CAPÍTULO 18. **DESIGN OF MECHANICAL ELEMENTS IN 3D MODELING PROGRAMS**

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1. INTRODUCCION

Computer-aided Manufacturing (CAM) technology have unquestionably grown and become a dynamic part of the manufacturing sector. Nowadays, using computer-aided design and engineering (CAD/CAE) techniques, the items are developed and computed virtually while simulating different environments. With the proper application of software platforms, product development is accomplished with lower costs, the strictest fulfilment of the necessary functionalities, and the best production process (Li et al., 2020). Various information technology systems support the stages of a product's whole life cycle. Significant developments in the field of computation, emerging patterns in the industrial market, and the development of information and communication technologies (Wang, 2018) have made it necessary to train young design engineers in an ecosystem that mimics the system where they will perform their work (Morales-Avalos & Heredia-Escorza, 2019). These industrial software platforms are appropriate for this. Platforms frequently move their methods of operation to the cloud, where several highly specialized modules enable cross-disciplinary and group design collaboration. Its new paradigm necessitates an academic assessment of this operability's viability. Due to the inability to use systems with individual licenses in the classroom and the need to adopt teaching strategies with more global design principles because of the COVID-19 epidemic, traditional teaching paradigms have had to be modified (Sola-Guirado et al. 2022).

Construction technology has great potential to improve productivity and decrease project duration. Delays can have significant negative effects, including

lawsuits between owners and contractors, lost productivity and revenue, and contract termination. Hence the importance of preparing students when it comes to developing and preparing a project (Separgozar et al. 2015; Abd El-Razek et al. 2008 and Le-Hoai et al. 2008).

Self-efficacy, the belief that one can achieve a certain level of achievement, is important for student retention in the fields of engineering and technology. In the context of engineering programs, developing ways to increase self-efficacy should be a primary concern. That is why the importance of design projects for the self-efficacy of engineering students and with it that they see reality outside the university (Michael et al. 2012; Schwarzer & Jerusalem 1995 and Todd et al. 2012) .

The best preparation for a contemporary mechanical engineering specialist can only come from a thorough investigation of the modern CAD that is currently in use in business. In many respects, the competencies future experts develop during their training in higher education institutions impact their competitiveness and capacity to adapt to the conditions of industrial activity. (Sarcar et al. 2008)

A review of the literature indicates that although various researchers have examined factors affecting student satisfaction, none of the studies examined the effects of curriculum design, teacher quality, timely feedback, and student expectations on student satisfaction. Student satisfaction with online teaching during the Covid-19 pandemic. This study sought to examine the factors influencing student satisfaction and performance related to online teaching during the COVID-19 pandemic. Due to the pandemic, educational institutions have been forced to go online with people they do not know well, including teachers and students. Students were not mentally prepared for such a change (Gopal et al. 2021).

Therefore, this study aimed to understand what factors influence students and how students perceive these changes, which is reflected in their satisfaction.

This project aims engineering students to obtain basic knowledge to be able to design elements used in the industry. The design of these projects is intended to serve as an example for the implementation of a model of project that simulates real work that students will have to perform during their professional activity when they face the real work environment. This project is a good way to teach students about the entire process of design, development, and implementation of the project, without forgetting the importance of working in team with others.

1.1. Related work

As early as 2005, while reflecting on the importance of professional skills included in ABET's "Engineering Criteria 2000," Shuman and colleagues recognized the variety of methods applicable to teaching professional skills (Shuman et al. 2005). These methods included decision-making exercises,

project management or business simulations, project-based classes, case studies, and integrated modules. More recently, Winberg et al. (2020) have attempted to classify these approaches in a systematic review of employability studies in engineering. While reporting important variations in what the reviewed studies refer to as 'professional skills', the authors defend the idea that professional skills cannot be considered generic but are linked to disciplinary practices. Therefore, they argue that engineering knowledge and professional skills should be better integrated.

2. METHODOLOGY

This work approaches a Cross Learning methodology focused on developing the interrelationship between different areas, linking theoretical and practical knowledge (Nwokeji & Frezza 2017). This project applies to Mechanical Engineering students with regard to the subject “Calculation, Construction and Testing of Machines”. Current labor market requires engineers to stay up-to-date steadily. Thus, it is a duty of faculties to provide students with the necessary tools to successfully develop their future tasks (Savin-Baden 2007; Faudou & Bruel 2016; Andriani 2021).

