Women, Science and Technology Chair - Promoting women's careers in STEM fields

Gurutze Pérez
Public University of Navarre
Pamplona, Spain
gurutze.perez@unavarra.es

Marisol Gómez
Public University of Navarre
Pamplona, Spain
marisol@unavarra.es

Patricia Aranguren
Public University of Navarre
Pamplona, Spain
patricia.aranguren@unavarra.es

Edurne Barrenechea
Public University of Navarre
Pamplona, Spain
edurne.barrenechea@unavarra.es

Leyre Catalán
Public University of Navarre
Pamplona, Spain
leyre.catalan@unavarra.es

Silvia Díaz
Public University of Navarre
Pamplona, Spain
silvia.diaz@unavarra.es

Aranzazu Jurío
Public University of Navarre
Pamplona, Spain
aranzazu.jurio@unavarra.es

Alicia Martínez
Public University of Navarre
Pamplona, Spain
alicia.martinez@unavarra.es

Nora Millor
Public University of Navarre
Pamplona, Spain
nora.millor@unavarra.es

Amalia Ortiz
Public University of Navarre
Pamplona, Spain
amalia.ortiz@unavarra.es

Idoia San Martín
Public University of Navarre
Pamplona, Spain
idioa.sanmartin@unavarra.es

***Abstract*— The Chair of Women, Science and Technology of the Universidad Pública de Navarra (UPNA) aims to increase the participation of women in the fields of science and technology. Scientific culture and dissemination are the main focus of the different actions of the Chair. These activities include: the theatrical performance "Yo quiero ser científica", experimental workshops and conferences and exhibitions for all audiences and ages. More than 6000 people have seen the play, more than 1500 secondary school students have participated in the workshops and the audiovisual material has received more than 20.000 visits.**

Keywords— STEM, gender gap, science outreach

I. Introduction

Science and technology are part of our lives and our culture. Everyone has the right to enjoy the results of scientific progress, and the dissemination of science is necessary to ensure this. In turn, the responsibility that universities have in the dissemination of science is clear (Universities Organic Law 6/2001 of Spain), and from this responsibility comes the first motivation to create this Chair.

The gender gap in STEM (Science, Technology, Engineering, Mathematics), especially in engineering and technology, is a problem that is being addressed internationally. A study of the CORDIS and Erasmus+ databases shows that Italy and Spain are the countries with the highest number of initiatives aimed at reducing the gender gap in different contexts [1].

Female participation in STEM curricula ranges from less than 1% in the Maldives to 41% in Oman. In 2017, in OECD countries, only 20% of new entrants to short tertiary degrees and 30% of new entrants to bachelor's degrees in science, technology, engineering and mathematics were female (UNESCO, 2020a). In Spain, women accounted for 24% of A-level researchers in science and technology in 2021[2]. The decline in scientific careers among women occurs internationally and in Spain is embodied in documents such as the "White Paper. Situación de las Mujeres en la Ciencia Española" ([3]) where it is reflected that despite the fact that already in 2007 the female university population was 54.5%, the percentage in engineering degrees decreased by 30%, a figure that has not changed today. According to the enrollment data of the Public University of Navarra for the academic year 2021/22, in the School of Industrial, Computer Science and Telecommunications Engineering, the percentage of women enrolled was 21%, while in the degree in Computer Science Engineering it was 17% and in the degree in Mechanical Engineering it was 13%. Looking at the trend over the last five academic years and analyzing some of the most gender-biased fields of study, there is little variation. Degrees such as Nursing, Teaching or Sociology have a very female student body, while some of the engineering degrees such as Computer Engineering, Mechanical Engineering or Electrical and Electronic Engineering have a very low percentage of women among their students.

The data show that this situation does not recede as the number of women in the university increases, and extraordinary measures are needed. The lack of role models is one of the causes identified by various studies, along with the prevalence of stereotypes [4].

Moreover, in the 2030 Agenda for Sustainable Development adopted by the United Nations Assembly, education and gender equality are an integral part of the action plan, as is the way we address climate change, protect biodiversity or manage limited water resources.

Taking into account all the previous considerations, the Chair of Women, Science and Technology of the Public University of Navarra (UPNA) was created in 2019, through a collaboration agreement between the UPNA and the Government of Navarra, with the objective of improving the participation of women in science and technology and increasing their contribution to the research developed in

them. This objective will be achieved through various outreach activities.

