Women in Telecommunication Engineering: Case Studies

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***Abstract*—The enrolment of women in STEM (Science, Technology, Engineering, Mathematics) degrees and, in particular, in Telecommunication Engineering shows a decreasing trend. Among the general competences common to all the degrees taught at the School of Telecommunication Engineering (ETSIT) of University of Malaga, there is the G-01, which is the ability to assume and attitude of respecting the fundamental rights and equality between men and women. In this context, a group of professors from ETSIT has been developing, since 2018. different practical case studies to make the role of women in the technological environment more visible, both for university students and for pre-university students. This article presents both the strategies proposed and the conclusions and results obtained from them.**

***Index Terms*— Gender equality, Telecommunications engineering, Educational programs, STEM**

I. Introduction

IN 2015, the United Nations set 17 Sustainable Development Goals for all countries, regardless of their level of development, to act to protect the planet. It is worth noting that the fifth goal to protect the planet is gender equality, given that it is one of the essential foundations for building a peaceful, prosperous and sustainable world [1]. In parallel and in line with Sustainable Development Goal 9, Industry, innovation and infrastructure, technology is becoming increasingly important in all societies. The Digital Society is a reality with exponential growth. This niche market needs professionals trained in all STEM disciplines (Science, Technology, Engineering, Mathematics) [2]. Paradoxically, the number of students choosing these disciplines is decreasing at an alarming rate, making education systems have to adapt to the new times [3]. In addition, there is a gender gap in the digital sector, as shown by European Union data estimating that there are three times fewer women than men in technology and engineering degrees [4]. All administrations and organisations are working to reverse this trend. Among the measures proposed by UNESCO [5], which involve society as a whole, to encourage the interest of women and girls in STEM careers, is to make STEM women visible, so that girls have female role models.

The study plans of all the degrees of the School of Telecommunication Engineering (ETSIT) of University of Malaga (Degree in Telecommunication Technology Engineering, in Telecommunications Systems Engineering, in Electronic Systems Engineering, in Sound and Image Engineering and in Telematics Engineering), have defined transversal competences common to all of them. This has led a group of professors at the ETSIT of the University of Malaga, since 2015, to implement a series of strategies to work on transversal competences [6], [7], [8], [9], [10]. These strategies have been worked within the framework of the groups and projects of Educational Innovation of the University of Malaga (GPIE22-036, PIE19-017, PIE19-170, PIE17-021, PIE17-071, PIE15-63).

As the transversal competences have been worked on in the ETSIT degrees, it has become clear that there is a low representation of women in engineering and, in particular, in telecommunication. This is due to a general trend of low enrolment of women in STEM (Science, Technology, Engineering, Mathematics) degrees and, in particular, in engineering [11]. Moreover, numerous studies on the role of women in higher education [12], and in particular in engineering [13], highlight the great work that all actors in society are doing to improve the gender gap. However, there is still a long way to go, where there is still a need for more female role models in STEM and in particular in engineering.

Therefore, since 2018, the group of ETSIT professors, who have been working since 2015 on the improvement of transversal competences, has put value on the competence [14]:

G-01: Ability to assume and attitude of respecting fundamental rights and equality between men and women.

To this end, a wide range of strategies have been designed and implemented to make the role of women visible both inside and outside the ETSIT. It should be noted that the strategies presented in this article have been implemented in the ETSIT of University of Malaga, but in view of the results and conclusions obtained, they can be applied to all STEM degrees.

This article is an extension of the one published in TAEE2022, entitled "Visibilising women in technology: Strategies for working in Telecommunication Engineering" [15], which has been chosen to be sent to IEEE-RITA as an

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extended article, for being one of the best articles of TAEE2022. Specifically, the organization of the work has been changed to make it more accessible, and a practical case study has been included; the work carried out by the students of the degree in sound and image engineering on relevant women in audio equipment, which was the first strategy proposed in this line of work. In addition, this new article will update the results and expand the conclusions, given that the chronological analysis of the work on women has allowed us to see the evolution of the problems and concerns that women have, particularly in the case of sound and image engineering.

The article is organized as follows. Section II describes the context in which the different case studies have been implemented. Then, in section III, the background and working methods selected are presented. Section IV shows the results obtained in each of the case studies. Finally, section V presents the conclusions drawn from all the strategies proposed.

