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Final Year Project: Students' and Instructors' Perceptions as a Competence-Strengthening Tool for Engineering Students*

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This work indicates the importance of the Final Year Project (FYP) in the strengthening of competences of engineering students.

The study also shows which personal competences of students are reinforced most during the FYP process, including the preparation, elaboration, presentation and defence stages. In order to gather information on this subject, a survey was conducted at two different Spanish technical universities—one public and one private—and a comparative analysis was performed of the questionnaires collected. The competence model considered is that used by the Accreditation Board for Engineering and Technology (ABET), since the official title of the public university has been accredited by this model.

The results indicate which personal and professional competences of students are reinforced well by undertaking the FYP. Any significant differences in response by university are explained in the study. For validation purposes, the results were contrasted with the instructor's perspective using the triangulation methodology.

Finally, the conclusions drawn will permit the design of new study plans to cope more effectively with the challenges of the FYP in the new Bologna framework.

Keywords: final year project; ABET competences; engineering education

1. Introduction

The Final Year Project (FYP) is an activity that is undertaken at the end of the engineering course. A passing grade must be received in the FYP in order to obtain a degree in engineering [1]. The FYP is regarded at both universities selected as an individual task to be performed by a student, who, under the guidance of one or more tutors, designs a solution that is capable of properly satisfying a real need. The FYP must be sufficiently complex to require the application of all of the student's knowledge and training acquired throughout his or her studies [2–7].

The problem of assessing the level of competence that students acquire during their course of studies is certainly challenging. In this sense, this research is aimed at assessing how this academic tool, FYP, strengthens the outcomes of engineering students. More precisely, the main objective is to determine which of the competences presented in the ABET model, students and instructors consider to be most reinforced when carrying out their FYP tasks.

As many observers have pointed out, engineering faculties tend to emphasize narrow technical competence at the expense of a more general preparation for thoughtful professional practice [8, 9]. One way to interpret this state of affairs would be to say that the better the job that engineering educators do in training their students with the present curriculum, the better prepared will be the graduates to contribute expertly to their employer's goal [10]. How might engineering educators strengthen those competences that differ from technical ones? The FYP is considered to be a useful tool in the attempting to achieve this goal.

With regards to methodology, two universities were selected for the research—the Technical University of Madrid ('Universidad Politécnica de Madrid' public university) and the Comillas Pontifical University of Madrid ('Universidad Pontificia Comillas', a private university) or, more specifically, their industrial engineering schools, ETSII and ICAI, respectively. Although the two institutions follow a similar degree curriculum, there are two singularities to consider when conducting the research. Project management subject, which describes the theoretical framework of the FYP, is

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considered at ETSII to be a *learning by doing* experience that concentrates on real work developed by multidisciplinary teams of students, whereas the ICAI teaching method is based much more on seminars or specific lectures. The second difference involves the availability to a specific FYP. There is an ICAI website where a complete FYP offer is available for every student, unlike the case of ETSII students.

This paper is organized as follows. Firstly, the model of competences used and its justification is described in Section 2. The research objectives, design, results and discussion are explained in detail in Section 3. Finally, Section 4 presents the conclusions.

2. Model of Competences

ABET, Inc., formerly the Accreditation Board for Engineering and Technology, is a non-profit organization that accredits postsecondary year programs in applied science, computing, engineering, and technology. Accreditation is intended to certify the quality of these programs.

The model of competences used to perform this research has been ABET because UPM was accredited in 2010. During the process stages, the university's board of directors realized the importance of strengthening students' outcomes and the need to evaluate them.

ABET specifies the minimum curricula for various engineering programs. For instance, ABET requires that all engineering graduates in a baccalaureate program receive at least one year of study in the natural or physical sciences and mathematics, and some more general education [11]. ABET also requires that each student complete a capstone project or design class during his or her education. Because of ABET′s involvement, engineering curricula are somewhat standardized at the bachelor′s level, thus ensuring that graduates of any ABET-accredited program have some minimal skill set for entry to the work force or for future education.