If true gender equality is to be achieved, it is important for society to know how women have contributed to the development of society and their participation in history. There is a general consensus that the lack of knowledge about this fact means that STEM degrees have maintained a male face and that stereotypes and prejudices about the abilities of young women in this field have been reinforced ([5], [6]). Other studies show that science education in childhood and adolescence promotes more scientific careers among young women ([6], [7], [8]).

Thus, outreach serves to bring citizens closer to women researchers of all times who do not appear in textbooks. Throughout the world, different types of associations, companies and organizations have carried out and continue to carry out outreach activities to give visibility to the role of women in science and technology ([9], [10]).

II. Actions

Between 2019, the year of the creation of the Chair, and 2022, various outreach activities will be launched, focusing on different age groups. The main activities are numbered in Fig. 1 and described in turn below.

Target audience	Actions	Timing	Performances
Children's	Theatre "I want to be a women scientist"	2 performances / month	5 years old
	Competition	1 competition / year	4 years
	Educational guides	On line since 2021	One
	Virtual Escape	Online since 2021	One
	Experimental workshops	4 events / year	2 years
Youth	workshops - mentoring	3 workshops / group / course	3 years
	Audiovisual material	1 video/year	2 years
	Illustrated panels	1 center / month	Newly inaugurated
Pre-University Students and Adult Audience	Audiovisual	2 videos / year	4 years
	Women, Science and Technology Week	1 month/year	4 years
	TFG/TFM poster competition	1 event/year	4 years

Fig. 1. Promotions, Target Audience, Timing, and Issues.

A. *Theater performance "I want to be a women scientist"*

This play, written and performed by UPNA professors, is aimed at elementary school students and has several objectives. On the one hand, to tell a very unknown part of history, the one in which the protagonists are women. Women from different periods are chosen, from Hypatia of Alexandria (5th century) to Maria Sibylla Merian (17th century) or Ada Lovelace (19th century) to Margarita Salas (21st century), in order to combine important historical moments with scientific discoveries and personal circumstances that help the public to understand the difficulties of women, out of the ordinary, who contributed to the advancement of science and technology and who are largely unknown. According to some studies, such as that of [11], the low presence of women in textbooks is confirmed, with an overall appearance percentage of only 12.8%. In the face of the apparent concealment of women in the history of history, this project of culture and dissemination seeks to alleviate this circumstance.

On the other hand, in addition to the objective of disseminating history, the aim is to add an action that helps to educate about equal opportunities and abilities, showing that the ability to engage in any profession, whatever the field, does not differ according to gender. Finally, it seeks to create role models for those girls who may want to dedicate themselves to any field of science and technology and who may falter because they have no one in whom to reflect.

The structure of this theatrical performance is divided into two parts. In the first, a series of interlinked monologues are presented, in which the different actresses appear on stage, coming out of a time machine that projects images. Each actress is a different women scientist who addresses the audience during her participation in the play, telling what her life has been like and what contributions she has made. The scientists (Figure 2) represented in the year 2022 are Hypatia of Alexandria, Maria Sibylla Merian, Ada Lovelace, Sophia Kovalévskaya, Emmy Noëther, Marie Sklodowska-Curie, Edith Clarke, Klara von Neumann, Hedy Lamarr and Margarita Salas. In the second part, the actresses become the researchers they are in the present and show something of their lives in a conversation in which they all participate at the same time and raise questions from the audience.

Fig. 2. Actresses of the play "Yo quiero ser científica" (I want to be a women scientist), representing the scientinsts in the story.

The system that has been followed to attract primary school students is to open registration dates every 6 months, with morning sessions in which a maximum capacity of 250 people is accepted. All the schools in Navarre are informed by e-mail. This activity has its own web page where it is disseminated through short also summaries about the women scientists and short videos (less than a minute) that give some information. These videos are also available on YouTube (see [12]).

B. *Experimental workshops in compulsory secondary education*

Capturing the attention of young people between 12 and 16 is a challenge, and to achieve this, we sought more participatory dissemination actions led by people close to this target group, who "speak the same language" as the target audience. In 2020, 6 working teams were formed with 12

women mentors to give workshops in 2nd and 3rd grade. In 2021 and 2022, more women mentors, and students from 1st and 4th High School were added to cover the entire training period of this cycle. Figure 3 shows one of the workshops held at High School Padre Moret-Irubide.

