Occupational health and safety start at school of engineering

M Ramirez*, A Pastor¹, E Diaz¹, D Piñero¹ and M Batista¹

¹School of Engineering, Universidad de Cádiz, Av. Universidad de Cádiz, 10, 11519, Puerto Real (Cádiz), Spain

*Corresponding author: magdalena.ramirez@uca.es

Abstract: The occupational risk prevention has been the subject of study for many years, but it could be said that in Spain, it is from the promulgation of laws in this regard when it becomes more important in view of the need to reduce the accident rate in all professions. Focusing on the engineering profession, the need arises to know if in their training stages, this matter is contemplated by developing a preventive culture in the person that helps to become familiar with and minimize risks. That is why this study aims to find out how this subject is dealt with in Spanish universities. To this end, it proposes the study through the Spanish universities best positioned in international rankings such as the Academic Ranking of World Universities (ARWU) and Quacquarelli Symonds, known as QS World University Ranking. The results of the study show that Spanish universities are not very well disposed towards this subject, thus depriving future engineers of the acquisition of competencies related to risk prevention.

Keywords: Occupational Health and Safety, Manufacturing Engineering, Training Methods, Risk Prevention, Occupational Hazards.

1. Introduction

The prevention of occupational hazards was born with the commitment to provide a work environment where workers can develop their activities without assuming risks derived from the activities they perform and with that intention the International Labour Organization (ILO) was constituted in 1919, developing policies, promoting programs and establishing work standards for the 187 member states that compose it [1].

ILO is a specialized organization of the United Nations for this matter and another agency is the World Health Organization (WHO) [2]. Further downstream, at the European level, is the European Agency for Safety and Health at Work (EU-OSHA) [3] in charge of occupational safety and health matters among the Member States. From here, each country has its own legislation and regulations to apply. Specifically in Spain, this is Law 31/1995 of November 8, 1995, together with the regulations derived therefrom [4].

The Ministry of Labour, Migration and Social Security is ultimately responsible for occupational safety and health in Spain and the National Institute of Occupational Safety and Hygiene, whose mission is to support and promote occupational safety and health in its technical aspects, reports to it. Among the information published by this institute is a report that includes the priority activities according to the accident rate. After consulting the data for the year 2019, the manufacture of metal products among the activities with the greatest impact on the accident rate (severity) are found, group to which the mechanical engineer belongs, as well as different associated manufacturing processes [5].
Taking into account government regulations, the curricula introduce workshop and laboratory practices. Practices that in many cases involve significant risks as may be the case of manufacturing engineering. Safety is a Required subject to be taught [6] which should be used by the students for their application in their own learning during the development of these practices. However, although there are studies that investigate how safety affects worker performance [7], and proposals aimed at reducing the accident rate [8], it is not known how different Spanish universities approach the subject and whether they promote a preventive culture.

The aim of this paper is to analyse training in the area of occupational health and safety in engineering degrees and its relationship with the field of manufacturing engineering. Analysing the coordination between subjects and the timing of training in Occupational Health and Safety.

2. Methodology
To carry out the analysis, the most relevant Spanish universities in the field of manufacturing engineering will be studied, analysing the specific degrees associated with this field. For this purpose, the classification offered by the Academic Ranking of World Universities (ARWU) published for the first time in 2003 and popularly known as the Shanghai Ranking, will be used to evaluate the quality of more than 1,000 universities in the world, among which Spain is found with a total of 40. It uses six indicators to measure among which are the number of students and employees who have been awarded Nobel Prizes or the Fields Medal, number of most cited researchers according to Clarivate Analytics, number of articles published in the journal Nature and the journal Science and the number of articles indexed in Science Citation Index and the Social Science Citation Index and per capita production [9].

In addition, the data provided by Quacquarelli Symonds, known as QS World University Ranking, which has been publishing comparative data on university performance since 2004, among others, will be analysed based on the result of the academic reputation based on a survey of more than 100,000 experts, on which 40% of the weighting is based, the employer reputation based on a survey of 10,000 employers with a weighting of 10% of the total, 20% weighting is based on the faculty/student ratio and another 20% on the number of citations per faculty evaluated over a five-year period plus 5% for the international faculty ratio and the last 5% for the international student ratio [10] as shown figure 1.

![Figure 1. Methodology.](image-url)
With the information obtained from both sources, it is intended to know the preventive culture that exists in the different selected universities. At the same time, it will be necessary to carry out a study of the approach given to the subject of Occupational Risk Prevention in the study plans and its relationship with the legislation in force in this area.