II. CONTEXT

The University of Malaga is made up of 21 centres, with the number of students enrolled between all of them, from the academic year 2016-2017 to 2022-23, exceeding 33,000 students each academic year. The number of students enrolled, in these same courses, in the ETSIT, has always been of the order of 1200. Fig. 1 shows the distribution of UMA and ETSIT students by year and gender. This figure shows the large difference between men and women in the School of Telecommunications Engineering, compared to the overall data of University of Malaga.

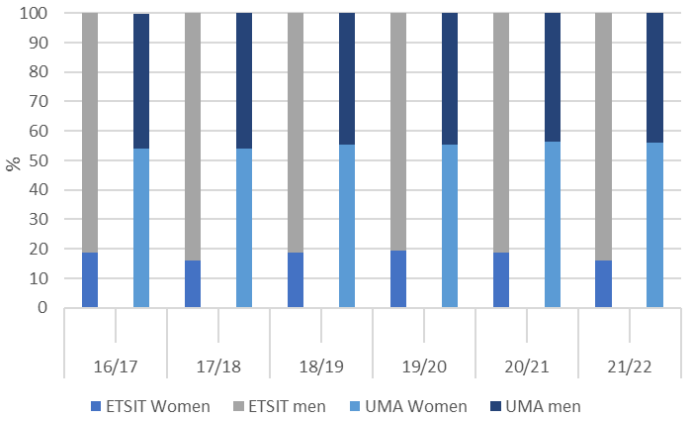

Fig. 1. Comparison of the percentage of students by sex and year in the ETSI of Telecommunications and in the University of Malaga (UMA) as a hole.

The students involved in this study are a significant sample of students from the five degrees taught at the school (Bachelor's Degree in Telecommunication Technologies Engineering, in Telecommunication Systems Engineering, in Electronic Systems Engineering, in Sound and Image Engineering and in Telematics Engineering) and three of its Masters (Master's Degree in Acoustic Engineering (MIA), Master's Degree in Telecommunication Engineering (MIT) and Master's Degree in Telematics and Telecommunication Networks (MTRT)). Therefore, the gender distribution is similar to that presented in Fig. 1.

III. BACKGROUND AND WORKING METHODS

Before starting to work directly with students on competence G-01: Ability to assume and attitude of respecting fundamental rights and equality between men and women, a survey was carried out with graduate students in sound and image engineering. Specifically, students of the subject Audio Equipment, which is a core subject in the third year. The results of this survey were one of the starting points for all the working methods applied to work on the problems of women in engineering, as well as their visibility and value.

Therefore, this section will first show the initial interest of students in working on this topic and then describe the different working methods that have been used.

A. Initial student survey

In the 2016-17 academic year, for the first time in the degree course in Sound and Image Engineering, a project on "Relevant Women in Audio Equipment" was proposed. This work was proposed in the third-year core subject, which is called Audio Equipment. This is a technical subject, completely removed from any non-technical subject. For this reason, proposing this type of work broke the schemes and expectations of many of the students enrolled in this subject. This made it necessary to carry out an initial survey on the opinion of the students about carrying out this type of work. Fig. 2 shows the questions asked, and the different options given to the students.

What kind of work would you prefer to do?

As a work-exhibition, there are two options and there will be a voting round until 7 March. The options are:

a) Group work, with group exposition (20 minutes with transparencies) of the different topics proposed in class.

b) Individual work, on a relevant woman in "Audio Equipment". It would be necessary to write 1-2 pages maximum, which would then be revised for publication in a book, with the name in each chapter of each of the authors. The presentation would be individual 5 minutes.

The idea is something similar to the "Goodnight book for rebellious girls", but a bit more "long" and "technical", keeping the informative character.

If this theme is decided, a file will be created, so that all the biographies are homogeneous and, above all, avoiding any kind of plagiarism.

Fig. 2. Survey on the type of work to be done in the subject Audio Equipment.

The result of the survey was that 82% of the students preferred to do the work on "Relevant Women in Audio Equipment", compared to 18% who preferred a more technical work, in line with the syllabus of the subject.

Therefore, this was the starting point for the line of work on women in telecommunications engineering, given that it had the support of the students.

B. Works on relevant women in Audio Equipment

In order to achieve homogeneity in the work presented by the Audio Equipment students, while at the same time avoiding the direct and unworked copying of information found on the Internet, the students were given a worksheet with questions to answer in their work. These questions were aimed at highlighting the role of women in audio equipment, motivating them to work in this field as well as the difficulties they have faced. Fig. 3 shows the worksheet that the students' work had to comply with.