The workshops cover disciplines ranging from chemistry to artificial intelligence, renewable energies, biomedical engineering and electromagnetism. The women mentors who teach them are specialists and researchers who work in these fields on a daily basis. In each course, two different workshops are held, and the groups that advance each year receive new workshops that build on the previous ones. Some of the workshops that have been carried out are the following:

- Interactive game about atomic orbitals
- Using mathematics to improve medical imaging
- What do you consume in a day? Calculating the impact of our activities on energy consumption
- Experimenting with redox reactions
- Using ultrasound sensors in rehabilitation
- Design a wind turbine
- Build a chemical traffic light
- Cybersecurity and Cryptography
- Build a Miniature Bullet Train
- Build your own thermoelectric generator
- Configure a Neural Network on Your Computer
- Develop a solar tracker
- Learn how a magnetic brake works on a freefall attraction

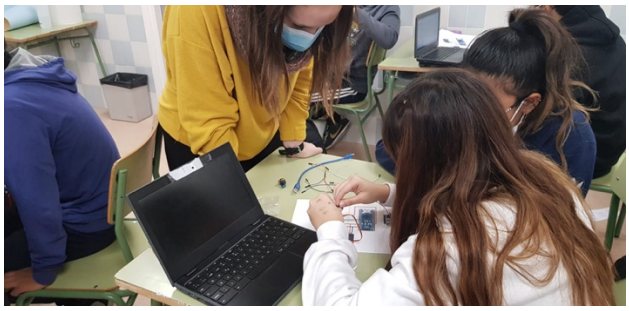

Fig. 3. Workshop at the Padre Moret-Irubide Institute.

C. *"I want to be a women scientist" contest*

With the idea of consolidating the knowledge and curiosity of the audience of the theatrical performance in elementary schools, the competition "I want to be a women scientist" is launched. This is a competition for elementary school students, in which they can participate by submitting works in any format (drawings, videos, presentations, murals, essays, etc.) and must be centered on the theme of science. In addition to a prize, the winning children and their classes will be invited to participate in a Science Day at UPNA, where they will carry out experimental workshops.

In 2020, due to the pandemic, it was not possible to hold the award ceremony, and a video with some details of the works and winners was edited, which can serve as an idea of the work done by these children (see [13]).

The quality and number of works received, as well as the variety of formats and the enthusiasm of the children who participate, make this action one of the most interesting and important. In the last edition, in 2022, 91 works from 14 different schools were submitted.

D. *Experimental workshops for primary education*

These experimental workshops consist of a series of activities divided into 2 educational levels (Level 1 from 1st to 3rd grade and Level 2 from 4th to 6th grade), developed under a "hands on" methodology of active learning. The main objective is to teach students the basic concepts of technology by putting them at the center of learning through experimentation. With this system, the goal is to introduce children to some complex concepts through simple experiments. Some examples are building a dump truck to teach hydraulics concepts, using a bee-shaped robot to learn about computer programming, learning about electronics by making LED postcards, mixing robotics and art in automatic drawing elements, or building a tightrope walker to learn about mechanics and balance. Figure 3 shows a moment from the programming workshop.

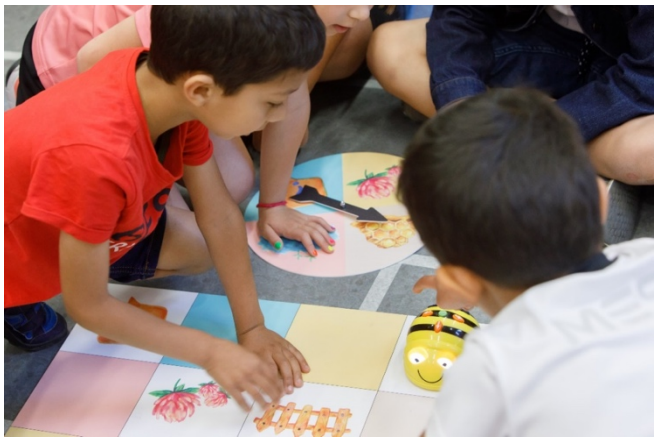

Fig. 4. Kids Programming Workshop.

