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MAY BE GEOTECHNICAL ENGINEERING LEARNING FUN?

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Abstract. Geotechnical Engineering, its technics and methods, are usually an awkward topic for many students of civil engineering degrees who are often more focused on getting the "final number" of a given problem than in the process, using the engineering thinking, conducted to plan first and later arrive to the solution. This issue is especially significant when teaching "advance topics" of Geotechnical Engineering such as Tunneling or Ground Improvement. Those topics are normally taught in the last years of the degrees and in many cases students are used to the classical teaching in higher education. All of this normally results in a low motivation of students, mainly interested in obtaining the Degree itself, more than in learning. In this article we show an active learning methodology based on autolearning, which with the help of the teacher and a series seminars and workshops, leads to involving the engineering students in those advanced geotechnical engineering topics, even enjoying with them. The core activity of the learning methodology is the preparation of a part of the subject by the own students, who work in groups and have to give a "real" lecture to their colleagues. The learning methodology presented follows several previous works conducted by the authors [1,2] and other researches [3], and aims the student to build knowledge, fostering their motivation as well as the responsibility of their own learning [4]. Assessment of the activities carried out by the students is conducted taking into account the evaluation of both the teachers and the students themselves.

1 INTRODUCTION

Typical students of civil engineering degrees usually give more importance to the result obtained of a problem, i.e. the "final number", than to the process followed to obtain it. This lack on the use of the "engineering thinking" causes that topics like Geotechnics and Geotechnical Engineering often result to be difficult and even uncomfortable subjects for them. Besides, students are accustomed to the classical teaching of higher education, a regulated education fundamentally based on the transmission of great theoretical and technical knowledge. Both issues cause that in the last years of the degrees, when advanced topics of Geotechnical Engineering such as Tunneling or Ground Improvement are taught, students are barely motivated. Many of them commonly decide not to attend classes, and some of them are mainly interested in obtaining the Degree in itself, rather than in learning.

Active learning methodologies to involve students are therefore necessary. Those methodologies should also consider the inherent pragmatism characteristic of the Civil Engineer profession, and why not, they may also be developed in a way that students can even enjoy learning. Based on those ideas, this communication presents a learning methodology that intends to achieve a greater motivation of the students towards a subject and its related field, while providing students a certain control over their own learning. The subject object of the innovation belongs to the thematic field of Geotechnical Engineering and is part of the last year (4^{th} year) of the Civil Engineering Degree taught at Civil Engineering School of Universitat Politècnica de València (UPV). The subject is taught since the academic course 2012-2013, when Bologna Plan was implemented.

The innovation presented addresses two basic aspects: (i) implementing a continuous assessment, based on a pragmatic approach to the subject, as opposed to the traditional formula of one or two unique exams; and (ii) proposing activities of an active nature, which makes it easy for all students following the subject, increases their motivation and involves them in learning.

Students are offered the opportunity to pass the subject through a continuous assessment throughout the semester. For doing this, and as the core activity of the learning process, students have to develop a part of the subject by groups, having to make partial deliveries (with subsequent feedback) to the teacher in charge of mentoring the group, as well as a final presentation to the rest of their classmates, teaching a real lecture. The topics developed by the students are eminently practical, and they are encouraged to teach them as actively and interactively as possible, even in a playful way, allowing being possible to "learn by having fun".

The innovation follows the work developed by the teachers both inside and outside the teaching activity as well as in several previous teaching experiences [1-3,5,6], encourages students' motivation and responsibility for their own learning [4,7] and fundamentally combines four types of learning methodologies: master lesson, cooperative learning, autonomous learning and flip teaching.

All in all, the following objectives are sought to be achieved with the innovation proposed:

- Involving students in the subject and awaken their interest in it.
- Involving students in their own learning and evaluation.
- Developing the student's capacity for self-criticism regarding their own knowledge.
- Fostering team-working.