NAME AND SURNAME

- PHOTO (1 to 3 photos of the selected woman). They must be correctly referenced:

[Photograph of Name and Surname photographer] (Place. Year).

- YEAR AND PLACE OF BIRTH
- YEAR AND PLACE OF DEATH (IF APPLICABLE)
- ORIGINS AND PERSONAL LIFE:
  - Family: Parents' work, siblings, relatives with or without relation to music.
  - Personal situation: Married or with partner, Divorced, Children?
- PROFESSIONAL LIFE:
  - Professional evolution: Including where your "vocation" comes from.
  - Relevance within audio equipment.
  - Important milestones in your career.
- BEING A WOMAN...
  - If there is any reference to difficulties/facilities, etc. in your professional career as a woman.
- OTHER DETAILS
  - If there is anything that is considered very noteworthy and does not appear in the previous points.
- REFERENCES/BIBLIOGRAPHY
  - Write the sources from which you have obtained the information (NOT WIKIPEDIA).

Length of paper: Times New Roman 12 point 2-3 pages.
Presentation in class: 5 min approx. with *.pptx or similar.
UMA ANTIPLAGIARISM system will be used, which includes all the internet. Please do not copy!!! Work on the content!!!

Fig. 3. Survey on the type of work to be done in the subject Audio Equipment.

C. Design of posters about relevant women in Telecommunication Engineering

The poster design activity began in the 2015/2016 academic year. However, it was not until the 2017/2018 academic year when the theme was set as relevant women in telecommunication engineering, within the specific themes of the subjects that have participated in this activity. In order to carry out this activity, the students have been provided with a poster design template, in which the size A2 is fixed and simply fixes the logos and references to the educational innovation projects that include the carrying out of this activity. In addition, they are given the directive to be as creative as possible and to be written in English, in order to increase their dissemination as well as practice in this language. One month before the end of each semester, the posters presented by the students are evaluated. In this way, in May, a temporary exhibition, of the best posters in terms of both content and design, is held, open to both university and non-university audiences. In addition, in June 2021, the 40 best posters were selected and reprinted, framed and distributed among the different classrooms of the ETSIT.

D. YouTube channel: Videos of relevant women in Musical Acoustics

In November 2018, the YouTube channel, Women in Music Acoustics [9], was created. This channel has been created to contain the videos about relevant women in Musical Acoustics that have been created by the students of this subject. Musical Acoustics is an optional subject in the 4th year of the graduate degree in sound and image engineering.

The students were given the following rules for the making of the videos:

- Duration: 2 to 5 minutes.
- Language: They can be made in Spanish, but it is recommended in English or in Spanish with English subtitles.
- Audio and video copyright: students must first upload the video to their personal YouTube channel and if there are no copyright problems, it is uploaded to the official channel of the subject.
- Content and realization: Freedom is given, but students are provided with a worksheet equivalent to those in Fig.3, concerning the realization of work on relevant women in audio equipment.

E. Technology Challenge: "Engineering is written with A"

Since the 2013-2014 academic year [10], the technological challenge has been held, which has been promoted since its inception by a group of professors from the ETSIT of the UMA led by Ana M. Barbancho since 2015. From the sixth edition, which was held in the 2018/2019 academic year, the slogan "Engineering is written with an A" was set as a way of making female engineers more visible and promoting the interest of girls and young women in STEM careers and, in particular, engineering. Furthermore, in order to increase the impact of the challenge, from the 2019/2020 academic year, the challenge has been extended to include, in addition to the university category for UMA students, a pre-university category, for students in ESO, Bachillerato and Ciclos Formativos from Malaga and the province.

The organisation of the challenge involves two major tasks: the dissemination plan and the definitions of the specific

challenges. These tasks are carried out from September to June each year.

It should be noted that UMADivulga [11], the UMA's Publications and Scientific Dissemination Service, actively collaborates in the dissemination work. For dissemination, in addition to the design of posters and banners, the websites and social networks of all the institutions involved in this challenge are used: UMADivulga, ETSI Telecommunication, ATIC Group and the Department of Telecommunication Engineering.