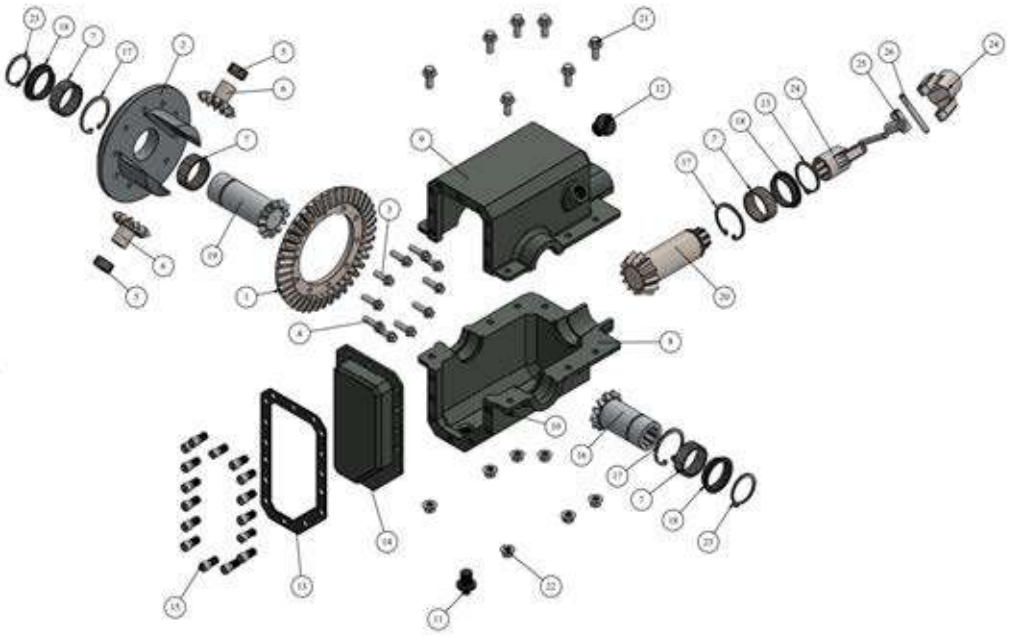
This work shows a PBL methodology developed for Industrial Engineering students. A series of works that have been performed by students are shown. According to the methodology, students are requested to develop a real project similar to the ones they would have to carry out during their future work in a company as engineers. In this task, they have to design a mechanical element from the beginning to the end. The topic in all these projects is to develop industrial engineering machinery. To accomplish their tasks, students have to use 3D modeling programs to draw all the work plans to be developed. Regarding the qualification, a rubric has been used to be the most fair and impartial with all the students.

The methodology approaches the selection of a mechanical element. Designing mechanical elements implies to execute a variety of different techniques like fastening elements calculations, which is widely applied in structural calculations, 3D design, and the use of advance CAD programs as SolidWorks, CATIA or Autodesk Inventor.

3. RESULTS

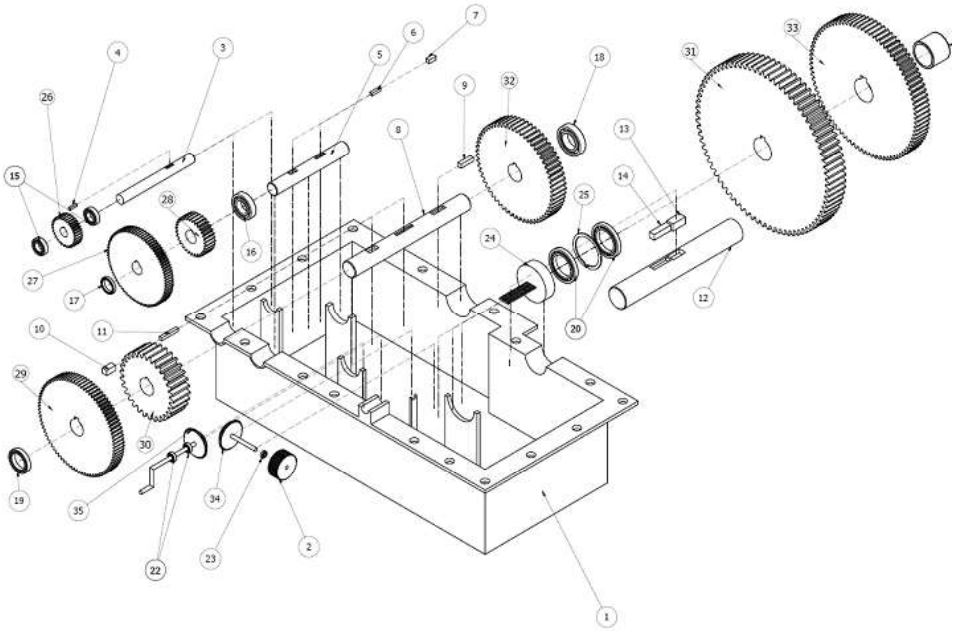
Regarding the results, works developed by the students have been selected as shown in Figures 1, 2 and 3. In which the differences between some groups and others can be seen.

