ASSESSMENT OF THE USE OF TECHNICAL SOFTWARE BY THE STUDENTS IN THE CONTEXT OF MECHANICAL ENGINEERING

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Abstract

In the framework of the European Higher Education area, university teaching has focused in recent years on adapting Master's and Bachelor's degrees to the demands of the professional sector. To this end, the training and development of generic and specific competences recommended for the incorporation of students into the job-market have been priority objectives in the planning of study plans. However, there is no general consensus on the methodologies for evaluating these competencies, especially regarding how to separate the acquisition and/or improvement of the generic competences from the knowledge and specific abilities of the subjects. Furthermore, the tight number of teaching hours to complete the syllabi of the subjects cannot be ignored, added to the greater number of continuous assessment tests. That is why the teaching staff looks for methodologies that do not involve additional tests for the evaluation of competences, avoiding the reduction of the syllabus.

In order to make a contribution in this regard, this work presents an approach for the evaluation of the ability to handle specific software applied to problems in the mechanical engineering area. This document states that, in order to acquire the skills required by the Specific Instrumental competence in the case of structural integrity analysis and design software such as ANSYS®, prior training is required in the use of such software. The hypothesis also considers that the way to evaluate the acquisition of this competence is through the autonomous realisation of a lab at the end of the subject. Some conclusions will be gathered from the results obtained with a view to optimising our proposal in future courses.

Keywords: Generic competences, Specific Instrumental competence, Evaluation.

1 INTRODUCTION

Within the framework of the European Higher Education Area, universities are mostly opting for the approach based on the evaluation of transverse competences [1][2]. There is broad consensus regarding the inherent relationship between these competencies and the subsequent professional development of students, linked to the potential professional development of students and, therefore, their contribution to social prosperity as a general objective [3]. Hence, the effort invested in the last decade by academic institutions to achieve international accreditation of their competency-based study programs.

In the development of their Bachelor's and Master's degrees, the Universitat Politècnica de València (UPV) to which the authors belong, has defined 13 generic competences [4] related to the generic capacities and abilities demanded by the business sector. This information allows the companies to adjust the profiles they are looking for in their personnel selection processes beyond a list of the subjects taken in the degrees [5]. At the same time, the curricular information of these competences makes it possible to boost student mobility based on evaluation criteria that are comparable between universities [6].

To facilitate the evaluation of generic competences, the UPV has established three different levels of development for each competence, from the 1st and 2nd year of undergraduate degrees (Level 1), the 3rd and 4th years (Level 2), up to Master's degrees (Level 3). The complexity of the learning outcomes associated with these skills increases according to the level [4]. In the present case under study, the results correspond to a subject of the 4th year (Level 2).

One of the problems that arises in the application of this approach is how to evaluate generic competences, which is a subject of continuous debate in the teaching field and which requires a change in pedagogical practices based on master classes, without hardly any teacher-student interaction. In this regard, the UPV has promoted in recent years the PIME programs for the

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development of innovative projects for the evaluation of competences, one of which is part of this work.

The academic experiences developed by the authors show the importance of using active learning-oriented methodologies to promote the implementation of their skills among students through activities that allow the direct evaluation of the competences required in each subject. In this line, through coordination between different subjects in the mechanical engineering area, an experience related to the design and development of strategies and tools has been carried out in order to assess the generic competence "Specific Instrumental", in its name at the UPV. There is no direct conversion to the list of generic competencies of the Tuning projects [7][8] or ABET [9], but its characteristics fit with those of "technological skills" or "technical skills". It refers to the use of tools and technologies necessary for the professional practice associated with mechanical engineering. Through their acquisition, development and improvement, the student will be able to identify the most appropriate tools for the context, know their utilities and integrate and combine them in order to solve problems, carry out projects or experiments. In this specific program, the authors have focused on the ability to use 3D engineering and design simulation software, which is fundamental to address problems of 3D design, dimensioning, elastic-plastic behaviour and structural integrity, ANSYS®. The domain of this type of software is today essential for professional integration. As it has been reiterated previously, the subject under assessment is included in the area of mechanical engineering, so that their lab reports are essentially related to the Specific Instrumental competence.

The main objective of the publication is to check if the evaluation of the acquisition of the Specific Instrumental competence could be properly performed through a final lab exam where the mastery of the software is required.

2 METHODOLOGY

2.1 Design of the methodology

The strategy designed to acquire the required skills for the Specific Instrumental competence has been tested at one acquisition level: Level II, corresponding to the 3rd and 4th grade courses, and whose learning result can be expressed as "Correctly integrate the basic tools of the professional field".

Domain level II establishes two different indicators: I1) Handles basic tools autonomously; I2) Select and combine the appropriate basic tools to carry out a project and/or solve a complex problem. Each of these learning outcomes is divided into four levels of achievement: D) Not Met, C) Developing, B) Good/Adequate, and A) Excellent. For the numerical evaluation, the respective numerical ranges are: 0–2.5, 2.6–5.0, 5.1–7.9, 8–10.