The task to which most time is devoted every year is the selection and definition of the theme of the challenges. The success of the challenge is largely conditioned by the choice of the theme. The themes chosen for the challenges since the 2018/2019 academic year have been:

- 6th Edition (2018-2019) and 7th Edition (2019-2020): "Engineering is written with A: Technological ideas to encourage girls' and young women's interest in Engineering". The aim of these challenges was to get students to come up with ideas to get girls and young women interested in STEM studies in general and engineering studies in particular.
- 8th Edition (2020-20201): "Engineering is spelled with an A: Don't let COVID stop you from being a STEM woman". Technological ideas are sought to avoid the disadvantages that COVID is causing for many girls and young women to study, especially STEM careers.
- 9th Edition (2021-2022): "Engineering is spelled with A: Improving the lives of older people and their connectivity to the digital world". People over 65, especially women, have many problems with connectivity to the digital world, so ideas are sought to solve these problems.
- 10th Edition (2022-2023): "Engineering is written with A: Spreading technology is the future". The aim of this challenge is to write a children's story for children from 5 to 10 years old, which will allow them to learn the basic functioning of some of the telecommunication technologies or some basic concept for the functioning of these technologies.
- 11th Edition (2023-2024): "Engineering is written with A: Technological ideas to improve pet care". With the passing of the Animal Welfare Act, pet care has become a topical issue. Therefore, in this challenge we are looking for ideas, based on new technologies, that help in the care of pets and, therefore, contribute positively to animal welfare.

F. WiSMC: Women Engineering Day

Since 2019, the WiSMC conference has been organised on an annual basis. These conferences are especially aimed at pre-university students between 15 and 17 years old who have to decide what they want to study once they have finished their secondary school studies. The aim of these meetings is to present STEM careers and, in particular, engineering, as a future study option regardless of whether you are a man or a woman. In May 2019, the 1st WiSMC[12] was organised on a face-to-face basis. However, the following editions, 2nd WiSMC[13], 3rd WiSMC[14], 4th WiSMC[15] and 5th WiSMC[16], have been online. The decision to go online was forced by the pandemic. However, the last two editions could have been face-to-face, but the online format was maintained, given that, thanks to it, educational centres from villages far from the city of Malaga and from other provinces are connected. In all WiSMCs, the speakers have been women. Given that the speakers are relevant women in the field of engineering and STEM careers, students from the ETSIT have been invited to attend. From the 2nd WiSMC onwards, the "Women in SMC" section was added to the website, where podcasts of STEM women have been included, telling their experience as students and professionals in this technological context, as a way of encouraging future university students to choose this type of careers.

G. Gender study in the bibliographies of the students' works

A good way of making women visible and highlighting the differences in the participation of women in technical careers is for students to analyse the percentage of women who appear in the bibliography consulted for their work. Moreover, this idea is valid for any subject in any degree or master's degree. For this purpose, tables have been prepared (Table 1) to be filled in by the students in each of the assignments they carry out.

TABLA I
TABLES FOR THE GENDER STUDY OF THE BIBLIOGRAPHIES OF THE STUDENTS' WORKS

Reference consulted	# total number of authors	# total number of female authors	% female authors	Female first author?
Authors, title, publication ...				

# total references	# total number of authors	# total female authors	% female authors	# female first author	% references woman first author

H. Informative lectures and quizzes on women and telecommunication

In relation to the different technological challenges and as a way of presenting them, several informative conferences have been given as part of the different activities developed by the Publications and Scientific Dissemination Service of the UMA for the International Day of Women and Girls in Science. The titles of these conferences were: "Engineering is written with A: Music + ICT (2019)", "Challenge yourself in STEM: ICT + Music (2021)" and "Engineering is written with A (2022)".

In these conferences, in addition to presenting the challenge, scientific advances made by UMA research groups in Telecommunication Engineering, with a high percentage of women, were presented.

In addition, in order to evaluate the knowledge that students of the ETSIT of the UMA have about women and telecommunication, several questionnaires have been carried out with questions related to relevant women in telecommunication. These questionnaires have been uploaded

to the virtual campus platform of various subjects.

IV. Results

This section presents the results obtained in each of the case studies presented in section III. The male-female distribution of the university students who participated in this study is 90%-10%, which is similar to the typical distribution of ETSIT students. The average age of the participants in these activities was 21 years old, given that they were mainly applied to undergraduate subjects.

A. Works on relevant women in Audio Equipment

When analyzing all the work carried out by the students in this area, some very interesting data can be extracted. The first striking fact is the nationality of the women that the students have highlighted: 69% come from the USA, 10% from the UK, 7% from Spain and 14% from other nationalities. It is therefore clear that, within the field of audio equipment, the United States has been a pioneer in the incorporation of women in this area.

