García-Holgado, A., Vázquez-Ingelmo, A., & García-Peñalvo, F. J. (2024). Gender mainstreaming and diversity in higher education: an experience in Software Engineering education. IEEE Transactions on Education, 67(5), 712-723. https://doi.org/10.1109/TE.2024.3411409

Gender mainstreaming and diversity in higher education: an experience in Software Engineering education

Alicia García-Holgado, *Member, IEEE,* Andrea Vázquez-Ingelmo, Francisco José García-Peñalvo, *Member, IEEE*

***Abstract*—*Contribution*: Gender mainstreaming in university teaching should be covered in all the knowledge areas. This work successfully introduces the gender perspective as part of the methodological approach to teaching and learning in Computer Science.**

***Background*: This study describes how gender mainstreaming has been introduced and matured during six academic years, from 2016-2017 to 2021-2022, in Software Engineering I course in the Degree of Computer Science at the University of Salamanca.**

***Intended outcomes*: The aim that has been pursued is to raise awareness among students of Computer Science about equality, equity, inclusion, and respect for diversity to build better professional ethics and advance in eliminating any gender-related gap in Computer Science.**

***Application design*: The introduction of gender mainstreaming in the Software Engineering I course has been done in six stages to advance in the gender-gap reduction improving in each academic year with the experience and voluntary feedback from the students of the previous year, using anonymized questionnaires.**

***Findings*: Gender mainstreaming requires special attention in careers with a visible gender gap, such as Computer Science. Incorporating the gender perspective as part of the teaching-learning process does not have a measurable impact in a short period but instead aims to make software engineers reflect in such a way that they reason about the need to promote diversity in software development contexts.**

***Index Terms*—Gender, Higher Education, Engineering Curriculum, Software Engineering, Diversity, Gender mainstreaming**

(Corresponding author: Alicia García-Holgado). Alicia García-Holgado, Andrea Vázquez-Ingelmo and Francisco José García-Peñalvo contributed equally to this work.

Alicia García-Holgado is with the GRIAL Research Group, Research Institute for Educational Sciences (IUCE), Computer Science Department, Universidad de Salamanca, (https://ror.org/02f40zc51), Salamanca, Spain (e-mail: aliciagh@usal.es) (https://orcid.org/0000-0002-8221-0161)

Andrea Vázquez-Ingelmo is with the GRIAL Research Group, Research Institute for Educational Sciences (IUCE), Computer Science Department, Universidad de Salamanca, (https://ror.org/02f40zc51), Salamanca, Spain (e-mail: soniavercas@usal.es) (https://orcid.org/0000-0002-9357-1747)

Francisco José García-Peñalvo is with the GRIAL Research Group, Research Institute for Educational Sciences (IUCE), Computer Science Department, Universidad de Salamanca, (https://ror.org/02f40zc51), Salamanca, Spain (e-mail: fgarcia@usal.es) (https://orcid.org/0000-0001-9987-5584)

I. Introduction

THE gender gap in science, technology, engineering and mathematics (STEM) is a problem that affects the development of society and depends on several factors before, during and after enrolling in STEM programs [1-7]. According to the strategy of the European Commission, increasing women's participation in the technology sector will boost the economy and enable their full participation in society. In particular, according to the report "Women in the Digital Age", the incorporation of more women into digital jobs would benefit Europe's Gross Domestic Product (GDP) by up to 16 billion euros per year [8].

The "Cracking the Code" report published by UNESCO [9], indicates around 30% of women in university studies choose STEM courses, and this figure drops by half (15%) if health sciences are not considered. Moreover, female student enrolment being particularly low in technology, information and communications (3%), natural sciences, mathematics and statistics (5%) and engineering, manufacturing and construction (8%) [9].

According to the last Global Gender Gap Index report (2023) which involves 146 countries [10], 95.2% of the gap in educational attainment has been closed, and over 99% for Latin America and the Caribbean, Europe and North America. At tertiary education levels, women have surpassed men's enrolment rates. However, there is a significant gap in STEM areas. This gap also has an impact in the professional context. Based on data from the LinkedIn platform, "female workers make up an estimated 26% of workers in Data and AI roles, 15% of workers in Engineering roles and 12% of workers in Cloud Computing roles" [11]. The World Economic Forum report highlight that women account for almost half (49.3%) of total employment in non-STEM occupations, but only 29.2% of all people working in this sector [10].

The gender gap in STEM does not depend on the region. A clear example is Iceland, ranked first for gender equality, where only 35.23% of STEM graduates are women (0.54 gender gap score), and the situation is worst in Information and Communication Technologies (ICT), where the gender gap score is 0.13 according to [11].

In Spain, ranked seventeenth for gender equality, there is a similar situation, only 29.56% of STEM graduates are women (0.42 gender gap score), and in ICT the score is 0.15. According to the statistics provided by the Ministry of Universities for the 2021-2022 academic year [12], the

presence of women in the field of computing is 15% of the total number of students enrolled in this field, the lowest of all fields of study. The percentage of women in Computer Science degrees has been declining more or less steadily since the 1985-1986 academic year when it was 30% until recently, having experienced a slight upturn with an increase of 3% since the 2016-2017 academic year [13]. This situation is repeated in other countries since 1990s according to [14-16], although there are particular cases, such as Tunisia, in which women represent half of computing students [17].

The gender gap in STEM, and specifically in the areas of engineering and technology, is a problem that is being addressed at the international level. Examples such as UNESCO's SAGA project, developed from 2015 to 2018, show the need to define policies and establish strategies to reduce the global gender gap in these areas both at the educational and research level [18-21].

In recent decades [22], with particular emphasis on the last ten years [23], a large number of research and initiatives have been launched to reduce the gender gap in the technology sector, both at the public and private levels [24]. Despite this, there are still decreasing numbers of women studying for technological careers [8]. On the other hand, the problem is not only to increase the number of women entering STEM programs, and particularly technology-related programs, but also to establish initiatives at different stages of their career. According to UNESCO [21] bridging the gender gap in STEM must be tackled from a holistic approach. Once women have enrolled, measures are needed to prevent them from dropping out of university and entering and staying in the profession [25-27]. During their studies, university context can have an impact on the dropout numbers, comfort in the university environment [28], teachers' support [1] or the support received from the faculty [29] are some factors identified in previous studies.

From the perspective of technology development, it is imperative to also address the underrepresentation of women. In a digital society where technology plays an integral role in the daily lives of a significant portion of the population, it becomes crucial to prioritize concepts like diversity and inclusion in technological advancements. The overarching goal is to build a society that upholds these values as fundamental principles. Therefore, it is essential that technology, particularly software, is designed with inclusivity in mind, ensuring that diversity and equality remain integral to technological progress [30].

From an employment perspective, the shortage of STEM graduates, particularly in the field of Computer Science, poses a significant challenge for the job market. There is a growing demand for qualified professionals, as highlighted in the most recent report on the future of work by the World Economic Forum in 2020 [31]. Market dynamics are increasingly favoring the development of technical skills and a set of cross-cutting competencies, including critical thinking, problem-solving, and innovation, all of which are closely associated with STEM fields.

Moreover, the “Women in the Digital Age” report [8] by the European Commission emphasizes that having more women in digital careers could substantially benefit the European Gross Domestic Product (GDP), potentially contributing up to 16 trillion euros annually. Numerous studies [20, 32, 33] have examined the obstacles that women face in pursuing successful careers in science and technology. These studies collectively underscore the pressing need to increase female representation in these fields.

It is noteworthy to emphasize the ongoing research within the field of computer science focused on Human-Computer Interaction (HCI). There is a clear need for collaborative efforts that prioritize gender equality and adopt a gender perspective to foster the development of more inclusive technologies. Such efforts tend to yield superior outcomes when incorporating users into the design and development processes [34-37]. This encompasses various domains, ranging from web application design and implementation ([38, 39] to robotics development [40, 41]. This issue extends beyond HCI to other facets of computer science.

Additionally, it is of particular significance to investigate gender bias within the various applications of artificial intelligence. This inquiry encompasses machine learning-based analyses across diverse domains [42, 43], sentiment analysis [44] language processing [45, 46],, facial recognition [47], and more.

In this context, higher education must go beyond the content of each discipline and include among its objectives training in values that will strengthen democratic coexistence based on the principles of equality and equity [48]. In Europe, most countries have policies to ensure the implementation of Gender Equality Plans (GEP) in higher education institutions and research organizations to develop a set of basic principles to safeguard gender equality in all spheres of academic life.

Higher education institutions should introduce the gender perspective in their courses as a tool to promote gender equality among students, not only during their studies but also when they join the labor market. Moreover, gender mainstreaming in engineering education will enable students to identify androcentric biases in their discipline/profession and to work in egalitarian teams that incorporate women’s perspective, experience and needs [49].