These workshops are usually held at the UPNA facilities, although sometimes they are held in the center of Pamplona for families.

E. *Didactic guides and virtual escape*

Through the web page of the Chair ([14]), didactic material has been created in 2021, so that it is available free of charge and can be used by anyone and especially by primary school teachers who may want to deal with these topics in their classrooms. They are didactic guides, in Spanish and Basque, divided into two levels of difficulty, category 1 (1st, 2nd and 3rd grades of primary school) and category 2 (4th, 5th and 6th grades of primary school), which allow them to learn information about women scientists in history and propose experiments and games that allow them to get a little closer to them.

The guides are structured in time in three blocks: past, present and future, in order to consider the work developed by the women scientists represented in the game, that of the women scientists who interpret them, and activities to promote scientific vocations among students, researchers and scientists of the future.

Each didactic unit is structured as follows:

- What did you know about them?
- Biographical sketch
- Contributions, discoveries and researches
- Experiences
- Play and expression

On the other hand, and also with two different levels of difficulty, there is a virtual escape in which the participants have to make the light return by turning on different light bulbs representing a series of women scientists who have remained invisible.

F. Final project Poster contest

The work done by some undergraduate and graduate students to complete their studies is of great scientific and social interest, and with the aim of disseminating it, this competition was created. The objective is for the participants to create a poster that summarizes the most important aspects of their research work in the simplest way possible, serving as a tool to explain a complex work in just a few minutes.

Female students from various science and engineering disciplines will present their work in this format, telling the people attending the Dissemination Day what they have done in 5 minutes. Two prizes will be awarded per category (Bachelor and Master). Highly specialized and complex topics are disseminated to all audiences. As an example, to get an idea of the topics that will be disseminated through this action, some titles of the posters presented during 2019, 2020 and 2021 are: "Analysis and implementation of feature extraction methods for emotion recognition using biosignals", "Design and development of a thermoelectric generator to exploit high enthalpy geothermal anomalies in Timanfaya National Park", "Biosmart control of ventilation systems using heat recovery", "Design and computational analysis of the mechanical properties of a new prototype of a customizable and 3D printable stent", "Zero Carbon Challenge: Wind power plants with energy storage system".

Until 2022, the dissemination event with all the contestants will be held in the UPNA facilities and the awards ceremony in the Ibn Ezra room of the Pamplona Planetarium. This change of venue aims to bring these works closer to the whole of society. With the same objective, in the 2022 edition, the whole event will take place during the European Night of Researchers, so that the informative posters will be exposed in the center of Pamplona for a few hours for consultation.

Once again, this action combines the objective of cultural and scientific diffusion with that of increasing the visibility of women working in technology and science.

G. Women, Sciende and Technology Week and audiovisual resources

The named “Women, Science and Technology Week” encompasses different activities that are concentrated on a few days of the year and that, in turn, aim to disseminate and, at the same time, provide society with female scientific role models.

The format of this week has varied over the years, maintaining the idea of disseminating scientific topics taught in locations in the center of Pamplona aimed at an adult audience. The activities organized consist of round tables with the participation of women professionals in fields such as research, entrepreneurship, biomedical engineering and renewable energies, and conferences given by a single woman expert in one of the topics. In recent years (2020, 2021), we have moved from the only in-person format in 2019 to the virtual format, broadcasting the conferences by streaming in 2020, and to the mixed format, in-person and deferred in videos posted on YouTube in 2021.

The circumstances that have arisen since 2020 have meant that attendance at these conferences is not as high as desired, and the format presented this week for 2022 is significantly different. Experimental workshops for families will be organized under the name "Do science in family", conferences aimed at high school students with topics such as "How machines learn", "NOBEL women", "What is the best place in a concert queue?", dissemination from the arts, with theatrical improvisations and guided tours of research laboratories, aimed at students of the experience classroom. In this way, the aim is to cover different age groups with actions that arouse the interest of the target audience and achieve both the objective of dissemination and that of making women in science and technology visible, from a more participatory idea.

In addition to the videos of the talks given during the week, there are other audiovisual resources, such as the trailer of the play "Yo quiero ser científica" (I want to be a women scientist) or the song "Busca en la Ciencia" (Searching in Science), recorded during the confinement, which, by mixing music, mystery and humor, achieve the effect of disseminating information in a simple and entertaining way.