The profession of sound engineer is the most repeated among the relevant women chosen by the students. It is worth noting that many of them combine this profession with music composition and performance. Regarding the technical tasks performed, they are equivalent to those of the men. The chronological analysis of the technical tasks performed at the beginning includes the construction of audio equipment both for recording and for generating new sounds.

The most interesting of the information collected by the students for each of the women highlighted are the references to the difficulties they have encountered because they are women. Below, in chronological order, the most relevant information on this subject will be summarized.

From the list of women highlighted by the students, Cordell Jackson [24], [25], [26] and Daphne Oram [27], [28], can be considered among the pioneers. It is clear that they faced great difficulties and that their only way out was entrepreneurship, which led them to create their own studios and found their own record labels.

Over the years, the lives of Ann Delia Derbyshire [29], [30] and Sylvia Rosy Moy [31], [32], show that the situation had not improved much and creative women faced two major obstacles: being a woman and being creative and innovative.

The use of computers and other types of electronic devices, both to perform complex calculations and to create and record music, began in the 1940s, and women such as Laurie Spiegel [33], [34], included them in the audio chain. However, despite the passing of the years, entrepreneurship remained the refuge for women's integration problems.

Leslie Ann Jones' [35] confidence and passion for music has made her one of the few women to succeed in what remains a largely male-dominated industry. Her success has made her a role model for many engineers and the longevity of her career has become her greatest attraction. This shows that, as the years go by, the situation, although hostile at times, is beginning to stabilize, and, above all, talent triumphs.

From this point, it is clear from the statements of women such as Leanne Ungar [36] or Susan Rogers [37], that, with intelligence, despite being in a hostile environment, it is possible to benefit from being a woman in a man's world.

It is clear that the problems, difficulties and facilities of being a woman are being ironed out over the years. Furthermore, the critical mass of women working in this field is becoming increasingly noticeable and initiatives such as SoundGirls, created by Karrie Keyes [38], have emerged, offering women working in the professional audio sector a community to turn to for support and advice, as well as empowerment and inspiration.

Veronica Font [39], is one of the pioneers in Spain as a sound recordist/sound editor. At the beginning of her career, in that first studio she worked in, she was the only one of 17 male technicians. Curiously, she herself comments that she did not know any other sound recordist or sound editor at that time, as it seems that she was one of the first female sound technicians in Spain. However, she recognizes that today we do have great professionals who are much better prepared, as the training provided is notably better. Although women in the audiovisual field have arrived later in Spain, it seems that their integration has been quicker and less costly.

It is possible to glimpse that, from the 1990s onwards, the situation of women has, to a certain extent, become more normalized. However, statements such as those of Emily Lazar [40] or Olga Fitzroy [41] show that women, finding themselves in a minority, are looking for ways to help and encourage other women to work as sound engineers and to reconcile this with their families.

It is curious that, in a world of art and technology, another barrier for women engineers to corss is aesthetics. As an example, the problems of Kesha Lee [42], who breaks with the stereotypes of the working woman, in the sense of being a woman who takes great care of her appearance and gives importance to her looks. This has led even other women to advise her to change the way she dresses. These problems suggest that there exist prejudices like if you work as a technician you can't dress up, and if you are dressed up it's because you are only trying to look good.

Although the work on relevant women in Audio Equipment was an enriching experience for all the students, the possibility of carrying out a more technical work was left open. It should be noted that 4% of the students enrolled took up this option. When evaluating the opinion of the students on the performance of this work, 98% rated the experience as good or very good, leaving 2% who rated it very unfavourably, considering it totally inappropriate.

B. Design of posters about relevant women in Telecommunication Engineering

Although this activity is still ongoing, the results obtained in the first five years will be presented here. In total, 100 posters were selected for the temporary exhibitions, representing around 300 students involved, as these are works are done in teams. After the temporary poster exhibitions, a selection of 40 posters was made again, to be framed and distributed among the different teaching rooms of the ETSI

Telecommunication. In this way, a collection of high-quality posters has been achieved, which are seen daily by students and teachers of the ETSIT. In addition, interviews and questionnaires have been carried out every year with both teachers and students involved in this activity. The results obtained are:

- The posters, which were put up on the walls of the classrooms, were seen and read by all the students and teachers surveyed.
- One of the biggest difficulties in making the posters was the language, as the student find it difficult to write in English. However, students recognized that they need to work more on this type of activity.
- Both students and teachers have positively valued working on the subject of women and engineering, given that normally it is not known about the existence of relevant women in this field, which means that there are no female references.

