo in the fight against digital sexism and the promotion of feminism in the digital environment.

3.1. Initiatives in University of Santiago de Compostela (USC)

The USC has been a pioneer in the implementation of equality policies, creating the *Gender Equality Office* (GEO) in 2006 and preparing its "First Strategic Plan for Equal Opportunities between Women and Men" in 2009. Before drafting its fourth equality plan, the USC evaluated its third equality plan (period 2021–2024) in order to introduce corrective measures into the plan being drafted, diagnosing weaknesses such as the limited incorporation of the gender perspective in research and teaching, or the gender gap in scientific and technological disciplines. The most consolidated action within the field of teaching, research, and transfer is the annual call for awards for the introduction of the gender perspective in teaching and research, which started in 2010. It is worth noting that this action was chosen in 2015 by the European Institute for Gender Equality (EIGE) as one of the ten best good practices for promoting gender equality in universities and research centres from among more than 50 across the European Union, and included in the online tool (GEAR) to support research organizations (such as universities) in the creation, implementation, monitoring, and evaluation of gender equality plans. However, the detailed analysis of Aguayo-Lorenzo and Calvo-Iglesias (2024) revealed a greater participation of the Social Sciences and Humanities areas compared to STEM. In addition, Alonso-Ruido et al. (2025) found that gender training is scarce even in education grades. In the technological field, we highlight the following award-winning experiences: Calvo-Iglesias (2020) on biographies of STEM women in the form Wikipedia; Cernadas and Fernández-Delgado (2021) on ethics embedded in the teaching of machine-learning subjects and Regueira et al. (2023) on educational technology that incorporates a critical feminist pedagogy.

The USC gender gap report[4] shows that there are gender differences among USC teaching and research staff. Differences are at the level of representation in professional categories, in consolidation and in positions of greater recognition, but also at the level of participation in the spaces and decision making with direct effects on the recognition of merits and in the remuneration received. In addition, Alonso-Álvarez and Diz-Otero (2022) identified strong resistances to conciliation measures in USC. Therefore, the GEO and the Interdisciplinary Center for Feminist Research and Gender Studies (CIFEX) developed a good practice guide to ensure that the working and material conditions of women at USC are more appropriate for their professional activity.

In relation to the presence, promotion, and retention area, Calvo-Iglesias and Aguayo-Lorenzo (2023a) developed the program "Unha enxeñeira ou científica en cada cole"[5] (in English "One female engineer or scientist in each school"). It includes science and technology workshops aimed at primary school students, to make female role models visible in degrees in which they are underrepresented. As reported by Calvo-Iglesias and Aguayo-Lorenzo (2023b), thousands of students participated in this program since it began in 2016, arriving in his tenth edition of 2025 to almost 200 schools from all over Galicia. The success of the computer workshops, which were always very well evaluated, led the authors to design a collection of online activities to introduce the concepts of computational thinking and artificial intelligence to students of elementary and secondary school, to help create a place for girls and women in this field. This program of activities will be explained in more detail in the following section.

4. An Alternative Proposal: Informatics and Life

In this section, an alternative proposal to introduce computational thinking (CT) and engineering concepts with a gender perspective is presented. Section 4.1 contextualizes and justifies the methodology used, and Section 4.2 describes the online material provided to school teachers in order to allow them to implement CT activities in their classrooms.

4.1. Methodology

The new educational legislative framework in Spain (LOMLOE) includes CT as an essential skill, but according to González-Gallego et al. (2025), its correct implementation requires giving teachers the necessary training and resources. The goal is to provide students with the necessary skills to meet the demands of an increasingly technological society. Since there is no specific methodology for implementing CT projects in educational institutions, these online activities were designed to facilitate teachers' introduction of CT in primary and secondary school, for students between 9 to 15 years, incorporating a gender perspective. These activities are necessary in primary school when gender stereotypes take root Bian et al. (2017) and hinder girls' perception of their own technological skills, even if they perform similarly to boys Sánchez-Canut et al. (2025). Mateos Sillero and Gómez Hernández (2019) state that girls' low self-perception impacts the choice of professional projects in adolescence and early adulthood. Gómez-Trigueros (2023) claims that negative evaluations in the self-perception of future female teachers regarding their ability to select, assess, and use the most appropriate digital technologies for their future teaching task, could lead to teachers' disinterest in or underuse of technologies.

