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Assessment of Ethical, Environmental and Professional Responsibility Training of Civil Engineers*

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The paper presents and analyses how the generic outcome "Ethical, environmental and professional responsibility" is achieved in the bachelor's degree in civil engineering at Universitat Politècnica de València (Spain). The analysis is based on the study of activities and evidences generated when assessing this outcome, interviews with responsible lecturers for courses developing this generic outcome and opinions from final year students. The aim of the study is to determine whether the activities carried out during the bachelor's degree ensure that students have been trained enough to achieve the two proficiency levels of this generic outcome. Conclusions are drawn and recommendations established to ensure that all graduated students achieve this essential learning outcome.

Keywords: generic outcome; ethical responsibility; professional responsibility; civil engineering; transversal skill

1. Introduction

In Spanish universities teaching Civil Engineering bachelor's degrees, ethical training has never played a relevant role from the point of view of the curriculum design. Traditionally, some schools offered elective courses related to ethics, but in most of them, ethics is directly ignored [1, 2]. However, this training is essential, considering the challenges that future civil engineers will face [3–5].

With the adoption of the European Higher Education Area (EHEA) based on the Bologna Process, degrees offered by Spanish universities were revised and updated. One of the consequences of the EHEA adoption was the division of the student learning process into three categories: knowledge, skills and competences [6]. This new vision emerged due to the need to provide students and future professionals with a comprehensive training that qualifies them to be excellent professionals not only from a technical point of view, but also in a more holistic dimension.

Since 2008 [7], universities teaching Civil Engineering bachelor's degrees in Spain increased significantly [8]. This fact encouraged school governing boards to apply for national and international accreditations to demonstrate the quality of their graduates compared to other schools. ABET and EUR-ACE are two of the most prestigious accreditation agencies, both considering the ethical responsibility of professionals as a learning outcome that students must obtain [9, 10]. Indeed, ABET considers as a mandatory learning outcome that students must achieve "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts". Therefore, on the one hand, there was the fact of designing new curricula to adapt undergraduate studies to the EHEA, and on the other hand, to make them competitive by achieving ABET or EUR-ACE accreditations. Both situations led to the need to incorporate ethical and professional responsibility as key learning goals for students on completing their bachelor's degree in civil engineering.

Universitat Politècnica de València (UPV) decided to incorporate this learning outcome into an institutional program to integrate thirteen generic outcomes (GOs) into every degree program taught at UPV. These generic outcomes, also referred as transversal competences, cover topics such as time management, effective communication, teamwork or ethical, environmental and professional responsibility [11].

1.1 The GO Ethical, Environmental and Professional Responsibility

The UPV's Generic Outcomes (GOs) project was launched in 2013 and its main objective is to certify that all students have achieved them once graduated from any of the UPV Bachelor and master's degrees. By the end of 2013–14 academic year, training activities were carried out in all schools to prepare the project and to inform management teams on the need to start carrying out pilot activities during the 2014–15 academic year. The project was definitively implemented during 2015–

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Table 1. Generic Outcomes at UPV [13]

GO-01. Comprehension and Integration
GO-02. Application and practical thinking
GO-03. Analysis and problem solving
GO-04. Innovation, creativity and entrepreneurship
GO-05. Design and project
GO-06. Teamwork and leadership
GO-07. Ethical, environmental and professional responsibility
GO-08. Effective Communication
GO-09. Critical thinking
GO-10. Knowledge of contemporary problems
GO-11. Lifelong Learning
GO-12. Time planning and management
GO-13. Specific instruments

16; moreover, the UPV 2020 strategic plan [12] includes the correct accreditation of GOs defined by UPV.

Within the thirteen schools at UPV, different courses were established as control points for each proficiency level of the thirteen GOs established by the Vice-Rectorate for Studies, Quality and Accreditation. Two proficiency levels were established for each competence corresponding to Bachelor's programs, and a third proficiency level corresponding to master's programs. The courses defined as control points must collect evidences of the proficiency level achieved by students in the assigned GO.