C. YouTube channel: Videos of relevant women in Musical Acoustics

This channel, which opened in November 2018, currently consists of 21 videos. These videos are a selection of the 32 videos made by the students in the four years that this activity was planned (from the academic year 2018-2019 to 2021-2022). The total number of students involved in this activity was approximately 90. The videos uploaded to the channel were just the ones that, in addition to complying with YouTube's intellectual property rights regulations, were of good quality in terms of both content and image. The total number of views of the videos on the channel was 6445 at the time of verification, with the most viewed video being that of the Malaga orchestra conductor María del Mar Muñoz Varo with 2284 views. It can be seen that the videos related to current women have more views than those of women who are already deceased and, to a certain extent, little known, as is the case of Rosetta Tharpe with only 22 views. It is surprising, however, that the video of Imogen Heap, designer of the MiMu gloves, has only 8 views, given that it is a pioneering and very interesting system for students of sound and image. From the surveys and interviews with the students participating in this activity, the following results should be highlighted:

- The activity has been favourably evaluated by the students, although they recognize that editing the videos was very time-consuming. They are aware that this type of activity is necessary and that the subject is highly topical.
- One of the greatest difficulties for the students has been to find relevant female figures in the field of musical acoustics.
- It is the first time that they have been asked to do a project in video format at University, whereas in secondary school studies and high school studies it was a format that they used to work with.
- The students recommend that this activity continue to be carried out in the following years.

D. Technology Challenge: "Engineering is written with A"

In general, participation has increased year after year [10]. This increase is due to two fundamental reasons: the repetitiveness of the challenge, which, for the 2023-2024 academic year, will be in its eleventh edition, and the inclusion of pre-university students. However, the 2019-2020 edition, which coincided with the pandemic, saw a significant drop in participation, given that, among other factors, the dissemination of the challenge was lower than in previous years.

The main results to be highlighted from the surveys and interviews with the students participating in this activity are the following:

- The technological challenge activity "Engineering is written with A" is favourably valued by the students. In addition, the subject matter seems to them to be appropriate and highly topical.
- All the agents involved in this activity demand more publicity for this initiative so that it reaches more centres both within the UMA and in secondary school studies, high school studies and professional training.
- Although there is great room for improvement in the percentage of student participation, they call for more activities of this type, in which creativity is valued.
- The prizes are a laptop and two tablets. Despite being great prizes, the students demand more attractive prizes.

E. WiSMC: Women Engineering Day

The number of participants in the different editions of WiSMC, although with certain fluctuations, has always been more than 200 students. The number of participants in the 1st WiSMC was 300 students from 4 secondary schools in Malaga city. At the 2nd WiSMC, held in on-line format, the number of centres connected was 4, with 2 from Malaga city, 1 from the province of Malaga and 1 from the province of Seville; the number of pupils connected was over 200. Interestingly, the 3rd, 4th and 5th WiSMC, held in on-line format, had the telematic presence of 4 centres, with 2 from Malaga city, 1 from the province of Malaga and 1 from the province of Huelva. Once again, in these last three editions, the number of connected students exceeded 200. In addition, students from the ETSIT were invited to attend all the conferences, with an average of 20 students connected to these conferences.

The main results obtained, after surveying and interviewing the teachers and students attending, are as follows:

- The face-to-face format allows for better interaction of the students with the speakers. However, it has some drawbacks, like the need to travel to the site in person, the limited capacity due to the size of the room and, similarly, the more limited attendance from schools in the province of Malaga or further.
- The on-line format allows the connection with schools both in and outside the province of Malaga, which in many cases do not have the option of attending this type of event to raise awareness on the importance of women's equality and technical careers.

- Although, above all, the teachers value the presentations in English favourably, the students confess that they sometimes find it difficult to understand and that they need to practise English.
- In the first editions, some of the presentations included the topic of balancing work with family and motherhood, in order to show students that choosing studies and a technical job is not incompatible with other aspects of life. However, the responses, both from secondary school and high school students and from 4th year ETSIT students, show that motherhood and having a family is something very distant and, therefore, they were not interested in this part of the presentations.
- Despite the fact that the conferences are aimed at pre-university students, the students in the last years of their degree courses consider them to be very interesting, given that they allow them to see the different professional opportunities available in their technical studies. In addition, they see the labour market as being closer to them than students in secondary school or high school.

