Students' Perception on Learning Methods in Engineering Disciplines

Abstract

Purpose - This study explores the preferences for learning methods among the students of seven engineering disciplines in a Spanish technical university. The purpose of this paper is to investigate the students' views and from them contribute to the knowledge of the effectiveness of learning methodologies.

Design / methodology / approach - An online anonymous questionnaire survey was adopted to collect students' perceptions. Seven learning methods were compared in seven engineering degrees. 1660 students were included in the survey and 426 completed responses were analysed. In addition to a descriptive analysis of the results, a Multiple Correspondence Analysis (MCA) was performed using R data processing software.

Findings - It was found that project-based learning and problem-based learning were perceived as the more effective learning methods. MCA identified response patterns between the preference and the efficiency of learning methods showing that students can be classified into two groups according to their preferred level of activeness in learning.

Research limitations - The study focuses on a single technical university and not all engineering degrees could be sampled. However, five different engineering fields were studied and no significant differences among them were found.

Practical implications – The results add up to the known literature showing that students have different learning needs and consequently they perceive some methods as more effective. Instructors can use this information to strengthen their learning activities. Results also suggest that students can be classified into two groups in relation to their level of activeness in learning. This can also help to enhance general student motivation if two paths with different levels of activeness are planned.

Originality – No previous studies have compared several learning methods in different engineering fields. Thus, this study contributes to fill this gap and contributes to the body of evidence around learning methodologies from the perspective of students.

Keywords: perception, assessment, active learning, teaching methods.

Introduction

In the last decades, there has been a slow but constant paradigm shift in higher education. Learning approaches applied in the classroom have moved from just lecturing to a whole set of active methodologies through which students can construct their own understanding (Mintzes 2020). The National Survey of Student Engagement in the USA recognized active learning as a key component for effective teaching in 2009 (NSSE 2019), and evidence in favour of active learning is increasing (Prince 2004, Deslauriers 2012). As an example, a meta-analysis of 225 studies showed that active learning approaches enhance learning over standard lectures at university STEM courses (Freeman 2014). Active learning has also been linked to an increase in student motivation and persistence (Brownell 2012). Moreover, it is known that a combination of methodologies enhances the learning process (Biggs 1987, Covill 2011).

Taking this into consideration, several questions arise: among the different active methods available in the literature, are some of them better adapted to enhance performance, motivation or engagement for students of certain disciplines? Are there differences in preferred learning methods among disciplines? Even, within a discipline, can different subpopulations benefit from different methods? To answer these questions it is interesting to get feedback from students on their point of view about learning strategies.

Literature review

There is a strong interest in enhancing the effectiveness of education at all levels. Effective learning has been the subject of thousands of studies, e.g. (Muijs 2018), with the aim of maximizing the impact of teaching, promoting deep rather than superficial learning and enhancing academic performance as well as motivation. Several learning methods have been developed. Some of these depart from traditional lecturing in which students assume a rather passive role to promote their active participation in the learning process and thus stimulate students to develop their own learning. With this aim many active learning methods have been proposed such as project and problem-based learning, flip teaching, portfolio, etc.

Considerable research has been carried out to characterize student perception on learning methods (Felder 1988) to study if there is an impact on learning outcomes and performance as well as its relation to better motivation and retention (Dai 2014).

Many studies survey a specific student profile: medicine (Albanese and Mitchell, 1993; Herrmann 2015, Tsang 2016), tourism (Casado 2000), pharmacology (Garg 2004), business administration (Pastor-Agustín 2009), psychology (Smith 2011), science undergraduates (Welsh 2012), drug-induced disease and clinical toxicology (Rivkin 2013), education (Daouk 2016), dentistry (Meguid 2017), computer science (Riek 2013, Arbelaitz 2015) and electronic engineering (Kim 2014, Magana 2018). And, in many cases, the comparison is between lecturing and second learning method.The present work is aimed at expanding previous studies by exploring the methodology preferences of students of different branches of engineering that were inquired to compare seven learning methodologies.