Figure 1: Differential Mechanism



Source: Own elaboration

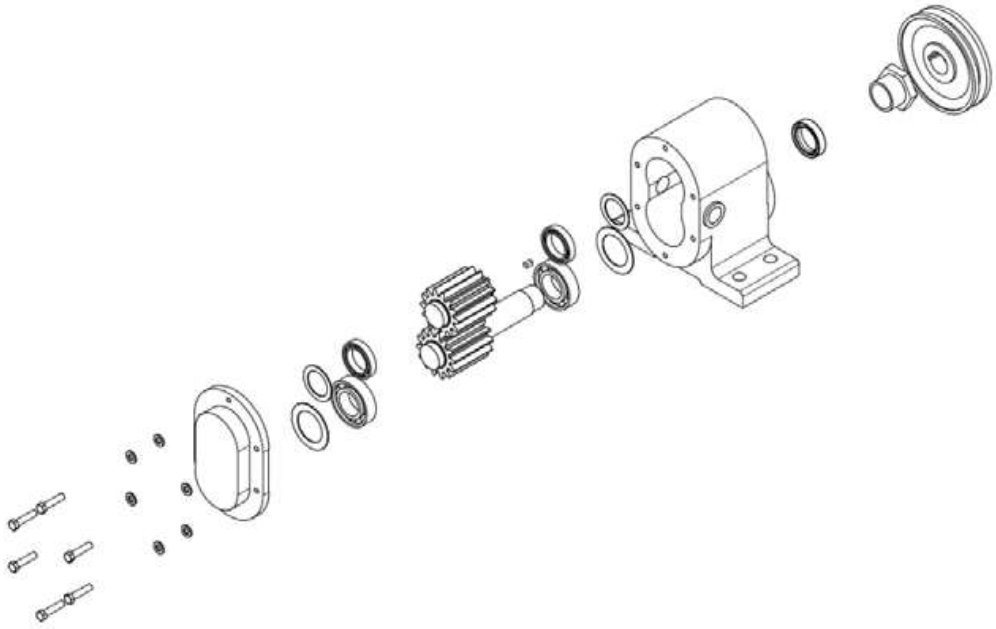
Figure 2: Gear Box mechanism



Source: Own elaboration

As can be seen in these two works that have been taken as an example, they have developed mechanical elements. It can also be seen that there are quite a few differences regarding the number of pieces that a mechanism has with respect to the others, as we can see in figure 3. In this type of work, the skill that students have when it comes to Manage 3D modeling programs. It must be taken into account that as an engineer in companies you can be asked to carry out any type of element without taking into account its complexity.

Figure 3: Gears pump 3D model



Source: Own elaboration

Regarding marks, the degree of difficulty has been taken into account.

This project involves the complete design of mechanisms such as gearboxes, differential mechanisms, crankshaft, etc. Thus, the methodology is based on Project-Based Learning through the implementation of Cross learning techniques in order to improve the quality of the learning process (International Labor Organization 2021).

This technique can be extrapolated to subjects related to building such as resistance of materials, calculation of structures or industrial architecture. In which, the realization of a real project, in which typical techniques of other disciplines are applied, in parallel with the development of the theory is very profitable.

These types of activities allow students to develop deeper and more deeply rooted knowledge, while reinforcing knowledge and skills in an interdisciplinary manner. This being a more realistic and practical approach to working life.

It must be taken into account that one of the problems that exist in universities is the little experience with which students leave the degrees, which makes it difficult when facing real life, with this type of work they are able to approach students to companies and that I have some experience in carrying out projects.

