Performance analysis of teaching methodologies applied to graduate subjects on risk engineering and management in industrial environments

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Abstract: In the risk engineering and management teaching, technical guides need to be complemented with standards, regulations, guides and professional criteria of Spanish and international prestigious institutions. This situation allows the extension of teaching opportunities, addressed to design teaching activities focused on the analysis and knowledge of considered industrial safety technologies. For this, from the Manufacturing Engineering area of the National Distance Education University, a methodology based on the simulation of the actual Health & Safety professional practice has been developed. In this work, an analysis of the student’s opinions on the teaching methodology of several National Distance Education University subjects related to industrial risk engineering and management is performed. The study covers a period of five academic years, collecting a total of 232 surveys. The analysis methodology has allowed to obtain a general view related to the student satisfaction. Among, the conclusions, it can be highlighted the satisfaction with evaluation model, the flexibility, the quality of contents and the teaching methodology. Finally, in the future, this methodology will be used to perform another teaching performance based on other approaches based, for example, specifically in the training -obtained in these subjects- for professional issues.

Keywords: Industrial risk, Quantitative analysis, Teaching innovation, Methodology.

1. Introduction
Engineering is a practicing profession devoted to harnessing and modifying the three fundamental resources that humankind has available for the creation of all technology: energy, materials, and information [1-2]. In Occupational Health & Safety (OH&S) field, the ISO 45001:2018 standard [3] defines an OH&S risk (the terms “OH&S risk” and “occupational risks” are used as equivalent in this paper) as the combination of the likelihood of occurrence of a work-related hazardous event or exposure (s) and the severity of injury and ill health that can be caused by the event or exposure(s) [4].

For risk engineering and management teaching, Technical Notes Prevention along with the technical guides, both issued by the National Institute of Safety and Health at Work (INSST), need to be complemented with standards, regulations, guides and professional criteria of Spanish and international prestigious institutions. This circumstance allows the extension of teaching opportunities, oriented to design of activities focused on the analysis and knowledge of considered industrial safety technologies [5]. The subjects analyzed in this work corresponds to the “Management of Occupational Risk Prevention and Related Techniques (4 ects)” (taught from 2017) and “Safety Management (5 ects)”
(taught from 2014 to 2016) belonging to the Master degree in Occupational Risk Prevention ([http://portal.uned.es/portal/page?_pageid=93,69878398&_dad=portal&_schema=PORTAL&idTitulacion=220701](http://portal.uned.es/portal/page?_pageid=93,69878398&_dad=portal&_schema=PORTAL&idTitulacion=220701)) and taught by Lecturers linked to the knowledge area dedicated to Manufacturing Engineering Processes. At the National Distance Education University, 1 ects corresponds, in general, to 25-30 hours of work, being in the upper limit (30 hours) when the subjects are of eminently practical and of professional nature. Therefore, the expected dedication for the analyzed subject is around 120 hours. Given the special characteristics of the subjects and in order to give maximum follow-up to the methodological recommendations of the European Higher Education Area (EHEA) arising from the Bologna Declaration of June 19, 1999, the following and evaluation of the subjects is carried out from the performance of a set of activities (grouped in Activity Blocks) that allow to improve student’s skills. Subsequently, the number of students has been increasing from the first academic year (in which the number of students were about 20); having around 180 students enrolled from 2017/18 course. The methodology consists of a “Learning by doing” typology and the prepared Activity Blocks connect with real case mini-projects which results are very fruitful and enriching for the student’s group due to the heterogenous access itinerary (psychology, law, social sciences, medical sciences and engineering). Subsequently, the structure and methodology have shown a robust and a resilient nature, as it has been contrasted in the current situation due to COVID-19 pandemic. Thus, the meeting expectations has been verified by a survey.