The aim of this paper is to describe an experience developed across the last six academic years, from 2016-2017 to 2021-2022, to gender mainstreaming in the teaching of computer science through a pilot experience in the field of Software Engineering. In particular, the actions proposed include the adaptation of typical activities of the course in order to give them a gender perspective (review of the materials, creation of mixed working groups, focusing the problem domain of engineering projects in the gender gap), the use of a Twitter hashtag to share contents with a gender perspective in engineering, the organization of talks given by women professionals from the technological sector, and the inclusion of a coach focused on issues of diversity and ethics in software development.

This experience has a double objective. First, to make visible the existing gender inequalities in the STEM field, with special attention to engineering and technology, so graduates will be aware of the problem and will be able to implement future actions to reduce the gender gap and achieve inclusive and diverse working environments. Second, in a digital society where technology is part of daily life, the introduction of concepts such as diversity and inclusion in technology

development is a crucial objective for achieving a society based on these values. Technology, and in particular software, must be developed for everyone, so diversity and equality are concepts related to technological development.

The paper is organized as follows. Section 2 presents the related papers. Section 3 summarizes the methodology. Section 4 presents the status of the course before gender mainstreaming. Section 5 describes the different phases and actions implemented. Finally, section 6 describes the main conclusions of the experience and future work.

II. BACKGROUND

Gender mainstreaming is the inter-governmentally agreed global strategy for achieving gender equality. According to the United Nations "Gender mainstreaming was established as a major global strategy for the promotion of gender equality in the Beijing Platform for Action from the Fourth United Nations World Conference on Women in Beijing in 1995" [50]. It is the "reorganization, improvement, development and evaluation of policy processes" [51].

While numerous policy statements since 1990s have called for the implementation of gender mainstreaming in education, including higher education institutions, several studies indicate that the gender equality is not a priority [52, 53]. According to [52], this resistance is also observed in Spain, where mainstreaming gender in higher education has been mandated by various national and regional laws.

At European level, the European Institute of Gender Equality (EIGE) has developed a set of toolkits for supporting gender mainstreaming implementation. Specifically, GEAR (Gender Equality in Academy and Research) toolkit provides tools and resources for developing and evaluating Gender Equality Plans (GEPs) for universities and research organisations [54].

Gender mainstreaming in higher education is a lonely practice that is constantly being questioned as to its appropriateness and effectiveness [55]. Likewise, co-education proposals and their consideration in academic guides, as well as innovation projects on education for equality, are scarce in engineering education [56, 57].

According to [58], the successful implementation of gender mainstreaming in higher education requires a structured approach involving not only teaching staff but also decision-makers:

- Identify institution-specific issues to develop projects or activities that generate themes related to gender equality.
- Implement strategies aimed at making gender disparities and inequalities within the institution visible.
- Establish context-specific initiatives to address gender mainstreaming.
- Utilize empirical research for providing a factual basis for decision-making and program development.

There are specific initiatives in various universities, but no proposals have been found that apply the gender perspective directly to the design of the teaching and learning process in the context of software engineering. Experiences have been mainly identified in Spanish higher education institutions. Among the works found, it is worth mentioning the programme of the School of Engineering at the University of Valencia which addresses closing the gender gap in engineering through mechanisms and strategies focused on reducing gender stereotypes in secondary schools, retaining and involving female students once they have entered the studies, and helping graduates as much as possible to find support networks throughout their professional careers [59].

On the other hand, mention should be made of the University of Alicante's Teaching Resources Portal with a Gender Perspective for University Teaching [60], where specific resources for computer science and support materials for incorporating the gender perspective can be found regardless of the area. This institution also collaborated in the publication of a guide with two brief examples of mainstreaming gender in computer science, one in Video Games I course, and another one in Analysis and Specification of Software Systems. However, the guide does not provide details about the specific actions developed for gender mainstreaming [49].

In terms of activities that directly affect the teaching-learning process, the Feminine Project [61] developed by the University of La Laguna in the 2016-2017 academic year should be highlighted, with the aim of serving as a formal platform for the collaborative design of good practices on equality in the teaching-learning process. Among the actions carried out, gender mainstreaming in the Degree in Computer Science was addressed through the course Human-Computer Interaction Systems [62].

At an international level, there is a high number of works that analyze the actions to increase the number of women in engineering studies [63-65]. It is also worth highlighting several works that focus on analyzing and preventing women from leaving engineering studies [66, 67].

III. METHODOLOGY

A. Context

In 2007 in Spain, an amendment to the Organic Act on Universities 6/2001, known as the Organic Spanish Act 4/2007, introduced provisions aimed at promoting gender equality within universities. This amendment mandated the establishment of equality units within universities to actively implement the principle of gender equality.

In response to this legal requirement, the University of Salamanca acted in 2008 by establishing the Equality Unit. The primary objective of this initiative was to facilitate the consensus-building process around university equality policies, oversee the implementation of the Equality Plan for men and women, and ensure compliance with relevant regulations.

Furthermore, it is important to emphasize that, in addition to adhering to the Equality Unit regulations, the University operates under the guiding principles of democracy, equality, justice, and freedom. Any form of sexism or discrimination based on gender, whether direct or indirect, contradicts these foundational principles, as well as the University's values and beliefs [68, 69].

Against this backdrop, during the academic year 2016-2017, the Equality Unit at the University of Salamanca conducted a study to analyze the gender-related courses taught at the

TABLE I
STUDENTS

Academic year	Number of students	Not first enrolment
2016-2017	76	12 (15.79%)
2017-2018	57	7 (12.28%)
2018-2019	59	10 (16.95%)
2019-2020	69	13 (18.84%)
2020-2021	80	5 (6.25%)
2021-2022	72	18 (25%)

University and the competencies in gender equality [70]. This study revealed that, in the academic curriculum for Computer Science, the sole mention of gender pertained to "fundamental rights and equal opportunities for both men and women," highlighting a clear need for gender mainstreaming.

This study documents the process of integrating gender mainstreaming into the curriculum of the University of Salamanca's Computer Engineering program, specifically focusing on the initial experience within the compulsory course, Software Engineering I.

Software Engineering at the University of Salamanca is organized into three courses that are developed consecutively in the last three years of the degree. In particular, the pilot experience described in this paper is developed in the first course that is studied in the fourth semester. This course has the dual objective of introducing the fundamentals of the course and introducing the models and methods of Requirements Engineering.

From a methodological point of view, the course has undergone several changes over the years to achieve greater student participation and improved learning outcomes. In the period that concerns this experience, the course has followed an active methodology through autonomous learning, collaborative learning with some cooperative learning techniques in specific issues, an inverted class approach for the more theoretical part and project-based learning [71, 72]. The approach and development of the course revolve around a final project that the students develop as a team during the course, carrying out a process of real software development [73].

Moreover, over the last six years, the course has reinforced the active approach due to COVID-19 pandemic. The experience described in this work has continued despite the changes from face-to-face to online (2019-2020), and hybrid lessons (2020-2021) [74].

B. Participants

The study involved two main actors, the teaching staff and the students. In particular, the changes associated with gender mainstreaming have been applied to six different groups of students, one per academic year from 2016-2017.

Three lecturers were involved in the study, one man (who coordinates the course) and two women. They remained unchanged for the entire project. However, for 2016-2017 and 2017-2018 academic years, the study was conducted only by two lecturers.

Regarding the students, the distribution per academic year is described in Table I, together with the percentage of students that did not take the course for first time. The theoretical lessons involve the whole group, and the students are divided into two subgroups for the laboratory lessons. The same lecturer taught the theoretical lessons during the six years; meanwhile, the other two lecturers have been in charge of the laboratory lessons.

C. Study design

Gender mainstreaming in teaching is a well-known approach, although the implementation depends on the knowledge area in which you want to apply. This study is focused on providing a guide to introduce gender mainstreaming not only in Software Engineering courses, but also in other courses related to Computer Science.

To carry out this research, it was necessary that the different actors involved in the teaching and learning process were part of the study. For this reason, the methodological framework for the gender mainstreaming in the Software Engineering I course was Action-Research [75]. Action-Research is a way of studying, exploring, a situation with the aim of improving it by involving the actors implicated in the reality under investigation [76].

Six Action-Research cycles were conducted, one per academic year (Fig. 1). Each cycle has covered four stages: planning, acting, observing, and reflecting. The first stage, planning, was conducted at the beginning of the academic year, before starting the Software Engineering I course. The teaching team reviewed the results of the previous year to introduce changes in the methodology and solve the problems detected. Moreover, this phase was focused on going further in the gender mainstreaming approach, introducing new mechanisms, and maintaining those actions that worked well. This stage also included preparing or updating the educational materials, tools and other tasks to prepare for the implementation, such as contacting experts or recording videos. Moreover, the definition of the actions takes into account the workload for developing them.

The second stage, acting, was developed across the four months of the course, from February to May. The actions were always carried out within the framework of the active methodology implemented in the course and described in previous works [71-73]. The actions conducted in each cycle are described in the next section.