The Institute of Education Sciences (ICE) at UPV published guidelines with support material for academic staff [13]. The document described the 13 GOs (Table 1). In addition to describing the content of each competence, this document established the learning outcomes that students should achieve for each proficiency level. It also provided rubrics for assessing them, and suggested different activities and techniques for working and assessing the competence in the classroom (materials related to the GO analysed herein can be found in the following section). In addition to this document, ICE offered training workshops, produced videos to disseminate the thirteen GOs and provided support to all lecturers, especially those who were selected to be control points to develop and assess pilot activities.

In 2017–18, Bachelor and master's students began to be certified as having completed all the

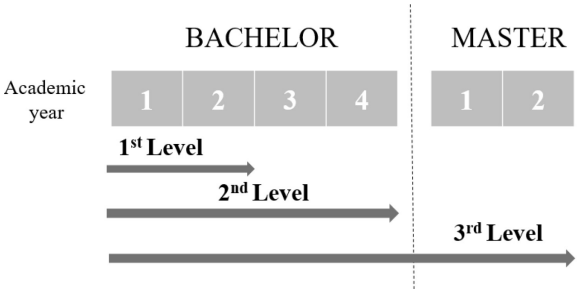


Fig. 1. Proficiency Levels of each GO.

proficiency levels corresponding to their studies and therefore UPV was ready to check the level of achievement for the different GOs.

The generic outcomes at UPV cover several aspects (Table 1). Many of these aspects were already worked in the pre-Bologna curriculum, even though they were not specifically called "generic outcomes". Indeed, engineers graduated before the implementation of the institutional GO project and adaptation to the EHEA, achieved competences in "comprehension and integration", "analysis and problem solving", or "design and project", for example. Indeed, many courses present in the civil engineering bachelor's degree curriculum develop these outcomes.

1.2 GO-07 in the Civil Engineering School at UPV

Some learning outcomes are difficult to include in the curriculum in a transversal way. They need a theoretical framework that can hardly be contained in other specific courses. This is the case of GO-07 "Ethical, environmental and professional responsibility". As noted above, this competence is explicitly cited in the learning outcomes required by the most prestigious quality accreditation agencies. Moreover, there is not much information on how to introduce and assess [14] professional and ethical responsibility into the students' curriculum. It would appear that the more content, the better the training, but this is not always the case. The ABET agency itself, responsible for promoting the incorporation of these learning outcomes into the students' curriculum, does not define how engineering programmes demonstrate compliance with its criterion 3.f ("an understanding of professional and ethical responsibility") [15]. As a consequence, this is a further difficulty: how to incorporate this learning outcome into civil engineering bachelor's degrees.

Additionally, "Ethical, environmental and professional responsibility" is the only GO at UPV that has different learning outcomes for each proficiency level, separating environmental responsibility from ethical and professional responsibility. It is possible to act in an environmentally responsible way, without considering the resolution of a moral dilemma (for example, by carrying out a correct waste management). On the contrary, problems can arise in which one must act with ethical and professional responsibility, without any relation to the environment. The control point courses within the civil engineering bachelor's degree decided to work only on one of these two aspects. Indeed, it is difficult to introduce activities related to both aspects of the GO and evaluate them by obtaining different evidences, in addition to developing the specific technical content of the course, considering

Table 2. Control point courses of GO-07, academic year 2020/2021

Subject	Type	Year	P. Level	ECTS
Topography	Compulsory	2	1	4.5
Science and Environmental Impact of Civil Engineering	Compulsory	2	1	4.5
Industrialised Construction	Compulsory	3	2	4.5
Construction Management and Organization	Elective	4	2	4.5
Ethics in Civil Engineering	Elective	4	2	4.5

the working load (4.5 ECTS) of the concerned courses (Table 2).

For all the above reasons, it is therefore time to analyse and evaluate how this competence has been developed within the curriculum and whether the required learning outcomes are achieved.

