DOI: 10.61782/fa.2025.0597

FORUM ACUSTICUM
EURONOISE 2025

MUSICAL ACOUSTICS STUDENTS FACED WITH THE CHALLENGE OF BUILDING NEW MUSICAL INSTRUMENTS

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ABSTRACT

One of the most difficult aspects to assess in university students is their level of initiative and creativity: teaching usually focuses on learning techniques for practical problem solving, mostly with systematic solutions. For this reason, in the subject Musical Acoustics, an optional subject in the fourth year of the Degree in Sound and Image Engineering at the School of Telecommunications Engineering of the University of Malaga, since the 2015-2016 academic year, students have been asked to make a new musical instrument as part of the assessment of the subject. The only condition that the instrument must meet is that it must produce three musical sounds of different frequencies. In this article, a brief compilation of all instruments is made in order to focus on the most original and creative ones. It should be noted that over the years, the pupils have made better and more creative instruments.

Keywords: *Musical Acoustics, Creativity, Musical Instruments, Higher Education*

1. INTRODUCTION

Nowadays, the job market is becoming increasingly competitive, and holding a university degree in engineering, while a necessary condition for accessing a qualified job, is no longer sufficient. For this reason, both students and professors must make a significant effort to ensure that the skills acquired during academic studies align with industry demands and provide students with a high degree of versatility. Among these skills, soft skills are gaining increasing importance. One of the most relevant soft skills is creativity. Traditionally associated with humanities and arts-related studies, creativity is now being increasingly recognized as a key competence in engineering education [1]. Furthermore, it is essential to acknowledge that engineering curricula are continuously evolving to adapt to the ever-changing technological landscape and to ensure that students acquire the necessary competencies for the professional world [2].

For this reason, elective courses such as Musical Acoustics [3], offered at the School of Telecommunications Engineering of the University of Málaga (UMA), must be in constant evolution to integrate competencies that are particularly relevant for the job market or that, despite their importance, may not have been adequately covered in other courses within the degree program. Musical Acoustics is a fourth-year elective course (final year of the program) in the Bachelor's Degree in Sound and Image Engineering. Due to the nature of its syllabus, its elective status, and its position in the final year of the degree—where the number of students enrolled is typically lower—it allows for more creative activities compared to mandatory courses from earlier years. For this reason, since the 2015-2016 academic year, the practical component of the course has included the construction and acoustic characterization of a musical instrument. However, since the 2022-2023 academic year, traditional lab practices have been replaced by personal projects, many of which still involve the creation of musical instruments [4]. The only requirement for the musical instrument is that it must be capable of producing at least three dis-

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tinct musical sounds. This practical assignment replaced the classical sound characterization practice based on pre-recorded sounds, which did not allow for any form of creativity from students.

This paper presents the various instruments built by students and analyzes the level of creativity demonstrated across different academic years.

The structure of this paper is as follows: Section 2 describes the context in which students engage in this creative activity. Section 3 details the process of constructing and measuring a musical instrument, along with a list of the instruments created in each academic year. Section 4 presents the results of the creativity analysis conducted on students' projects over multiple academic years. Finally, Section 5 outlines the main conclusions drawn from this study.

2. CONTEXT

The University of Málaga has 21 faculties and schools, with an annual student population of approximately 33,000, although this number fluctuates slightly depending on the academic year [5]. Fig. 1 illustrates the evolution of student enrollment at UMA.

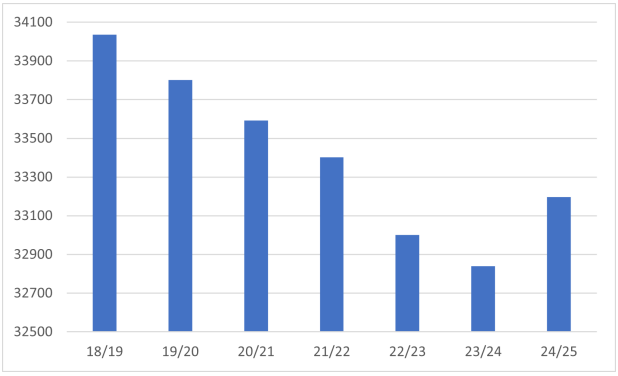


Figure 1. Evolution of the number of student enrolled at the UMA.

The students considered in this study are enrolled in the School of Telecommunications Engineering (ETSIT) within the Bachelor's Degree in Sound and Image Engineering (GISI). Specifically, they are students taking Musical Acoustics, a fourth-year elective course offered in the first semester. This subject has a teaching load of 6 ECTS, equivalent to 60 hours of classroom instruction, distributed as follows: 30 hours of theoretical lectures, 18 hours of laboratory sessions, 6 hours of problem-solving classes, 2 hours of student presentations, and 4 hours dedicated to other activities (such as visits to recording studios and theaters, as well as attendance at conferences). Fig. 2 compares the number of students enrolled at the ETSI of Telecommunications of UMA over the past five years with those enrolled in the Sound and Image Engineering degree. This figure shows that enrollment rates have remained quite stable, although a slight increase in total student numbers can be observed in recent academic years.

