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# Analysis of Motivational Factors in the Choice of Engineering Degrees: Evidence from a Teaching Erasmus Experience

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**Abstract**

*Promoting STEM subjects (Science, Technology, Engineering and Mathematics) in pre-university education is essential to prepare society to face the challenges of the 21st century and promote the nation's sustainable and economic development]. STEM education encourages critical thinking, problem-solving, and creativity, essential skills for training professionals in innovation, scientific research, and solving global issues such as climate change, renewable energy, and public health. Furthermore, early contact with these subjects can motivate young people, especially women and underrepresented groups, to choose careers in these fields, which currently suffer from a shortage of skilled labor. This study reports on the experience of a group of teachers from higher education institutions offering a wide range of engineering courses in Jaen (Spain) and Coimbra (Portugal), who shared their experiences within the framework of the Erasmus+ Programme.*
*Through this cooperation, a general analysis of engineering student groups was developed, considering factors such as gender, age and cultural diversity. Likewise, we investigate the motivation that led these students to choose courses related to STEM areas and how these motivations are linked to central aspects, such as innovation, social responsibility, and sustainability. This analysis also reflects on the importance of adapting pedagogical methods to encourage student engagement in global challenges and build a more sustainable future.*

**Keywords:** *STEM Education, Student Motivation, Student engagement*

## 1. Introduction

The growing demand for engineering professionals, driven by the accelerating technological and digital transformation, has highlighted the need to foster STEM vocations [1]. In recent years, the European Commission and country governments worldwide have faced the problem of how to enhance STEM (Science, Technology, Engineering, and Mathematics) education and how to motivate young people to choose STEM fields of study in high school and university. This issue is even more relevant in women, an underrepresented group, and it is urgent and essential to engage them actively in STEM careers.

STEM became popular in the United States during the 1990s and early 2000s [2]. Since then, STEM research and education have extended to every continent. Between 2004 and 2022, the number of STEM-related publications evolved in three phases: from 2004 and 2010, from 2011 to 2018 and from 2019 to 2022. Compared to the first phase, 26 times more papers were published in the second phase and 120 times more STEM-related papers in the third phase, demonstrating the scientific community's growing interest in this topic. Initially, studies emphasize the challenge of implementing the interdisciplinary nature of STEM fields. In the second phase, research focused on student performance and engagement, as well as the underrepresentation of women in STEM education. In the third phase, studies include the importance of teacher training and the practical implementation of STEM [3]. More recently, the link between STEM and sustainability has been investigated [4].

STEM education in children and young people is vital to developing interest in these areas and motivating students to choose STEM fields in higher education and professional careers [5], [6]. Integrating STEM learning from an early age allows students to acquire essential skills and knowledge such as critical thinking, problem-solving and creativity, which are increasingly demanded in a technology-driven society and various aspects of everyday life. On the other hand, STEM education initiatives encourage participation from different backgrounds, including women and minorities [7] [8]. Many projects in very different areas are aimed at children and young students. The projects include hands-on activities with real concepts and technologies, collaborative projects and emerging technologies. From the second period, the number of publications focusing on STEM research in early childhood increased [9] [3]. [10] described the impact of education on children in contact with nature through practical and exploratory activities involving science, engineering, technology, and sustainability. [11] [12] [13] [14] explored logical thinking and program skills using digital tools and robotics. On the other hand, [15] focused on how STEM activities can promote creativity and scientific competencies through craft and problem-solving projects. In Portugal, there are several initiatives to introduce STEM to children. The European STE(A)M IT programme[1], coordinated by European Schoolnet, involves the Portuguese Directorate-General for Education and Erasmus+ collaboration with the STEM Alliance and Scientix. Learning scenarios and resources are developed for teachers to promote innovative approaches in these areas. Microsoft Portugal's STEM Dream Space centre, provides opportunities to develop technological skills through experiences that relate scientific, engineering, and coding concepts to practical applications. The content is available on Dream Space TV, in Portuguese[2]. The Scratch4All project, which includes the Scratch on Road activities, the Programming and Robotics Laboratory, and the Scratch4All Digital Platform, gives primary school children in the districts of Coimbra and Aveiro in Portugal access to Scratch programming and robotics in regular classes [16].

