Chapter 5
Flipped Classroom and Technology Enhanced Learning in Mechanical Engineering

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Abstract A change in the pedagogical approach and techniques is established in two subjects of the Mechanical Engineering Degree of the University of Cantabria, in order to solve problems detected during the last decade and accentuated with the pandemic. Specifically, in first pilot, two main changes are to be performed with respect to previous years. A mixed pedagogical approach is adopted, where both the Traditional and Flipped Classroom are combined, making the class time more valuable and engaging better with the students, and a collaborative project to an "open-problem" is proposed for the students to solve in groups of three, where the majority of the competences are exercised. In this regard, the use of Technology Enhanced Learning has been seen essential in order to facilitate students' access to the knowledge and contents. In University of Cantabria context, Kaltura tool was used for this purpose, which is embedded in Moodle platform. In the second pilot, students currently have the contents of the course in "slide" format before the class sessions, therefore, the generation of audiovisual resources will consist of the complement and support of the current teaching mechanisms used. In order to aid a better student follow-up, a one-year action plan has been developed. Within this plan, it is the second month of the project and therefore, the need of the audiovisual resources has been outlined and some videos have been created.

Keywords Flipped classroom · Technology enhanced learning · Mechanical engineering

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5.1 Introduction

In the last two decades, the European Higher Education Area (EHEA) has promoted a change in educational paradigm: from teaching-oriented to learning-oriented, promoting therefore different pedagogical approaches and modes for teaching and learning [1].

Until the entry into force of the EHEA, the "Conductivist" current, based on the fact that the center of the teaching–learning process is the teacher, dominated university teaching in Spain. The lecturer characteristics (such as ability, personality or cultural values themselves) are considered fundamental determinants of results or achievements in the classroom. Therefore, scientific studies based on this current focus on the identification of which qualities are necessary to be an effective teacher, such as objectivity, empathy, interpersonal sensitivity, flexibility, enthusiasm or expressiveness. Despite the fact that the Conductivism current has been followed mainly until the end of the twentieth century, it has the great shortcoming of leaving out the context variables associated with the student. Furthermore, it does not frequently stimulate and motivate students [2–4] who, in the end, do not acquire the competences, learning outcomes, skills and knowledge that the labor market requires [5].

In this sense, the current of "Cognitive" theories advances. This approach moves the center of the teaching–learning process to the student, since it considers the student as an active and essential part of the knowledge construction process [6]. In this regard, knowing how students learn and establishing a rational teaching plan, capable of stimulating the most appropriate strategies to transmit the contents or curricular subjects, become two important lines of action to face any process of improvement in the university classroom. Within the current of Cognitive theories there are several lines of research; for example, the theory of learning by construction [7], which defends that learning is carried out by inserting information into the network of knowledge and own experiences; or the theory of social learning [8], which adds to the previous one the condition that learning is inseparable from the situation in which it occurs. Furthermore, several methodologies and techniques have emerged during the last decades in this line, such us flipped classroom [5, 9], problem/project-based learning [10], inquiry-based learning [11], work-based learning [12], technology enhanced learning [13–15], etc., that, in the end, aid students to obtain the expected competences. All of them focused on achieving an active role of the students and increasing their motivation. This fact acquires special importance during the development of the learning process. It is evident that no one will learn if they do not want to learn [16]. However, the will to learn can be activated, inhibited or limited by direct actions of the teaching staff, which is why it constitutes a fundamental factor in the teaching approach choice.

These two fundamental currents should not be considered as individual options, but rather the opposite. Trying to integrate both should be the goal, since there is no single valid theory for all cases. What must be clear is that the role of the teacher should no longer be a task with a unidirectional meaning (transmission from the teacher to student) and, therefore, it does not consist solely of the oral presentation of a series of knowledge, nor the delivery of written information to students. Although these kinds of activities are necessary for the true teaching function, of course they are not enough, and it is necessary to contribute with something more.