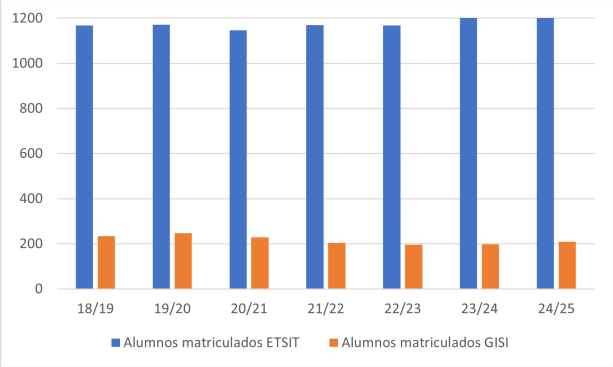


Figure 2. Evolution of student enrolled at the ETSI of Telecommunications of the UMA together with those enrolled in the Sound and Image Engineering degree (GISI).

Fig. 3 presents the evolution of student enrollment in Musical Acoustics, as well as the ratio between students who successfully complete the course and those who drop out. Notably, after the increase in enrollment in the academic year following the COVID-19 pandemic (2020-2021), the number of students taking the course has remained stable. More importantly, the number of students failing the subject has decreased. This suggests that students find the course appealing, both in terms of its description in the official syllabus [3] and through their experiences in class. Considering that overall student enrollment at UMA, and consequently across all degree programs, is declining, the sustained interest in Musical Acoustics, despite being an elective course, can be considered a success. Regarding the gender distribution of enrolled students, the percentage of male and female students is consistent with the average enrollment figures at the ETSI of Telecommunications of UMA [6].

The typical profile of students enrolled in this elec-

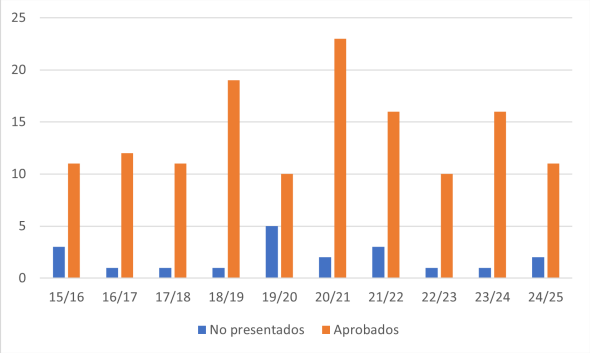


Figure 3. Evolution of students enrolled in Musical Acoustics, as well as the ratio between students who pass and student who drop out of the subject.

tive course includes those with a strong interest in music—either because they have formal conservatory training or because they seek to acquire musical concepts to apply them professionally, given their future careers as sound and image engineers. Additionally, students are often drawn to the course because of its distinctive pedagogical approach [4].

3. MUSICAL INSTRUMENTS DESIGNED IN MUSICAL ACOUSTICS

This section first outlines the required characteristics of the musical instruments to be constructed (subsection 3.1), followed by a summary of the instruments created in each academic year (subsection 3.2).

3.1 Required characteristics of the musical instrument

On the first day of the Musical Acoustics course, students are introduced to the syllabus and the various activities associated with the subject. Among these activities is the practical assignment of constructing a musical instrument, which was incorporated into the curriculum in the 2015-16 academic year. The specifications for this assignment are as follows: students must construct an analog musical instrument capable of producing at least three distinct, tuned musical notes. Additionally, they must record and acoustically characterize these sounds in both the time and frequency domains. A technical report must be submitted detailing the instrument's design, the materials used, the construction process, and the acoustic analysis of the sounds it produces.

Since the 2022-23 academic year, students have been given the option to replace traditional laboratory practices with a personal project. The theme of this personal project must be related to the subject matter of the course and aligned with the student's personal interests and future professional aspirations. Several project ideas are proposed to the students, including the construction of musical instruments, with an emphasis on integrating digital components into their design. The personal project requires the submission of a project report, which may take the form of a direct link to a website or an Instructable [7].

Furthermore, whether students choose to undertake the instrument construction assignment or a personal project, they must deliver an in-class presentation in the format of a masterclass, allowing their peers to learn the fundamental concepts underlying each project. The instrument or personal project may be completed individually or in teams of up to two students, depending on the scope of the work.