2. Presentation

2.1 Objectives

The general objective of this work is to analyse and carry out a diagnosis of the level of achievement of the generic outcome GO-07 ''Ethical, environmental and professional responsibility'', in each of the proficiency levels foreseen in the Civil Engineering bachelor's degree at UPV.

This diagnosis includes the review of the methodologies, activities, evidences and rubrics used, as well as the study of the suitability of the courses selected as control points. Based on this diagnosis, improvement actions will be studied, ranging from improving institutional rubrics for their adaptation to the context and to the development of training actions consistent with GO-07. New ''pilot'' courses will be established as control points and new activities will be introduced with new evidences. If necessary, new rubrics will be defined to ensure the achievement of this generic outcome by students at the end of the bachelor's degree. All these improvements are already designed based on the conclusions of our work and ready to be implemented during the next academic year, 2021–22.

From the diagnosis, the analysis expects to highlight the following aspects:

(a) the courses in which students develop the generic outcome GO-07, specifying whether they are compulsory (they must be taken by all the students) or elective;
(b) review of evidences and evaluation methods for each proficiency level;
(c) analysis of the degree of complexity of the tasks regarding the corresponding proficiency level;
(d) design of activities and review of the institutional rubrics of each proficiency level of the competence;
(e) finally, establishment of a vertical coordination for all the control point courses working with GO-07.

In this way, activities to be developed by students for the achievement of the learning outcome will be organized throughout the program. Within this background, the key questions we aim at responding with our work are the following:

- What activities are designed and implemented for students to achieve the GO-07? Are the activities aimed at achieving both dimensions of this competence?
- Do students take all control point courses?
- What do lecturers think about this method of including ethical, environmental and professional responsibility across the curriculum? What problems do they identify in its implementation?
- What is the students' perception on how the competence is acquired and assessed throughout the program?

2.2 Materials and Methods

To gather information about activities and evaluation methods of this generic outcome, we studied and analysed the course syllabi of the control point courses and their competence report. This report is written at the end of each academic year by the school governing board to assess the status of the program.

Personal interviews with lecturers responsible for these courses completed the analysis. In addition, a group dynamics performance with last year students was developed to collect their opinions and perceptions about the achievement of the competence.

3. Results and Discussion

There are many opinions in the existing literature related to the acquisition of ethical and professional responsibility skills, but it is not clear how to properly assess these learning outcomes. In general, there are two main currents, those universities incorporating it as a compulsory course within the curriculum, and those that opt for a transversal integration across the curriculum with different approaches. Even so, there is no evidence on studies comparing the different methods of incorporating this competence into the curriculum [16]. The following presentation of results and their discussion will show that the methodology currently used at UPV is not achieving the expected results.

Table 3. Overall assessment results of the GO-07 in the Civil Engineering bachelor's degree

Year	Students assessed					Mean*	Mean	%ABC	%AB	Mode
	D	C	B	A	Total					
2019	4 2.5%	32 19.9%	73 45.3%	52 32.3%	161	2.1	B	97.5%	77.6%	B
2018	3 1.2%	59 23.3%	117 46.2%	74 29.2%	253	2.0	B	98.8%	75.5%	B
2017	4 3.7%	16 14.7%	51 46.8%	38 34.8%	109	2.1	B	96.3%	81.7%	B
2016	2 1.6%	31 24.6%	59 46.8%	34 27.0%	126	2.0	B	98.4%	73.8%	B
2015	11 5.1%	13 6.0%	137 63.7%	54 25.1%	215	2.1	B	94.9%	88,8%	B

(*) for comparison purposes: A = 3, B = 2, C = 1, D = 0. Source: public annual management reports.

Table 3 shows the performance achieved by students during the last five academic years, regarding the assessment of GO-07. Results are denoted by grades A, B, C, and D, where A means an excellent performance, B means a correct achievement of the generic outcome, C indicates the student is still progressing to the competence achievement and D means the student has not achieved the learning outcome.