2 INNOVATION DEVELOPMENT

2.1 Subject planning

The subject is divided into two parts, a first one more regulated and conducted by the teachers, in which the master lesson and cooperative and autonomous learning are combined, and a second part, almost exclusively based on the flip teaching methodology. In this second part the student is the central character of the learning process, being students themselves who give the lectures (in groups) to their classmates.

Table 1 shows the subject planning followed during the last academic year (2017-2018), which, with small variations, is similar to that proposed since 2013. In addition to these classroom classes, the subject also includes some laboratory sessions and a field session, in which students are guided in the learning process by one or several teachers.

Table 1: Subject planning (course 2017-2018)

Date	Topic	Learning methodology
05/09/2017	Subject presentation	Master lesson
06/09/2017	Geotechnical investigation planning	Cooperative and autonomous learning
12/09/2017	General prospection techniques	Cooperative and autonomous learning
13/09/2017	Soil and rock data geotechnical interpretation	Cooperative and autonomous learning
19/09/2017	Rock masses characterization	Master lesson
20/09/2017	Instrumentation and monitoring	Cooperative and autonomous learning
26/09/2017	Rock masses strength I	Master lesson
27/09/2017	Rock masses strength II	Master lesson
03/10/2017	Rock masses deformability	Master lesson
04/10/2017	Case Studies on rock masses	Cooperative and autonomous learning
10/10/2017	Conference: Earth's ground movements	Master lesson
11/10/2017	Seminar: Real case of slope movement (Movie)	Cooperative and autonomous learning
17/10/2017	Rock slopes stability I	Cooperative and autonomous learning
18/10/2017	Rock slopes stability II	Cooperative and autonomous learning
24/10/2017	Soil slopes stability	Cooperative and autonomous learning
25/10/2017	Landslides correction techniques	Cooperative and autonomous learning
31/10/2017	Project and design of an underground work	Flipped classroom
07/11/2017	Geotechnical-Structural calculation of a tunnel	Flipped classroom
08/11/2017	Tunneling building methods and monitoring	Flipped classroom
14 11/2017	Case Studies on tunnels	Flipped classroom
15/11/2017	Dynamic compaction	Flipped classroom
21/11/2017	Vibroflotation and gravel columns	Flipped classroom
22/11/2017	Preload	Flipped classroom
28/11/2017	Injections and Jet Grouting	Flipped classroom
29/11/2017	Case Studies on ground improvement I	Flipped classroom
05/12/2017	Case Studies on ground improvement II	Flipped classroom

This planning is known by the students from the beginning of the course, so, besides syllabus distribution, students know the teaching methodology to follow on each session. As learning terminology is generally unknown by students, the first class of the subject is used to briefly explain each one of the learning methodologies to be used throughout the course.

Thanks to this, students become aware of what is expected of them in each session and what can they expect from the teacher. This makes it easy that each student acquire control over their own learning.

2.2 Subject development

The first part of the subject is similar to the classical theoretical lectures, being the teacher who guides the classes, structures the content to be discussed and fixes to a certain extent the rhythm of learning. However, it is sought that the teacher does not have the complete leadership. Thus, the teacher gives some guidelines of basic points that will be worked on activities proposed to the students. The aim of this is students play a role as active as possible, developing the classes in an interactive way. For doing this, techniques such as the use of expert panels, viewing some fragments of documentary videos obtained directly from the internet (through the platform "Youtube"), presentation of real cases and performing simple tests using the computer application "Kahoot" are conducted. This is intended to both motivate the student and capture their interest, showing different alternatives to the typical masterclass, a methodology that is usually associated by students with what a lecture is.

The second part of the subject is developed with the flip teaching methodology and its development is based, as indicated above, on the fact that the students themselves teach the lectures. Through this flip teaching methodology, the student become the central character and the responsible of their own learning [8,9]. The first day of class, after informing the students about the operation of the course, the learning methodology and the evaluation system, they are asked to freely form ten groups of 3-5 people (depending on the total number of students) and communicate to teachers before one week what people will form each of the groups.