3.2 Revision de los instrumentos construidos

Tab. 1 presents a summary of the musical instruments constructed across different academic years. In the first year of implementation (2015-16), the instrument construction activity was highly structured, requiring all students to build an electronic monochord (Fig. 4). This guided workshop proved to be highly successful, leading to the continuation of the activity in subsequent years with greater flexibility granted to students.

In the 2016-17 academic year, students were encouraged to design instruments based on the golden ratio, which led to the development of the UMA-registered Auralófono® [8]. In the following years, students were given complete creative freedom in the design of their instruments (examples of analog instruments created in different academic years are shown in Fig. 5). A review of the constructed instruments reveals that most of them are pan flutes or recorders, although some academic years exhibit a higher degree of creativity than others.

Additionally, the activity has become increasingly consolidated, with a growing number of students incorporating electronic components into their designs. Fig. 6 showcases examples of such electronic instruments. Finally, it is worth noting that with the introduction of personal projects, the number of musical instruments constructed has decreased. However, the quality of the instruments has significantly improved, with most of them

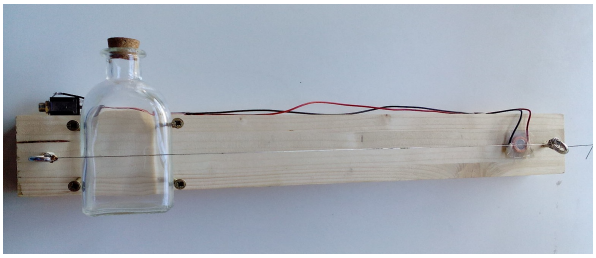
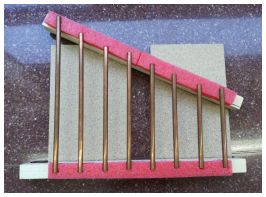


Figure 4. Electronic Monochord (15/16).

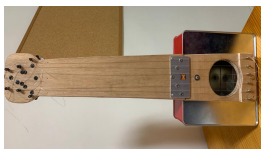
(a) 8-string lyre (17/18).

(b) Bicycle Spoke Kalimba (18/19).



(c) Xylophone copper (19/20).

(d) Cafelófono (21/22).



(e) Metal can guitar (21/22).

Figure 5. Examples of some of the analogue instruments built by the students of musical acoustics.

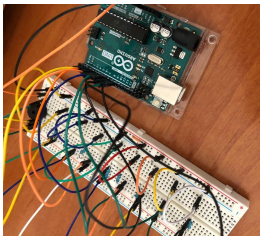
now featuring electronic components.

Conducting an analysis of students' creativity is a complex task, as defining creativity itself is challenging. However, by closely examining the instruments constructed along with the presentations given in class, some key observations can be made.

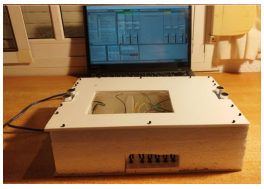
- Students generally struggle to be creative and to take risks with innovative proposals. Interestingly,

Table 1. List of musical instruments created by academic year

Academic Year	Musical Instruments
2015-16	Electronic Monochord (5 groups)
2016-17	Auralófono® (2 groups) Electric Guitar with Frying Pan
2017-18	8-String Lyre PVC Flute Pipe Organ with Cardboard Tubes
2018-19	Bicycle Spoke Kalimba Irish Flute Xylophone with PVC Tubes Cookie Tin Ukulele PVC Trombone Acoustic Bass
2019-20	Pan Flute PVC Flute 7-String Lyre Xylophone with Copper Pipes
2020-21	Pan Flute (10 groups) Recorder (4 groups) Rubber Band Lyre (3 groups) Clarinet with Rubber Bands Xylophone with Copper Pipes
2021-22	*Cafelófono*: Coffee Kalimba Xylophone with PVC Tubes Piano with Arduino and Sensors Guitar with Metal Can 3-String Monochord
2022-23	*Tubophone*: 3 Percussion Tubes Synthesizer with Arduino Clarinet with Rubber Bands
2023-24	Electromagnetic Microphone Ultrasonic MIDI Theremin 3D-Printed Violin Bela Synthesizer
2024-25	Banjo: Cookie Tin Banjo: 3D-Printed Body



(a) Piano with Arduino and sensors (21/22).



(b) Ultrasonic MIDI Theremin (22/23).

(c) Arduino synthesiser (22/23).

Figure 6. Examples of some of the electronic instruments built by the students of musical acoustics.

the most innovative proposals—precisely because they do not conform to traditional musical instruments—are those suggested by the course instructor (electronic monochord and Auralófono®).

