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Application of Multiple Simultaneous Methodologies in the Realisation of CAD Practices

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Abstract
Innovation in the simultaneous application of new methodologies arises from the need to adapt to the different types of learning that students may have. This research evaluates the simultaneous application of multiple methodologies in the implementation of CAD practices. Specifically, it compares the performance of this practice with the traditional methodology of guided practice and, in the following year, the performance of the same with the implementation of other methodologies simultaneously. It is applied to a computer-aided design practice in the creation of a mechanical assembly. The practice belongs to the subject of Graphic Engineering of the third year of the Degree in Mechanical Engineering taught at the Polytechnic School of Zamora of the University of Salamanca. As a consequence of the statistical analysis of the results, the benefit that can be obtained from the simultaneous application of different methodologies has been accomplished. The main objective is to improve the learning process through educational innovation based on experimentation in the classroom. The results show an improvement of 35 % in grades compared to the previous year. Innovation ratifies the importance of adapting resources and teaching to the different learning processes of the students. The application of multiple simultaneous teaching methodologies gives the student the opportunity to choose, as well as the teacher, the opportunity to be aware of the possible specific needs of the students. This research concludes with the suitability of the application of simultaneous teaching methodologies in CAD practices for the improvement of the teaching-learning process. To implement multiple methodologies, we have used and attempted to use common generative AI tools on the market today.

Keywords: CAD, Multiple Methodologies, Practical Lessons

1. Introduction
Teaching and teaching innovation has made use of the application in the classroom of different methodologies in almost all fields of study in order to fulfil the teacher's function of teaching the learner. In the changing world of education, there is an almost infinite number of teaching techniques that have been described [1], the latest concerning the use of artificial intelligence and web applications [2-5]. However, almost all the studies analysed focus on teaching techniques without taking into account that each student may have a completely different teaching-learning process, as well as starting from different bases of established knowledge which may or may not facilitate this process.

In the field of Engineering, more specifically in Computer Aided Design (CAD), there are many challenges that teachers face, and traditional lectures have proven to be insufficient to ensure that students acquire the skills required in these subjects and in the degrees in which they are taught. The importance of CAD teaching in engineering and its subsequent professional impact has been evaluated in numerous recent research studies, not only for its involvement in the daily work of engineers but also for its wide application and versatility in innovative disciplines such as Additive Printing [6-10]. Conventional methods often involve passive learning, where students listen to lectures and perform individual tasks. To overcome this problem, recent studies advocate Project-Based Learning and collaborative teaching methodologies [11,12].

Students of engineering degrees, specifically mechanical engineering, in the first year of engineering acquire competence in the set of drawing skills that includes the generation of orthographic projections of any component. By the third year, they are ready to learn how to generate three-dimensional geometric CAD models from the given orthographic projections [13,14].

The present research is framed within the area of teaching innovation applied to the third year of the Degree in Mechanical Engineering, in the subject of Graphic Engineering. Specifically, it is carried out in the practice of assemblies, which is key to the skills of a graduate in Mechanical Engineering. The aim is to make the teachinglearning process more efficient by proposing the use of multiple methodologies in practical CAD classes, making the practical class more dynamic and helping each student to learn in a way that is adapted to their knowledge needs.

2. Methodology

2.1. Guided Practice

The practical class is part of the unit on assemblies within the subject of Graphic Engineering in the 3rd year of the Degree in Mechanical Engineering taught in the first term. The traditional practice of the subject, in the 2023-2024 academic year, consisted of making an assembly using CAD software based on the exploded view of the assembly, shown in figures 1 and 2, accompanied by the relevant explanation for the assembly. This practice was carried out with only the guidance of the process in situ. The results of the practice in the traditional way compared to the rest of the practices of the subject showed learning difficulties for the students, the marks were notably lower than in other practices of similar complexity. The perception of the teaching staff was unanimous, the students were lost in some parts of the process, it was observed in the corrections that there was a great disparity of steps in which the student made mistakes. The realisation of this need was what prompted us to generate a solution for the following academic year 2024-2025 to make the teaching-learning process more effective.