Regarding the observing stage, a mixed method was applied [77], specifically, data triangulation. Qualitative data was collected through observation by the lecturers and a set of open questions in the satisfaction questionnaire answered by the students at the end of the course, before the final exam. The quantitative data was collected through the satisfaction questionnaire and complemented with the assessment indicators.

Finally, the reflection stage was focused on analyzing the data collected and sharing the different perceptions of the lecturers, considering not only the students' information, but also the effort to implement the different actions. This stage served as input to define the next cycle so that a clear evolution can be observed throughout the experience.

Likewise, from the first cycle, an instrument has been developed and applied to find out the students' perception of the gender gap in IT. This instrument, as well as its application in the course, is described in previous works [78, 79].

D. Instruments

Three instruments were used for data collection. First, a satisfaction questionnaire to get the feedback from the students regarding the development of the course. The questionnaire is an adaptation of the instrument developed and validated by [80, 81].

The questionnaire is divided into four sections [74]. First, sociodemographic items (gender, highest course enrolled, the order of career choice, grade point average in the file, number of times enrolled in the subject, previous studies).

Later, two sections focused on the overall satisfaction with the degree (ten five-point Likert items) and the satisfaction on the course including five dimensions: Personal work methodology (five-point Likert), depth degree in the study (Multiple choice), perception of the methodology (five-point Likert), general satisfaction (five-point Likert), usefulness for the subjects' study (five-point Likert) and subject rating (five-point Likert).

The third section get information about the hours of work that students considered that they invested in the course. Finally, the last section includes three open questions for collecting the positive and negative aspects, and suggestions for improvement.

Regarding the observation protocol template, it was defined for collecting information of each action implemented. The template used had the following sections:

- Name of the observers.
- Action identifier and name.
- Number of students involved.
- Number of sessions working on this action.
- Number of lecturers supporting the implementation.
- Identified problems.
- Applied changes (solutions).

The last instrument used during the development of the course is a Google Sheets spreadsheet to record learning outcomes, a complex variable composed of a series of both qualitative and quantitative measures. A total of 27 evaluation items are collected for each student. The detailed description is available at [73].

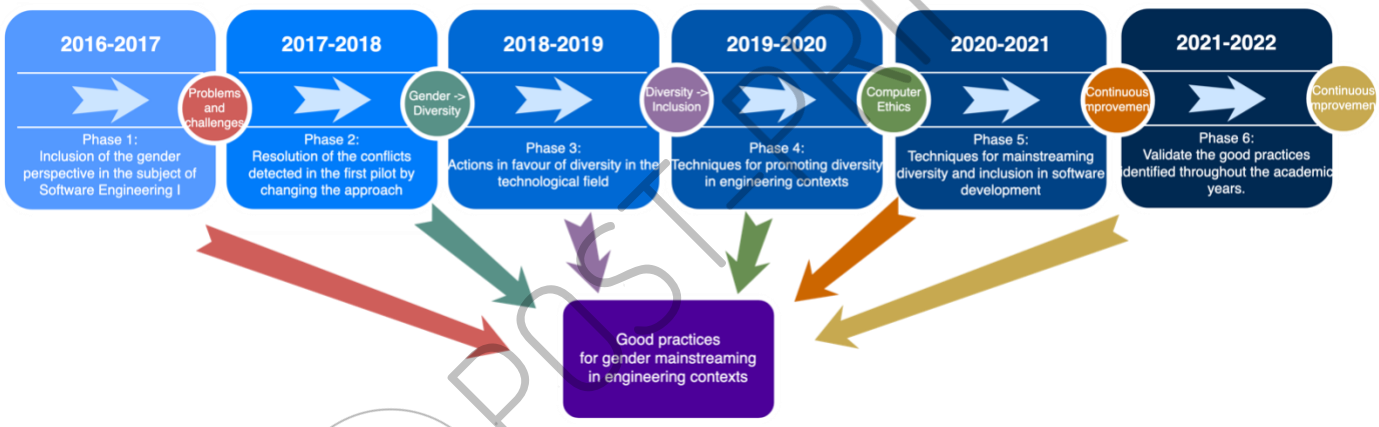

Fig. 1. Implementation of the different phases throughout six academic years.

IV. Gender Mainstreaming

The gender mainstreaming in the Software Engineering I course is proposed through a series of teaching innovation projects financed by the University of Salamanca. This is a process of continuous improvement, in which each academic year a series of changes are established to improve the actions implemented or to introduce new actions, according to the Action-Research framework.

Each course is considered as a Action-Research cycle that provides information to identify a set of good practices to gender mainstreaming in engineering contexts (Fig. 1).

The initial phase focused on laying the foundations and implementing the first gender mainstreaming actions. After this first phase, some problems were detected and a set of challenges to be solved to improve student satisfaction while continuing to build an environment of equality within the framework of Software Engineering were posed. The second phase was used to improve the actions defined in the previous course in such a way that no new actions were incorporated, but the problems detected were solved. Regarding the third phase, it was proposed to address not only issues related to gender, but also to cover the concept of diversity, building an inclusive environment and working on the teaching-learning process from perspectives related to gender, culture, sexual-affective diversity, etc. The fourth phase addressed not only generating inclusive environments in the context of the course but also in the processes associated with software development, so that future computer engineers acquire knowledge and techniques to create inclusive environments in work contexts. Finally, the fifth phase covers ethics.

Across the five phases, four general objectives were achieved. Each objective involves the implementation of a set of actions:

- Objective 1 (O1): To incorporate activities that promote the gender perspective in the context of Software Engineering.
- Objective 2 (O2): To carry out a mixed study on students' perceptions of the gender gap in technological contexts.
- Objective 3 (O3): To offer an academic guide that considers the gender perspective.

- Objective 4 (O4): To promote diversity and inclusion in the technological context through software development processes.

A. Cycle 1

The first phase aims to address the incorporation of the gender perspective in the assignment. At this stage, Software Engineering did not consider the need to train future computer engineers in values of equality and equity.

Objectives 1 to 3 were achieved through a set of actions. First, four actions were proposed to achieve the first objective, the incorporation of activities to promote the gender perspective. Moreover, an introductory talk for students was organized to present the reasons for working on gender equality in computing during the course.

Action O1.1. Promote the presence of women in as many internship groups as possible. Project-based learning techniques and cooperative and collaborative work are used throughout the course, so that the students are organized at the beginning of the course into teams of 2-4 people who remain throughout the course. The teams are formed by the students, but they were informed about the benefits of creating mixed teams, and they were urged to have as many mixed teams as possible.

Action O1.2. Twitter. Although in previous academic years a hashtag associated with the course was used, in this course its use was proposed to share information and current news related to the gender gap in the technology sector. The shared tweets can be found at the following link http://bit.ly/31KfVrz.

Action O1.3. Gender mainstreaming in the workshops as part of the activities of the course, workshops are held in the classroom where students present and discuss various diagramming solutions at UML. All the problems raised have been related to gender issues in the technological field. Each statement has been accompanied by a brief introductory text to contextualize the problem raised, accompanied by links to news and reports on the course. The problems raised to outline a solution through class diagrams or Use Cases were:

- A web application to promote the acquisition of STEM skills in pre-university education with a special emphasis on girls.
- A job portal for women specialized in IT, telecommunications, and technology.
- The portal of an association whose main objective is to give visibility to women in the technological field through different projects.

Action O1.4. To orientate the practice or final work that is developed throughout the course to a theme related to women and technology. In particular, the objective was "to model a portal to promote the visibility of women in the STEM context, providing a space where all the initiatives, projects, associations, institutions, etc. related to reducing the gender gap in the technology sector can be found".

Regarding the objective of analyzing the students' perception of the gender gap in IT, the GENCE questionnaire was developed during the different phases [78]. More information on this study can be found in [82, 83].

Finally, regarding the third objective, a single action was proposed.

Action O3.1. Review and modify the course materials. The exercises proposed as examples modeling situations in society (human relations, professions, etc.) were reviewed. Likewise, the linguistic recommendations for a non-sexist use of language included in the Equality Guide of the University of Salamanca and the United Nations guidelines were followed [84].

B. Cycle 2

During the academic year 2017-2018, the same general objectives defined in phase 1 were maintained, but a series of adjustments were made to solve problems detected in the previous year. Mainly, it was decided to avoid the introductory talk made at the beginning of the course because it raised complaints and various problems with several students about the inadequacy of gender mainstreaming in a course of the Degree in Computer Science. In this way, when it came to the size and the final work, the chosen topics were presented as if it were any other problem such as the management of a hospital or a cinema.

On the other hand, in the satisfaction questionnaire for the 2016-2017 academic year, several of the answers showed that the use of Twitter only to transmit women's and technology issues was not considered relevant. For this reason, in phase 2 tweets purely related to software engineering were combined with others more focused on women and technology or engineering.