Many initiatives at the global and European levels seek to increase girls and young women's interest in engineering careers, thus promoting greater diversity and talent in this strategic sector [17]. Among the most prominent international initiatives is IEEE TryEngineering, an IEEE global platform that offers a wide range of educational resources, programmes and events specifically designed to foster interest in engineering, especially among girls. [18]. Through hands-on activities, collaborative projects, and educational materials, TryEngineering aims to inspire young people and show them the possibilities engineering offers to solve real problems and build a better future. A vibrant community of STEM enthusiasts, educators and volunteers was built to inspire young students to pursue careers in these areas. On the other hand, EU Code Week and European Programming Week aim to teach programming to people of all ages and promote digital literacy. This event has established itself as a reference to promote the teaching of programming and digital culture throughout Europe. They help to break stereotypes and offer exciting activities to inspire the next generation in the endless possibilities of STEM careers. By encouraging the acquisition of digital skills from an early age, this initiative helps to prepare young people for challenges. It highlights how they are encouraged to explore the various engineering disciplines that require programming skills [19]. Emphasis is placed on developing algorithmic thinking through programming using age-appropriate learning tools. Also, at a more local level, universities and research centers worldwide develop various initiatives to foster engineering vocations. From lab tours and hands-on workshops to mentoring programs and innovation competitions, these institutions offer enriching experiences that allow young people to discover the engineering world and develop their skills and knowledge.

Undoubtedly, fostering vocations in STEM areas, especially in engineering, is a topic of great interest globally. Several initiatives and programs are designed to attract more students to these disciplines at both pre-university and university levels. At the university level, there is a tendency to involve companies to a greater extent [20]. These initiatives are updated, Hackathons are proposed, and events where multidisciplinary teams work to solve real problems through software or hardware development[3]. Mentoring programs are also designed so engineering students are paired with professionals in the sector to receive guidance and support in their academic and professional development[4].

STEM programs are challenging, so all this effort is needed to encourage students to enroll. As a result, several studies have been done to determine the essential drivers that may influence the decision to pursue degrees in STEM fields [21]. It is proposed to investigate whether intrinsic interest

[1] https://www.dge.mec.pt/projeto-steam-it#
[2] https://dreamspace.microsoft.com/pt-PT/dreamspace/portugal
[3] www.kreativdistrikt.com
[4] www.togetherplatform.com

in mathematics as a subject is an essential factor in choosing a STEM career, as well, as family support. Family involvement in science may be associated with a prior interest in science and a higher possibility of following a scientific profession. Brown research examines students' persistence in STEM programs during their first three university years [22]. Studies also analyzed the entrepreneurial attitudes of students in STEM fields to identify key factors and differences according to gender, age, and field of study [23].

Some studies focus more on personality, such as the one proposed by [24]. This article investigates the intersection between motivation and emotion regulation in academic contexts using an intra-individual approach. Other studies [25] look at the effect of integrating science curricula with STEM education practices to examine the effects of these practices on students' problem-solving skills, scientific creativity, and critical thinking dispositions. In addition, there are concerns about the entry of some groups into this area, and there are studies that analyze the experiences and motivations of women and racial and ethnic minorities. Using Self-Determination Theory as a theoretical framework, the study, through interviews, explores the intrinsic and extrinsic factors that influence participation and persistence in the STEM field. It identifies social, cultural and institutional barriers, such as lack of access to resources, safety concerns and lack of role models, which disproportionately affect these groups. Finally, the study proposes strategies to encourage minority participation in STEM, highlighting the importance of engaging young people, creating inclusive spaces and using representative figures as role models.

This article stems from a collaborative effort between the authors, facilitated by an Erasmus+ mobility program. The collaboration centers on investigating the efficacy of pre-university motivational programs at each respective institution. These programs are implemented before students commence their university education and are designed to enhance the visibility of both engineering schools. Recognizing the critical role of STEM education in addressing 21st-century challenges, driving social progress, fostering innovative learning approaches, and positively influencing educational policies, this paper seeks to investigate the primary motivations that drive students to pursue engineering careers. To accomplish this, the study employs a questionnaire administered to students participating in Erasmus+ mobility programs from Escuela Politécnica Superior de Jaén (Spain) and engineering students from Polytechnic University of Coimbra (Portugal). The survey instrument is based on a comprehensive review of relevant literature and the authors' experience in STEM programs [4], [16] and incorporates quantitative and qualitative data analyses to identify key motivators among current engineering students.

The findings of this research are expected to provide valuable insights for educators, enabling them to apply these learnings in their teaching practices and potentially influencing educational policies within their respective institutions.

## 2. Material and Methods

This section addresses the educational environment that will be used to study the factors that motivate students from these two higher education institutions to choose to study for a degree in engineering. The methodology used in this study will also be detailed.

### *2.1 The UJA's Educational Environment*

The Escuela Politécnica Superior de Jaén (UJA), an engineering school with a century-long history of excellence, offers a two-tiered approach to industrial engineering curriculum. Undergraduate studies encompass four-year degrees (240 ECTS) in Electrical, Industrial Electronics, Mechanical, and Industrial Organization Engineering, each comprising an average of ten subjects per year with 6 ECTS each. Postgraduate studies culminate in a two-year master's degree in Industrial Engineering (120 ECTS). Both programs are designed to equip students with the professional competencies necessary to undertake engineering projects of varying complexity.

