An Experience with Difference Teaching Methodologies at Mechanical Engineering Program

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Abstract

This article present a college course experience taught in second year of Mechanical Engineering program, 'Strength of Materials' a course of 6 ECTS points. With the aim to improve the learning process, to develop competences and skills and to create opportunities for interaction between students and between student and lecturers, several active learning strategies have been set up in the course. Several actions have been introduced in our lectures, making use of different teaching methodologies: master class, active learning (AL) and problem based learning (PBL). The actions introduced in the practical lectures are focused in program specific and professional competences related to the academic discipline, but also want to train core and cross-cultural competences such as management of information, team work and development of technical reports. At the end of the course a questionnaire was passed to the students in order to analyse which of these activities is the one they believe has the greatest influence in the learning process.

1. Introduction

The European Community aims to be a dynamic and competitive society based on the knowledge, with a greater social cohesion. It has been reflected in the formulation of common educational objectives, into the European Higher Education Area (EHEA). The future of our society is dependent upon democratic participation and the continuous development of the global knowledge base. Quality, accessible higher education equips the world with active, responsible citizens, ready to take on tomorrow's challenges, and student-centred learning is essential in ensuring this.

The ineffectiveness of teaching through the transmission of knowledge has also has been confirmed through years of pedagogical research. The massive protests, the rise of critical pedagogy and the research done on the teaching and learning process spawned the concept of student-centred learning; putting students in the driver's seat of their learning experience and facilitating the process of learning to learn.

The increasing student population and its growing diversity presents challenges to the traditional methods of teaching and learning, making it necessary to adapt the classroom to focus on the diversity of students' experiences, engage with many different types of learners and inspire students through a mutual learning experience. Throughout the years the European Students Union (ESU) has been focusing on student-centred learning (SCL), together with many educational stakeholders.

Emotions influence deeply and directly the cognitive process and the final performance of students. In many studies about motivation and strategies, [1-3], point out the importance of affective and motivation components in the learning process. Positive psychology studies [4] claim the need to generate security climates and positive emotions in the classroom to facilitate the development of students. In this line, students must be the centre of the teacher lectures.

In a typical lecture class, the lecturer talks and students up their notes and simply go to the next lecture. In the traditional methods of teaching, the teachers do most of the talking and students are passive. Student-centred learning requires empowering individual learners, new approaches to teaching and learning. SCL is not limited to certain methodology, there are good practices, which put emphasis on students and encourage them to take a more active role in designing their learning path, take advantage of collaborative learning methods and develop critical thinking through challenging established knowledge.

Students and their learning needs should become the centre of the teaching/learning process. There is a quite range of existing teaching methods that can be employed to actively engage students in the learning

process and increase their retention. Some examples of these teaching methods are problem-based learning or active learning. The benefits to using these kinds of activities are many: improved critical thinking skills, increased retention of new information, heightened motivation and enhanced interpersonal skills.

Active learning is a method that involves the participant directly during the learning process. Any activity that engages students besides listening to lecture is a form of active learning. Active learning does not mean leave over the classic lecture format, the theory master class and practical problems solved by the teacher are developed as lecture-based classes with the distinctness that the teacher pause frequently during the period to give students a few minutes to work with the information in order to engage student to be 'the teachers'.

Problem based learning is a pedagogical approach that enables students to learn while engaging actively with meaningful problems. Students are given the opportunities to problem-solve in a collaborative setting, create mental models for learning, and form self-directed learning habits through practice and reflection [5, 6]. Problem based learning has been widely adopted in diverse fields and educational context to promote critical thinking and problem-solving in authentic learning situation [7,8]. There are studies that examining its effectiveness on the quality of student learning and the extent to which its promise of developing self-directed learning habits, problem-solving skills and deep disciplinary knowledge [9-11] achieves its intended results.

In engineering, teaching style of an instructor and the learning method of a student are very important [12, 13]. Hence a course of 'Strength Materials' of a Mechanical Engineering Program was chosen to apply different teaching methodologies based on SCL. The following section detail the different activities developed.

2. Activities developed based on Student Centred Learning

The course of 'Strength of Materials' has 6 ECTS points. With the aim to improve the learning process, to develop competences and skills and to create opportunities for interaction between students, and between student and lecturers several actions have been set up in the course. Several actions have been introduced in our lectures, making use of different teaching methodologies: master class, active learning and problem based learning.

The course is divided into two parts: theory and practice. The theory part (TP) of the course has been introduced to students by master class with groups of sixty students. These masters class have been developed using active learning: pause frequently to give students a few minutes to think and work with the information, the students are asked or to compare points of view with a partner.

The sixty students are divided in two groups of thirty students in order to develop the practice part of the course. The practical part of the course is subdivided into two parts: 'problems master class' (PMC) and 'student's practical problems' (SPP).

PMC is focused on the resolution of practical problems by the teacher as master class using active learning. During these master classes the teacher poses practical problems, to solve these problems, the teacher uses different active learning strategies in order to engage students to participate actively in the development of these problems. The idea is that students guide the teacher to solve the problem.

SPP is focused on the development of practical problems by students using problem based learning. Five problems have been proposed to students: two PBL developed in the laboratory (Aluminium flexure; Deformation), a PBL making use of a Finite Element Method (FEM) program, a PBL named 'Diada Castellera' and a PBL named 'Advanced Problem'.