Method

Participants

This study involved a sample of undergraduates and graduate students from a Spanish technical university. In particular, the sample was extracted from six different Bachelor degrees (4-year) in different areas of Engineering: Chemical Engineering, Telecommunication Engineering, Audiovisual Engineering, Forest and Environmental

Engineering, and Industrial Design Engineering; and, a Master degree in Telecommunication. Finally, to test for singularities in engineering students, undergraduates from the Bachelor's degree in Audiovisual Communication (akin to journalism) were also included. All the students enrolled in the 13 selected subjects were enlisted to complete the survey. The population of the study included 1660 students ranging between 18 and 22 years old. Table I shows the specific subjects and the distribution of the population (completed questionnaires) by each engineering discipline. The subjects were chosen by convenience (non-probabilistic sampling) to represent different areas of engineering plus a less technically-oriented profile for comparison. Here, the results obtained from this population during three academic courses are reported.

Table I.- List of subjects involved in the survey, grade level, degree and number of completed questionnaires by degree and percentage over the total of answers.

Subject	Grade level	Degree	Cases (percentage)
Circuit Theory	1	BSc in Telecommunication Engineering	100 (23.5%)
Fundamentals of Computer Networks	1		
Signals and Systems	2		
Video Capture, Storing and Screening Systems	4	BSc in Sound and Image Engineering	6 (1.4%)
Pollution control in industry	4	BSc in Chemical Engineering	72 (16.9%)
Building Material Manufacturing Processes	4		
Laboratory of Chemical Analysis	1		
Chemical Analysis I	2	BSc in Food Science & Technology	20 (4.7%)
Business Administration	1	BSc in Industrial Design Engineering	119 (27.9%)
Business Administration	1	BSc in Forest Engineering	38 (8.9%)
Telecommunication Internetworking	5	MSc in Telecommunication Engineering	49 (11.5%)
Audiovisual Technology	1	BSc in Audiovisual Communication	22 (5.2%)

The sample used to extract the results was made of 426 completed questionnaires from a population of 1660 potential students, i.e. the response rate was 25.6%. The survey was filled out in students' spare time. In the classroom, instructors explained the aim of the survey, encouraged participation and later they reminded students about this optional ask. No further pressure nor reward was applied to increase participation. As a control, in two subjects of two degrees (BSc in Telecommunication Engineering and MSc in Telecommunication Engineering), all students attending the class were asked to fill the survey during one lesson and, in this case, similar results were attained, being the average response rate 72%.

Instrument

Authors did not find in the literature questionnaires suited for the purpose of the research, aiming to gain student feedback on their interest in learning methodologies, their knowledge about them and their perception of their effectiveness. Therefore, a specific questionnaire had to be developed, even dough it partially used previous published surveys (Zeidner 1987; Pastor-Agustín, 2009). A preliminary questionnaire was developed and tested on a pilot survey, with a small class (21 students) of the first year of Telecommunication Engineering. This test included both an analysis of the questionnaire results as well as interviews with selected students. It allowed identifying deficiencies and ambiguous points in the questions thus improving the actual survey.

The final survey used (Table II) was performed through an anonymous questionnaire carried out using the online teaching platform of the university (Sakaibased). In this survey, teaching innovations refer to any learning method different from traditional lecturing.

Table II.- Survey questionnaire.