The initial hypothesis is that to acquire and evaluate the Specific Instrumental competence, in the context of structural integrity analysis and design software such as ANSYS®, a specific training program followed by a final exam would be an adequate alternative balancing the level of mastery acquired by the students and the load suffered by the professors. Thus, the objective of this work is to give some data that supports the previous hypothesis. The proposed methodology for supporting this hypothesis is to perform a cross evaluation of the students. Some of the students takes the course Computational Techniques in Mechanical Engineering (CTME) in which the training program and the final exam is scheduled. Thus, CTME has the training role in this context. A second subject, Mechanical Vibrations (MV) in which only a part of students have taken CTME, uses the software ANSYS® as a tool for solving one of the labs. This will allow us to observe if those students previously trained obtains different results in the lab. The data is collected from the results of these two subjects in the academic year 2019/2020 as shown in Table 1:

Table 1. Information of the subjects.

Subject	*Degree*	*Semester*	*Role*
Computational Techniques in Mechanical Engineering (CTME)	Degree in Mechanical Engineering. 1st semester (GIM)	4ºA	Training
Mechanical Vibrations (MV)	Degree in Mechanical Engineering. 1st semester (GIM)	4ºA	Check

The training program at CTME for acquiring the specific competence consists of 7 labs divided into 15 sessions of two hours duration, after which an exam is carried out that consists of repeating one of the labs carried out with some small modifications. This is the proposed training and evaluation methodology that is under investigation through an external check at MV.

To externally check if the students had effectively acquired a level of mastery in the software, a lab in the MV subject is used. In this case, the lab requires to use ANSYS® software as a tool to solve the lab. Not all the students in MV have attended the CTME course, then not all of them have been trained in the handling of ANSYS®. For this reason, a user manual is prepared for this checking lab at MV. The students are assessed in two ways: *i*) the mastery of the software and *ii*) the application of the concepts of the subject. Finally, in order to check the quality of the training process and evaluation in CTME, a correlation between the results in the checking subject and in the training subject is carried out.

2.2 Software description

In engineering practice, it is often necessary to know the behavior of physical systems that can be mathematically modeled using partial differential equations. One such problem is the elasticity analysis of mechanical components. When the geometric complexity of the component is high or the boundary conditions of the problem are not trivial, it is practically impossible to solve the partial differential equations by analytical methods and it is only possible to use numerical methods. Among all the known numerical methods, the most versatile, and therefore the most widespread is the Finite Element Method (FEM). In fact, today it is essential for any engineer to know its existence, fields of application and how to use it.

ANSYS, Inc. was founded in 1970 (Swanson Analysis Systems, Inc.). ANSYS develops, sells and supports engineering through simulation software to predict how a certain product will work and react in a real environment. ANSYS, Inc. for structures is developed to work using the finite element method. The program is divided into three modules: preprocessor, solver and postprocessor (Figure 1).