Approximately two weeks after the start of the course, each group is summoned to entrust them with the part of the subject that they must prepare and about which they must give a 2-hour lecture. Thus, each group is aware to see that they will be responsible for one of the lectures of the second part of the subject, so they will take the "teacher's role". To prepare the class, students have the help of one of the teachers of the subject, who tutors the group and controls the pace of work through more or less periodic meetings in which feedback is provided to students. However, the role of this tutor is a minor one.

After having assigned to each group the topic to be taught, in order to "focus" them on their learning development, the tutor instructs students to prepare the lecture. There is no restriction in the way students can give the lecture, and they have to decide how to do it, as well as the documentation to provide to "their students" (i.e. their classmates). Everything is entirely their responsibility. This creates, in a first moment, bewilderment, fear and disbelief in the students.

After this first "stage" and once the group begins to sketch a first idea of the contents of the lecture, the tutor reminds the group the importance of practical aspects in civil engineering and encourages them to prepare the lecture to be interactive, dynamic and playful, trying that everyone "learn by having fun". This is sometimes followed with the following sentence: "Give the lecture as if it were the ideal lecture that you would have liked to receive in your life".

This ensures that students prepare really interesting and fun activities. Thus, in Figure 1 we

can see the students of the group responsible for teaching the class doing a “Kahoot” to their classmates, in which as a prize the winner was given a chocolate tablet.

Figure 1: Students giving the lecture “Geotechnical-Structural calculation of a tunnel” corresponding to the 18th session of the subject

In Figure 2 we can see learning the topic “dynamic soil compaction” through a real simulation prepared by the students of the group responsible of teaching the lecture so that their classmates could understand by “playing” the basics of this technique and the effects that it brings when it is applied on a real ground.

This type of activities, together with the reality that their own classmates are who are teaching (Figure 3), leads to a notable participation of the students as well as a great involvement when compared to what was observed before implementing this methodology. Students usually finish overcoming their “stage fright” to speak in public and in some lectures there are debates and discussions on the subject taught with a very high participation.

Furthermore, it is interesting to note that this “change” in the behavior of students begins to occur in the first part of the subject in which the methodologies used are the masterclass and the cooperative and autonomous learning. This is because of at that time they have been working for weeks to prepare “their lecture” and that give them some security in class and predisposes them to collaborate in it.

Figure 2: Students giving the lecture "Dynamic compaction" corresponding to the 21st session of the subject

Figure 3: Students giving the lectures "Preload" (left) and "Tunneling building methods and monitoring" (right) corresponding to the 23rd and 19th sessions of the subject, respectively

2.3 Resources used for the subject preparation

Resources used as material for students to achieve the success of the innovation can be summarized as follows:

- Information to develop autonomous work: students are provided with plenty of material available at the webpage of the subject from the beginning of the course, both written material and videos that may be used as a starting point and approach to the subject.
- Theoretical material: this material is the basis for the development of the regular sessions of the first part of the subject and it provides feedback to students learning; all the material discussed in class is available at the webpage of the subject.
- Theoretical-practical material: this material, also available at the webpage of the subject, can be used by students to carry out cooperative learning and team-working.
- Bibliographic resources: at the beginning of the course and during the preparation of lectures by students (second part of the subject), a broad list of bibliographic references, both generic and specific, is provided; all bibliographic references are available at the University Library.

2.4 Evaluation

Students who follow the proposed innovation methodology are mainly evaluated according to the two parts in which the subject is divided as indicated above:

- The first part of the subject, which focuses on more theoretical aspects, is evaluated by means of an open answer written test, where the student must solve a series of questions similar to those made at class. This test represents 40% of the final grade.
- The second part, corresponding to the lectures given by the students in groups, represents 40% of the final grade and is assessed by co-evaluation based on three items with the same weight (one third each): (i) peer evaluation conducted by those classmates who were present in the lecture given by the student group; (ii) peer evaluation conducted by each of the students of the group that has given the lecture, of the other components of the group; and (iii) evaluation by the teacher who has supervised the group.

It is important to note that both peer evaluations are anonymous and are performed once the class is finished (there is a time limit of one week to do it). In addition, laboratory sessions represent 10% of the final grade and are evaluated by a written report done individually by each student.