#1.1	Do teaching innovations favour your learning? *(Student's feedback can be found in Fig. I.1)*
#1.2	Do teaching innovations make it easier to pass the subject in the first call? *(Student's feedback can be found in Fig. I.2)*
#1.3	Do teaching innovations enhance your motivation about the subject? *(Student's feedback can be found in Fig. I.2)*
#1.4	From the next active learning methods, which one do you prefer? (you can choose more than one answer): 1. The instructor explains the subject and students only have to study the material for the exam 2. The instructor explains parts of the subject and students complete the lessons with debates, exercises, problems, etc 3. The instructor explains the subject in some lessons and later students continue learning through autonomous work that will be presented/applied in the following classes 4. Learning is based on problems/projects where the instructor only solves students' doubts 5. The instructor provides the material and students solve their doubts through instructor tutorials or seminars *(Student's feedback can be found in Fig. I.4)*
#1.5	Which is your preferred evaluation method? 1. A single final exam 2. A pair of independent exams (midterm and final) 3. A combination of a pair of independent exams (midterm and final) with a few tests through the semester 4. Doing several (4-5) independent short exams throughout the semester as units are finished 5. Continuous assessment through the semester to follow the student evolution *(Student's feedback can be found in Fig. I.5)*
#1.6	In collaborative assignments, what is your preferred group size? 1. Individual assignments 2. Pairs 3. Small groups (3-5 students) 4. Large groups (8-10 students) *(Student's feedback can be found in Fig. I.6)*

#1.7	Concerning the effort needed for teaching innovations, would you say that 1. They do not require much effort; neither for the instructor nor the student 2. They do not require much effort for the instructor, but they do for the student 3. They require much effort for the instructor, but not for the student 4. They require much effort for both, the instructor and the student *(Student's feedback can be found in Fig. I.7)*

#2.1	When attending a lecture, which method do you like the most? (choose only one): 1. The instructor explains and uses the blackboard while students take notes 2. The instructor explains following a book that is available to students 3. The instructor provides basic slides that students complete with other materials 4. All the content of the subject is included in the slides and students take some notes from the instructor explanations 5. The instructor provides materials to review before the lecture and the class time is dedicated to solving doubts, problems, etc *(Student's feedback can be found in Fig. I.8)*
#2.2	In the next questions, students were asked whether they knew each of the following methods; whether they like them and if they find them effective for learning 1. The instructor exposes the unit and students take notes 2. The instructor exposes the theory during the lecture and students solve problems at home 3. The instructor exposes part of the unit and the students, at home, complete the theory and do problems with complementary materials 4. Students prepare the unit with videos and other materials at home, and during the lecture time problems are discussed 5. A group of students, autonomously but guided by an instructor, must do problems 6. Students compile in a folder (portfolio) all the personal work carried out in the subject 7. All the subject is oriented to carrying out a specific project *(Student's feedback can be found in Figures. I.9, I.10 and I.11)*
	Student open comments

Note 1: The actual questions were in Spanish.

Note 2: Question #1.2 is aimed at testing whether innovations encourage students to face the exams in the first call as usually, they have two chances to pass final exams.

As can be seen in Table II, the first block consisted of three general five-point Likert scale questions (#1.1 to #1.3), on which 1 corresponds to strongly disagree and 5 to strongly agree; multiple-choice questions (#1.4 to #1.7), allowing single or multiple answers depending on the question. The questions on the first block were related to the general view of the students on teaching innovations, i.e. the use of active learning strategies in the class. This was explained by the teacher when informing the students about the survey. The second block was composed of one multiple choice question (#2.1), one multiple choice question based on yes/no ratings (#2.2). Finally, an open question was also included to gain feedback from students on issues not considered by the previous items. The questionnaire was elaborated using a consensus categorization of teaching techniques and methodologies (Table III) and minimizing all pedagogical terms to avoid any misunderstandings.

Once answers were gathered, and to examine patterns in the missing responses, a missing value analysis was first conducted. The results showed that no variable had more than 5% of missing values and therefore those values were excluded from the analysis.

Table III. Learning methods considered in the student survey

Method Label	**Explanation**
Lecture	The lecturer exposes a topic of the subject and students take notes
Lecture w/ exercises	The instructor exposes a topic of the subject in the class and students make problems at home
Autonomous	The instructor exposes a topic of the subject, and students, at home, complete the theory and solve problems with complementary materials
Flipped	Students prepare the unit with videos and other materials at home and problems are discussed in the classroom

Problem	A group of students, autonomously but guided by an instructor, must solve problems
Portfolio	Students compile in a folder (portfolio) all the personal work carried out in the subject
Project	All the subject is oriented to carrying out a specific project

Along with the descriptive analysis of the results, a Multiple Correspondence Analysis (MCA) has been carried out to find relationships between students and answers; for this R software was used (LeRoux et al, 2010; R Core Team, 2016; Le et al, 2008). MCA allows observations described by a set of nominal variables to be analysed. As a matter of fact, it can be seen as a generalization of principal component analysis for categorical variables.