The results show that less than 5% of students obtain a grade D in achieving this GO. This would indicate that the majority of UPV graduates are still developing or have acquired this GO. Between 74.8% and 88.8% have achieved the learning outcomes described in the GO, and more than 25% have done excellently (grade A). However, these results do not show what happens in the classroom, neither the knowledge acquired by the students. In the authors' opinion they do not correctly assess the acquisition of GO-07.

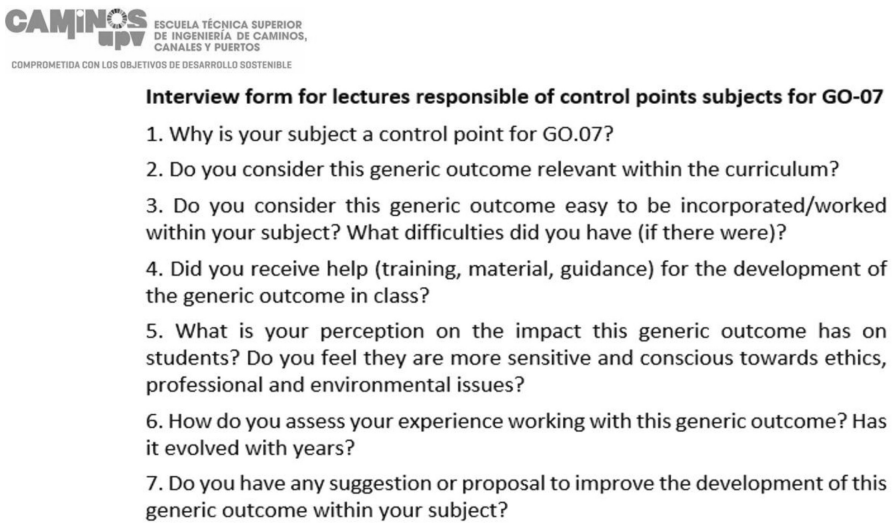
3.1 Analysis of Course Syllabi

The analysis of the course syllabi for the control point courses (Table 2 and 3) for GO-07 ''Ethical, environmental and professional responsibility'' highlight the following points:

(a) All courses adapt the difficulty of the GO-07 activity to the difficulty of the course.
(b) Not a single course uses institutional rubrics to

Table 4. Description and assessment criteria for activities related to the GO-07 within the control point courses

Subject	Activity developed to train GO-07	Evaluation criteria
Topography	Regarding a surveying work, students must write an economic report justifying, from an ethical a professional responsibility point of view, the best alternatives regarding material and human resources, estimation of costs, assessment of self and/or others' work and criteria for distribution among the intervening parties and incidence of decisions in the intervention of third parties.	A control list is previously distributed to students, in order to make them aware of the relevant aspects to be assessed. Specifically, students are assessed regarding two indicators: (1) the student is aware of and critically accepts new perspectives by questioning his/her own; (2) the student thinks about the consequences and effects those decisions and proposals might have on people. He/she establishes the procedure to obtain a practical solution and recognises the ethical and deontological concepts of the profession.
Science and Environmental Impact of Civil Engineering	Students attend a seminar taught by the Environmental Area of the UPV. The seminar deals with general concepts of environmental responsibility. After the lecture, a debate on practical cases takes place. Students are asked to argue about the environmental dilemmas.	The activity is assessed through a test, focusing, first, on general topics about environmental responsibility and, then, on how to act, from an environmentally responsible perspective, in a hypothetical professional case.
Industrialised construction	Students develop, in groups, an analysis commenting and giving examples after reading a technical text related to professional, ethical and environmental aspects inherent to professional activity. The text is provided by the lecturer.	Students are assessed according to a questionnaire on the text and to their participation in the debate developed after the activity.
Construction management and organisation	Students participate in a simulation activity. They assume the role of a Project Manager, focusing on ethical decisions. Additional work related to ethical aspects in Civil Engineering is also developed.	Each student is assessed based on his/her individual report and on his/her participation in group activities.
Ethics in Civil Engineering	The whole course focuses on ethical aspects in Civil Engineering. Students develop several individual and group activities, facing ethical problems raised by themselves or by the lecturer. All the activities are presented and debated in class.	Each student is assessed based on his/her individual report and on his/her participation in group activities, their presentations and the debate.