The only action that was incorporated to complement Twitter and the direct communication of the need to make women in technology visible was the incorporation of logos and links to information about events around the gender gap in the course space on the virtual campus. Among the events shared were the International Day of Women and Girls in Science (11 February), International Women's Day (8 March) and International Girls' Day in ICT (23 April).

Regarding Action O1.3, the workshops held in this phase addressed the following issues:

- System for managing an art gallery focused on giving visibility to women as scientists and technologists.
- Application for teachers with resources and tools to promote interest in science and research from an early age.

The objective of the final work was to "model an application (web or mobile) whose central theme is women and girls in Science and Technology in order to reduce the gender gap in the scientific and technological field".

C. Cycle 3

The third phase was proposed as an evolution of the gender approach, addressing other aspects related to diversity in technological contexts. This phase was focused on the fourth objective, promoting diversity and inclusion in the technological context through software development processes.

To achieve it, in addition to the actions proposed and improved in the first two phases, the following specific objectives were considered:

- To introduce the figure of a coach or external expert who provides a vision from the company/real world about technology, diversity, and ethics.

- To hold specific talks throughout the course that allow different experiences in the technological field to be shared, where the concepts of diversity and inclusion in the field of software product development are reflected.
- Introduce gamification techniques to activate student motivation in relation to diversity and inclusion in the technological field.

Action O4.1. An external expert is incorporated into the sessions related to the development of the final work to guide the students and play the role of the client, with special emphasis on issues related to diversity and ethics.

Action O4.2. Organization of three talks throughout the course lasting between 15-20 minutes on topics related to software engineering and the professional environment. The talks were as follows:

- Beginning of the course. Talk was given by a young woman developer about her experiences in the professional field in both the public and private sectors.
- Before Easter. Talk about remote work. It was given by a young doctor in computer science who works for an international company.
- Before the end of the course. This talk introduced the use of agile methodologies to show how companies develop software today and how these methodologies can help to promote inclusion and equity in teamwork.

Action O4.3. The first approach to the gamification of the course incorporating only a set of badges associated with diversity and inclusion [85]:

- Diversity first: for those teams that propose solutions to promote diversity as a main objective.
- Inclusion policies: for those teams that propose solutions to promote inclusion or to support inclusion policies.
- Questions and answers: students asking questions to the speakers in relation to diversity and inclusion in their working contexts.
- Inclusion in practice: for those teams where the point of view of all members is considered.
- Inclusive UML: teams or learners using inclusive language in their diagrams.

Regarding the themes addressed in the workshops, topics were chosen from the first two phases. As for the final work, the objective was to "model an application (web or mobile) focused on promoting inclusion and addressing diversity issues in the technological field at the business level.

D. Cycle 4

The fourth phase maintained the objectives and actions defined in the previous phases (actions O1.1, O1.2, O1.3, O1.4, O3.1, O4.1, O4.2, and O4.3). Furthermore, it incorporates as a novelty, working techniques to promote inclusive working environments, in such a way that they acquire the knowledge and skills necessary to create this type of environment when they enter the labor market. Specifically, techniques used in agile methodologies will be selected and adapted to establish dynamics that promote inclusion both internally (student work teams) and externally (relationship between different work teams).

Action O4.4. Selection and adaptation of techniques used in agile methodologies to establish group dynamics that promote internal and external inclusion.

Action O4.5. Guide the definition of the final work during the first teamwork sessions with design thinking techniques.

E. Cycle 5

The fifth phase considers ethics. Even though the social and ethical aspects of technology have been included in some computer science curricula for more than twenty years, there is a great variety among computer ethics courses in terms of the contents taught [86, 87] and the way they are incorporated into the curriculum [88]. Likewise, there is a lack of integration of computer ethics in the Spanish context. The number of Spanish universities is much lower than in other countries based on the collaborative database on higher education subjects or programs that work on “technological ethics” [89].

According to the Computer Science Curriculum 2013 developed by two of the leading associations in technology and engineering issues [90], computer science graduates should have a range of soft skills not only focused on technological issues, but also on the social, legal, ethical and cultural issues inherent in the discipline of computer science.

The main objective of this phase was to introduce the concept of computer ethics and the different implications that software development can have on society.

Action O4.6. To incorporate the ethical aspects related to software development in the Degree in Computer Science through a SPOC (Small Private Open Course). The main objective of the SPOC is to provide Computer Science students with a knowledge base on ethics in software development. The SPOC syllabus is divided into four main blocks: introduction to computer ethics, ethics and human-computer interaction, ethics and universal design, and ethics and artificial intelligence [91].

Action O4.7. To include informatics ethics as a transversal aspect of the final work of the course. Modify the evaluation criteria to consider it within the rubric.

Furthermore, the talks (O4.2) were organized outside the official timetable of the course. The talks covered introduction to informatics ethics, ethics and human-computer interaction, ethics and universal design, and ethics and artificial intelligence.

E. Cycle 6

The final phase of the project was developed during the academic year 2021-2022, and its primary focus was to validate the good practices identified over the previous five years. This phase did not introduce any new approaches or actions. The only change made was the topic of the final project, which varies every year. For this year, the topic was centered around the use of technology to eradicate racial discrimination and promote diversity.

During this phase, several actions were implemented:

- Action O1.1. Gender diversity in student teams.
- Action O1.3. UML workshops about problems related to gender, diversity, and inclusion.

- Action O1.4. Objective of the final work focused on solving a problem related to gender, diversity, or inclusion.
- Action O3.1. Review the learning materials and examples.
- Action O4.1. Coach.
- Action O4.3. Gamification.
- Action O4.4. Agile methodologies to foster inclusion.
- Action O4.5. Design thinking techniques.
- Action O4.6. SPOC introduction to informatics ethics.
- Action O4.7. Assessment criteria related to informatics ethics in the final work.

Although O1.2 was not highly valued in previous satisfaction surveys, it is the easiest and quickest way to share additional materials in a dynamic way, and therefore, it was also included. To make it more efficient, a unique hashtag, #INSOUSAL, was created to avoid depending on the year.

Action O4.2, which had previously been included, was removed, although it performed well. Other actions were given higher priority, focusing more on the final project, which is the core element of the entire course. Additionally, action O4.7 was integrated into the SPOC on informatics ethics (O4.6). Students did not receive separate lectures on the topic, but instead, had access to the SPOC as part of their preparation for the final project.

Overall, the final phase of the project was aimed at validating the identified good practices from previous years and making minor adjustments to the course to improve its effectiveness. By implementing the actions mentioned above, the course was made more efficient, dynamic, and better aligned with the current societal needs.

V. Results

A satisfaction questionnaire was applied at the end of each academic year to measure the acceptance of the gender mainstreaming actions. This questionnaire complements the official one shared by our institution every two years. However, the institutional questionnaire does not evaluate the course but the teaching staff. The satisfaction instrument is an adaptation of [80, 81].

The study population consisted of 413 students (Fig. 2), of whom 61 (14.77%) were female. Nevertheless, the sample are 115 students because students must answer anonymously and freely. According to gender are 80 men (69.57%), 16 women (13.91%), 19 prefer not to answer (16.52%).

Overall satisfaction with the course during these six academic years is 3.69 rating on a 5-points Likert scale. Participants agree that the methodological approach used in this course should be applied in other courses with 4.09 score. Moreover, they consider the content of this course useful for their professional future (4.09 score).

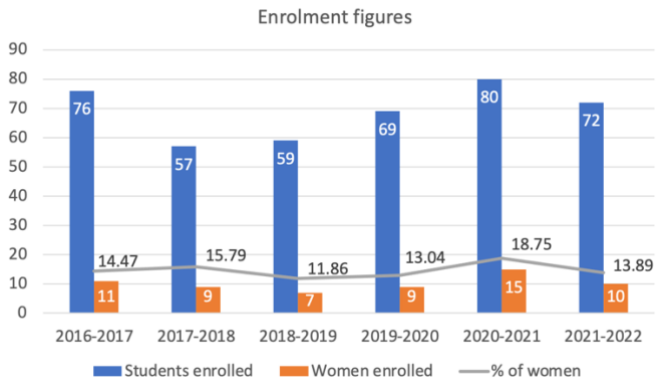

Fig. 2. Population distribution in the Software Engineering I course.

Regarding the gender mainstreaming actions, students rate them positively. Highlight the workshops (O1.3) with a mean score of 4.15 and the final work (O1.4) with 4.08. The coach (O4.1) and the talks (O4.2) have also good mean scores, 4.4 and 4.25 respectively. Note that some of the items have not been rated by the whole sample, as items/actions have been added over the academic years.

On the other hand, the hashtag in Twitter (O1.2) has the worst score (2.16); students consider that it is not useful for studying the course.

The definition of the student teams for the final work is done by the students (O1.1). However, lecturers foster them to create gender diversity groups as a mechanism to "boosts the quality of STEM outcomes by aggregating creativity and reducing potential gender biases (given that women's expertise is taken into account)" [49]. Throughout these six years of gender mainstreaming, the number of teams with women has exceeded 50% of the total number of possible teams that could have a woman (Fig. 3). This percentage is calculated from the number of women who take the course and carry out the final work and the total number of teams that finally have a woman.