Results

Motivation

There is a worldwide tendency to shift university lessons from traditional lecturing to student-centred approaches, aiming to promote deeper learning. Although this topic might polarize some academic faculties, it is generally agreed that active learning enhances student engagement and improves students' thinking and writing skills. The empirical support for active learning is extensive (e.g. Bonwell and Eison 1991; Prince 2004; Deslauriers 2012; Freeman 2014), but among the different active strategies available, instructors must choose those more suitable for their lectures. To get further knowledge about the preferred learning method by students, the survey shown in Table II was developed and applied.

Unidimensional analysis

The results of each question were individually analysed (Appendix I, supplementary material). In general, students seem to be in favour of active learning since 65% of the students think that this approach is good for their learning process (question #1.1, mean 3.76, std 0.97) while 58% claim that it enhances their motivation (question #1.3, mean 3.59, std 1.07); these results are consistent with previous studies (Rivkin 2013). However, only 42% of the students think that active learning helps to pass the subject in the first call (question #1.2, mean 3.27, std 1.06), while around 20% of them think that innovations do not contribute to this goal and 37% do not see a relation. Similarly, when asked in general about the degree of activeness that they prefer, 60% of the students choose a rather mild active learning approach with considerable guidance by the instructor (question #1.4).

To assess students' preferences on teaching methods, the students were asked to choose one preferred method from a list (question #2.1). Figure I.8 collects the results and shows that students overwhelmingly selected as their first choice a traditional method (63%), i.e. lecturing with slides, rather than other more innovative methodologies. Moreover, the combination of methodologies in which the students have a rather passive role sum up to nearly 80% of the answers.

Regarding the level of knowledge of the students on different methodologies, the results are shown in Figure I.9. As expected, traditional lecturing is very widely known, but other more active methodologies are becoming widespread and they have been used by 50-70% of the students. More recent learning approaches are logically less known. Thus, flip-teaching is one of the less known, only around 30% of the students in the population have used it.

Next, students were asked about their preference. Figure I.10 shows, among the students who have used a method, whether they like it or not. It can be seen that methodologies that can be considered as familiar to a certain point in engineering, such as project and problem-based learning and portfolio, are preferred by more than 60% of the students. As shown in Fig. I.10, students do not favour methods with a higher degree of autonomy such as partial autonomous learning. The preference for flip-teaching is rather low when compared to a previous study with pharmacy students (McLaughlin 2013). Among engineering students flip teaching is preferred by 42% of the students who have previously used it versus a 26% among students who are not familiar with it.

Finally, students were asked to assess the efficiency of each method. The results among the students who have claimed to be familiar with each methodology are shown in Figure I.11. The most effective methods, from the student point of view, were problem-based learning together with project-based learning.

Students were also asked about some other features related to different teaching methods, such as the preferred group size for doing assignments (question #1.6). From the answers attained in the survey, it can be inferred that most students (54%) think that small groups (3-5 students) is best; followed by working in pairs (30.9) and individually (12%). The less preferred option (2.4%) is working in large groups (8-10).

The method applied to evaluate the learning process is also an important point that strongly conditions student efforts (Struyven, K., Dochy, F., Janssens, S. 2005). When asked about the degree of ongoing assessment preferred by the students (question #1.5), the slightly preferred method was continuous evaluation (36%) with very little support (1.3%) for a single final exam.

When students were asked about their perception of the effort needed to carry out active learning strategies (question #1.7), the majority (around 66%) consider that active methods suppose additional workload to the instructor, while only 29% of the students consider that active learning involves a lot effort for themselves.