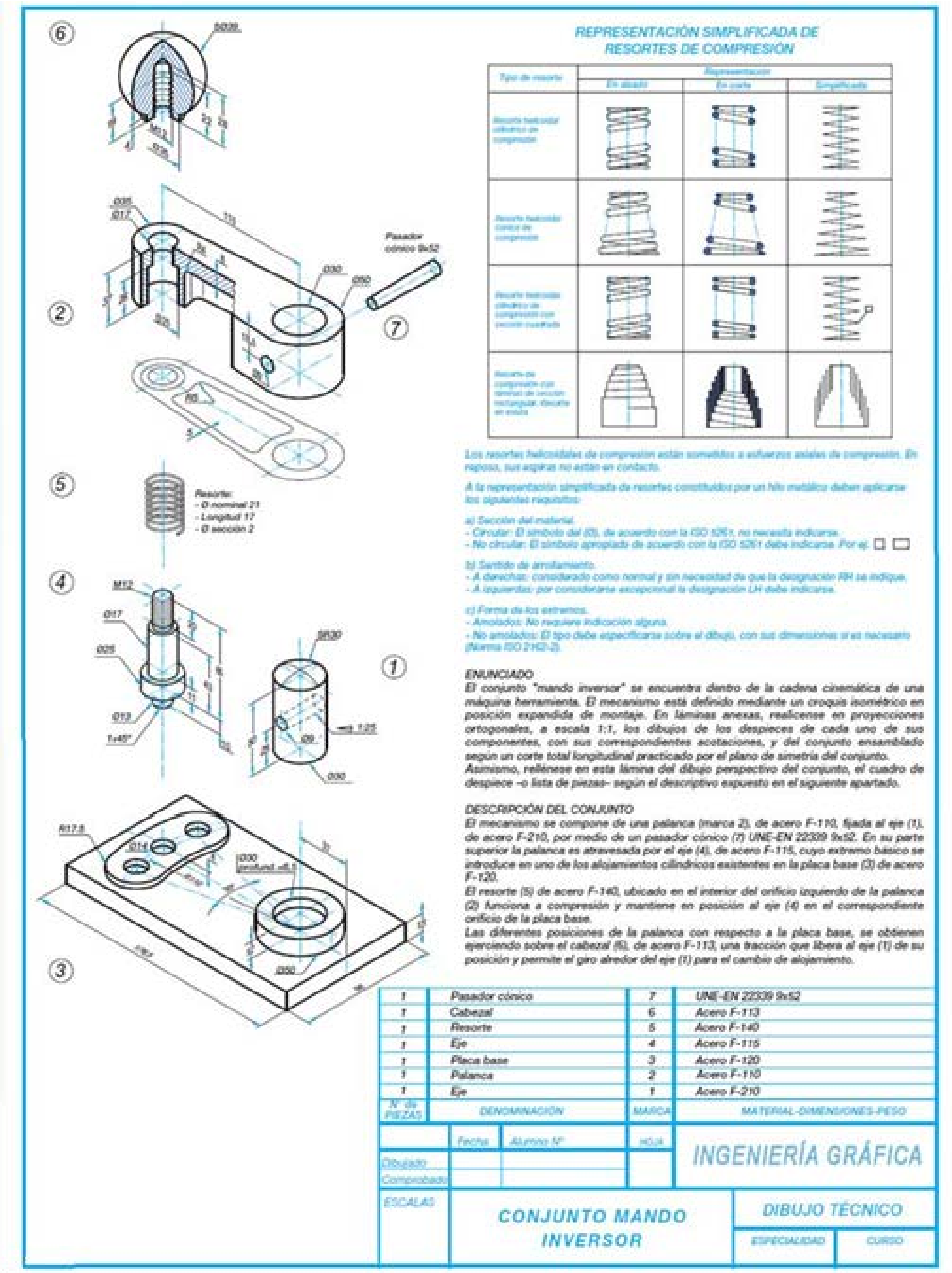

Figure 1: Exploded Drawing with Explanation of Practice

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2.2. Methodologies Applied

In the current academic year 2024-205, the same exercise described in Figure 1 of the previous section was carried out, with the difference that two interactive educational resources were added that the student could consult at any time during the exercise. The two resources that were uploaded to the student's virtual platform and downloaded in the same folder as the practical consisted of a step-by-step guide to the exercise, Fig. 2, and a video of the exercise in which the same steps were followed as in the guide, and the explanation was guided by the teacher. In this way, the aim was to address the objective that the teaching-learning process should be personalized, with the student being able to consult any step in the practice, either in writing or visually, in order to avoid making mistakes.