F. Gender study in the bibliographies of the students' works

In four different subjects, 2 undergraduate and 2 master degree courses, during three consecutive years (2018/2019,2019/2020, 2020/2021), students have been asked to fill in the gender study tables presented in Table I as part of their work. In these three courses, 76 gender study tables have been compiled from different bibliographies. Table II shows the average results obtained in these studies.

TABLA II
TABLES OF RESULTS, ON AVERAGE, OF THE GENDER STUDY OF THE BIBLIOGRAPHIES OF THE STUDENT' WORK

# total references	# total number of authors	# total female authors	% female authors	# female first author	% references woman first author
11	15	4	28%	2	15%

The results to be highlighted in this case study are:

- The students did not find, in certain works, any reference in which any of the authors were women.
- In some cases, the students had problems finding out the gender of the authors.
- The result obtained of a low percentage of women in technical works, although to be expected, was quite surprising for the students. This is clearly shown in Table II.

G. Informative lectures and quizzes on women and telecommunications

The main result obtained from the informative conferences has been to meet teachers of secondary and high schools in Malaga, who seek to keep up to date with new technologies, as well as activities to motivate students. In this way, collaborations have been initiated with secondary and high schools, which participate in the activities organised by the University for pre-university students.

The results obtained in the questionnaires on women and telecommunication show that students have some knowledge about women and technology. Fig. 4 shows an example of the grades obtained by the students in the particular case of the subject Audio Equipment (compulsory in the 3rd year, 2nd semester of the Degree in Sound and Image Engineering). It is worth highlighting the high level of participation in the questionnaire, bearing in mind that it was a voluntary activity that did not count towards the final mark.

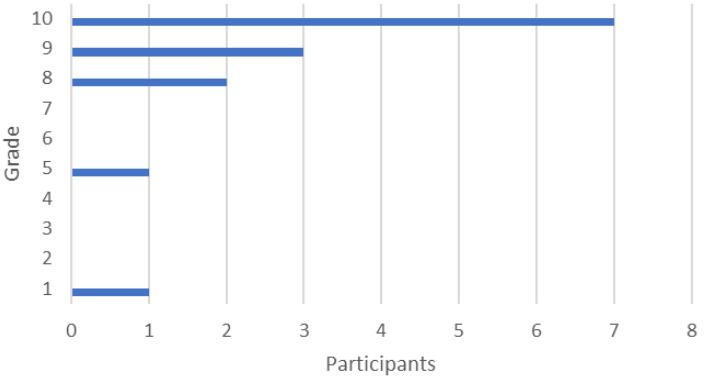

Fig.4. Grades obtained by students in the subject Audio Equipment in the academic year 2019/20 (compulsory 3rd year, 2nd year, 2nd semester, of the Degree in Sound and Image Engineering), in the questionnaires on women and telecommunication.

V. CONCLUSIONS

Many conclusions can be drawn from this work, ranging from the attitude of the students to the tasks related to women and telecommunication, to the content of the tasks carried out.

- At the beginning, students are very surprised by the proposal of activities on women and telecommunication. In general, these practical case studies are the first with this theme that they have carried out throughout their university studies at the ETSI Telecommunication of the UMA.
- Regarding the demographic data of the university students, the average age of the university students who have participated in these case studies is 21 years old, with a male-female distribution of 90%-10%, which is the typical distribution of ETSIT students. Regarding the students' grades, given that whole groups of students participated, the distribution of grades is normal for ETSI students. Therefore, the group of students does not present any notable differential characteristics.
- In the cases in which they have had to present their work, defend their posters or their proposals to the Technological Challenge, it can be seen that the students, both men and women, put interest in the realization of the work and have been involved in favour of women's equality.
- One of the greatest difficulties faced by the students in their work on relevant women in audio equipment and, above all, in musical acoustics, was to identify relevant women in these areas. Clearly, there are still many female references to be identified.