Finally, an open question was included in the survey in order to collect additional feedback. Only 27% (110 students) of the completed questionnaires provided this feedback. It mainly follows the trends observed in previous questions. Most students emphasize the importance of solving problems to foster learning and they also highlight the importance of instructors to motivate students.

Multidimensional analysis

Response patterns were searched in data about learning methodologies (question #2.2). An algorithm of correspondence analysis was used to detect and represent underlying structures in the data set. Using MCA, associations between teaching methods according to the liking or disliking of the students were detected. In this method, the interpretation is based on proximities in a low-dimensional map (Fig. II.1). It provides information about groups of students with similar answers and associations between students' answers.

Learning methods were distributed in a low-dimensional space with the highest percentage of explained variance (Fig. 5). These two dimensions explain 53% of the variance. It shows the students (each grey point) and the position of the barycentre of the students with the same answer for every question. The proximity of the barycentres allows to draw some conclusions. A group of students can be characterized by their preference for active learning methods; i.e. students who like flip teaching also like problem-based, portfolio and project-based learning. Another group of students shows the opposite behaviour, they do not like active approaches. As regards to more standard methods (traditional, exposition and homework, and partial exposition and homework) they are not clearly grouped. It means that the students who like or dislike these methods do not answer as any others. It is also noteworthy that there is not any association between like and dislike (i.e. no like is near to any dislike). This lack of a pattern can be attributed to the existence of a polarity. Some students can be characterized by their dislike of active learning methods whereas another group of students is defined by their liking.

When analysing knowledge, opinion and perceived effectiveness, MCA shows that students who like and consider that a given method is effective are the ones who have used the method. On the contrary, the students who have not used a method tend to dislike it and consider it ineffective. It points out towards some prejudices by students and the need for some training to fully benefit from active learning. Considering only students who have used each method, those who like a method tend to consider it effective (correlation coefficient = 0.94).

Finally, Figure II.2 shows an MCA analysis on questions #1.1 to #1.3. It shows that students seem to be rather coherent since similar answers cluster together in Figure 6. For example, students who strongly disagree about “whether teaching innovations favour learning” have also a negative perception about their contribution to passing the course or motivation. It is also interesting to observe that the group of students who show a higher level of disagreement has also a higher distance with respect to the rest of the groups.

Discussion

The results achieved indicate that, from the students' point of view, the most effective methods were problem-based learning together with project-based learning. This adds evidence to a list of previous studies which similarly found that both students and faculty generally have good attitudes towards problem and project-based instruction in engineering.

Portfolio is the next method in terms of perceived effectiveness closely followed by lecturing. Surprisingly, flip teaching is only assessed as an effective method by 54% of the students who have used it. This result seems to go against recent works on flip teaching (Bergmann, J., Sams, A. 2012; Mason, Shuman, Cook, 2013) where it has been argued that flip teaching enhances engagement. These results might be partially attributed to the reluctance of students towards methods requiring increased out-of-class workload and the need for students of time before adopting new learning paradigms.

The perception of the effort needed to carry out active learning strategies shows that around 66% of the students consider that active methods require additional workload to the instructor. This result agrees with other studies that identified an increase in workload for faculty (Kingsland, 1996; Gleason 2011), and an increase in stress among staff (Lackritz, 2004) as barriers that restrain the spread of active learning; surprisingly students seem to be aware of this fact.

The analysis of the student affinity for learning methods shows a clear polarity in the student answers: some students clearly like all the active methodologies whereas some others do not like any of them. This agrees with previous studies in electric and electronic engineering (Magana 2018) which suggested that students could be grouped into two groups according to their level of independence in terms of learning. These outcomes suggest that educational institutions should offer alternative study routes to foster motivation and engagement among students with tailored learning strategies, thus matching student preferences.

When asked about their preferred size for group activities, most students agreed on choosing to work in small groups (3-5 students). It is consistent with previous studies (e.g. Norman and Schmidt 1993; Johnson, Johnson and Smith, 1998) which point out that cooperation in small teams has a positive effect on academic achievement.