The step-by-step guide was elaborated from the ChatGPT with the use of sequential prompts, with the aim of creating a logical progression in the conversation, using a sequence of previous texts that allowed for more contextual and precise answers. However, once the text had been completed, the authors had to revise the content, as the prompts were less and less effective in refining the text, despite the fact that the writing of the text was simple. In terms of text imaging, several tests were carried out with the AI tool DALL-E , Midjourney and Blue willow. This was not able to generate better images than the existing ones of the programme itself modified by the authors; the complexity of the prompts made this option discarded.

Generative AI has proven to be able to create original content, from texts to images and videos of great utility in higher engineering education [15,16]. However, in certain simple and specific practices, it does not facilitate the customization of educational resources [16]. In our humble real-world case, the training time costs of the promts, as well as the learning curve, outweighed the benefits, and the results were neither accurate nor comparable to those obtained by humans.

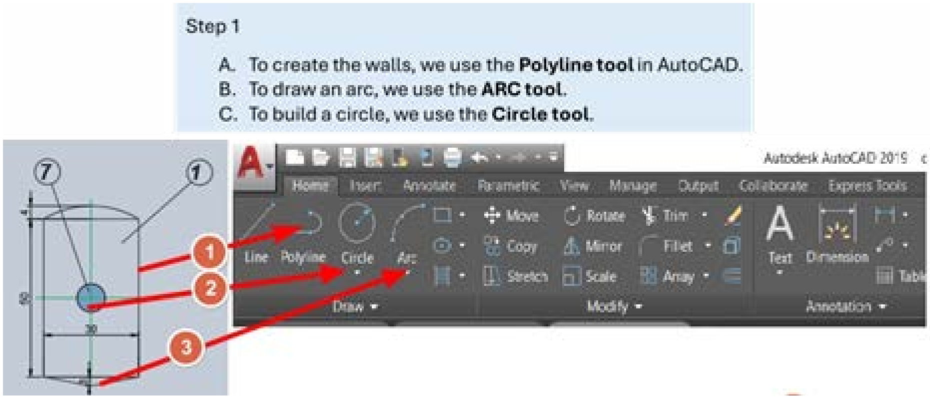

Figure 2: Description Step 1 of the Realisation of the Assembly Plan of the Assembly

The practice guide was divided into 7 in line with the video made and the guided practice. All the methodological resources were synchronised to facilitate their use by the students. Fig. 3 below shows another of the steps in the guide as well as screenshots of the video that were also incorporated into the guide.

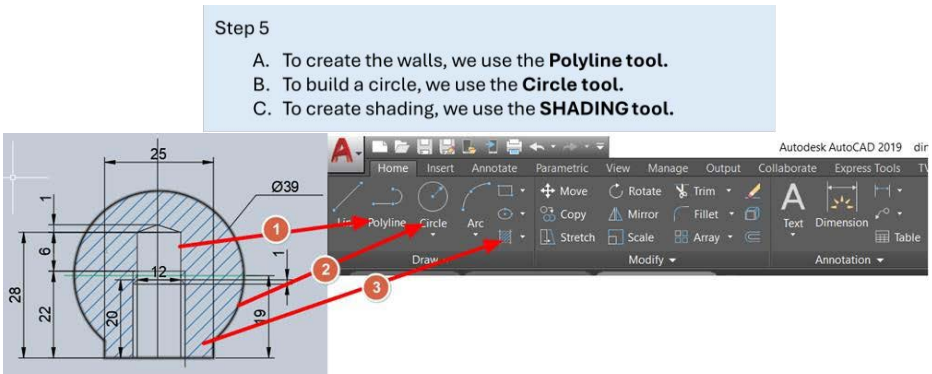

Figure 3: Description Step 5 of the Realisation of the Assembly Plan of the Assembly

3. Results

This section presents the results of the grades of the practice carried out both in the 2023-2024 academic year, in which the methodology was the classic guided practice, and in the 2024-2025 academic year, in which simultaneous resources belonging to methodologies other than the classic one, such as the video tutorial and the step-bystep guide, are implemented.