This collaboration has focused on two specific topics: Electronic Instrumentation, a third-year course from the Industrial Electronics Engineering degree, and Electronic Systems and Industrial Instrumentation, a first-year Master's program in Industrial Engineering. These subjects were selected due to the advanced level of student maturity, having completed five semesters of prior training.

### *2.2 The Coimbra Institute of Engineering*

The Polytechnic University of Coimbra is a public higher education institution established in 1979 that has six teaching facilities: Coimbra Agriculture School, Coimbra Education School, Coimbra Health School, Oliveira do Hospital Management and Technology School, Coimbra Business School, and Coimbra Institute of Engineering. The Portuguese authors of this paper are from the Electrical Department of Engineering of the Coimbra Institute of Engineering (ISEC). ISEC offers two years of Professional Higher Technical Courses (120 ECTS), three-year Undergraduate degrees following the Bologna process (180 ECTS), and two-year Master's degrees (120 ECTS). The students that answered the questionnaire were mainly from the third year of Biomedical Engineering Bachelor (BEB), the Medical Image Acquiring and Processing course, and the Electronics course, the second year of Electrical and Computer Engineering Bachelor. A small number (three of each) come from the Electrical Engineering Master (Smart Buildings and Domotics course) and Industrial Management Engineering Bachelor (Electricity and Electronics course). Its inclusion was based on the similarity of topics and teaching methodologies to UJA subjects and gender diversity, as BEB has a higher percentage of female students.

### *2.3 Description of Methodology*

This research draws upon the authors' extensive experience and over two decades of expertise in engineering education. Their involvement in initiatives with children and pre-university students further enriches this work. These initiatives include the Scratch4All and Make a Lab projects [4][16], the Science and Technology Fair (an annual event fostering collaboration among students, teachers, researchers, and industry to showcase scientific and technological advancements), participation in Physics, Chemistry, Mathematics, Computer Science, and Biology Olympiads, and engagement in public outreach programs such as the European Researchers' Night. The design, validity, and reliability of the survey are also based on previously validated instruments [23][26][27][28].

The authors propose a Likert-scale questionnaire ranging from 1 (strongly disagree) to 5 (strongly agree) to evaluate the potential impact of various factors on student career decisions. These factors incorporate pre-university influences (including academic preparation and self-efficacy beliefs), first-year experiences (academic performance and high-impact internships), and career projections.

This research aims to achieve a deeper understanding of the factors that influence student choices throughout time. This insight will facilitate the development of more effective strategies to improve student enrollment in engineering careers and augment the total number of engineering graduates.

## 3. Results and Discussion

A total of 79 students from Jaen and Coimbra answered, comprising 30.4% females, 68.4% men, and 1.3% (one) who preferred not to disclose their gender. Figure 1 illustrates the age diversity, indicating that the 20-22 age group is the most predominant, representing just over one-third of the total student population.

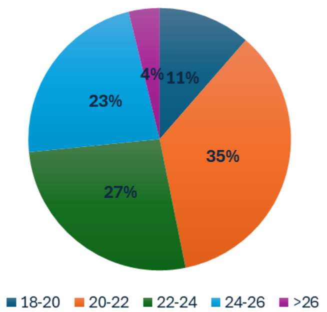


**Fig. 1.** Representation of student age groups

When asked about their gender preference in selecting a colleague for laboratory work, the majority of students exhibited no discernible preference, as over 80% of respondents indicated this sentiment.

The questions that guided the research are summarized in Table 1 and Table 2. The first group of questions tries to answer the global question, “Why did you choose to study engineering?”. This was given to the students as a multiple-choice question, where each question was scored between 1 and 5, and also with an open answer for students to provide other options. The potential answers are presented in Table 1. Through this question, the authors sought to identify the key drivers influencing the students' choices in their future degrees.

**Table 1.** Why did you choose to study engineering?

| Answers | Spain | Portugal | Combined |
|---|---|---|---|
| Your vocation has always been engineering. | 3.65±1.22 | 3.42±1.15 | 3.54±1.19 |
| To have good professional opportunities | 3.98±1.11 | 4.17±0.64 | 4.06±0.92 |
| Carry out cooperation projects and support others. | 3.48±1.09 | 3.78±0.87 | 3.61±1.00 |
| For economic reasons | 3.88±0.99 | 3.61±1.02 | 3.76±1.01 |
| For social recognition | 3.23±1.27 | 2.53±1.13 | 2.91±1.25 |
| Because my family motivated and/or advised me | 3,09±1.22 | 2.58±1.03 | 2.86±1.15 |
| For professional projection in society (social recognition) | 3.70±1.17 | 2.72±1.11 | 3.25±1.23 |
| To balance my professional and social life | 3.02±1.42 | 2.78±1.02 | 2.91±1.25 |
| To be able to work as a team | 3.29±1.27 | 3.03±0.97 | 3.13±1.14 |

Regarding the first reason, “Your vocation has always been engineering”, the average score of 3.55 indicates a strong overall identification with engineering as a profession. It is pretty interesting that 43 out of 79, more than half of the responses (54%) were given the scores 4 and 5.