Thus, in this work, an analysis of the student’s opinions on the teaching methodology of several National Distance Education University (UNED) subjects related to industrial risk engineering and management is performed. The study covers a period of five academic years, collecting a total of 232 surveys. Consequently, the motivation to perform this work was obtaining key conclusions that allows to improve the teaching of the subjects analysed. The methodology has been based on the design and performing of an original survey.

2. Methodology

From the Manufacturing Engineering area of the National Distance Education University, the teaching methodology has been developed based on the simulation of actual Health & Safety professional practice. It is important to highlighted that the scientific, professional and teaching experience provided by the manufacturing engineering team that teaches the subject, help impulse the integration of real practice and cutting-edge topics in the subject content. The expertise of teaching team provides a singular and cross view, integrating -for example- several related matters such as quality assurance, standardized management systems, risks analysis and safety management related to manufacturing operations (machine tools, welding processes, etc…).

In this work, an analysis of the student’s opinions on the teaching methodology of several The research was performed by making a preliminary analysis the most relevant aspects to consider in the study (stage A), followed by a selection of 9 different questions (stage B) and, finally, the evaluation of results (stage C) to established conclusions and allowing to improve the teaching of risk engineering and management subjects (figure 1).

**Figure 1.** Methodology of analysis.
The Stage A is developed in the section 2.1, while Stage B is developed in section 2.2. and Stage C in section 2.3.

2.1. Stage A.- Preliminary analysis

The growing need to provide students with solid enough foundations that allow them to successfully enter a world that is changing rapidly, leads to propose a new direction in teaching practice that favours the development of essential skills and competencies in the risk management professional field according to standards such as the formerly one OHSAS 18001 [6] related to the occupational health and safety management certification and the new one that supersedes this one, ISO 45001 related to the Occupational health and safety management systems [7].

Competences are understood to be the set of knowledge, skills, abilities and attitudes that are integrated into certain personal characteristics. The increasing need to provide engineering students with sufficiently solid foundations that allow them to successfully enter a world that is changing rapidly, leads to propose a new direction in teaching practice that favors the development of a series of essential skills and competencies in the professional field [8].

Thus, among the basic competencies associated with Master's teachings, RD 1393/2007 [9] indicates that students must be able to apply the knowledge acquired and its ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study [10]. Previous to analyze the performance of teaching material and methodology, the percentage of passing for ordinary call (February) and extraordinary call (September) has been calculated. The results are shown in the table 1.

| Analyzed year | % Passed (ordinary call) | % Passed (extraordinary call) | % Total passed |
|---------------|--------------------------|-------------------------------|----------------|
| 1st           | 61.11                    | 16.67                         | 77.78          |
| 2nd           | 61.90                    | 9.53                          | 71.43          |
| 3rd           | 48.53                    | 13.23                         | 61.76          |
| 4th           | 56.40                    | 9.95                          | 66.35          |
| 5th           | 59.12                    | 8.86                          | 67.98          |

Table 1. Percentage of passing students.

| Nº  | Question (to be valued with 1 to 5 points)                                    | Value |
|-----|--------------------------------------------------------------------------------|-------|
| Q1  | The contents of the subject seem interesting to me                            |       |
| Q2  | The methodology followed in the subject seems interesting to me              |       |
| Q3  | The follow-up of the subject has been flexible enough and adapted to my personal requirements |       |
| Q4  | In carrying out the set of activities for this subject, I have used a total of 120 hours |       |
| Q5  | The activities carried out contain sufficient practical and application content |       |
| Q6  | The focus and sequencing of the activities have seemed didactic to me        |       |
| Q7  | The level of difficulty of the activities carried out seems adequate to me   |       |
| Q8  | Following the course has provided me with enough information from the point of view of my curricular interests |       |
| Q9  | I am satisfied with the "evaluation model" of the subject                    |       |

Table 2. Survey.