As can be seen, an important weight is given to the peer evaluation based on the preparation of a part of the subject syllabus by the students and the later lecture giving to their classmates. Since the innovation is addressed to 4th year students who are on the verge of become civil engineering practitioners, it is intended to promote the capacity of students to technically select and present the information that they consider interesting for their target audience (in this case the rest of classmates), as well as their ability to technically discuss the engineering work carried out by themselves or by another practitioner.

Likewise, it is important to say that from the beginning of the course students are aware of the evaluation system, and they are given the opportunity to be evaluated both by following the mentioned methodology and through the traditional formula consisting of two exams. In the latter case, the first exam is identical to the test of the first part of the innovation, while the second exam is an open answer written test which deals with the topics related to the second part of the subject.

3 RESULTS

Figure 4 displays the academic results of the students on the subject from 2012-2013 academic course up to the present one (2017-2018). During the first year (2012-2013) a more traditional methodology was followed, based almost exclusively on the use of the masterclass during the whole academic period and the evaluation through two exams. In 2013-2014 the methodology described in this communication began to be implemented, and it has undergone little variation from that point, although it has been improving and polishing little by little over time.

Results show that the change on the learning methodology led to a clear and drastic decrease in the number of students who abandon the course, being less than 5%. Besides, the implementation of the teaching innovation has led to a general increase in the percentage of both pass (D) and average (C) grades, although there is no significant increase in the number of higher grades (A and B).