The competences that are required by this model are:

C1: An ability to apply one's knowledge of mathematics, science, and engineering.
C2: An ability to design and conduct experiments, as well as to analyze and interpret data.
C3: An ability to design a system, component, or process to meet the needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
C4: An ability to function on multidisciplinary teams.
C5: An ability to identify, formulate, and solve engineering problems.
C6: An understanding of professional and ethical responsibilities.
C7: An ability to communicate effectively.
C8: A broad education in order to understand the impact of engineering solutions in a global, economic, environmental and societal context.
C9: A recognition of the need for, and an ability to engage in, life-long learning.
C10: Knowledge of contemporary issues.
C11: An ability to use the techniques, skills and modern engineering tools that are necessary for engineering practice.

Several authors have proved that this model improves the engineering environment at different universities [12, 13]. Some articles focus on different approaches to assessment. McGourty et al. [13] reported on a multi-institutional project that considered twelve different assessment methods and their application to engineering education. Wellington et al. [14] addressed multiple, authentic, assessment methods applied to a multi-disciplinary industry project. J. M. Williams [15] described the use of engineering portfolios as an assessment vehicle. R. S. Adams, et al. [16] described the importance of the use of multiple methods and the triangulation of these results in assessment. Other articles have focused on the interaction between administrators and faculty in the assessment process. Nault and Hoey [17] argue that establishing a culture of trust in an organization is a necessary first step towards creating a sustainable assessment system. Still other articles have addressed a variety of models that can be used in the development of a framework for assessment. Besterfiel-Sacre et al. [12] described the use of empirical methods that can be used to develop a model of the engineering education process. Kaw et al. [18], Steward et al. [19] and Mitchell et al. [20] presented innovative course-level assessment techniques. Finally, Howell et al. [21] suggested a program assessment process that links program objectives to course objectives and educational activities. L. A. Shay et al. [22] focus on the important issue of improving the efficiency of the outcome assessment process (reducing the burden on already busy faculties) without sacrificing the quality of results.

Professional skills, such as competence 6 (an understanding of professional and ethical responsibilities) and competence 8 (a broad education in order to understand the impact of engineering solutions in a global, economic, environmental and societal context), have proved difficult to teach [23, 24]. The importance of teaching management ethics has been emphasized [25, 26].

This makes us consider the importance of implementing social responsibility systems in the university in view of the efficacy that they may have in strengthening those competences.

3. Research Design

3.1 Objectives

As previously indicated, the main objective of this research was to determine how the academic tool, FYP, strengthens the outcomes of engineering students. Additionally, we intended to determine which of the outcomes that are presented in the ABET model are perceived by the students and instructors to be most strengthened by the development of the FYP.

To accomplish this, a sample of students and instructors was recruited from the two Industrial Engineering Schools previously mentioned (i.e., ETSII and ICAI).

3.2 Hypotheses

With reference to the students' perceptions of FYP, it was expected that a significant difference would be found between the responses of the two groups, since the students at a private university are educated according to a different educational model and in a more personalized way than students at public universities. The FYP work approach is no exception, as mentioned in the introduction.

Significant differences between the perceptions of instructors and students were also expected, for least some of the eleven ABET competences.

Consequently, it was anticipated that some ABET competences might be reinforced more than others when considering FYP as an educational strengthening-tool.

3.3 Methodology

Firstly, a specific analysis of how the FYP strengthened the eleven ABET competences was conducted. By contrasting both models (public and private), not only would any differences between the two schools of engineering be highlighted, but also which competences had been reinforced most, according to the students, would be revealed.

Secondly, using the triangulation methodology, the same analysis was also conducted taking into account the instructors perceptions' of the same subject. This is considered to be the most appropriate technique to obtain independent assessments that reinforce the conclusions. Triangulation in this research increases the credibility and validity of the results by cross-verification [27] and provides a more detailed and balanced picture of the situation [28].

3.4 Research tool

A self-administered questionnaire was designed as a mean of exploring students and instructors' personal characteristics, opinions and levels of satisfaction with their competences.

The voluntary interviews were conducted during 2010 by the use of a specialized, internet survey application. An interactive HTML form was preferred because of rapid collection of results and user-friendly properties in data creation, manipulation and reporting. Data sets were created in real time and the anonymity of respondents was guaranteed. Clear instructions for completion of the questionnaire were provided, as well as the research objectives. When contacting students by e-mail, it was emphasized that replies were voluntary and free of obligation.