This becomes essentially these days, just after the COVID-19 pandemic situation, which has aroused a latent issue: student's absenteeism to onsite lessons. Authors conducted a survey to all Mechanical Engineering Degree (MED) students; which goal was to learn the reasons that motivate their nonattendance to face-to-face (F2F) sessions. The results shed some light to this particular issue, highlighting one common answer shared by the majority of the students: they perceive that some instructors just read the slides in the onsite lessons, which turn their presence into useless.

In this work, two pilot experiences, which are being performed in two subjects of Mechanical Engineering Degree in the first semester of academic year 2022/2023, are presented. The aims are for students to obtain the competences which are required in their future jobs, to increase their motivation in Higher Education Curricula, and to reduce the absenteeism. These goals are planned to be achieved with the help of the University of Cantabria (UC) participation in a European Project denominated as "E-desk project", which *believes in the importance of having proficient university teachers in digital and entrepreneurial competencies to enhance European Youth's lifelong learning, improve its employability and foster the European values.* This project, under the EntreComp framework that promotes the entrepreneurial competences [17], fosters the creation of audiovisual teaching resources, as support for F2F teaching in the classroom and even as eliminating the read-the-slides problem, because the first two levels of Bloom's taxonomy revised in 2001 [18], namely, remember and understand, can be achieved previously to the onsite lessons. The envisaged result is to facilitate the understanding of the contents, which can be adapted to students' learning pace and to their needs and abilities, promoting self-learning and improving accessibility for students with specific educational support needs. It is also expected to increase the student's motivation because they feel more comfortable with digital contents in their daily activities and leisure.

5.2 Context of the Two Pilot Experiences

Firstly, the Mechanical Engineering Degree of the UC where the two subjects belong, is briefly described. It is also summarized the plan and the subjects that are advisable the students have passed before these two (Fig. 5.1). Furthermore, the competences that students will acquire once they pass the subjects.

The Report [19] of the degree establishes a classification based on its level of specialization, distinguishing, in addition, the transversal competences. This document includes the skills that students must acquire, and which are transcribed in Table 5.1.

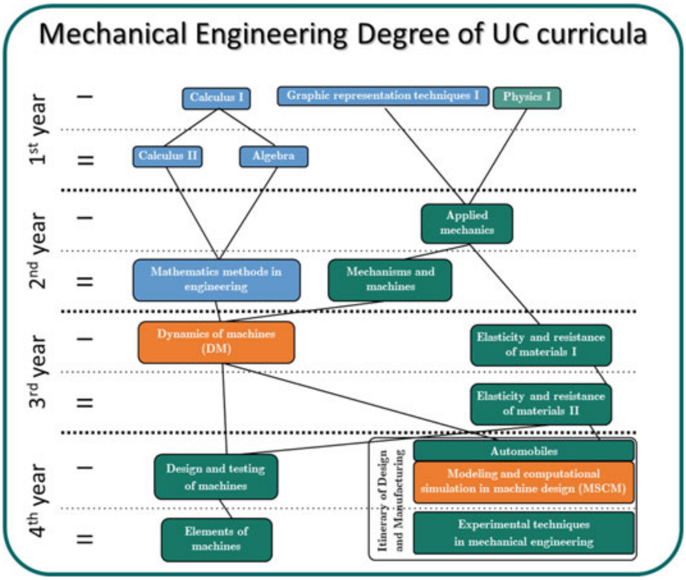


Fig. 5.1 The two subjects (orange) in the mechanical engineering degree of UC plan

Table 5.1 Competences students must acquire in the two subjects

Code	Description	Subject
ITI_GT3	Knowledge in basic and technological subjects, which enables them to learn new methods and theories, and gives them the versatility to adapt to new situations	DM, MCSM
ITI_GT4	Being able to solve problems with initiative, decision-making, creativity, critical reasoning and to communicate and transmit knowledge, skills and abilities in the field of mechanical engineering	DM, MCSM
ITI_TM1	Knowledge and skills to apply graphic engineering techniques	MCSM
ITI_TM2	Knowledge and skills for the calculation, design and testing of machines	DM, MCSM
GTRA4	Problem solving	DM, MCSM
GTRA7	Being able to communicate verbally	MCSM
GTRA13	Being able to work in a team	MCSM

To exercise the competences that students must acquire, lecturers have to plan in advance the contents, activities and assessments in which our students apply the information from our discipline to the resolution of relevant problems [9]. Taking this into account, the two pilot activities developed by the authors are presented next. Each one will be tracked in real time, in order to check the participation of the students when an activity is proposed. Two weeks after each activity, another control will be performed. By the end of the course, a survey will be distributed among the students in order to check their subjective perception about the competences and learning outcomes they have acquired, which will be based on previous experiences [20, 21].