On the other hand, the student workload is also very important because it has been identified as a factor that strongly influences the quality of learning (Kyndt 2014). Concerning student's workload, the survey showed that only 29% of them consider that, in general, active learning involves much effort for themselves. Similar results have been reported for flip teaching (Bouwmeester 2019). However, problem-based learning has been related to the perception of an increase in workload among students (Kingsland 1996; Breton 1999; Vardi and Cicarelli 2008). This could suggest that, in general, students do not associate active learning methods with increased workload although some specific strategies might carry this perception.

A grouped analysis of the results showed no statistical difference between groups in terms of group size (small class vs big class) and study level (year and undergraduate vs graduate students). Regarding learning, success and motivation perceptions no statistical difference between groups was found with variations smaller than 5%. This lack of variation agrees with the contradicting results shown in previous studies. Felder pointed out, in 2005, that graduate students and undergraduates in the last years might favour active learning methods while Welsh (2012) showed opposite results. This contradiction might be explained by the diffusion of active methods of learning in high schools which make students already confident in their use before accessing university.

As a comparison, the survey was also evaluated among students of Audiovisual

Communication, a degree similar to journalism. Some differences were observed between students from engineering subjects and Audiovisual Communication. In the latter, students seem to show less interest in active methodologies. For example, when asked whether teaching innovations favour learning (question 1.1) only 8.8% of students of engineering disagree, while 18.2% of the students of Audiovisual Communication disagree. When asked for their preferred teaching method (question 2.1), in engineering, lecturing was the preferred option for 63% of them whereas it rises to a strong 86% in Audiovisual Communication. No significant deviations were found among engineering degrees. This can point out to underlying differences between student profiles. It agrees with other studies which have shown better perception of problem and project-based learning among students of medicine and engineering (Bédard 2012).

Limitations of the present study and suggestions for future research

This study was focused on a single technical university and not all engineering degrees could be sampled. It would be interesting to apply the survey at different technical universities to check the consistency of the results among engineering students. Although five different engineering fields were studied and no significant differences among them were found, it could be interesting to expand the study to include other engineering areas as well as architecture, which couldn't be sampled in the present study.

The multidimensional analysis has shown that students can be grouped in two sets depending on their preference for the degree of activeness of the learning methods. At the researched university there is a small-scale program for hands-on transversal subjects across several degrees. It would be interesting to survey students within this program and compare the results with the general student population.

Conclusions

Feedback from engineering students on their perception of learning strategies was obtained. Although the effectiveness of methodologies, and consequently the student perception, varies considerably with the implementation in the class, this feedback provides a general overview that can contribute to the knowledge of the effectiveness of the learning methodologies.

It was found that, among engineering students, some active forms of teaching are perceived as more effective. In particular, project-based learning (77% of the students) and problem-based learning (72%) were better assessed, i.e. they were found to be more effective, than traditional lecturing (64%), which still attracted many students. These results support previous works which show the preference of engineering students for project- and problem-based learning (Bédard 2012). Similar results were found among medicine students (Albanese and Mitchell, 1993; Yadav 2011) but in other disciplines such as psychology and pharmacy (Covill 2011, Rivkin 2013) it was found that lecturing was perceived as the most beneficial strategy.

Other active teaching methods were considered to be less effective. Methods such as autonomous learning and flip-teaching are seen by individuals as less useful, with a support of 40% and 54% of the students, respectively.

The feedback obtained in the present study aligns with previous research to suggest that among engineering students in general, and especially, within a subset of them, project and problem-based learning are perceived as better suited for achieving learning goals. A multidimensional analysis, MCA, allowed the identification of a pattern between the preference and the efficiency of learning methods showing that students can be classified into two groups according to their preferred level of activeness in learning. These results can contribute to enhance the effectiveness of university education..

Disclosure statement

The authors report no conflict of interest.

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