The term *computational thinking* was described in 2006 by Wing (2006) as a fundamental skill for everyone, involving using computer science concepts to systematically solve problems. González-Gallego et al. (2025) collect other recent definitions, many of them centered in problem solving, robotics, electronics, programming, and other technological issues. CT can be addressed either as a theme that is cross-curricular over all the subjects, or alternatively as an independent subject of computer science, that uses primarily technology to develop CT projects. However, the study of González-Gallego et al. (2025) confirms that girls in secondary school show less interest in technology, and its use as a primary element could dampen their interest in this type of content. Therefore, we consider that CT must be developed as a cross-curricular theme, designing projects that increase girls' confidence and provide them with STEM role models.

Recently, Ayuso et al. (2021) reports that girls already in primary school perceive themselves to be less competent than boys in mathematics. This could also happen in relation to technology as mentioned at the beginning of this section, and furthermore, technology could be uncomfortable for girls (see Section 2). In this respect, our activities are planned in a way does not require computer materials or programming languages such as Scratch[6], as Shute et al. (2017) and Kim et al. (2013) note. For example, Scratch could be related by students to video games, that is a very specific topic in computer science, which are perceived negative by girls due to their gender bias, as mentioned in Section 2. Video games, access to online communities, and the time spent on them are conditioned by gender and can generate a privileged environment for boys, both in terms of leisure opportunities, and learning and development of digital competence Regueira and Alonso-Ferreiro (2022). The examples used were gender-neutral and related to everyday life as recommended in the Inspira STEM guide[7] for integrating a gender perspective in STEM disciplines in primary education, since, as different studies compiled by Merayo and Ayuso (2023) conclude, girls are more interested in STEM subjects when they are taught from an applied and practical perspective.

The proposed activities are related to other subjects like maths, natural and social sciences, and languages, following experiences and didactic methodologies common in the teaching of these disciplines at each educational level. In these activities, students are encouraged to design technology, rather than use it, by teaching them the underlying concepts so they understand how technology works. Since technology must always be at the service of people, we will need to verify its correct operation from different perspectives, instilling critical thinking by teaching how technology works and how to evaluate its correct functioning.

4.2. Online Material for School Teachers

The proposed activities are grouped under the title A informática e a vida[8] ("Informatics and life"), which is available to all Galician schools in the local language under free registration. The online material encloses instructions to teachers, together with other material to download like images, files, presentations, software tools, videos, and computer programs for an advanced use of the material in the last two activities. As mentioned, CT and AI concepts are introduced as an extension of how humans solve different situations in life, and relate them to the contents of language, mathematics, or natural sciences specific to that educational stage, using playful and fun activities. In addition, we have tried to find activities that show the importance of computing in helping other disciplines and improving society to motivate girls Merayo and Ayuso (2023). We also want to highlight that the activities that use technology never collect data from students or invade their right to privacy.

Engineering is an ancient discipline, predating computers and robots, that produces devices and services to improve people's lives. CT is rooted in all engineering disciplines. We believe it is important to use the word "engineering" from childhood, so that girls associate engineering with this useful knowledge Paderewski-Rodríguez et al. (2017). Typically, the suggested activities include exercises of varying difficulty levels. For the youngest students, teachers should pick up the ones that do not require technology in their development. For the oldest ones, teachers can develop the most advanced exercises, in which students can develop their first professional computer programs. The provided material gives age recommendations for each activity. Instead of using `Scratch`, we propose the use of professional programming languages like `Python`[9], the vocabulary of which is very close to human languages, specifically the English language. So, activities for the oldest students are developed in Python in order to learn programming as a task of writing a story in a new language, normally in secondary school. In this way, students acquire digital competence, but use it as a occasional tool at our service to solve problems, and not as a prominent tool in the classroom. Figure 1 shows a screenshot of the web page. The ten activities included are:

1. Quen inventou a informática? ("Who invented computing?"): addresses the role of women in the birth of computer science, making visible many female scientists and professionals in this field. It also includes materials and instructions for developing games that explore the inspiration and importance of some female scientists' inventions, using the paradigm of unplugged computational thinking.
2. Como son as tripas dun ordenador? ("What are the insides of the computer like?"): explains the operation and parts of a computer by establishing analogies between the computer hardware and our human body. It relates engineering to biology, which is frequently very enjoyed by girls.
3. Os recordos dos ordenadores: escribindo nunha libreta ("Memories of computers: writing in a notebook"): uses a squared notebook page to explain the process of storing information on a computer's memory or hard disk.
4. As fotos e imaxes: que son os megapíxeles nas cámaras de fotos? ("Photos and images: what are megapixels in cameras?"): defines the concept of picture element (pixel) in the digital images and its capacity measures, relating image size with camera characteristics. The storage of color images in the hard disk is also introduced.
5. Xoguemos a ser científicas e científicos na medicina e na pesca ("Let's play at being scientists in medicine and fishing"): the objective of this activity is to show the interrelation of computer science with other sciences, such as medicine or biology. As other engineering fields, computer science provides tools to help other disciplines. The work environment of scientists in biomedicine and biology is simulated through two research software products shared with students, STERApp and CystAnalyser, described by Mbaidin et al. (2021) and Cordido et al. (2020), respectively. Software tools and videos can be downloaded to simulate the diary work of researchers in the biomedical and fishering labs.

6. Medindo células contando puntos (píxeles) nas imaxes ("Measuring cells by counting pixels in images"): the objective here is to make students aware that all the results provided by a computer program have to be verified with the established method, that is, it always has to be validated by people in order to ensure that calculations are right. In this case, students validate that the CystAnalyser software measures correctly the area of irregular objects in images.
7. A escala dixital: medindo a realidade que nos rodea ("The digital scale: measuring the reality around us"): this activity introduces the concept of calibration to relate picture elements with truth measures of objects, in this case, the area of geometric shapes in images. Provide materials and instructions to discuss with students how humans measure the surface area of geometric shape compare to how computers do.
8. Medindo a realidade nas ciencias naturais e sociais ("Measuring reality in natural and social sciences"): the concept of a digital scale allows us to measure every object in the world which can be captured by a digital camera. This technology is used to measure the area of a plant leaf, and the extension of a region on a map.
9. En que se parece un conto a un programa? ("How is a story similar to a computer program?"): ICT professionals use programming languages to build computer programs. Our goals are to introduce the concept of programming language as if it were the learning of another human language, that people uses to communicate with a computer.
10. Que é a intelixencia artificial? ("What is artificial intelligence?"): This activity is open access[10]. We model a computer program as a box that receives data to provide an answer. In classical programming, the programmer sets rules to the program in order to achieve a positive answer or outcome to the input data. Supervised machine-learning (SML) algorithms are a specific type of computer program, which represent the majority of programs within AI. In SML programs, the programmer gives to the box examples (data) and the desired answer (outcome) in order for the box (AI system) to learn the rules to produce the outcome from the data, in a process called training. Once the box or AI algorithm is trained, it can operate to give answers to examples not seen in the training. Many people in society do not understand the differences between classical and SML programs. This activity explains both concepts without using technology, through the sorting of spaghetti by their length (classical programming), and the distance traveled by a ball kicked by a girl (ML program). Depending on the educational level, this activity can be extended by putting on a mini-play in the classroom with the students, or creating programs with a professional programming language like Python[11] for the oldest students. Since AI systems introduce bias in different ways, this activity, using common examples, explains how the different types of bias are encoded in the ML algorithms. Gender bias is normally due to bias in data used for training, and in the criteria for the outcome verification. Other biases are due to the statistical representation of minority groups. The provided examples allow us to reflect with the students about gender bias in AI systems, following the recommendation of Vicente and Matute (2023).