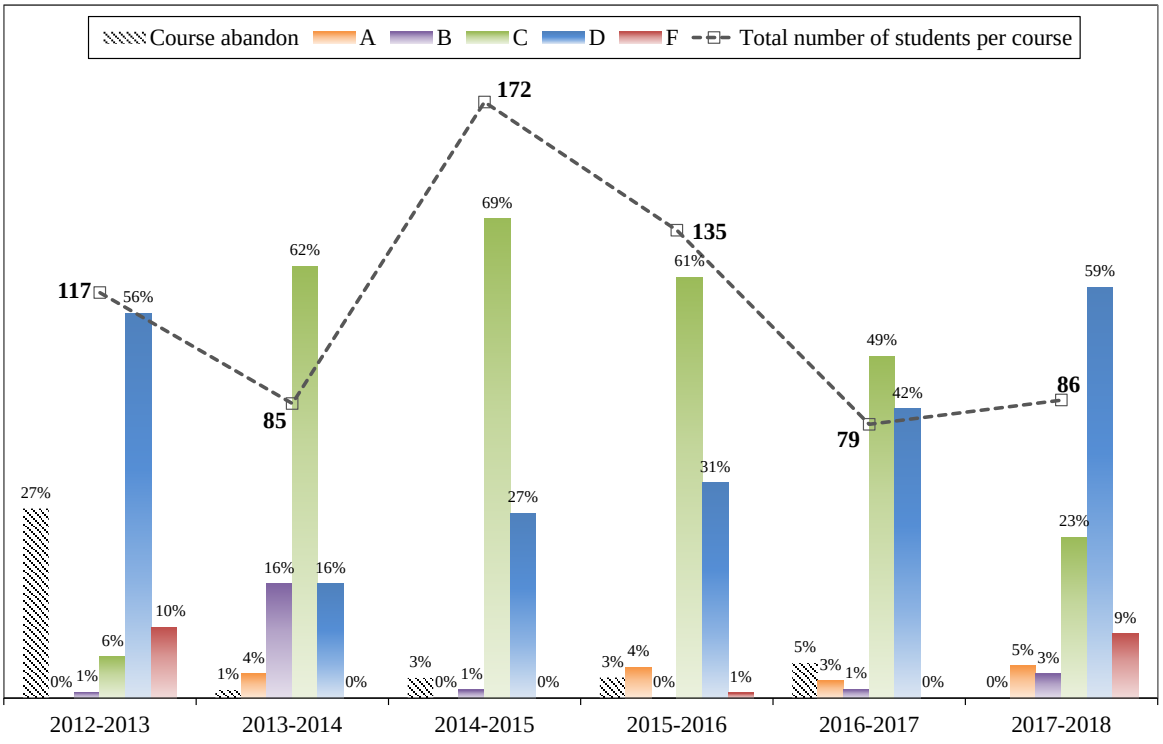

Figure 4: Students performance results

This indicates that the new methodology manages to improve the academic performance of the "average students", who increase their grades. On the other hand, students who were already excellent still are. It is also interesting to note that of the total number of students who have been enrolled in the course since 2013, when innovation was launched, of the 543 students who decided to follow the new learning methodology almost all of them have passed, only 9 failed.

Regarding those aspects related to the level of involvement and motivation of the students and their assessment of the subject and the innovation, Table 2 shows the results of a survey carried out by the Education Institute Center (ICE) of the UPV in the last academic course with the aim of assessing the implementation of the flipped class methodology. It should be noted that there is no data from previous years, so it is not possible to make any objective comparisons. However, from a qualitative point of view, it was already observed from 2013-2014 that the innovation significantly increased the degree of involvement and motivation of the students.

The analysis of Table 2 shows that the active methodology proposed in the innovation achieves the objectives of fostering team-working and increasing the level of involvement in the subject. The latter seems to have a side effect, because it motivates the student to attend the class and work on it, helping the student to some extent to arrive better prepared to the exams.

Moreover, what students value most, besides the material given by teachers, is the possibility of learning together with their classmates both inside and outside the classroom. As expected, the creation of a good social environment fosters the learning process and it also

makes the learning experience more enjoyable. The evaluation system of the subject is also positively valued by the students, who appreciate the possibility of passing the subject by a continuous evaluation and not by one or two "independent" exams.

Finally, it is important to point out that the great majority of the students liked the teaching methodology followed and would recommend their colleges to enroll on it.

Table 2: Survey students results about the learning methodology used (course 2017-2018)

Issue	Value scale*				
	1	**2**	**3**	**4**	**5**
Enjoyable and good experience	8%	17%	25%	42%	8%
Recommended experience	0%	17%	33%	42%	8%
Raising implication in the subject	8%	8%	17%	42%	25%
Facilitating relationship with the teacher	0%	8%	8%	33%	50%
Cooperative work (with colleagues) development	0%	17%	8%	42%	33%
Evaluation system	8%	17%	0%	42%	33%
Material given by teachers	8%	8%	8%	58%	17%
Work class activities	0%	17%	33%	33%	17%
Work in groups with colleagues experience	8%	0%	17%	50%	25%

** Value scale ranges from 1 ("negative", "dislike", "not interesting, "disagree") to 5 ("positive", "like", "interesting", "agree")*

4 CONCLUSIONS

After five courses applying the new active methodology based on self-learning and the use of flip teaching, its implementation has undoubtedly managed to increase the motivation of students as well as their willingness to participate actively in the subject.

Innovation has allowed students to transform, at least to some extent, their typical vision of memorizing "strange" theories and "systematizing" the resolution of problems, classic approach of civil engineering students towards a theoretical-practical subject like Geotechnical Engineering, to a new framework in which they are the ones who learn continuously, day by day, guided and accompanied by the teachers who help them to face the "obstacles". Students are the true central characters of lectures, even being themselves who teach to the rest of their classmates. And all this with a focus on practical and interactive aspects, even in a playful way in some cases, which clearly seeks that the student "learn by doing" as well as "learn by having fun".

Thus, the implemented learning methodology has enhanced the formative evaluation of students, has improved their academic performance, especially that of the "average students", and has ostensibly reduced the "academic absenteeism", with a very low or even null student failing rate figures.

Finally, it is interesting to note that this innovation has been the outcome of the cooperative work of all the teachers of the subject, who have collaborated to a greater or lesser extent in the innovation and helped in the successfully implementation of it throughout these five academic courses. Team-working and shared reflections, as indicated by Santos et al. [3], have enabled to overcome the insecurities generated by doing something different and innovative.

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