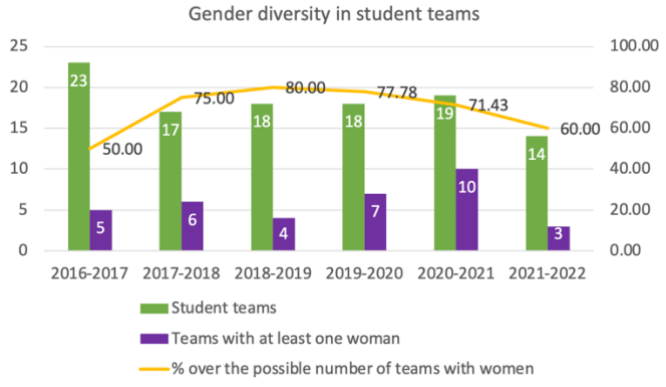

Fig. 3. Gender diversity in student teams.

Regarding the qualitative feedback provided by the students, 80 participants wrote positive comments (69.57% of the sample), and 65 identified problems and issues (56.52% of the sample). The main characteristics highlighted by the students are:

- Practical application of theory: Students appreciate seminars that apply theoretical concepts in practice.

- Continuous assessment and daily work: Many students value ongoing evaluation over final exams, emphasizing the importance of daily work in defining their abilities.
- Teacher engagement and support: There is a recurring mention of the closeness of the faculty and their commitment to student learning, which align with gender mainstreaming by fostering an inclusive and supportive learning environment.
- Interactive and practical methodology: The methodology of the course seems to be focused on practical learning, with interactive workshops and milestone-based project submissions, which can be more engaging for diverse learning styles.
- Content of workshops and final work: The subjects explored in the final project were engaging. The opportunity to devise solutions for actual societal issues provides a greater incentive during the completion of the learning activities.
- Use of technology and tools: The ability to use relevant tools for project development is highlighted.
- Teamwork and collaboration: Emphasis on group work and the practical environment reflects a collaborative approach, which is often encouraged in gender mainstreaming to ensure equal participation.
- Inclusion of feminist perspectives: The explicit inclusion of feminist perspectives within the course material provides diverse viewpoints in the field of software engineering.

Finally, the problems and issues identified during each cycle were used to introduce new actions and update the gender mainstreaming approach. Highlight the problems related to teamwork dynamics; there are complaints about unequal participation in group work, which might indicate a lack of a supportive environment for fostering equitable teamwork. This was particularly disadvantageous for students who were marginalized due to their gender, race, or other diversity factors. For this reason, since 2019-2020, the fourth cycle, some actions to promote inclusive working environments were included.

Another problem detected during the first two cycles, 2016 to 2018, was related to understand the problem domain, which is a crucial competence for a software engineer. The topics selected about gender equality and diversity were difficult to understand for some students. To consider these comments, the third cycle integrated the figure of a coach or external expert who provides a vision from the company/real world about technology, diversity, and ethics.

They also provided feedback about the active methodology problems that were closely related to the gender mainstreaming approach. In particular, the requirement for mandatory attendance, especially for theoretical lessons, has been criticized. This rigid structure may not consider the diverse needs of students who may have other responsibilities. Across the different cycles, more flexibility has been applied to facilitate the attendance to students with different backgrounds, such as double-degree students or students that enroll in course for second time.

VI. Discussion and Conclusion

The gender gap in STEM, with a particular focus in technology and engineering, is one of the problems that are faced at all societies, both educational and professional level [92]. Computer Science is one of the most affected fields, the participation of women is decreasing since early 1990s [14-16, 93].

According to research conducted within the SAGA project [18, 21], addressing the gender disparity within STEM fields necessitates the pursuit of seven broad objectives. These objectives span various domains, encompassing the challenge of societal norms, the reform of educational and professional pathways, and the improvement of research and decision-making processes.

Gender mainstreaming is a holistic approach that recognizes the multifaceted nature of the gender gap in the society and works to address it comprehensively [50]. By challenging stereotypes, promoting diversity, and ensuring equitable access to opportunities, gender mainstreaming contributes to the goal of reducing the gender gap. Although gender mainstreaming in education is not new [94], there are not enough studies of applying it in higher education [52].

The gender mainstreaming in Software Engineering I course in the Degree in Computer Science of the University of Salamanca during six academic years has allowed knowing which techniques or approaches work better in the context of Computer Science, without leaving aside the heterogeneity of the student body. Likewise, it is important to highlight that the changes made around the incorporation of the gender perspective are part of the methodological approach and the development of the course. The results obtained after each of the cycles, in relation to the satisfaction questionnaires applied at the end of the course and the observation protocol conducted by the lecturers, have allowed to improve the approach, and strengthen the initial strategy proposed so that in the sixth Action-Research cycle a balance has been reached between the actions proposed and their acceptance and impact by the students.

Furthermore, the workload for the lecturers has been one of the indicators used to introduce changes among the cycles. The first two cycles were conducted by two lecturers that faced the problems raised during the implementation and achieved the objectives related to gender mainstreaming. The active involvement of a third lecturer allowed combining the gender mainstreaming and the workload related to the active methodology, which required a high involvement of the teaching staff to provide continues feedback as part of the formative evaluation approach.

Although it can be considered that the outcome proposal in the last cycle would be appropriate to transfer to other courses and universities, it is essential to consider that the six cycles should be implemented in order to avoid a high workload during the gender mainstreaming for first time. The results at the sixth cycle are developed over the effort invested in previous years. Gender mainstreaming at Computer Science programmes in higher education should follow an iterative and incremental approach. This approach is useful in identifying institutional and individual resistances and the informal rules

underpinning them [52], serving as an approach to adapt the experience to other contexts.

Furthermore, it is important to clarify that the incorporation of the gender perspective as part of the teaching-learning process does not have a measurable impact in a short period of time, but rather aims to make students reflect in such a way that they reason about the need to promote diversity in software development contexts.

On the other hand, although the social and ethical aspects of technology have been included in some Computer Science curricula for more than twenty years, there is a great variety among informatics ethics courses in terms of the contents taught [86, 87] and the way they are incorporated into the curriculum [88]. There is also a lack of integration of informatics ethics in the Spanish context. According to the collaborative database on higher education courses or programs that deal with "technological ethics" [89], the number of Spanish universities is much lower than in other countries. Moreover, connecting informatics ethics with gender mainstreaming is fundamental to transferring gender equality to software development in the professional context, as some of the ethical problems are related to the lack of women in testing software solutions [35], or the reproduction of stereotypes [41].

This proposal has some limitations, mainly related to the heterogeneity of the students who take the course, which makes it necessary to constantly monitor the actions carried out to adapt them to the different situations that can be generated in the classroom. On the other hand, this adaptive approach only reinforces the creation of a teaching and learning environment which considers the diversity of its students, and which promotes equality and equity, transmitting to the students the need to promote this type of environment in software development contexts.

REFERENCES

[1] C. A. Moss-Racusin, J. F. Dovidio, V. L. Brescoll, M. J. Graham, and J. Handelsman, "Science faculty's subtle gender biases favor male students," *Proceedings of the National Academy of Sciences*, vol. 109, no. 41, pp. 16474-16479, 2012, doi: 10.1073/pnas.1211286109.

[2] R. W. Lent, S. D. Brown, and G. Hackett, "Contextual supports and barriers to career choice: A social cognitive analysis," *Journal of Counseling Psychology*, vol. 47, no. 1, pp. 36-49, 2000, doi: 10.1037/0022-0167.47.1.36.

[3] S. O. Salami, "Influence of culture, family and individual differences on choice of gender-dominated occupations among female students in tertiary institutions," *Women in Management Review*, vol. 22, no. 8, pp. 650-665, 2007, doi: 10.1108/09649420710836326.

[4] M. C. Cadaret, P. J. Hartung, L. M. Subich, and I. K. Weigold, "Stereotype threat as a barrier to women entering engineering careers," *Journal of Vocational Behavior*, vol. 99, pp. 40-51, 2017, doi: 10.1016/j.jvb.2016.12.002.

[5] C. Leaper and C. R. Starr, "Helping and Hindering Undergraduate Women's STEM Motivation: Experiences With STEM Encouragement, STEM-Related Gender Bias, and Sexual Harassment," *Psychology of Women Quarterly*, vol. 43, no. 2, pp. 165-183, 2019, doi: 10.1177/0361684318806302.

[6] R. W. Lent, S. D. Brown, and G. Hackett, "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance," *Journal of Vocational Behavior*, vol. 45, no. 1, pp. 79–122, 1994, doi: 10.1006/jvbe.1994.1027.

[7] A. García-Holgado, C. S. González-González, and A. Peixoto, "A comparative study on the support in engineering courses: a case study in Brazil and Spain," *IEEE Access*, vol. 8, pp. 125179-125190, 2020, doi: 10.1109/ACCESS.2020.3007711.