In the 2023-2024 academic year, a total of 42 students were enrolled in the subject of Graphic Engineering, of which 37 took the practical assembly plan. In the 20242025 academic year, enrolment dropped to 33 students, of which 30 students took the practical. Cohort 1: Exam year 2023–

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2024 (37 students) and Cohort 2: Exam year 2024–2025 (30 students).

The graph in Fig. 4 shows the detailed results of the students in the two courses assessed. On the one hand, there is a clear increase in the marks of the 2024-2025 students, exactly 35% higher on average than the marks of the 2023-2024 students. On the other hand, Fig. 5 shows the grades grouped by general grades, being less than 5 fail, equal to or higher than 5 pass, 7 or higher merit and 9 or outstanding. This graph shows not only the increase in the number of grades, but also the large decrease in failure in terms of the number of failures and the increase in the number of outstanding grades such as 'merit' and 'outstanding' for students in the 2024-2025 academic year.

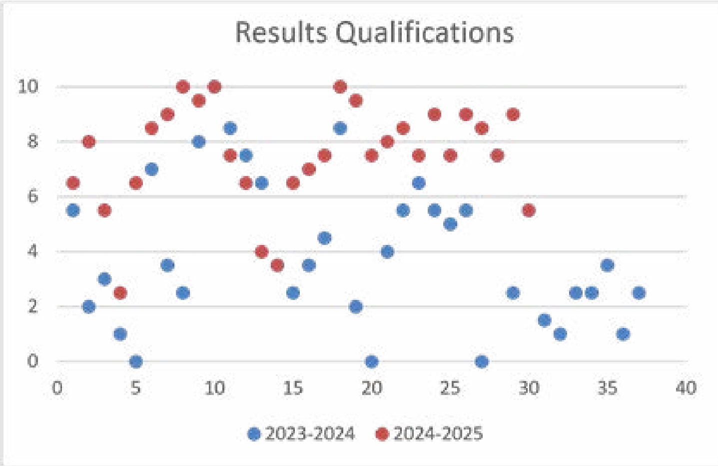

Figure 4: Result of the Numerical Grades of the Students Belonging to the Courses 20232024 and 2024-2025

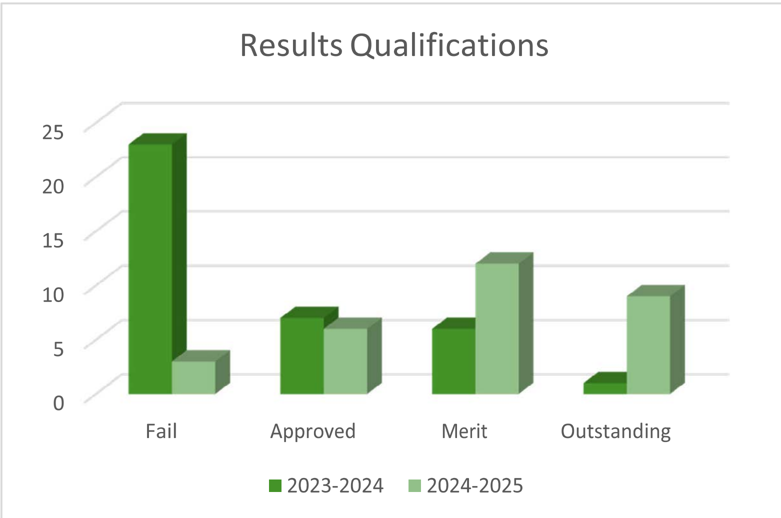

Figure 5: Result of the Numerical Grades of the Students Belonging to the Courses 20232024 and 2024-2025

Statistical analysis of the two cohorts analysed has been carried out in order to verify the results obtained. Table 1 below shows the values of the metrics.