In addition, a series of videos featuring young female engineers talking about their experiences has been launched. The first video is called "What if you could change the future?

The purpose of these videos is to introduce today's youth to female engineers from a personal perspective and experience.

H. Traveling exhibition of illustrated panels

In November 2022, a traveling exhibition of informative panels will be shown in secondary schools in Navarre. These panels will represent, through illustrations accompanied by short texts, 10 women scientists in the history of humanity. The aim of this action is to combine science and history with art, and to combine the story of these women with the appeal of illustrations designed for young people.

III. Results

After four years of uninterrupted activity, the actions carried out and the people who participated in them were numerous.

Since the "I want to be a women scientist" theatrical play had been launched before the creation of the Chair, we were sure of the success of this activity among primary schools and part of the qualitative result was reflected in the series of questions of the final part and the surveys received from the schools. The implementation of this theatrical performance in 2017 was complex and required a very high commitment in hours. The writing of the script, the creation of the set, the costumes, the rehearsals, required several months of work by the nine women researchers involved, who had never worked on such a project before. It also required the collaboration of

other people outside the cast, such as the director of the UPNA theater group, audiovisual technicians, set designers, and the Creanavarra School, which collaborated in the creation of the costumes. Based on the success of this first action, the Chair served as an umbrella to generate other activities that allowed reaching other audiences of different ages.

The selection of activities has been made through the reflection of a working group formed by women professors and researchers of the UPNA, which was subsequently approved by the Joint Monitoring Committee formed by representatives of the UPNA and the Instituto Navarro para la Igualdad, the funding entity of the Chair between 2019 and 2022. The goal was to reach out to different age groups, so a range of activities was created that allowed workshops for young adolescents, lectures and round tables for adults, theater and workshops for children, and a competition for young university graduates. Perhaps the most difficult audience is that of young people between 13 and 17 years of age, and we have tried to bring audiovisual resources that could be viewed from computers and cell phones, although this year we inaugurated an exhibition of panels of scientists in history with illustrations considered appropriate for this age group. Another critical point was to bring the adult public closer to the various lectures organized. After the pandemic, the number of attendees decreased, and in the 2022 edition of Women, Science and Technology Week, it was decided to give this event an important turn by replacing these lectures with scientific workshops for adults and shows. It was a success.

Another obstacle that had to be overcome was the commitment required to sustain this type of action over time. The people who have worked in this chair have had to combine their teaching, research and often management work with these dissemination actions, which require a considerable amount of time. Personal motivation, the certainty of the need to change some stereotypes that persist in the society of the 21st century, has been the main driving force, but it would be desirable to have a greater recognition of this type of outreach work in the context of universities.

The quantitative results of the actions carried out by the Chair of Women, Science and Technology between its creation and the year 2022 can be summarized in the following tables:

Year	No. performances	No. att. Prim. schools	Audience	No. submitted projects
2019	15	27	2700	-
2020	5	7	745	131
2021	10	16	1191	20
2022	12	25	2800	91
Total	**42**	**75**	**7436**	**242**

Fig. 5. Impact of the play “I want to be a women scientist”.

It has already been mentioned that the preparation and performance of the play "Yo quiero ser científica" preceded the creation of the Chair of Women, Science and Technology, and therefore the total number of spectators is higher than what appears in this table. In this article, only the data from 2019, the year of the creation of the chair, are collected. As already mentioned in the section on Actions, this activity is mainly aimed at primary schools, although data are included for some performances open to all audiences and held in the afternoons at the Pamplona Planetarium, the Gayarre Theatre and civic centers in towns such as Sangüesa, Estella, Olite, etc. This table also includes the number of entries received in the "I want to be a women scientist" competition for primary schools.

Year	No. mentors	No. primary levels	No. groups	No. female students	No. male students	Total No. of students
2020	12	2	32	293	315	608
2021	15	3	49	479	519	998
2022	16	3	50	495	523	1018

Fig. 6. Impact of experimental workshops at ESO.

The action of mentoring and experimental workshops aimed at secondary education was launched one year after the creation of the Chair and the evaluation of the results will be made at the beginning of the year 2023, so the influence it may have had on the enrollment data in scientific-technological baccalaureate or vocational training choices is not included in this article. We only include data on the impact on the number of groups and people who participated in the workshops.