3. Results and Discussion
In order to be able to locate the population affected by the study, the existing university offer in Spain is evaluated in which there are 786 Degrees in the field of Engineering and Architecture composed of a total of 229,510 students, which represents 17.74% of the total number of students enrolled in all the degrees according to data provided by the Ministry of Universities 2020 of the Government of Spain, of which 91.3% were carried out in public universities and the remaining 8.7% in private universities [11].

Once the population affected by the study is known, we now move on to the results obtained in each of the rankings consulted. Starting with the Academic Ranking of World Universities (ARWU) - Shanghai Ranking – 2020 where table 1 shows the position of the top ten Spanish universities, the degrees they offer, the subjects that include occupational risk prevention concepts, the type of subject, i.e., whether it is required or elective, the year in which it is taught and the number of European Credit Transfer System (ECTS) credits each one of them has.

| University Ranking Position | Degree                          | Subject                                                      | Type    | Year | ECTS |
|-----------------------------|---------------------------------|---------------------------------------------------------------|---------|------|------|
| Autonomous University of Barcelona [12] 201/300 | Mechanical Engineering          | Industrial Production Systems                                 | Required | 3rd  | 3    |
|                              | Industrial Organization Engineering | Quality, Safety and Environmental Management                  | Required | 3rd  | 6    |
|                              | Industrial Design and Product Development Engineering | Prevention Methodology in the Design and Marketing Sector | Elective | 4th  | 6    |
|                              | Industrial Design and Product Development Engineering | Prevention and Safety in the Design and Marketing Sector | Elective | 4th  | 6    |
|                              | Industrial Design and Product Development Engineering | Prevention Technology in the Design and Marketing Sector | Elective | 3rd  | 6    |
| Polytechnic University of Valencia [13] 301/400 | Mechanical Engineering          | Prevention Methodology in the Mechanical Sector              | Elective | 4th  | 6    |
|                              | Mechanical Engineering          | Prevention Methodology in the Mechanical Sector              | Elective | 4th  | 6    |
|                              | Mechanical Engineering          | Prevention Technology in the Mechanical Sector              | Elective | 3rd  | 6    |
| Industrial Organization Engineering | Safety and Occupational Risk Prevention. Basic Legislation for Industrial Companies | Elective | 4th  | 4.5 |
| Industrial Technologies Engineering | Occupational Risk Prevention | Elective | 4th  | 4.5 |
| University of the Basque Country [14] 301/400 | Engineering in Process and Product Innovation | Organizational Engineering                                  | Required | 3rd  | 6    |
|                              | Industrial Organization Engineering | Engineering Projects Management, Health and Safety and Ergonomics | Required | 4th  | 6    |
|                              | Industrial Technology Engineering | Engineering Projects                                        | Required | 4th  | 6    |
| University of Oviedo [15] 401/500 | Industrial Technologies Engineering | Occupational Risk Prevention                                 | Elective | 4th  | 6    |
Table 1. (Continued) Top ten Spanish universities ranked in the Shanghai Ranking.