5.3 Pilot Experience 1: Modeling and Computational Simulation in Machine Design

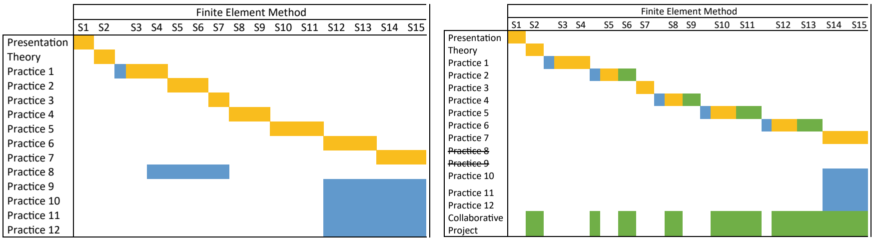
This subject, entitled "Modeling and computational simulation in machine design", belongs to the 7th semester of the degree and is eligible, which means that not all students will select it as part of their studies. It usually has around 25 students enrolled each academic year. It is divided into two blocks of contents: Finite Element Method (FEM) and Multi-Body Systems (MBS). The former is the only one partially changed at this point, since, first, validating the methodology is required and, second, in the case of a full subject transformation, making it smoothly is advisable.

Two main changes are to be performed with respect to previous years. Firstly, a mixed pedagogical approach is to be implemented, where both the traditional and Flipped Classroom (FC) are combined. Secondly, a collaborative project to an "open-problem" is proposed for the students to solve in groups of three, where authors have previous experience [20, 21].

In order to understand better the changes introduced to the FEM block of contents, the Old Plan (OP) of the course is compared with the new one (NP) and presented in Tables 5.2 and 5.3. In these tables, the half-of-semester-timeline is represented by the fifteen class sessions (2-h sessions) and the contents are listed by the theory and practice activities. The subject start with a session of theory where the context is established and then the rest of theories and concepts are incorporated and applied in the practical activities throughout the half of the semester. Moreover, orange is the Work in Class (WC) F2F time, blue the Individual Autonomous Work (IAW) and green the Collaborative Autonomous Work (CAW) both outside the class.

It can be seen that in the OP, as traditional approach was mainly used, the students did not have to make much IAW in understanding the concepts, since they were explained and practiced in the class time. Their IAW was mainly dedicated to solve

Table 5.2 Old plan of FEM block (Traditional) versus new plan (mixed of traditional-FC)



a) OP of FEM block b) NP of FEM block

Table 5.3 Comparison between old plan (OP) and new plan (NP)

	Sesiones	
	OP	NP
WC	15	11
IAW	21	11
CAW	0	14
TOTAL	36	36

five practices and write a report of each one. In these reports, students must answer what the problem is, how they solve it and why, analyzing the results and outlining some conclusions.

On the other hand, in the NP, a mixture of traditional and FC approaches is established. Currently, students have to make IAW to prepare the concepts in advance of some practices, otherwise they will not be able to assess the results properly. In this way, some steps of the problem solving, which had to be repeated to obtain the FEM model, are not performed during class time. This saves approximately ten hours of class time, of which two are currently dedicated to outline conclusions and solve interesting questions (students come with the lesson learned before starting the class) and the remaining eight are used to guide during F2F time the student groups and aid with the Collaborative Project (technical and report issues).

To include FC pedagogical approach, the use of Technology Enhanced Learning is advisable, in order to facilitate students' access to the knowledge and contents. In this regard, in previous years, students had the contents uploaded in Moodle platform in pdf format, and the lecturer made them available sequentially with the pace of the F2F classes. To aid this FC approach, delivery mode implemented is blended, which means that some contents must be acquired outside the class. In this line, some self-explained videos where recorded with Kaltura tool, which is embedded in Moodle platform.