Regarding the didactic guides and the virtual escape, the motivation to offer these resources came from the demand of teachers who participated in the play with their kindergarten and primary school students. These teachers indicated to us that experiences based on games, tools, and techniques that can evoke emotions, motivate, and promote attention, arouse curiosity, and facilitate learning [15]. In this game, through puzzles and challenges, participants go through screens until they reach the end and discover all the scientists. Once they start the game, they have one hour to complete it. Again, this informative resource is geared toward elementary school students and can be played at home or at school.

The goal of both Women, Science and Technology Week and the poster competition is to increase the visibility of women working in STEM fields. The impact of both activities is measured by the number of women who participated as disseminators. No data was collected on the number of participants, but the videos that resulted from the various talks given during these weeks have more than 3000 views. In addition to these videos, other videos have been disseminated through the Chair, such as a trailer of the theater, which provides a brief glimpse of the women scientists in history represented in the theater, as well as the small informational videos about scientific women. These videos have more than 37000 views.

Numerical data can be used to partially assess the impact of the dissemination activities carried out. However, the qualitative evaluation is more difficult to measure and we only have tools such as surveys and the impressions of the protagonists of the actions carried out. In both cases, the results are very satisfactory and we note that each of the dissemination activities carried out has been evaluated very positively, both by the people who receive it and by those who carry it out.

In the surveys of the primary schools that participate in the play, we find that all of them say that "the students learn something new" and that they consider this activity to be entertaining or fun. Some of the comments received from the centers are: "It is attractive and allows them to leave the school environment to receive motivating contributions" (Azpilagaña), "It is an interesting activity that makes women's science visible. It is a different theatrical format that the

students are not used to". (Colegio La Presentación FESD). "It is very interesting to combine theater with biographies of women scientists. We encourage you to continue in this direction. Thank you for spreading science in such a pleasant way. (Sisters Úriz Pi), "We loved it, the students enjoyed it very much and some of them are only 6 years old, we were surprised that they were so attentive. An entertaining and very well done play. Thank you very much." (Luis Amigó School). Some suggestions that have been received are: "We would like you to arrange for us to visit the university to see the real work of the people who participated in the play." (Buztintxuri), "It would be interesting if you could provide us with a brochure or website with the names of the women scientists we work with before and after the performance. They are little known names and the students did not remember them (but they remembered details like the butterflies, the skater...) (Sisters Úriz Pi). These comments have given rise to subsequent actions such as the website with information about the scientists, the experimental workshops, the didactic guides, the virtual escape or the videos.

The number and diversity of people reached, especially in terms of age, is significant. We have worked mainly in Navarre, although some of the plays have been performed in neighboring communities, such as La Rioja, and the idea is to continue expanding the range of activities to reach a wider audience. In order to achieve this, it will be necessary to obtain the appropriate funding and the commitment of a significant number of people who want to participate in this project.

IV. Conclusion

The culture and dissemination of science are key to building a free, informed, educated, and prepared society for the future. The difficulty of attracting people far from these fields to dissemination activities is high due to the label of difficulty that still prevails, although interest is growing and many people are approaching activities that promote scientific culture.

The success of the actions aimed at children is clear, with theatrical registrations always full and high participation in the competition. Moreover, the impact of this education on the new generations is essential to guarantee freedom of choice, equal opportunities and abilities. Therefore, there is no doubt about the continuity in this direction.

Despite the difficulty of reaching the young audience, we believe that the experimental format chosen to attract their attention is the right one and, after analyzing the results, we will look for ways to expand and increase this project as much as possible.

The poster competition, with its ability to bring high-level science and technology topics to the general public, is another key activity. The number of participants remains high, considering the low enrolment of women in these fields, and the quality of the work presented is excellent. In 2022, the exhibition has been included in the European Researchers' Night and is considered a success due to the attraction effect it has and the increased impact that scheduling it on this date implies.

As for the Women, Science and Technology Week, the format has been modified for 2022 and the results will be analyzed in terms of increasing the number of people benefiting from this action.

In this way, with a few activities aimed at different audiences, the aim is to contribute a grain of sand to create references, promote the culture and dissemination of science, make visible and try to increase the presence of women in science, which in turn benefits society as a whole.

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