CAMINOS upv ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA DE CAMINOS, CANALES Y PUERTOS
COMPROMETIDA CON LOS OBJETIVOS DE DESARROLLO SOSTENIBLE

Interview form for lectures responsible of control points subjects for GO-07

1. Why is your subject a control point for GO.07?
2. Do you consider this generic outcome relevant within the curriculum?
3. Do you consider this generic outcome easy to be incorporated/worked within your subject? What difficulties did you have (if there were)?
4. Did you receive help (training, material, guidance) for the development of the generic outcome in class?
5. What is your perception on the impact this generic outcome has on students? Do you feel they are more sensitive and conscious towards ethics, professional and environmental issues?
6. How do you assess your experience working with this generic outcome? Has it evolved with years?
7. Do you have any suggestion or proposal to improve the development of this generic outcome within your subject?

Fig. 2. Questionnaire answered by lecturers.

carry out the assessment; only one course (Topography) uses an own rubric.

(c) In all courses, only one of the two aspects of the generic outcome (either environmental or professional and ethical responsibility) is developed. This will result in students not achieving both aspects of GO-07.
(d) Among the assessment methods presented, simplified rubrics and Likert scale questionnaires are used.
(e) Most of the activities are contextualised into the specific course scope.
(f) It is not evident that the proposed activities in each course will let students to achieve the proficiency level expected for the generic outcome.
(g) The fourth-year courses in which this GO is introduced are elective, so it is not likely that all students will take them.

Before UPV, other universities tried to integrate engineering ethics across the curriculum of engineering students, especially in a transversal way [17–19]. However, the main difference with UPV is that there is perfect coordination in all courses involved and that experts have developed teaching material, so that lecturers have sufficiently developed and tested tools to tackle this task successfully.

3.2 Opinion of Responsible Lecturers for Control Point Courses

In order to ratify the content of the syllabi of the control point courses, personal interviews were scheduled. Fig. 2 shows questions asked. The main objective of these interviews was to know the lecturer's opinion on how their courses are contributing to the achievement of GO-07.

All the faculty members interviewed consider this

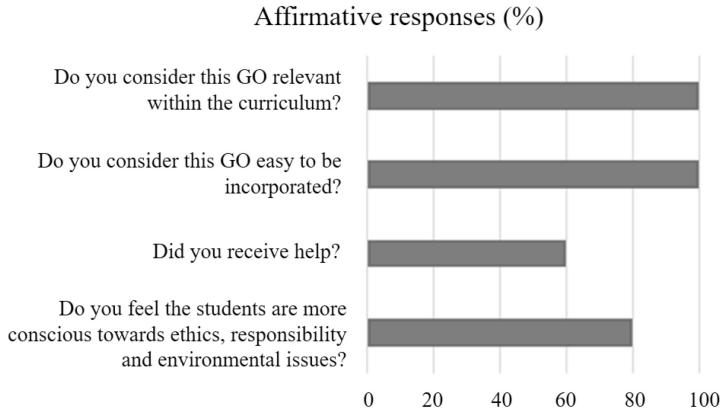


Fig. 3. Lecturers responses (presented as percentage of affirmative responses) to the interviews about the UPV GO "Ethical, environmental, and professional responsibility" (GO07).

generic outcome essential to develop the civil engineering profession with excellence.

Another aspect to be highlighted is the different perception that students and lecturers have on how the competence is introduced in the course. For half of the lecturers, it has been very easy to introduce the competence as a transversal content of their specific course, but the students have not perceived this point in the same way, as it will be described in the next section. Indeed, a great majority does not notice that the competence is developed within the course.