For the project appraisal process generally involves evaluating reports and presentations, and then assigning relatively broad performance categories to the work. Unfortunately, the use of professional judgment in this process varies from one faculty member to another; therefore, what is "excellent" for one person may be "very good" for another. The lack of standard definitions for such terms acts as a barrier to the fair and impartial grading of student performance. For this reason, a rubric is created to be able to qualify all students together and impartially (Chen et al. 2021; Estell & Hurtig 2006 and Bishop et al. 2012).

For the correction of these projects, a rubric has been made with which the students are qualified and the minimum requirements that are requested are shown (Pop-Iliev & Platanitis 2008; Gustafsson et al. 2002a and Gustafsson et al. 2002b).

Table 1 describes the qualification rubric used in order to assign marks in the most objectively possible way. This rubric is composed by four different factors, which have been taken into account. These factors are:

- Organization and writing quality, rated from 0 to 10, it has a weight of 15 % regarding the complete punctuation of the work.

- Content, rated from 0 to 10, it has a weight of 15 % regarding the complete punctuation of the work.

- Methodologies, rated from 0 to 10, it has a weight of 15 % regarding the complete punctuation of the work.

- Conclusions, rated from 0 to 10, it has a weight of 15 % regarding the complete punctuation of the work.

4. DISCUSIONS

According to the results, it can be seen that the results vary based on the group in which the study was conducted. This is because students have varying talents and levels of preparedness for activities linked to design works.

The issue that was raised in the previous sentence illustrates how, even when given the same design subjects, students perform differently depending on their grade or group. As a result, even though both subjects are based on the same subject, different standards are put on the students in each subject. That occurs when some races are classified as "Easy" or "Difficult." The kind of students who enrol in one engineering discipline over another is also a result of this.

Table 1: Marks Rubric

Marks Range	Organization and writting quality	Content	Methodologies	Conclusions
0,00 To 2,49	Lack of structure, illegible and/or careless with figures and citations.	Serious mistakes (scale of magnitude, concepts, etc) lack of content (less than 50% of required tasks).	Inadequate methodology for calculus or design.	Results do not provide any conclusion.
2,50 to 4,99	Swallow or badly structured and/or careless with figures and citations.	Serious mistakes (scale of magnitude, concepts, etc) and/or important lack of content	Do not apply some methods for calculus or not included design to develop a functional model.	Results provide conclusions that do not enable to determine the mechanical design.
5,00 to 6,99	The structure is clear enough and figures and citations visible and correctly organized	Not relevant mistakes	Correct methodology for calculus or design. Not evaluation of different alternatives.	Conclusions enable to define the 50% of the mechanical design.
7,00 to 8,99	Correct structure and figures and citations are visible and correctly organized	Without mistakes. All tasks are fulfilled.	Correct methodology for calculus or design. All mechanical aspects are analyzed.	Conclusions enable to define the 100% of the mechanical design.
9,00 to 10,00	Excellent structure and elaboration.	Without mistakes. All tasks are fulfilled and the student implements new methodologies (development of new skills).	The applied methodology for calculus or design means a development of new skills for the student.	Very interesting conclusions.
%	15	40	30	15

Another factor to consider are years of pandemic that have been experienced. This has resulted in a worse preparation by the students. Since most of these students have had to teach classes online in recent years. It must be borne in mind that, especially in the first year of the pandemic, entities, whether schools, institutes or universities, were not prepared for this type of situation. All these entities have needed an adaptation process that in many of these cases has not been short due to the high cost that this adaptation has involved.

Finally, one can see a difference when viewing the study from the perspective of the professors. This can be since some teachers communicate with some students more effectively than others. Additionally, it is possible that teachers lack the necessary skills to train students in this topic. The high presence of non-permanent teachers in Spain could be one of the main explanations.

5. CONCLUSIONS

With the results obtained, the following conclusions have been reached;

It can be seen the level of difficulty of making the pieces depending on the group that has done it. This implies that depending on the group/grade they are studying, it can seen that there are students with a lot of knowledge of design and use of 3D design programs, such as Auto Cad, SolidWorks, CATIA, etc. and other types of students where knowledge in this area is scarce.

In this work it has been possible to observe a great improvement in the students skills with regard to the elaboration of projects during the development of this. They have been able to feel like engineers and see what awaits them outside the university environment.

It must be taken into account that the development of the project and its execution entails many responsibilities since in many cases human lives are put in risk and not just materials.

Finally yet importantly, the students have had to work as a team, since this section is highly regarded by companies, knowing how to work as a team corresponds to one of the most demanded skills nowdays.

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