- The defense of the selected women was in many cases very interesting, as they showed their displeasure at seeing how talented women could have had problems in their work because they were women.
- In the first activity, in the 2016-17 academic year, which was carried out with the students of the ETSI in Telecommunication to work on competence G-01, 2% of the students made very harsh criticisms, as well as refusing to carry out this type of activity, given that they considered it inappropriate for a technical degree. It should be noted that this attitude has not been repeated in any of the cases presented in this article.
- A detailed analysis of the problems encountered by women in the context of audio equipment work shows how these problems have changed over the years: from being ignored, like Cordell Jackson or Daphne Oram, to being judged by the way they dress, like Kesha Lee.
- When analysing all the work done by the students on relevant women in audio equipment, a very interesting piece of data is extracted in relation to the nationality of the women: 69% are from the USA, 10% are from the UK, 7% are from Spain and 14% are from other nationalities. Therefore, it is clear that, within the field of audio equipment, the United States has been a pioneer in the incorporation of women in this area.
- Initially, the best refuge for women who wanted to go into audio technically was entrepreneurship. However, as time went by, talent, whether male or female, began to triumph.
- Despite the evolution of society in recent times, associations such as SoundGirls show that women still need to come together to help each other.
- The posters that have been distributed among all the classrooms where all the degrees of the ETSI Telecommunication are taught, have been seen and read by all the students and teachers of the centre. Therefore, it is a very effective dissemination activity on which we must continue to work.
- In the proposals presented in the VI, VII, VIII, IX and X editions of the technological challenge, whose theme was "Engineering is written with an A", the interest and respect of the students in the subject of women's equality can be seen. Furthermore, the students state that this activity works directly on the transversal competence G01: Ability to assume and attitude of respecting fundamental rights and equality between men and women.
- Participation in the Technology Challenge activity is increasing every year. This shows that it is a successful activity and that it is reaching more and more schools. Moreover, this activity is very favourably valued by both teachers and students.
- Both students and teachers are calling for more publicity for the Technology Challenge, as well as more activities of this type, in which creativity is valued. Also, although the prizes are two tables and a laptop, they demand more attractive prizes, although they do not detail what they might consist of. For this reason, we continue to work intensively with the department of scientific dissemination of UMA.
- One of the challenges of organising events that involve the attendance, both physical and online, of students from any educational stage is attendance itself. First of all, sufficient publicity must be achieved to capture the interest of the centres and, subsequently, they must be able to include it in their programmes. Once these steps have been taken, it is necessary to get the students interested and involved.
- Interaction with students is always difficult and even more so when events are held online. However, the adoption of the on-line format, in the different editions of WiSMC, has allowed access to centres far from the city of Malaga and even to centres in other parts of the country. Moreover, the assessment made by the teachers in charge of the centers has been favorable. With regard to the lectures in English, although they have allowed practice in another language, in some cases the students complained about the difficulty they had understanding the language.
- In the first editions of the WiSMC meetings, some of the presentations included the topic of balancing work with family and motherhood, in order to show students that choosing studies and a technical job is not incompatible with other aspects of life. However, the answers, both from ESO and Bachillerato students and from 4th year ETSIT students, show that motherhood and having a family is something very distant and, therefore, they were not interested in this part of the presentations.
- Although the WiSMC meetings are aimed at pre-university students, the final year undergraduate students found them very interesting, given that they allow them to see different career opportunities for their studies and they are at the point where they are deciding what they want to work in.
- The students were happy to study gender in the bibliographical references in the work of the subjects involved in these case studies. The results of this study show that only 28% of the authors of the references consulted by the students are women and, moreover, only 15% are first authors. Therefore, the students could clearly see that there is still a long way to go on the road to equality between men and women in technical careers.
- The number of visits to the YouTube channel "Women in music acoustics" is increasing every year. However, the videos of current women have more views than those of women who have passed away. The most viewed video is the one dedicated to the orchestra conductor María del Mar Muñoz Varo, which has more than 2209 views. Making women's work visible is a subject of interest to society in general.
- The informative conferences, as well as making it possible to share the innovations developed at the university, open up new avenues of collaboration with people and

educational centres, which would otherwise be very difficult.

- From all areas of society, a great deal of work is being done to disseminate the work of women in different fields, including engineering. This is evident in the results of the questionnaires on women engineers (average student score 8.5 out of 10 points), which show that students have prior knowledge about women and engineering.
- The realisation of these case studies has shown that it is necessary to involve as many professors as possible from ETSIT as well as from other technical schools in order to increase the number of participating students. In addition, this would create new synergies allowing for joint activities between students from different schools.

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