[8] European Commission, Directorate-General for Communications Networks, and Content Technology, "Women in the Digital Age: Final report," Publications Office of the European Union, Luxembourg, 2018.

[9] UNESCO. Director-General 2009-2017, *Descifrar el código: la educación de las niñas y las mujeres en ciencias, tecnología, ingeniería y matemáticas (STEM)*. Paris, Francia: UNESCO, 2019.

[10] World Economic Forum, *Global Gender Gap Report 2023*. Geneva, Switzerland: World Economic Forum, 2023.

[11] World Economic Forum, *The Global Gender Gap Report 2021. Insight Report*. Geneva, Switzerland: World Economic Forum, 2021.

[12] Subdirección General de Actividad Universitaria Investigadora de la Secretaría General de Universidades, "Datos y cifras del Sistema Universitario Español. Publicación 2021-2022," Ministerio de Universidades, Madrid, Spain, 2022. [Online]. Available: https://www.universidades.gob.es/stfls/universidades/Estadisticas/ficheros/DyC_2021_22.pdf

[13] J. J. Merelo Guervós and C. Merelo Molina, "Evolución de la matrícula femenina en el grado de Informática en universidades públicas españolas," Universidad de Granada, 22 July 2022 2017. [Online]. Available: https://doi.org/10.13140/RG.2.2.19608.08969

[14] M. Holanda and D. D. Silva, "Latin American Women and Computer Science: A Systematic Literature Mapping," *IEEE Transactions on Education*, vol. 65, no. 3, pp. 356-372, 2022, doi: 10.1109/TE.2021.3115460.

[15] D. Gürer and T. Camp, "An ACM-W literature review on women in computing," *SIGCSE Bull.*, vol. 34, no. 2, pp. 121–127, 2002, doi: 10.1145/543812.543844.

[16] K. A. Frenkel, "Women and computing," *Commun. ACM*, vol. 33, no. 11, pp. 34–46, 1990, doi: 10.1145/92755.92756.

[17] R. Colomo-Palacios, N. Ben Yahia, and X. Larrucea, "Gender diversity among computing students: reflections from Norway, Spain and Tunisia," in *Proceedings of the 7th International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM 2019) (León, Spain, October 16-18, 2019)*, M. Á. Conde-González, F. J. Rodríguez Sedano, C. Fernández Llamas, and F. J. García-Peñalvo Eds. New York, NY, USA: ACM, 2019, pp. 196-200.

[18] UNESCO, *Measuring gender equality in science and engineering: The SAGA science, technology and innovation gender objectives list (STI GOL). SAGA Working paper 1*. Paris, France: UNESCO, 2016.

[19] UNESCO, *STEM and Gender Advancement (SAGA): improved measurement of gender equality in science, technology, engineering and mathematics*. Paris, France: UNESCO, 2016.

[20] UNESCO, *Measuring gender equality in science and engineering: the SAGA toolkit. SAGA Working Paper 2*. Paris, France: UNESCO, 2017.

[21] UNESCO, *Telling SAGA: Improving measurement and policies for gender equality in Science, Technology and Innovation. SAGA Working Paper 5*. Paris, France: UNESCO, 2018.

[22] K. Beddoes, M. Borrego, and B. K. Jesiek, "Mapping international perspectives on gender in engineering education research," presented at the Proceedings of the 39th IEEE international conference on Frontiers in education conference, San Antonio, Texas, USA, 2009.

[23] A. García-Holgado, S. Verdugo-Castro, C. S. González, M. C. Sánchez-Gómez, and F. J. García-Peñalvo, "European Proposals to Work in the Gender Gap in STEM: A Systematic Analysis," *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje*, vol. 15, no. 3, pp. 215-224, 2020, doi: 10.1109/RITA.2020.3008138.

[24] C. S. González *et al.*, "Gender and Engineering: Developing Actions to Encourage Women in Tech," in *2018 IEEE Global Engineering Education Conference (EDUCON), (17-20 April 2018, Santa Cruz de Tenerife, Canary Islands, Spain)*. USA: IEEE, 2018, pp. 2082-2087.

[25] J. Mills, M. Ayre, and J. Gill, *Gender Inclusive Engineering Education*. New York, USA: Routledge, 2010.

[26] A. García-Holgado and F. J. García-Peñalvo, "A Model for Bridging the Gender Gap in STEM in Higher Education Institutions," in *Women in STEM in Higher Education: Good Practices of Attraction, Access and Retainment in Higher Education*, F. J. García-Peñalvo, A. García-Holgado, A. Dominguez, and J. Pascual Eds., (Lecture Notes in Educational Technology. Singapore: Springer, 2022, pp. 1-19.

[27] L. Kvasny, F. C. Payton, V. W. Mbarika, A. Amadi, and P. Meso, "Gendered Perspectives on the Digital Divide, IT Education, and Workforce Participation in Kenya," *IEEE Transactions on Education*, vol. 51, no. 2, pp. 256-261, 2008, doi: 10.1109/TE.2007.909360.

[28] A. M. Gloria and S. E. Robinson Kurpius, "Influences of self-beliefs, social support, and comfort in the university environment on the academic nonpersistence decisions of American Indian undergraduates,"

Cultural Diversity and Ethnic Minority Psychology, vol. 7, no. 1, pp. 88-102, 2001, doi: 10.1037/1099-9809.7.1.88.

[29] S. L. Eddy and S. E. Brownell, "Beneath the numbers: A review of gender disparities in undergraduate education across science, technology, engineering, and math disciplines," *Physical Review Physics Education Research*, vol. 12, no. 2, p. 020106, 2016, doi: 10.1103/PhysRevPhysEducRes.12.020106.

[30] A. García-Holgado, A. Vázquez-Ingelmo, F. J. García-Peñalvo, and C. S. González-González, "Perspectiva de género y fomento de la diversidad en la docencia de Ingeniería del Software," in *Actas de las Jornadas de la Enseñanza Universitaria de la Informática (JENUI)*, vol. 5. Palma de Mallorca, Spain: AENUI, la Asociación de Enseñantes Universitarios de la Informática, 2020, pp. 269–276.

[31] World Economic Forum, *The future of jobs Report 2020*. Geneva, Switzerland: World Economic Forum, 2020.

[32] C. Hill, C. Corbett, and A. St Rose, *Why so few? Women in science, technology, engineering, and mathematics*. Aamerican Association of University Women, 2010.

[33] T. Hill and R. Westbrook, "SWOT analysis: it's time for a product recall," *Long range planning*, vol. 30, no. 1, pp. 46-52, 1997.

[34] S. Stumpf *et al.*, "Gender-Inclusive HCI Research and Design: A Conceptual Review," *Foundations and Trends® in Human–Computer Interaction*, vol. 13, no. 1, pp. 1-69, 2020, doi: 10.1561/1100000056.

[35] M. F. Roig-Maimó and R. Mas-Sansó, "The Female Effect: The Case of Gender Parity on User Studies," presented at the Proceedings of the XX International Conference on Human Computer Interaction, Donostia, Gipuzkoa, Spain, 2019. [Online]. Available: https://doi.org/10.1145/3335595.3335606.

[36] S. Bardzell and J. Bardzell, "Towards a feminist HCI methodology: social science, feminism, and HCI," presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Vancouver, BC, Canada, 2011. [Online]. Available: https://doi.org/10.1145/1978942.1979041.

[37] M. Burnett *et al.*, "GenderMag: A Method for Evaluating Software's Gender Inclusiveness," *Interacting with Computers*, vol. 28, no. 6, pp. 760-787, 2016, doi: 10.1093/iwc/iwv046.

[38] M. K. Scheuerman, A. Jiang, K. Spiel, and J. R. Brubaker, "Revisiting Gendered Web Forms: An Evaluation of Gender Inputs with (Non-)Binary People," presented at the Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, Yokohama, Japan, 2021. [Online]. Available: https://doi.org/10.1145/3411764.3445742.

[39] T. Katerina and P. Nicolaos, "Examining gender issues in perception and acceptance in web-based end-user development activities," *Educ. Inf. Technol.*, vol. 23, no. 3, pp. 1175-1202, 2018/05/01 2018, doi: 10.1007/s10639-017-9650-x.

[40] C. S. González-González, R. M. Gil-Iranzo, and P. Paderewski-Rodríguez, "Human–Robot Interaction and Sexbots: A Systematic Literature Review," *Sensors*, vol. 21, no. 1, p. 216, 2021. [Online]. Available: https://www.mdpi.com/1424-8220/21/1/216.

[41] C. González-González, R. M. Gil-Iranzo, and P. Paderewsky, "Sex with robots: analyzing the gender and ethics approaches in design," presented at the Proceedings of the XX International Conference on Human Computer Interaction, Donostia, Gipuzkoa, Spain, 2019. [Online]. Available: https://doi.org/10.1145/3335595.3335609.