The second reason, “To have good professional opportunities”, has an even higher average score of 4.06 (in 5), pointing out the widespread knowledge that studying engineering provides access to good career opportunities, is true. This reason valuation is in line with “For economic reasons”, which receives a score of 3.86 out of 5, as expected, as usually good job opportunities are associated with higher salaries.

When considering familiar factors, the responses to questions like “Because my family motivated and/or advised me” and “To balance my professional and social life” yield an average score below 3, indicating that family exerts a neutral impact on career selection.

Responses to the "professional projection in society (social recognition)" question reveal a significant disparity between Portuguese and Spanish students. This disparity could be attributable to a broader general acknowledgement of the engineering profession in Spain compared to Portugal. Future studies need to clarify this aspect.

Teamwork and the execution of collaborative projects receive moderate to high scores (3.61 and 3.25), suggesting that students anticipate good collaboration in engineering tasks, regardless of project scale.

The other research topic in this study concerns how coursework, the division between theory and practice, seeks to evaluate the importance of the practical/laboratory classes. The questions and Likert mean values (1 to 5) are presented in Table 2.

The first question is answered with a mean value of 3.47, indicating a moderate influence in choosing an engineering degree. Thus, this is not a key factor during the degree selection process.

**Table 2.** The importance of practical classes

| | Question | Spain | Portugal | Combined |
|---|---|---|---|---|
| $Q_1$ | Is practical training in engineering something that made me opt for this program? | 3.07±1.25 | 3.94±0.94 | 3.47±1.20 |
| $Q_2$ | Is the method used in practical classes (guide, a brief explanation of lab work in class, experimental work and report delivery in one week) satisfactory? | 4.14±1.25 | 3.86±0.76 | 4.01±0.85 |
| $Q_3$ | What is the importance of practical classes in the learning of a course? | 4.44±0.73 | 4.69±0.62 | 4.56±0.69 |
| $Q_4$ | Does practical/laboratory training in a subject give me autonomy in learning, allow me to work on theoretical concepts and increase my interest in the subject? | 4.33±0.93 | 4.44±0.60 | 4.38±0.80 |
| $Q_5$ | Regardless of your grades in a subject, how much do you think practical training has influenced the final result? | 4.09±0.86 | 4.11±0.70 | 4.10±0.79 |

Conversely, from Q2 to Q5, all recorded values exceeded 4, indicating that the students prioritised their education's practical and laboratory components. In Q3, the highest value recorded is 4.56, with 88.6% (70 out of 79) of students rating it a 4 or 5. Students unanimously acknowledge the significance of practical classes, the autonomy acquired, their greater engagement in the subjects, and the enhanced comprehension of the issues associated with each laboratory work. This fits with the STEM literature, which indicates that practical classes in these programs are essential for bridging theoretical concepts with real-world applications.

The valuation in answer to question $Q_5$ shows a close connection between the grade in laboratory works and the final grade, pointing again to the importance of practical classes to global understanding and the subject's final grade.

The findings align with prior research on student motivations in engineering education. Specifically, the results emphasize that economic aspects and professional opportunities are central to students' decision-making when choosing an engineering program. Moreover, the emphasis on experimental teaching is consistent with prior studies, reinforcing its role in fostering student engagement, autonomy, and the practical application of theoretical concepts. Finally, the author's experience teaching STEM courses supports the findings, making their work feel especially fulfilling.

## 4. Conclusions

This study highlights the importance of integrated STEM education in improving students' problem-solving, creativity, interpersonal, and critical thinking skills. An analysis of the factors that influence the choice of engineering programs shows that economic aspects and professional opportunities play a central role in students' decision-making. Moreover, the relevance of experimental teaching was widely emphasized as a crucial factor for student engagement and autonomy, allowing them to apply theoretical concepts to real problems. This work identified cultural and institutional differences between the educational contexts of Portugal and Spain, particularly in the social recognition of engineering.

The impact of Erasmus+ initiatives on improving teaching competencies and promoting innovative practices highlights the need for global cooperation in developing educational strategies that address 21st-century challenges.

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