At the beginning of the semester (presentation session), students are informed that they have to perform, in groups of three, the design of a component, in this case a chair. As it is an open problem, they have to choose the application (spot opportunities) and technicalities (size, movement or not, material, external forces, etc.), using the tools and knowledge acquired. With this collaborative project, first, all the competences are exercised (ITI_GT3, ITI_GT4, ITI_TM1, ITI_TM2, GTRA4, GTRA7, GTRA13). Second, most of the entrepreneurial competences are also necessary to be used [17, 22]. Lastly, the report of this collaborative project has the specific format of the End-of-Degree Project, as well as a presentation where students have to defend and sell their product/design in front of a jury. In this way, when they draft and present the real End-of-Degree Project, it is not the first time they face a real problem.

5.4 Pilot Experience 2: Dynamics of Machines

This second subject, entitled "Dynamics of machines", belongs to the 5th semester of the degree and is mandatory for all students. It usually has around 50 students enrolled each academic year. In order to have the proper context of the subject, first, the summary of the contents is presented in Table 5.4.

Students currently have the contents of the course in "Slide" format, on which they take notes in the sessions. This generation of audiovisual resources will consist of the complement and support of the current teaching mechanisms used. For this, the use of the Kaltura tool is proposed, with which explanatory videos of the taught concepts will be generated and developed, as well as computer-assisted simulation or laboratory application examples, in which the student visualizes and relates analytical formulations with the real physical phenomenon.

In order to aid a better student follow-up and complement and support the current teaching mechanisms, an action plan has been scheduled, which consists of initially identifying the need for the audiovisual resource within the contents of the course. Subsequently, the authors have to design, plan, carry out and record representative application examples of the course contents. This stage consists of numerical simulation, using specific mechanical design software (multibody software such as Adams or Working model or finite element software such as Nastran/Patran), or carrying out experimental tests in the laboratory of the Mechanical Engineering group (analysis experimental modal or vibration measurement and control), which also will help the instructors to show their research work in the latest projects. Once the relevant recordings have been made, the editing and processing of the audiovisual resources

Table 5.4 Contents of the subject

Block of contents I: Rigid-body dynamics	
Unit 1	Direct and inverse dynamic problem
Unit 2	Flywheels
Unit 3	Balancing of rigid rotors
Unit 4	Gear dynamics
Block of contents II: Vibrations theory	
Unit of contents II.1: Discrete systems	
Unit 5	Free vibrations of single-degree-of-freedom (DoF) systems
Unit 6	Forced vibrations of single-DoF systems
Unit 7	Transmissibility, vibrations isolation and damping measurement in 1DoF systems
Unit 8	Vibrations in two and multi-DoF systems
Unit of Contents II.2: Unidimensional continuous systems	
Unit 9	Beam vibrations under axial, torsion and bending stress
Unit of Contents II.3: Random and control of vibrations	
Unit 10	Introduction to random and control of vibrations

is proposed, incorporating the explanatory discourse of the teachers involved in the project. Finally, the teacher responsible for each subject in which these audiovisual resources are used must enable them in a timely manner, as well as organize them within the virtual classroom (Moodle platform) of the courses involved.

5.5 Conclusions

A change in the pedagogical approach and techniques is established in two subjects of the Mechanical Engineering Degree of the University of Cantabria, in order to solve problems detected during the last decade and accentuated with the pandemic. The two pilot experiences are work in progress, so no general conclusions are available by the deadline of this call of papers. Nevertheless, some outcomes can be stated at this point; in order to fully embrace the change of mentality, both instructors and students must be willing to do it. It has been noticed up to this point by the monitoring of the visualization of virtual content, that students are used to work within the frame of the traditional approach in most subjects of the degree. So, when their studies are coming to an end and there are some subjects that are shifting the paradigm, they are reluctant to do it. There are some reasons than can motivate this situation; because usually it means more work for them and because they are simply not used to it.

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