- The level of creativity in the instruments built varies significantly depending on the student group. A noteworthy example is the instruments from the 2018-19 academic year, all of which were distinct and made from novel recycled materials, in contrast to those from the 2019-20 and 2020-21 cohorts, which were more conventional and similar in design. Interestingly, these student groups also differed in terms of academic performance and interpersonal dynamics.
- During the 2020-21 academic year, due to the COVID-19 pandemic, classes were held online, and projects were completed individually. This clearly influenced the students' level of creativity and effort in constructing their musical instruments.
- Although students in the Sound and Image Engineering program have a foundational knowledge of electronics, it is clearly insufficient for them to independently undertake projects requiring circuit construction. Students acknowledge their interest in creating electronically integrated instruments but do not feel adequately prepared to do so.
- The introduction of personal projects has resulted in the creation of instruments with an electronic component and increased complexity in terms of functionality, assembly, and capabilities. These instruments have proven to be more satisfying, even for the students themselves.
- Despite some highly developed instrument proposals, there is still significant progress to be made in fostering students' creativity.

4. CONCLUSIONS

This study has explored the implementation of a creative pedagogical approach within the Musical Acoustics course, an elective in the final year of the Bachelor's Degree in Sound and Image Engineering. The primary objective was to engage students in the construction of musical instruments that generate at least three distinct tuned pitches. The findings derived from this study offer valuable insights into the intersection of engineering education and creative practice:

- The integration of creative tasks within a traditionally technical curriculum is well-received by students, who demonstrate enthusiasm for hands-on, innovative learning experiences beyond conventional laboratory exercises.
- Over the years, as the activity has become institutionalized within the course, the diversity and complexity of the musical instruments produced have increased, reflecting a growing engagement with the creative process.
- The introduction of personal projects has led to fewer instrument constructions overall; however, the complexity, originality, and inclusion of electronic components in these projects have significantly improved. Students report a heightened sense of achievement and deeper conceptual understanding as a result.
- The choice of instrument type, level of innovation, and overall difficulty of construction are strongly influenced by the particular cohort of students. This suggests that group dynamics, peer collaboration, and prior experience play a crucial role in determining creative outcomes.

- A noticeable trend is the recurrence of simpler designs, particularly pan flutes and recorders. These choices are often associated with students who demonstrate lower engagement, possibly due to the abundance of readily available online instructions, reducing the necessity for independent problem-solving and innovation.
- While some students exhibit significant creativity in their projects, many struggle with the concept of innovation. The root causes of this reluctance remain unclear—whether due to a lack of intrinsic creativity, a hesitancy to invest additional effort, or a pervasive fear of failure in an academic setting.
- These findings highlight the urgent need to systematically incorporate creativity-enhancing methodologies within engineering education. By integrating more open-ended, interdisciplinary, and exploratory tasks into curricula, students can be encouraged to develop critical thinking, adaptability, and problem-solving skills essential for their future professional careers.

5. ACKNOWLEDGMENTS

This publication is part of project PID2021-123207NB-I00, funded by MCIN/AEI/10.13039/501100011033/FEDER, UE. This work was done at Universidad de Málaga, Research Group TIC208, Campus de Excelencia Internacional Andalucia Tech.

6. REFERENCES

[1] D. Bairaktarova and M. Eodice, eds., *Creative ways of knowing in engineering*. Springer, 2017.

[2] J. Mitchell, A. Nyamapfene, K. Roach, and E. Tilley, "Faculty wide curriculum reform: the integrated engineering programme," *European Journal of Engineering Education*, vol. 46, no. 1, pp. 48–66, 2001.

[3] E.T.S.I. de Telecomunicación, *Programación docente. Curso académico 2024-25*. Málaga: E.T.S. de Ingeniería de Telecomunicación, 2024.

[4] A. M. Barbancho, A. Peinado, I. Barbancho, L. J. Tardón, and S. Guillén, "Musical acoustics: Students facing the challenge of carrying out a personal project," in *2024 XVI Congreso de Tecnología, Aprendizaje y Enseñanza de la Electrónica (TAEE)*, pp. 1–6, 2024.

[5] Universidad de Málaga, "UMA, portal de transparencia. https://www.uma.es/portal-de-transparencia-universidad-de-malaga/info/120015/datos-de-matriculacion/," 2024. Accessed: March 6, 2025.

[6] A. M. Barbancho, I. Barbancho, L. J. Tardón, and A. Peinado, "Women in telecommunication engineering: Case studies," *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, vol. 19, pp. 61–70, 2024.

[7] Instructable, "Instructables, colección musical acoustic student projects. https://www.instructables.com/musical-acoustic-student-projects/," 2025. Accessed: March 6, 2025.

[8] Universidad de Málaga, "Auralofono®. https://www.oepm.es/es/," 2016. Accessed: March 6, 2025.