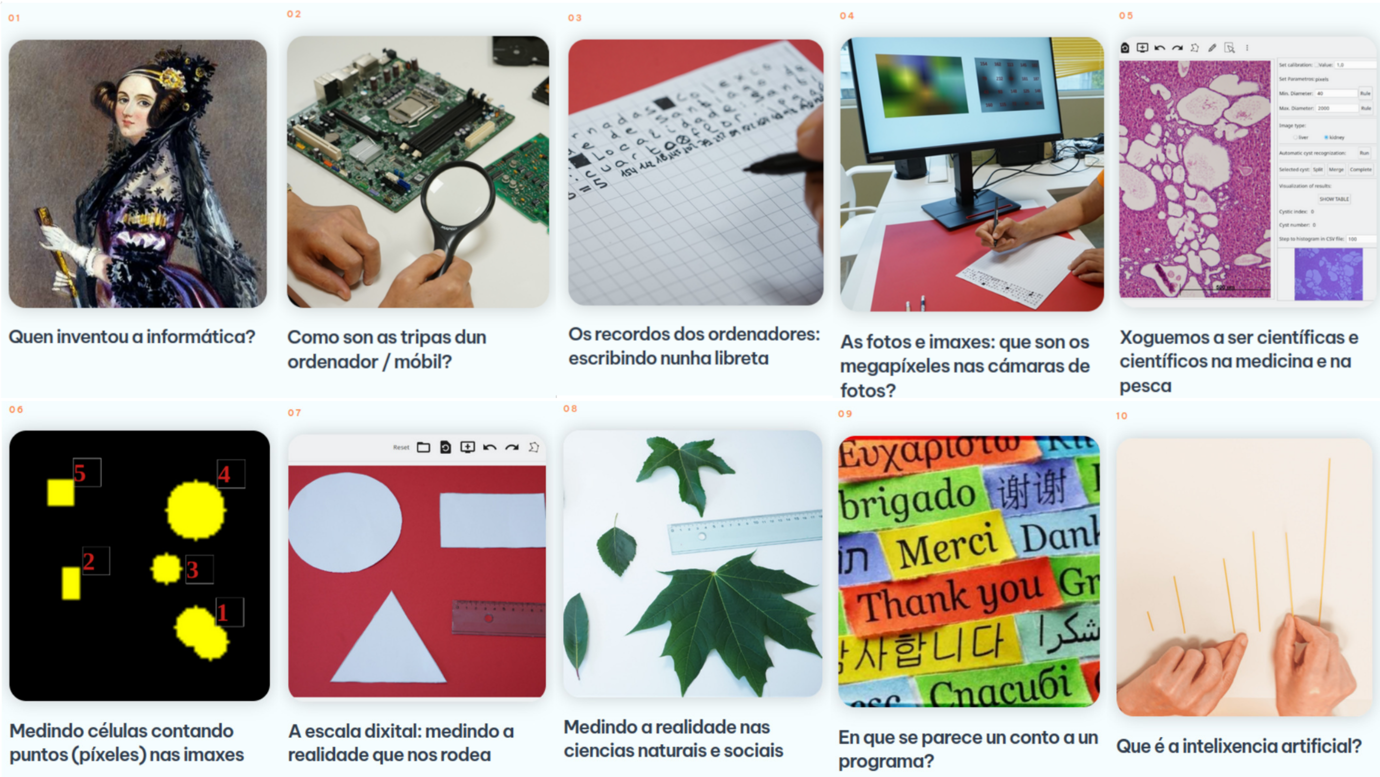

Figure 1. Ilustrative image with the ten activities of the program A informática e a vida ("Informatics and life"). The numbers in the figure are the activities: (01) Who invented computing?; (02) What are the insides of the computer like?; (03) Memories of computers: writing in a notebook; (04) Photos and images: what are megapixels in cameras?; (05) Let's play at being scientists in medicine and fishing; (06) Measuring cells by counting pixels in images; (07) The digital scale: measuring the reality around us; (08) Measuring reality in natural and social sciences; (09) How is a story similar to a computer program?; and (10) What is artificial intelligence?.

5. Results and Discussion

In February 2024, the Centro Singular de Tecnoloxías Intelixentes da USC (CiTIUS)[12] made the first edition of the *A informática e a vida* activity program available to schools. Only 15 schools registered for this first edition. In March 2024, Dr. Cernadas participated in the *Artificial Intelligence and Education Symposium* with an invited plenary talk to discuss gender biases in artificial intelligence systems and presented the program *A informática e a vida* to the educational community. The conference was organized by the Galician regional government (Xunta de Galicia) and was attended by 610 non-university teachers. In May 2024, Dr. Cernadas has conducted a training course to primary and secondary school teachers. This course, entitled *Getting started with artificial intelligence in education* was organized by the Regional Centre for Training and Innovation of our region (Xunta de Galicia). Both participations were evaluated by Xunta de Galicia through a satisfaction questionnaire among teachers. In the first symposium, there were 610 teachers enrolled and 353 filled the questionnaire. In the second course, there were 18 teachers enrolled and 9 filled the satisfaction questionnaire. Table 1 reports the four questions of the questionnaire with their scores (ranged from 0 to 5) and average/deviation values. All the scores are close to 4, with an average value above 4 that means a positive reception of teachers for alternative initiatives to the predominant teaching of AI.

Table 1. Questions and scores in the questionnaire.

Questionnaire No. Answers	**Plenary 353**	**Course 9**
Question	**Score (0–5)**	
Adaptation of content, time, and media to the attendee's needs	3.89	3.88
Mastery of the subject taught	4.38	4.38
Communication skills	3.93	4.14
Methodological adequacy and resources used	3.90	3.71
Average	4.03	4.02
Deviation	0.24	0.29