| University                      | Field                                      | Course                          | Type    | Rank | Credits |
|---------------------------------|--------------------------------------------|---------------------------------|---------|------|---------|
| University of Seville [16]      | Industrial Organization Engineering        | Analysis and Prevention of Labor Risks | Elective | 4th  | 4.5     |
|                                 | Industrial Technologies Engineering        | Integral Project of Industrial Plants | Elective | 4th  | 4.5     |
|                                 |                                              | Analysis and Prevention of Labor Risks | Elective | 4th  | 4.5     |
|                                 | Industrial Design Engineering and Product Development | Occupational Health and Safety | Elective | 4th  | 6       |
|                                 |                                              | Product Engineering Projects    | Required | 4th  | 6       |
| University of Zaragoza [17]     | Mechanical Engineering                      | Occupational Risk Prevention Engineering | Required | 4th  | 6       |
|                                 |                                              | Project Office                  | Required | 4th  | 6       |
| Polytechnic University of Madrid [18] | Industrial Design Engineering and Product Development | Safety and Health at Work | Elective | 4th  | 3       |
|                                 | Mechanical Engineering                      | Occupational Health and Safety  | Elective | 4th  | 3       |
|                                 | Industrial Technologies Engineering        | Quality Management, Prevention and Sustainability | Elective | 4th  | 3       |
| University of Navarra [19] [19] | Industrial Design Engineering and Product Development | Quality Management Systems | Required | 4th  | 6       |
|                                 | Industrial Organization Engineering        | Quality Management Systems      | Required | 4th  | 6       |
|                                 | Industrial Technologies Engineering        | Quality Management Systems      | Required | 4th  | 6       |
|                                 | Mechanical Engineering                      | Quality Management              | Required | 4th  | 6       |
| University of Vigo [20] 501/600 | Industrial Organization Engineering        | Quality, Safety and Sustainability Management | Required | 3rd  | 6       |
|                                 |                                              | Technical Office                | Elective | 4th  | 6       |
|                                 | Industrial Technologies Engineering        | Safety and Industrial Hygiene   | Required | 4th  | 6       |
|                                 |                                              | Technical Office                | Elective | 4th  | 6       |
|                                 | Mechanical Engineering                      | Safety and Industrial Hygiene   | Required | 4th  | 6       |
|                                 |                                              | Technical Office                | Elective | 4th  | 6       |
|                                 |                                              | Safety and Industrial Hygiene   | Required | 4th  | 6       |
|                                 |                                              | Technical Office                | Elective | 4th  | 6       |
|                                 |                                              | Safety and Industrial Hygiene   | Required | 4th  | 6       |
|                                 |                                              | Technical Office                | Elective | 4th  | 6       |
|                                 |                                              | Safety and Industrial Hygiene   | Required | 4th  | 6       |
| University Miguel Hernández [21] 601/700 | Mechanical Engineering | Industrial Safety          | Elective | 4th  | 4.5     |

Following the data obtained from the QS World University Ranking, table 2 shows the results in which only the differences with the previous ranking are shown in the position it occupies.
Table 2. Top 10 Spanish universities ranked in the QS World University Ranking.

| University Ranking Position | Degree | Subject | Type | Year | ECTS |
|-----------------------------|--------|---------|------|------|------|
| Autonomous University of Barcelona/188 [12] | Industrial Technologies Engineering | Technical Office | Required | 4th | 3 |
| University of Navarra/245 [19] | Mechanical Engineering | Technical Office | Required | 4th | 3 |
| University of Navarra/245 [19] | Mechanical Engineering | Quality and Integrated Systems Management Quality / Safety / Environment | Elective | 4th | 6 |
| Carlos III University of Madrid [22] 298 | Mechanical Engineering | Occupational Health and Safety | Elective | 4th | 6 |
| Polytechnic University of Catalonia [23] 300 | Mechanical Engineering | Occupational Health and Safety | Elective | 4th | 6 |
| Polytechnic University of Valencia/336 [13] | Mechanical Engineering | Occupational Health and Safety | Elective | 4th | 6 |
| University of Zaragoza/432 [17] | Mechanical Engineering | Occupational Health and Safety | Elective | 4th | 6 |
| Polytechnic University of Madrid/435 [18] | Mechanical Engineering | Integrated Management of Quality, Environment and Occupational Hazards | Elective | 3rd | 3 |
| Polytechnic University of Madrid/435 [18] | Mechanical Engineering | Integrated Management of Quality, Environment and Occupational Hazards | Elective | 4th | 3 |
| Polytechnic University of Madrid/435 [18] | Mechanical Engineering | Technical Office | Required | 4th | 6 |
| University of the Basque Country | Mechanical Engineering | Project Management | Not subject specified |
| University of Oviedo | Industrial Organization Engineering | Occupational Risk Prevention Projects | Upcoming implementation |
| University of Oviedo | Mechanical Engineering | Projects and Technical Office | Not subject specified |
| University of Seville | Industrial Technologies Engineering | Projects | Not subject specified |
| University of Zaragoza | Industrial Technologies Engineering | Safety and Risk Prevention in Industrial Processes | Not currently offered |
| Polytechnic University of Madrid | Industrial Organization Engineering | No subject included |
| Polytechnic University of Catalonia | Industrial Design Engineering and Product Development | No subject included |
| Polytechnic University of Catalonia | Industrial Technologies Engineering | No subject included |

The comparison between the two rankings adds little considering that they coincide in 60% with respect to the universities involved and the rest of the parameters analysed are the same for both.

Finally, a third table, table 3, contains additional information on the different universities that participate in both rankings but have not been included in the study for different reasons shown in the table.