The mean of percentage of students that has passed the subjects in each analyzed year was a 69.06%.
2.2. Stage B.- Development of the survey: selection of the 9 questions

The analysis is performed based on a 9 questions survey specifically designed for this issue (table 2). The questions have been selected according to ensure that the contents, duration, methodology and evaluation model are suitable considering also that it is necessary to help students develop competences for the professional activity. Consequently, the answers can allow to obtain an updated analysis of the degree of satisfaction, being able to improve the methodology, the contents or the evaluation metrics.

3. Results

Once analyzed the answers for the 9 questions included in the 232 surveys received during the five academic years studied, a representation of the results obtained is performed in Stage C, as follows.

3.1. Stage C.- Analysis and final considerations

Figure 2 provides the participation (expressed in %) along five academic years.

![Figure 2. Participation (in %).](image)

As figure 2 shows the participation was between 45% and 72%. Subsequently, the participation mean was equal to 55.71%. Once analyzed the 232 surveys, the main results can be observed in figure 3.

![Figure 3. Results of survey (mean values).](image)

In all cases, the answer exceeded the 80% (a qualification of 4/5) excepted for the question Q4 that it is slightly less. The answers more important for the teaching team were Q5 and Q8 (due to the information it provides in relation to the interest from a professional development point of view), as well as Q4 (for its value to evaluate actual dedication) and Q9 (about the evaluation model). Thus Q5, Q8 and Q9 exhibit good results. Specifically, the two most relevant values for being analyzed by the teaching team were those corresponding to questions Q5 and Q9 (because answer to Q9 may be affected...
for the high number of approved (“passing rate”) students and good qualifications obtained.

The question Q4 is related to the hours dedicated to the subjects analyzed (120 hours considered as a premise). Therefore, it is necessary to consider that question Q4 is quite subjective, increasing usually the real time dedicated to the subject as other works like the one performed by Nosair and Hamdy [11].

On the other hand, it is interesting to represent the standard deviation between answers for each question. Figure 4 exhibit the mean of standard deviation for each question (Q1 to Q9).

![Figure 4. Standard deviation (mean value) in the answers to the questions Q1 to Q9.](image)

Almost all questions showing a standard deviation less than 0.8, excepting the questions Q3 (flexibility of the methodology according to personal requirements) and Q4 (hours dedicated), where the value is 0.91 and 1.21 respectively. The mean hours necessary to complete the subjects has been 128.28h (i.e. very closed to the premise stablished in 120 hours).

4. Conclusions

An analysis of the student’s opinions on the teaching methodology of several National Distance Education University (UNED) subjects related to industrial risk engineering and management has been performed. The study has covered a period of five academic years, collecting a total of 232 surveys containing 9 questions aimed at finding out if the current subjects approach is suitable and if there are highlighted aspects to consider in the next reviews of contents. Thus, the major conclusions can be summarized as follows:

- The analysis methodology has allowed to obtain a general view related to the student satisfaction. Thus, the use of Activity Blocks connected with real case mini-projects have resulted very fruitful and enriching for the student’s group due to the heterogenous access itinerary (psychology, law, social sciences, medical sciences and engineering) and the practicality of the selected teaching strategy.
- The structure and the “Learning by doing” methodology have shown a robust and a resilient nature, as it has been observed in COVID times.
- The scientific, professional and teaching experience provided by the manufacturing engineering group, help impulse the integration of real practice and cutting-edge topics in the subjects content.
It can be highlighted the satisfaction with evaluation model (Q9), the flexibility (Q3), the quality of contents (Q1) and the teaching methodology (Q2).

Another important aspect is the student’s feedback on time dedicated to these risk engineering and management subjects.

In the future, this methodology will be used to perform another teaching performance based on other approaches based, for example, specifically in the training -obtained in these subjects- for professional issues.

Acknowledgements

This work has been performed in the frame of the Teaching Innovation Project of the GID2016-28 group, focused on “Reliability and Advanced Failure Prognosis in industrial applications applied to the teaching of Materials Technology and Processing”. In addition, this work has been funded by the Annual Grants Call of the E.T.S.I. Industriales of UNED through the project of reference 2021-ICF08.

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