Figure 2 shows photographs developing workshops in a school classrooms and screenshots of the materials of the program. At the end of the workshops, we had informal conversations with the school teachers to gather their feedback. They recognized that this way of approaching the subject of computer science and artificial intelligence is not the usual one. In general, they were surprised because we propose an alternative to work in the classroom on concepts that are very relevant today and necessary for the training of students, but with a completely different approach, prioritizing the critical and conceptual learning that underlies the technology, instead of being end users who work with the tools as black boxes and without understanding their internal functioning. We believe that this is a way to empower students and can be a beginning to dismantle the oppressive tools of the technopatriarchy following Freire's pedagogy. We do not use commercial software because, to paraphrase Audre Lorde, the master's tools do not serve to dismantle the master's house. Furthermore, by using technology as another tool, on the same level as a pencil or a notebook, we can generate cooperative work environments based on gender equality to create equal opportunities for boys and girls. Good experiences have also been gained in previous activities with younger students, where the concepts from activities 2 and 9 were applied to build a robot with our bodies Cernadas and Fernández-Delgado (2025). Our computer program was a cookie recipe, and we ran it with the cooking robot (our bodies) to make the cookies, see the chapter "La inteligencia artificial explicada desde las primeras etapas educativas" in the online book *Inteligencia artificial en la educación. Desarrollo y aplicaciones*[13] (pp. 66–78). These experiences suggest, as pointed out by Fernandez-Morante et al. (2020), that the girls prefer collaborative and group work. The preferences of girls for cooperative learning was also observed teaching basic programming courses in higher education Cernadas et al. (2023). As noted by Cheryan et al. (2025), gender disparities can be reduced by increasing the positive experiences of women and girls in STEM. This experiences can be implemented using neutral examples or those closer to a girl's life. According to Hallström et al. (2015), girls and boys learn to approach and handle technology differently. For example, the robot built by our body can be used to dance a program (the choreography is the computer program), similar to Sepúlveda Durán et al. (2025), who carry out an intervention focused on the development of CT through body expression, music, and movement with elementary school students.