None of the lecturers interviewed has been trained to introduce ethical, environmental and professional responsibility in their courses. At this point, we should remember that ICE offers voluntarily specific training, but lecturers have either not been able to attend these courses or have considered them unnecessary. It is also interesting to note that among the teaching staff in charge of integrating and evaluating this generic outcome in their specific courses (all engineers), a small part considers that they do not need training to introduce GO-07 into their subjects. This opinion is in opposition with the fact that ethics is "a type of knowledge that seeks to guide human action in a rational sense: that is, it seeks to make us act rationally (. . .). Ethics is essentially a knowledge to act rationally (. . .) in the whole of life" [20]. Being a type of knowledge, it is a discipline with key reference authors and reference works, as well as an own working method. Therefore, dealing appropriately with ethics requires study and knowledge, and as all knowledge, it can be learned, and it can be taught beyond knowing the deontological codes of a profession. Fortunately, most of the lecturers interviewed asked to be trained or thought that this type of content should be taught by people trained to do so, recognizing and expressing their limitations in carrying out the task entrusted to them.

In our opinion, it is necessary to train lecturers [19] in charge of introducing this subject in a transversal way (regardless the fact that there is a compulsory subject related to ethics). This training can be carried out in different ways [18, 21] and the efforts of these lecturers to improve in the performance of their profession should be valued. Lecturers should be supported in carrying out this task and provided with resources to introduce this competence within their courses.

3.3 Group Dynamics with Final Year Students

As mentioned above, in order to diagnose the level of achievement of this GO during the Civil Engineering bachelor's degree, we developed a group dynamic with last year students. During the session, future engineers were also asked about the courses of the curriculum they considered most appropriate to incorporate this generic outcome. The students worked, first, in groups, sharing and debating opinions. Then, the questions were answered in writing, and, at the end of the session, they were delivered anonymously. Once the students had debated and answered the questions, an oral discussion of all people present in the classroom was initiated. A suitable climate had been created for the students to express their opinion freely. Many of the opinions expressed orally were harsher than those answered anonymously in writing.

As discussed by Lee et al. [22], understanding of student expectations (related to this type of learning outcomes, which are not the traditional ones in Engineering bachelor's degrees curricula) is critical to the development of concrete competences and assessment approaches that legitimate them.

In relation to the institutional program (Fig. 4),

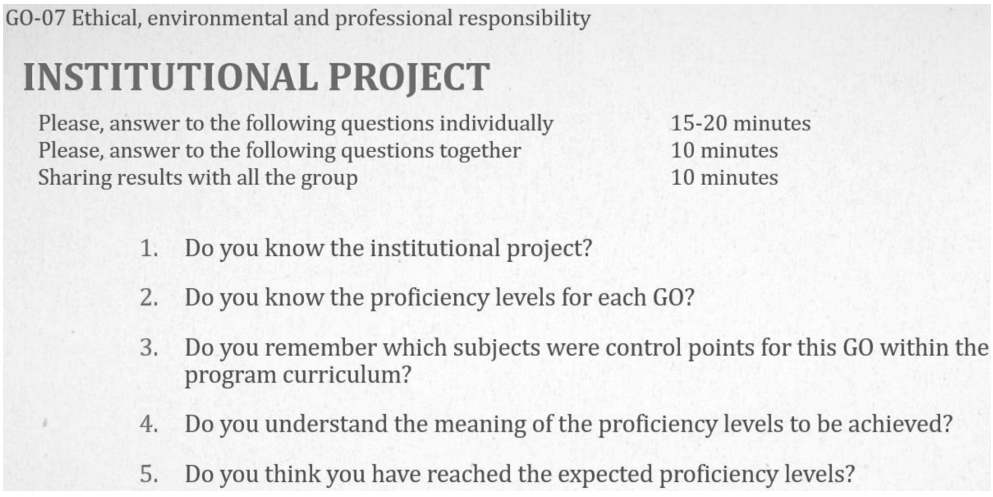


Fig. 4. Presentation used in the group dynamics with students to evaluate the Institutional Project of GO at UPV.

the overall impression is that students do not know much about the project. They know that learning outcomes exist, many do not know the 13 different GOs, nor the levels of proficiency of each outcome, and they hardly remember some courses in which some generic outcome were assessed.