	2023-2024	2024-2025
Mean	4,09	7,52
Median	3,5	7,5
Maximum	10	10
Minmum	0	2,5
Variance	7,09	3,61
Standard Deviation	2,66	1,90
Mode	2,5	7,5

Table 1: Statistical Summary

Subsequent to obtaining the metrics, a two-sample independent t-test was run in Excel to compare the mean scores between the 2023-2024 and 2024-2025 cohorts, Table 2.

	2023-2024	2024-2025
Mean	4,09	7,52
Variance	7,09	3,61
Observations	37	30
Hypothesized Mean Difference		
df	0	
t Stat	64 -6,12	
P(T<=t) one-tail	3,09E-08	
t Critical one-tail	1,67	
P(T<=t) two-tail	6,18E-08	
t Critical two-tail	1,997	

Table 2: Compare Means of Both Samples Using T-test

Since |t Stat| = 6.13 > 1.998 and p-value 0.05, we reject the null hypothesis. This means: There is a statistically significant difference between the two years' average exam scores.

The average score in the 2024–2025 cohort (7.52) is significantly higher than in the 2023–2024 cohort (4.10), and this difference is not due to random chance ($p < 0.0000001$). This points to a real improvement in student performance or a systematic change in the examination or preparation process.

4. Discussion

As mentioned in the introduction and in the methodology section, the main objective of teaching research is to establish methodologies that increase the efficiency of the student's teaching-learning process. This study arises to try to solve the deficiencies of a guided practice in the subject of the Degree in Mechanical Engineering and it is shown due to its excellent results.

In the classic teaching-learning process of guided practice, it could be observed that the students made mistakes at different stages of the assembly process, but the mistakes were not centred on one stage or one CAD tool; they were random mistakes that seemed to depend on the student's knowledge base, his degree of concentration and/or his own difficulty with some of his tools[17,18]. Although the learning base was good, as demonstrated by the numerous practicals carried out in the same subject, there was no good follow-up in the completion of this particular practical. The solution proposed by the teaching team was to provide the student with resources from other methodologies such as a video tutorial and a guide, all synchronised in stages that the student could easily follow. During the practice with these resources, the student could review the steps of the stages that had become blurred, proceeding to carry out or correct those steps that were more difficult during the course of the practice itself.

The use of different methodologies is a widely studied topic the simultaneous application of several methodologies, especially in the case of a combination of classical and innovative methodologies, is still under study[19-21]. The most innovative methodologies are based on project-based learning, gamification, collaborative learning, Design Thinking, Flipped Classroom...all these methodologies show very good results separately [22-25]. This article shows a new methodology based on the simultaneous use of classical methodologies, guided practice, and innovative methodologies, video tutorials with the aim of adapting the teaching-learning process to the student, which in many research is relegated to a generic and poorly adapted teachinglearning process.

The results of the research show how the simultaneous use of classical and innovative methodologies can efficiently improve the teaching and learning process.

5. Conclusion

In this article we have shown the results obtained by the students in carrying out a CAD practice, specifically an assembled assembly drawing, in two successive courses. The first of the courses evaluated 2023-2024 with the teaching of practice with classical methodology, guided practice and the second course 2024-2025 with simultaneous teaching of classical and innovative methodology. The results show a 35% improvement in the average results for students in the 2024-2025 course, with a drastic reduction in the number of students with failing grades.

This study opens the door to teaching research into the use of simultaneous methodologies that combine, as is the case here, classical and innovative methods in the performance of CAD practices for advanced engineering courses. The results show how the combination of methodologies can be key to the personalization of teaching, with the adaptation of the same to the student's teaching-learning process becoming more relevant.

The use of generative AI in our particular case did not achieve the desired results, and as in the case of the image and video creation, it was discarded. Although our experience is controversial, it reflects one of many realities: the use and training of AI requires a cost in time and learning that, in our case, is not offset by the results. The limitations of training effective prompts make the task complex and tedious compared to traditional methods. However, we are aware of our limitations in terms of prompt training and the use of AI in such specific tasks. This humble investigation perhaps reflects one of the greatest handicaps of applying AI: its learning curve.

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