[42] S. Leavy, G. Meaney, K. Wade, and D. Greene, "Mitigating Gender Bias in Machine Learning Data Sets," Cham, 2020: Springer International Publishing, in Bias and Social Aspects in Search and Recommendation, pp. 12-26.

[43] S. Leavy, "Gender bias in artificial intelligence: the need for diversity and gender theory in machine learning," presented at the Proceedings of the 1st International Workshop on Gender Equality in Software Engineering, Gothenburg, Sweden, 2018. [Online]. Available: https://doi.org/10.1145/3195570.3195580.

[44] M. Thelwall, "Gender bias in sentiment analysis," *Online Information Review*, vol. 42, no. 1, pp. 45-57, 2018, doi: 10.1108/OIR-05-2017-0139.

[45] M. R. Costa-jussà, "An analysis of gender bias studies in natural language processing," *Nature Machine Intelligence*, vol. 1, no. 11, pp. 495-496, 2019/11/01 2019, doi: 10.1038/s42256-019-0105-5.

[46] K. Lu, P. Mardziel, F. Wu, P. Amancharla, and A. Datta, "Gender Bias in Neural Natural Language Processing," in *Logic, Language, and Security: Essays Dedicated to Andre Scedrov on the Occasion of His 65th Birthday*, V. Nigam *et al.* Eds. Cham: Springer International Publishing, 2020, pp. 189-202.

[47] I. Serna, A. Peña, A. Morales, and J. Fierrez, "InsideBias: Measuring Bias in Deep Networks and Application to Face Gender Biometrics," in *2020 25th International Conference on Pattern Recognition (ICPR)*, 10-15 Jan. 2021 2021, pp. 3720-3727, doi: 10.1109/ICPR48806.2021.9412443.

[48] E. Bosch Fiol, V. A. Ferrer Pérez, and V. Ferreiro Basurto, "Incorporación de los contenidos en igualdad de oportunidades y género en grado," in *Actas del I Congreso Internacional de Educación para la Igualdad*, F. J. del Pozo Serrano, M. M. Jiménez Ramírez, M. S. Entrena Jiménez, and R. A. González Puntas Eds. Granada: Natívola, 2011, pp. 55-65.

[49] P. Moreno Pozo, *Guides to mainstreaming gender in university teaching. Computer Science*. Castelló de la Plana: Xarxa Vives d'Universitats, 2020.

[50] United Nations, "Gender mainstreaming. An overview," Office of the Special Adviser on Gender Issues, Department of Economic and Social Affairs, United Nations, New York, USA, 2002.

[51] Council of Europe, "Gender mainstreaming. Conceptual framework, methodology and presentation of good practices," Directorate General of Human Rights, Strasbourg, 2004.

[52] T. Verge, M. Ferrer-Fons, and M. J. González, "Resistance to mainstreaming gender into the higher education curriculum," *European Journal of Women's Studies*, vol. 25, no. 1, pp. 86-101, 2018, doi: 10.1177/1350506816688237.

[53] E. Lombardo and L. Mergaert, "Gender Mainstreaming and Resistance to Gender Training: A Framework for Studying Implementation," *NORA - Nordic Journal of Feminist and Gender Research*, vol. 21, no. 4, pp. 296-311, 2013/12/01 2013, doi: 10.1080/08038740.2013.851115.

[54] S. Kalaitzi, "Navigating barriers to gender equality in the European Union context: The case of healthcare sector.," Doctoral Thesis, Maastricht University, 2019.

[55] T. Donoso-Vázquez and A. Velasco-Martínez, "Why a proposal for gender training at university?," *Profesorado: revista de curriculum y formación del profesorado*, vol. 17, no. 1, pp. 71-88, 2013.

[56] E. Calvo-Iglesias, I. Epifanio, S. Estrade, and E. Mas de les Valls, "Gender Perspective in STEM Disciplines in Spain Universities," in *Women in STEM in Higher Education: Good Practices of Attraction, Access and Retainment in Higher Education*, F. J. García-Peñalvo, A. García-Holgado, A. Dominguez, and J. Pascual Eds. Singapore: Springer Nature Singapore, 2022, pp. 165-179.

[57] J. Müller, M. Sáinz, and C. Castaño, "Institutional Barriers to Gender Mainstreaming in Spanish ICT Higher Education," presented at the 6th European Conference on Gender and ICT - Feminist Interventions in Theories and Practices, Umeå University, Sweden, 2011.

[58] H. Yang, "Transforming concepts into practices: Mainstreaming gender in higher education," (in English), *Asian Journal of Women's Studies*, vol. 22, no. 4, pp. 392-413, 2016 2016, doi: https://doi.org/10.1080/12259276.2016.1242940.

[59] C. Botella, S. Rueda, E. López-Iñesta, and P. Marzal, "Gender Diversity in STEM Disciplines: A Multiple Factor Problem," *Entropy*, vol. 21, no. 1, p. 30, 2019, doi: 10.3390/e21010030.

[60] J. V. Berná Martínez, M. J. Rodriguez Jaume, and F. Maciá Pérez, "Portal de Recursos Docentes con Perspectiva de Género para la Docencia Universitaria," in *Actas de las XX Jornadas de la Enseñanza Universitaria de la Informática (JENUI)*, 2014, pp. 177-184.

[61] A. Vega Navarro *et al.*, "Una experiencia de innovación en los procesos de enseñanza-aprendizaje desde la perspectiva de género," in *De la innovación imaginada a los procesos de cambio* Servicio de Publicaciones de la ULL, 2018, pp. 177-200.

[62] C. S. González-González, A. García-Holgado, and F. J. García-Peñalvo, "Introduciendo la perspectiva de género en la enseñanza universitaria: co-creación de guías docentes y proyectos de innovación," in *Libro de Actas IX Jornadas Internacionales de Campus Virtuales (11-13 de septiembre de 2019, Popayán, Colombia)*, C. A. Collazos Ordóñez, C. S. González González, A. Infante Moro, and J. C. Infante Moro Eds. Huelva, España: United Academic Journals, 2019, pp. 44-47.

[63] B. I. Imasogie, G. M. Oyatogun, and K. A. Taiwo, "Enhancing Gender Balance in Engineering Education and Practice," in *2018 World Engineering Education Forum - Global Engineering Deans Council (WEEF-GEDC)*, Albuquerque, NM, USA, 2018: IEEE, pp. 1-8, doi: 10.1109/WEEF-GEDC.2018.8629657.

[64] M. G. Ballatore *et al.*, "Increasing gender diversity in STEM: A tool for raising awareness of the engineering profession," in *Proceedings of the 7th International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM 2019) (León, Spain, October 16-18,*