In relation to their perception about whether they have achieved the GO-07 in the expected level of proficiency or not (Fig. 5), they are basically dissatisfied. Among the criticisms they express, we highlight the following:

(a) In some of the control point courses, they do not remember having done any activity related to GO-07.
(b) They think that activities are not well related to the proficiency level to be achieved, and they disagree with being assessed for a competence for which they have not been trained.
(c) They are dissatisfied with being, in some cases, evaluated for a GO, in this case ethical, environmental and professional responsibility, without being aware of it.
(d) Less than 2% of the students believe that they have fully achieved the competence with the activities carried out in the control point subjects. This perception is not according to the good performances previously shown in Table 3.

At present, addressing changes in the curricula of the different university degrees must consider the opinion of students [23]. They are the most important actors in this scenario, those who are going to study the program and future professionals who will acquire their initial training for developing their profession. One of the aspects to be highlighted after the group dynamic is the great willingness of students to participate. In addition, they positively acknowledge their opinions to be considered for future improvements.

On the other hand, the different perception between lecturers and students about the relevance of the different activities carried out to achieve the level of proficiency required in GO-07 is disturbing. The fact that only 2% of students believe they have been sufficiently trained in this GO justifies a review of the incorporation of GO-07 within the curriculum and encourages its improvement. Previous studies have verified the mismatch between lecturers' and students' perceptions of ethics [24]. To reduce this bias, students might be involved in the design of course activities, and even to have an active and important role to play in transferring ethics from the periphery to the Civil Engineering bachelor's degree curriculum.

3.4 General Remarks

In 2010, Walczak et al. [25] analysed and identified the institutional barriers to incorporating ethics into the engineering curriculum. In this study, five common issues were found; (1) the curriculum is already full, and there is little room for ethics education, (2) faculty lack adequate training for teaching ethics (3) there are too few incentives to incorporate ethics into the curriculum, (4) policies about academic dishonesty are inconsistent, and (5) institutional growth is taxing existing resources. At least the three first obstacles already exist at UPV. The same authors analyse how to overcome these obstacles. The rules they define to progress into a better integration of the generic outcome into the curriculum are fully applicable to UPV, which must get inspiration from other successful experiences to improve the model.

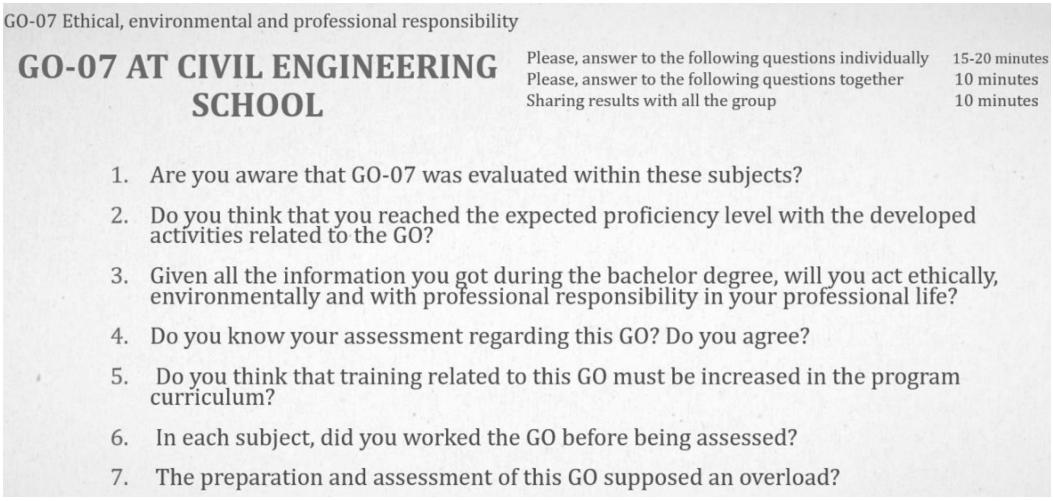


Fig. 5. Presentation used in the group dynamics with students to evaluate the acquisition of the GO-07 in the Civil Engineering bachelor's degree at UPV.