Table 3. Additional Information on Universities.

| University | Degree | Subject | Comments |
|------------|--------|---------|----------|
| University of the Basque Country | Mechanical Engineering | Project Management | Not subject specified |
| University of Oviedo | Industrial Organization Engineering | Occupational Risk Prevention Projects | Upcoming implementation |
| University of Oviedo | Mechanical Engineering | Projects and Technical Office | Not subject specified |
| University of Seville | Industrial Technologies Engineering | Projects | Not subject specified |
| University of Zaragoza | Industrial Technologies Engineering | Safety and Risk Prevention in Industrial Processes | Not currently offered |
| Polytechnic University of Madrid | Industrial Organization Engineering | No subject included |
| Polytechnic University of Catalonia | Industrial Design Engineering and Product Development | No subject included |
| Polytechnic University of Catalonia | Industrial Technologies Engineering | No subject included |
Within the information provided by both tables, it should be noted that only the engineering specialties considered as industrial have been taken into account. However, occupational risk prevention does appear in other fields such as aerospace engineering or automotive engineering.

Examples are the University of Seville with the elective subject taken in the fourth year called Analysis and Prevention of Labour Risks and 4.5 ECTS in aerospace engineering. Also, the case of Automotive Engineering of Polytechnic University of Catalonia with the subjects Project Methodology, Management and Orientation and Occupational Risk Prevention, both elective courses in the fourth year and 6 ECTS each.

Analysing the rest of the degrees under study, it is observed that there are certain universities where there are specific mentions, as is the case at the Polytechnic University of Valencia, specifically the School of Design Engineering, which recognized the need of companies and created the mention in prevention, consisting of 18 credits, divided into three subjects: Technology of Prevention 6 credits, Methodology of Prevention 6 credits, and Safety and Prevention 6 credits[26,27], although they do not enable according to current legislation. At other times, it is a matter of individual topics within a subject as in the case of the Projects or Technical Office course, which includes some topics related to occupational risk prevention regulations, industrial regulations and, on occasion, the performance of health and safety studies.

But in one way or another, these concepts can be seen to be contemplated in the third and fourth courses where the student has already been able to experience laboratory practices, as advised by Europe [28], without prior knowledge of occupational risk prevention except those learned in previous formative cycles such as secondary school [29].

None of the Universities contemplates introducing risk prevention as a transversal subject prior to the beginning of the laboratory practice. Taking into account that the objective of laboratory practices for a student is that students acquire their own skills, broadening their knowledge, deepening and consolidating the theoretical foundations, not only will they not have them, but it will not be one of the habits and skills that are considered of vital importance in their professional future [30]. A fact that should also be addressed not only from the personal point of view of safety, but should be extended to different concepts with which it is closely related, such as productive efficiency or quality [31]. Both bring a revaluation to the meaning of safety to the point of considering a company that does not contemplate high safety standards as a non-competitive company [32].

Furthermore, the type of subject indicates whether the subject is required or elective, which means, based on the data provided in the table, that less than half are required subjects. This means that more than half of the students who study engineering do not have any knowledge of occupational risk prevention since there is no obligation to study it.

Considering the number of ECTS (European Credit Transfer System) credits, it can be seen that in the most favourable case a total of 6 credits are assigned and in the most unfavourable case only 3 credits, which translates into 2.5% of the total number of credits required for an engineer to obtain his degree and 12.5% of the minimum content of the training program focused on the performance of higher level functions established by the Spanish legislation that will allow them to carry out preventive activities in a company [33].

4. Conclusions

According to the results and discussion section, the training received by future engineers in the area of occupational risk prevention is far from what can be considered sufficient to face the risks to which they will be exposed in their professional development. Nor is the preventive culture guaranteed, since it has been demonstrated that in some cases it is possible to obtain the degree without having any contact with the subject. These shortages do not allow them to know the relationship between safety and productive efficiency and between safety and quality, which are so valuable for the exercise of their profession.

In addition, the new training paradigms consider training in competencies, specific and transversal. The latter competences allow the development of activities that are common to all engineering, including those related to the prevention of occupational risks. This suggests the inclusion of occupational risk
prevention as a transversal subject in case the competent organization, either the Government or the Autonomous Community, does not do so and to overcome the barriers that make it difficult, such as the unknown of the subject by the teaching staff or the lack of interest due to the insufficient sensibilization of the professional development of the engineer.

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