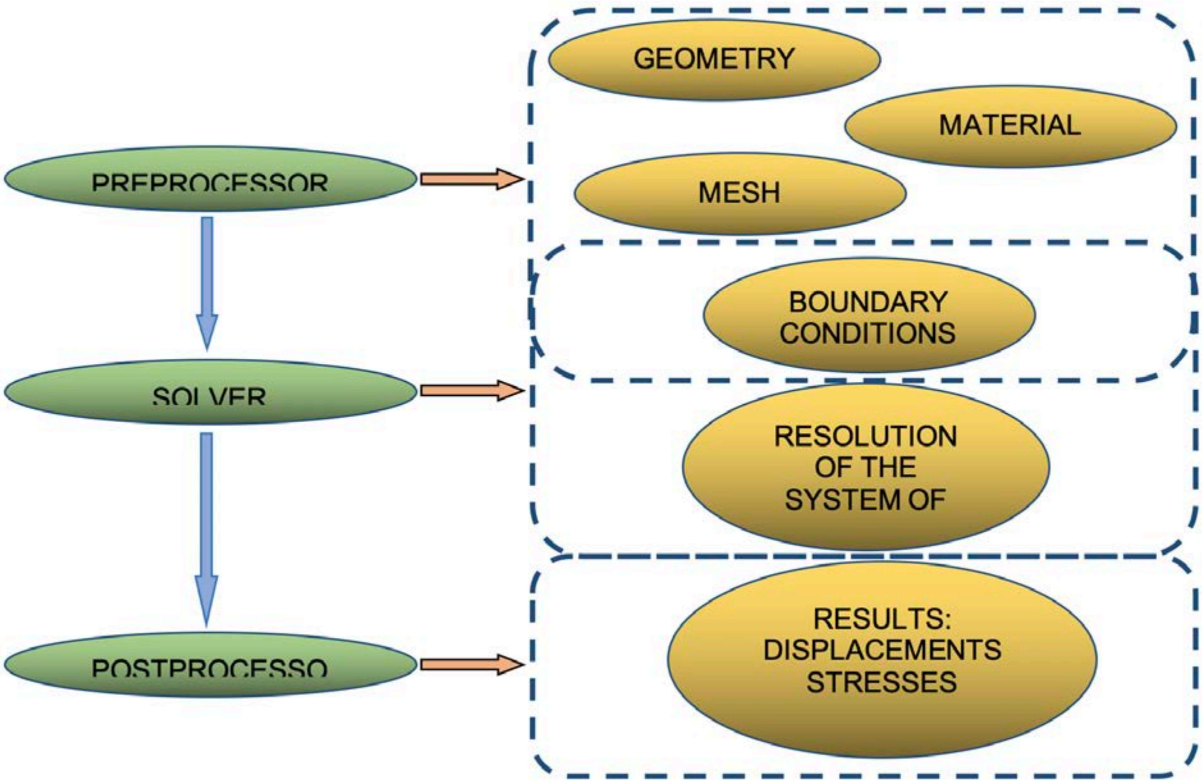

Figure 1. General structure of a Finite Element software.

In the preprocessor, the geometry of the problem and the properties of the materials are defined. The mesh is created and the boundary conditions are applied. If you want to check the safety factors, it will be necessary to additionally define additional material properties. Then the algebraic system of equations associated with the FEM can be generated and solved. Finally, the results can be obtained and plotted.

The development of the labs follows a natural learning of the software. That is, it begins with an introductory session to ANSYS® and progresses in introduction to the management of the different tools provided by the software for the solution of more complex problems during the subsequent labs. The indicators used to define the level of acquisition of the competence in the use of the software are:

- Generation of a geometry.
- Generation of a mesh.
- Definition of the boundary conditions.
- Interpretation of the results.

3 RESULTS

A first group formed by 46 students belongs to the training group, who takes the subject CTME. Figure 2 shows the final lab assessment, which considers the four indicators for each student. Note that from indicator 1 to 4, the student must follow a process, that is, it is not possible to obtain the mesh without the geometry. Then the students increase the mark as they obtain positive results in the indicators, progressively. In general, the results are positive since 96% of students passed the exam and obtained a grade A or B in the corresponding transversal competence evaluation. This would show the satisfactory results of the methodology if the evaluation proposed is representative. For that reason, the second step consists of comparing these results with those of MV in which the students need to use ANSYS® as a tool.

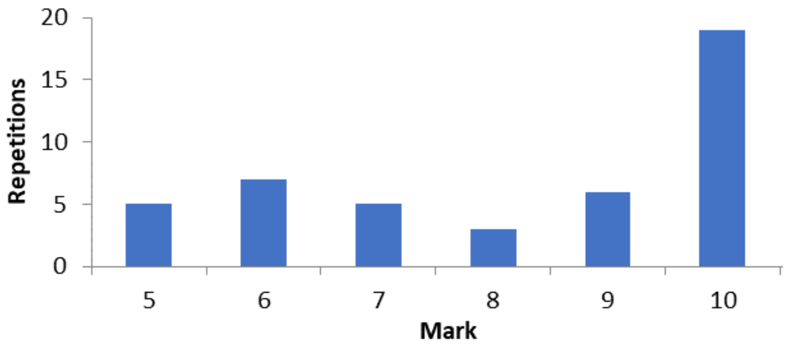

Figure 2. Histogram (mark vs repetitions) of the results of the final lab evaluation in CTME.

For the checking subject (MV) 150 students are considered. This group contains the students in CTME. In this subject a binary evaluation method is used. The evaluation method consists of a checking list considering two aspects:

1. The students use ANSYS® properly.
2. The students solve the contents of the lab properly.

In the evaluation, all students achieve the first objective, but this is not a relevant result since: *i*) the students have a lab guide in which all steps needed to use ANSYS® are perfectly explained. Remember that 2/3 of the students that never used ANSYS® before. *ii*) The students who had already used the software helped the others in this aspect of the lab.

Therefore, the second indicator is used for checking purposes. It is clear that the students that had been already trained in the use of ANSYS® required less time in reading the ANSYS® manual and could invest more time in solving the contents of the lab. Additionally, they are trained in interpreting the results in ANSYS® (fourth indicator). Therefore, a better performance was expected. In this regard, 82% of students with previous experience in ANSYS® managed to solve the lab properly while only 71% without previous training were able solve the lab properly. This fact suggest that the training process and evaluation could be a promising strategy for this purpose.

4 CONCLUSIONS

In this publication we present a methodology for the training and the evaluation of an engineering commercial software. The students are trained during 15 lessons in different aspects of the software and a final exam is used to check their level of mastery. The mark obtained in the exam is used to specify the level of the Specific Instrumental competence acquired by the student.

On the other hand, a second subject is used to check if the students who had been trained overperform those who were not previously trained. The results supported the expected thesis. Therefore, the proposed training and evaluation strategy could be considered as an interesting option for further studies in other subjects and other academic courses.

These conclusions justify that the evaluation tool proposed could be considered as a practical option to evaluate the Specific Instrumental competence in the mechanical engineering context, even more if we consider that the effort for the professor is reduced since only one final evaluation is required. In any case, further research must be carried out to strongly support the initial conclusions of this experiment.

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