Figure 2. Photograph developing workshops in a school classroom and screenshots of A informática e a vida materials.

On February 2025, CiTIUS opened the registration to the second edition of the *A informática e a vida* activities program to celebrate the International Day of Women and Girls in Science. By the end of March, more than 30 educational centers from Galicia had registered for the program. We have planned to design a specific questionnaire to collect the teachers and school perception at the end of the academic year. This high participation shows that there is a need for training by non-university teachers to meet the new training needs in digital skills and that resources are scarce. Though, INTEF (National Institute of Educational Technologies and Teacher Training) has launched a MOOC course Initiation to Robotics and Programming with a gender perspective. There are also experiences in the literature Valdeolivas et al. (2022) of, through an action-research experience, working on the design of didactic activities on aspects related to gender and educational robotics to improve learning in the university classroom based on a real educational context.

6. Conclusions

Many international and national reports analyze the causes of the lower participation of women in the STEM fields. Despite all institutional efforts to achieve full gender equality, differences in female representation in the STEM fields still persist as a non-place, mainly in areas such as ICT, computer science and engineering, or artificial intelligence. AI systems and technology in general are tools that we rely on more and more in our daily lives. However, their use may have social risks that are not yet sufficiently studied, including gender bias.

This paper also analyses the role of Spanish universities in promoting gender equality in academia and, specifically, in the STEM field. To overcome this situation, we propose introducing engineering content from early childhood with a gender perspective, exercising cooperation between both genders on equal terms, and rethinking how engineering is introduced in schools and what examples we use. Based on the experience in schools with face-to-face workshops driven by the gender equality office, we propose an alternative way of introducing computer thinking in primary and secondary schools with A informática e a vida ("Informatics and life") program. These activities take into account in their design that the behavior and enthusiasm of girls and boys in the classroom is influenced by the type of activity being carried out and propose examples close to everyday life. These program has attracted the interest of the non-university teachers, who have rated it very positively both through the satisfaction survey and in the comments in person or by e-mail. However, a more appropriate evaluation instrument is needed to be able to determine the impact of the educational proposal. Therefore, in the next editions, two questionnaires will be sent to the participating centers, an initial one to ascertain the reasons that led them to participate in this program and their expectations, and another one to know their assessment. In the future, we will continue with these activities, trying to improve them with the contributions of the non-university teachers who have put these activities into practice. At the same time, we believe that these activities could be enriched by showing not only female STEM referents but also male allies, to offer boys referents in the new masculinities.

In addition, it will be necessary to introduce the gender perspective at all stages of education, from childhood to higher education, which will value the strengths of girls and women in the STEM fields—an education aimed at inclusion of all genders growing and respecting each other. These initiatives will not be able to succeed if the violence, harassment, professional contempt, and discrimination that women endure in STEM environments are not eliminated.

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Abbreviations

The following abbreviations are used in this manuscript:

STEM	Science, technology, engineering, and maths
ICT	Information and communication technologies
AI	Artificial intelligence
CT	Computational thinking
GPT	Generative pre-trained transformer

Notes

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[10] https://tec.citius.usc.es/ainformaticaeavida/que-e-a-intelixencia-artificial/ (accessed on 12 June 2025).
[11] See Note 9.
[12] https://citius.gal/news/news/citius-publishes-a-informatica-e-a-vida-workshop-to-promote-equality-in-technology-learning/ (accessed on 12 June 2025).
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