2019), M. Á. Conde-González, F. J. Rodríguez Sedano, C. Fernández Llamas, and F. J. García-Peñalvo Eds. New York, NY, USA: ACM, 2019, pp. 216–222.
[65] K. A. Kim, A. J. Fann, and K. O. Misa-Escalante, "Engaging Women in Computer Science and Engineering: Promising Practices for Promoting Gender Equity in Undergraduate Research Experiences," *Trans. Comput. Educ.*, vol. 11, no. 2, pp. 1-19, 2011, doi: 10.1145/1993069.1993072.
[66] J. L. White and G. H. Massiha, "The Retention of Women in Science, Technology, Engineering, and Mathematics: A Framework for Persistence," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 5, no. 1, pp. 1-8, 2016, doi: 10.11591/ijere.v5i1.4515.
[67] L. Salas-Morera, A. Cejas Molina, J. L. Olivares Olmedilla, L. García-Hernández, and J. M. Palomo-Romero, "Factors Affecting Engineering Students Dropout: A Case Study," *International Journal of Engineering Education*, vol. 35, no. 1, pp. 156-167, 2019.
[68] *Statutes of the University of Salamanca*, 2011.
[69] *Action plan for promoting equality between men and women*, 2008.
[70] Unidad de Igualdad, "Análisis de las asignaturas sobre género impartidas por la USAL/Competencias en materias de igualdad de género," University of Salamanca, Unidad de Igualdad, University of Salamanca, 2017. [Online]. Available: https://igualdadefectivablog.files.wordpress.com/2017/05/asignaturas-sobre-gecc81nero-impartidas-por-la-usal.pdf
[71] A. García-Holgado, F. J. García-Peñalvo, and M. J. Rodríguez-Conde, "Pilot experience applying an active learning methodology in a Software Engineering classroom," in *2018 IEEE Global Engineering Education Conference (EDUCON), (17-20 April 2018, Santa Cruz de Tenerife, Canary Islands, Spain)*. USA: IEEE, 2018, pp. 940-947.
[72] A. Vázquez-Ingelmo, A. García-Holgado, F. J. García-Peñalvo, and M. J. Rodríguez-Conde, "Resultados preliminares tras tres años aplicando aprendizaje basado en proyectos en ingeniería del software," in *Aprendizaje, Innovación y Cooperación como impulsores del cambio metodológico. Actas del V Congreso Internacional sobre Aprendizaje, Innovación y Competitividad. CINAIC 2019 (9-11 de Octubre de 2019, Zaragoza, España)*, M. L. Sein-Echaluce Lacleta, Á. Fidalgo Blanco, and F. J. García-Peñalvo Eds. Zaragoza, Spain: Servicio de Publicaciones Universidad de Zaragoza, 2019, pp. 692-697.
[73] A. García-Holgado, A. Vázquez-Ingelmo, F. J. García-Peñalvo, and M. J. Rodríguez-Conde, "Improvement of learning outcomes in software engineering: active methodologies supported through the virtual campus," *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje*, vol. 16, no. 2, pp. 143-153, 2021, doi: 10.1109/RITA.2021.3089926.
[74] F. J. García-Peñalvo, A. García-Holgado, A. Vázquez-Ingelmo, and J. C. Sánchez Prieto, "Planning, communication and active methodologies: Online assessment of the software engineering subject during the COVID-19 crisis," *RIED. Revista Iberoamericana de Educación a Distancia*, vol. 24, no. 2, pp. 41-66, 2021, doi: 10.5944/ried.24.2.27689.
[75] K. Lewin, "Action research and minority problems," *Journal of social issues*, vol. 2, no. 4, pp. 34-46, 1946.
[76] M. Suárez Pazos, "Algunas reflexiones sobre la investigación-acción colaboradora en la educación," *Revista Electrónica de Enseñanza de las Ciencias*, vol. 1, no. 1, pp. 1-17, 2002.
[77] J. W. Creswell, *A concise introduction to mixed methods research*. SAGE publications, 2014.
[78] A. García-Holgado, J. Mena, F. J. García-Peñalvo, and C. S. González, "Inclusion of gender perspective in Computer Engineering careers: Elaboration of a questionnaire to assess the gender gap in Tertiary Education," in *2018 IEEE Global Engineering Education Conference (EDUCON), (17-20 April 2018, Santa Cruz de Tenerife, Canary Islands, Spain)*. USA: IEEE, 2018, pp. 1547-1554.
[79] A. García-Holgado *et al.*, "Estudio piloto sobre la percepción de la brecha de género en estudios de ingeniería informática," in *Aprendizaje, Innovación y Cooperación como impulsores del cambio metodológico. Actas del V Congreso Internacional sobre Aprendizaje, Innovación y Competitividad. CINAIC 2019 (9-11 de Octubre de 2019, Zaragoza, España)*, M. L. Sein-Echaluce Lacleta, Á. Fidalgo Blanco, and F. J. García-Peñalvo Eds. Zaragoza, Spain: Servicio de Publicaciones Universidad de Zaragoza, 2019, pp. 698-703.
[80] A. B. González-Rogado, M. J. Rodríguez-Conde, S. Olmos-Migueláñez, M. Borham, and F. J. García-Peñalvo, "Key factors for determining student satisfaction in engineering: A regression study," *International Journal of Engineering Education (IJEE)*, vol. 30, no. 3, pp. 576-584, 2014.
[81] A. B. González Rogado, "Evaluación del impacto de una metodología docente, basada en el aprendizaje activo del estudiante, en computación en ingenierías," Departamento de Didáctica, Organización y Métodos de Investigación, Universidad de Salamanca, Salamanca, España, 2012. [Online]. Available: http://hdl.handle.net/10366/121366
[82] A. García-Holgado, C. S. González-González, and F. J. García-Peñalvo, "Gender gap perceptions of computing students: a case study in two Spanish universities," in *2020 X International Conference on Virtual Campus (JICV)*, C. S. González González, A. Infante Moro, and J. C. Infante Moro Eds. Tetouan, Morocco: IEEE, 2020, pp. 10-14.
[83] C. Lacave, A. I. Molina, A. García-Holgado, and C. S. González-González, "Delving into gender gap perceptions of computing students: A replication study," in *Proceedings of the Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'21) (Barcelona, Spain, October 26-29, 2021)*, M. Alier and D. Fonseca Eds. New York, NY, USA: ACM, 2021, pp. 103-108.
[84] Naciones Unidas. "Lenguaje inclusivo en cuanto al género." https://www.un.org/es/gender-inclusive-language/toolbox.shtml (accessed 18 Mayo, 2022).
[85] A. García-Holgado, A. Vázquez-Ingelmo, S. Verdugo-Castro, C. S. González, M. C. Sánchez-Gómez, and F. J. García-Peñalvo, "Actions to promote diversity in engineering studies: a case study in a Computer Science Degree," in *2019 IEEE Global Engineering Education Conference (EDUCON), (9-11 April 2019, Dubai, UAE)*. USA: IEEE, 2019, pp. 793-800.
[86] C. Fiesler, N. Garrett, and N. Beard, "What Do We Teach When We Teach Tech Ethics? A Syllabi Analysis," presented at the Proceedings of the 51st ACM Technical Symposium on Computer Science Education, Portland, OR, USA, 2020.
[87] O. Nasir, S. Muntaha, R. T. Javed, and J. Qadir, "Work in Progress: Pedagogy of Engineering Ethics: A Bibliometric and Curricular Analysis," in *2021 IEEE Global Engineering Education Conference (EDUCON)*, 21-23 April 2021 2021, pp. 1553-1557, doi: 10.1109/EDUCON46332.2021.9453923.
[88] M. J. Casañ, M. Alier, and A. Llorens, "Teaching Ethics and Sustainability to Informatics Engineering Students, An Almost 30 Years' Experience," *Sustainability*, vol. 12, no. 14, p. 5499, 2020, doi: 10.3390/su12145499.
[89] C. Fiesler. "Tech Ethics Curricula: A Collection of Syllabi." Medium. https://medium.com/@cfiesler/tech-ethics-curricula-a-collection-ofsyllabi-3eedfb76be18 (accessed 25 de agosto de 2021, 2021).
[90] ACM and IEEE Computer Society, *Computer Science Curricula 2013*. 2013.
[91] A. García-Holgado *et al.*, "Development of a SPOC of Computer Ethics for students of Computer Science degree," in *2021 XI International Conference on Virtual Campus (JICV)*, A. García-Holgado, F. J. García-Peñalvo, C. S. González González, A. Infante Moro, and J. C. Infante Moro Eds. USA: IEEE, 2021.
[92] S. Verdugo-Castro, A. García-Holgado, and M. C. Sánchez-Gómez, "The gender gap in higher STEM studies: a Systematic Literature Review," *HELIYON*, 2022, doi: 10.1016/j.heliyon.2022.e10300.
[93] J. B. Main and C. Schimpf, "The Underrepresentation of Women in Computing Fields: A Synthesis of Literature Using a Life Course Perspective," *IEEE Transactions on Education*, vol. 60, no. 4, pp. 296-304, 2017, doi: 10.1109/TE.2017.2704060.
[94] E. Leo-Rhynie, *Gender mainstreaming in education: a reference manual for governments and other stakeholders*. Commonwealth Secretariat, 1999.

Alicia García-Holgado received the degree in Computer Sciences (2011), a M.Sc. in Intelligent Systems (2013) and a Ph.D. (Cum Laude) (2018) from the University of Salamanca, Spain. She is Associate Professor at the Computer Science Department and member of the GRIAL Research Group of the University of Salamanca since 2009, where she currently leads the research line "Social Responsibility and Inclusion". Her research is related to the development of technological ecosystems for knowledge and learning processes management in heterogeneous contexts, and the gender gap in the STEM areas. She is also a member of the Women in Computing Committee of the Scientific Society of Spanish

Informatics and coordinator of the CLEI (Latin American Centre for Computer Science Studies) Community for Latin American women in computing. She is a member of IEEE and AMIT (Spanish Association of Women Researchers and Technologists).

Andrea Vázquez-Ingelmo received her bachelor's degree in Computer Science from the University of Salamanca (USAL), in 2016, her master's degree in Computer Science (USAL) in 2018, and her Ph.D. degree in Computer Science (USAL) in 2022. She is a member of the Research Group of Interaction and eLearning (GRIAL) since 2016. She is lecturer in the Computer Science Department at the University of Salamanca. Her area of research is related to human-computer interaction, software engineering, data visualization, and machine learning applications.

Francisco José García-Peñalvo holds a PhD in Computer Science (2000, USAL). He is a Full Professor in the Department of Computer Science at the Universidad de Salamanca (USAL). Since 2006 he is the director of the USAL-recognised research group GRIAL, a group that is a Consolidated Research Unit of the Junta de Castilla y León (UIC 81). He received the Gloria Begué Award for teaching excellence in 2019 and the María de Maeztu Award for research excellence in 2023. For more detailed information on publications, these are the links to the Google Scholar (http://goo.gl/sDwrr0), (https://www.webofscience.com/wos/author/record/D-5445-2013) or Scopus (https://www.scopus.com/authid/detail.uri?authorId=16031087300) profiles.