After reviewing all the teaching materials and gathering input from interviews to lecturers and students of the bachelor's degree, the following remarks arise:

(a) At present, it is necessary to evaluate the level of development of the institutional project of incorporating 13 generic outcomes in all the degrees taught at UPV. Despite this fact, students are assessed and graded (Table 3).
(b) In general, not enough evidence has been collected to be able to certify that Bachelor students in Civil Engineering have achieved the required level of proficiency at the end of the program.
(c) It is necessary to split GO-07 into two different competences, since if only one of the aspects is evaluated (the environmental or ethical and professional responsibility), it is not possible to ensure that the competence has been fully achieved.
(d) Institutional rubrics for evaluating this GO might be too complex and even confusing. This may be the reason why the analysed courses do not use them.
(e) It is necessary to correctly explain to students the purpose of all GO, name the ones that are worked on in each specific course (especially if they are going to be assessed), and give training related to the competence before assessing whether students have reached the expected proficiency level and to what extent (what grade they obtain). Students want to learn.
(f) For the success of the project, the collaboration of lecturers responsible for the control point courses is essential. This generic outcome is difficult to work and to assess, therefore all available help and collaboration must be provided to lecturers. All the lecturers responsible for control point courses considered that it was easy to incorporate activities to work on and to assess this outcome. However, reviewing and analysing evidences from each course for assessing the degree of acquisition of GO-07 (Table 3), a large discrepancy is observed between "what is actually assessed" and "what is intended to be assessed". This fact shows, once again, the difficulty of evaluating the achievement of this GO [14, 26, 27].

After the analysis, the results obtained and the social demand, school governing boards should consider introducing a compulsory subject in the program curriculum aiming at training future engineers to develop their professional activity with the necessary responsibility and ethics. This view is not new, as Professor Unger noted in 2005: "engineering ethics should be an important part of the undergraduate engineering curriculum (. . .). So, while we should do the best we can to encourage faculty members to incorporate ethics related concepts in their courses where appropriate, we should also develop courses specifically designed for engineering students, and at least one such course should be a required course" [28].

4. Conclusions

The general objective of this paper is to analyse and diagnose the level of achievement of the generic outcome GO-07 "Ethical, environmental and professional responsibility", at each of the proficiency levels foreseen in the Civil Engineering bachelor's degree at UPV.

This work analysed objective data and subjective interpretations from interviews and questionnaires to develop the diagnosis and build-up conclusions. Objective data from course syllabi let us prove if all students had the possibility to achieve both proficiency levels of the generic outcome. The subjective analysis of interviews and questionnaires from students and lecturers let us assess if the foreseen activities within each course are feasible to achieve those proficiency levels of the generic outcome.

Given these objectives and considering the key questions stated within aour work, the following conclusions can be highlighted:

- The diagnosis of the level of achievement of the GO-07 "Ethical, environmental and professional responsibility" has been completed.
- The different activities carried out to achieve the GO-07 are not specifically aimed at achieving the two dimensions foreseen by the competence. All the activities implemented have room for improvement.
- We must ensure that all students develop activities to achieve the competence within compulsory subjects. The achievement of the GO-07 must not rely on elective courses.
- There are differences in the perception between lecturers and students about the way in which GO-07 is taught and achieved. Lecturers are reasonably satisfied with how this generic result is incorporated into their subjects, without requiring additional training to do so. However, only 2% of students believe they have received sufficient training regarding this GO.

These conclusions highlight that there is still room for improvement in the way future civil engineers are trained on ethical, environmental and professional responsibility. In the future, we will extend the study to graduates with professional experience to collect their opinions about the training obtained during their degree studies in this field and, its usefulness. It would also be interesting to

assess their perception on the lack of training and their needs in the field of ethical, environmental and professional responsibility.

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