All these actions not only focus program-specific and professional competencies, related to the academic discipline, also seek to train core and cross-cultural competences as management of information, team work, critical thinking and development of technical report. These actions allow the evaluation of both the specific competences as well as the transversal ones.

The different actions introduced in lectures are presented in the next table with the corresponding learning strategies of each action, the delivery required, the competences that students work in each activity and how the activity is developed.

Table 1. Activities introduced with the corresponding learning strategy, the delivery and the competences worked in the activity

Action	*Learning strategies*	*How the activity is developed*	*Delivery*	*Competences*
Aluminium flexure (SPP)	PBL	Groups of four students	Technical report	Specific Management of information Team work Development of technical report
'Diada castellera' (SPP)	PBL	Groups of four students	As an exam	Specific Management of information Team work
Project with a Finite Element Method Program (SPP)	PBL	Groups of two students	Technical report	Specific Management of information Team work Development of technical report
Deformation (SPP)	PBL	Groups of four students	Technical report	Specific Management of information Team work Development of technical report
'Advanced Problem' (SPP)	PBL	Groups of two students	As an exam	Specific Management of information Team work
Theory lecture (TP)	AL	Teacher	Anything	Specific
Problem master class (PMC)	AL	Teacher	Anything	Specific Critical Thinking

These actions have given to lecturer important feedback in order to improve the program development.

These actions allow the continuous evaluation process that has been set up by following the framework of the academic regulations, and the evaluation of the different competencies separately.

3. Evaluation by the students

At the end of the course a questionnaire has been passed to the students, in order to analyse how they perceive that these activities contribute to their learning and which of these activities is the one they believe has the greatest influence in the learning process. Forty-seven students answered the questionnaire.

The questions of the questionnaire:

1. Check the learning activity that you perceive is the most effective to understand the subject
   (a) Theory part (TP)
   (b) Practical Master Class (PMC)
   (c) Student's Practical Problems (SPP)
2. Have the group been problems during SPP? (Ex: a member of the group hasn't work)
   (a) Yes
   (b) No

3. Three positive aspects of SPP
4. Three negative aspects of SPP
5. Three positive aspects about the development of masters classes by the teacher
6. Three negative aspects about the development of masters classes by the teacher
7. Opinion about the subject and the organization

The most important aspect of the questionnaire's results is the result of the first question. The 100% of students check PMC as the activity that they perceive as the most useful by their learning.

About positive aspects of SPP, 85 % of students remark that SPP are useful to connect the theory with the practical part and to understand the subject.

About negative aspects of SPP the 100% of students remark that technical reports of SPP are too extensive.

About fifth question: 90% of students remark as a positive aspect the attitude of the teacher: pause frequently to give students a few minutes to think and work with the information, the students are asked or to compare points of view with a partner.

4. Discussions

The course has been focusing on student-centred learning (SCL), students and their learning needs have been the centre of the teaching/learning process. Different existing teaching methods, active learning and problem based learning, have been employed to actively engage students in the learning process and increase their retention. These teaching methods have been employed into three types of activities: TP, PMC and SPP.
In order to analyse the impact of each type of activity in the student learning process, students have pass a questionnaire.
It is necessary to emphasize that 'Strength of Materials' is a subject of the second year of a Mechanical Engineer Program. The subject has theoretical and mathematical content, related with the generic competencies of the Mechanical Engineer Program. This data is important because is linked with the type of activity that the students perceive as the most useful by their learning.

All the students remarks the activity Problem Master Class with active learning methods as the activity that has most positively influenced the learning process.

The most of the students remarks that the PBL activities had contribute to the development of the transversal competences as Team work, manage information and how to develop a technical report, but these activities involves a lot of work and these work doesn't compensate that they learn with these activities.

Possibly the students of the last years are more interested in carrying out PBL activities, but students of the first years possibly need activities

5. Conclusions

Analysing the result of the questionnaire we can conclude that the practical part of the course is the part that most contributes to the learning process. All the students remarks the activity Problem Master Class with active learning methods as the activity that has most positively influenced the learning process. Possibly the students of the first years appreciate more the activities carried out by the teacher for the reliability that offers the teacher.

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Table list

Table 2. Activities introduced with the corresponding learning strategy, the delivery and the competences worked in the activity

Biography

Inmaculada Ortigosa Barragan works at Nautical Faculty of Barcelona, Politecnical University of Catalonia (UPC) since 2008. Actually is working as part time tenure track. I have taught different subjects: Thermotechnics and Fluid Mechanics, Fluid Mechanics and Thermal and Hydraulic Turbomachinery, Physics, Theory of Machines and Mechanisms, Strenght of Materials, Basics of Thermal and Fluids Engineering and Applied Thermodynamics and Thermotechnics. I collaborated in the development and implantation of the new academic Degrees within the European Education Area which came into effect in the 2011/2012 academic year.

I have developed my research career in the Nautical and Naval Area. I have focused my research in the development of Decision Support Systems for sailing. Aside from the research carried out during my doctoral studies I participated in different competitive research projects at both a national and international level, in which I was able to investigate different areas.