A group of questions was formulated to properly describe the student's profile. This included year of admission to the school of engineering, type of specialization, FYP duration time, average time dedicated per week, usefulness of knowledge acquired during the career and FYP's grade of difficulty.

Then, a second group of closed-ended questions was designed. The purpose of these questions was to better understand how each group of graduates perceived the skills that they acquired during completion of the FYP. Five Likert-type [29] options were presented as possible replies to each competence contribution question, with 0 meaning 'no contribution at all' and 1, 2, 3, and 4 meaning 'low contribution', 'medium contribution', 'high contribution' and very 'high contribution', respectively.

Finally, the questionnaire was validated by a group of academics from both schools, who carefully reviewed the proposed questionnaire.

3.5 Data samples

The sample of students consisted of 291 respondents, who were in the process of defending their FYP work or had graduated from one of the two schools and had submitted their FYPs in the previous year. 73 replies to the questionnaire (a response rate of 29%) were received from the ETSII students and 218 replies (40%) were received from the ICAI students.

The questionnaire was also sent to 29 teachers who regularly tutor FYP. 19 replies were collected (a response rate of 65.5%)

Most ETSII students who answered the survey were admitted to the School in 2000 or later (91.3%). The 2001 and 2002 years each contributed 43.4%. On the other hand, in the ICAI group, 72.5% of graduates entered the school between 2000 and 2002, with 2001 the value most repeated.

The most popular specializations among ETSII students was mechanical engineering (23.3% of the total), followed by industrial organization (21%), electronic engineering (17.8%) and electrical engineering (9.5%). At ICAI, the most common specializations were electrical industrial engineering (23.9% of the students), mechanical engineering (21.1%) and electronic industrial engineers (10.6%).

4. Results

4.1 Descriptive analysis of the student survey

For FYP duration, ETSII students needed an average of one year to complete the project, whereas those at ICAI spent an average of 9.2 months.

In both cases, the FYP dedication time was an average of 20 hours a week. When asked about FYP difficulty, the most common answer of students of ETSII and ICAI was 'Difficult' (64% at ETSII, 53.2% at ICAI)

Students and graduates of both schools also acknowledged that they had used all the competences that they had acquired during their studies when preparing the FYP. About 36% chose 'indispensable' at ETSII compared to 45.9% at ETS-ICAI.

The charts that appear in Fig. 1 provide a frequency distribution of responses by school on the contribution of various competences:

For the first competence (*an ability to apply one's knowledge of mathematics, science, and engineering*), 'high contribution' was the most frequently selected reply with a total of 34 responses, which represents 46% of respondents at ETSII, while similar results were obtained at ICAI (97 responses, 44%). These responses mean that completion of the FYP contributed positively in most cases to acquisition of important skills for an engineer, such as in math, science and engineering.

The results for the second competence (*an ability to design and conduct experiments, as well as to analyze and interpret data*) show that the influence of the FYP on this competence was ranked on average as being between a 'medium contribution' and a 'high contribution.' The latter was selected by 34.25% of respondents at ETSII and 36.2% at ETS-ICAI. In contrast, 'no contribution at all', 'low contribution' and 'medium' options accounted for 43.8% and 47.7% of responses at ETSII and ICAI, respectively. These results are due to the increasing number of projects in the organizational and economic areas versus the traditional technical and research areas.

The third competence (*an ability to design a system, component, or process to meet desired needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability*) was assessed as having made an average contribution between 'medium' and 'high contribution.' The latter response was most frequently selected, accounting for 32.9% and 31.1% of the responses at ETSII and ICAI, respectively. The least chosen response was 'low contribution' (5.5% and 10%).

The average response for the fourth competence (*an ability to function on multidisciplinary teams*) was between 'medium' and 'low contribution.' For this ability, the answer most often repeated is 'no contribution' with 31.5% of responses at ETSII and 33.9% at ETS-ICAI. This can be explained by the fact that FYP must be done individually and not in a multidisciplinary team context.

The average response for the fifth competence (*an ability to identify, formulate, and solve engineering problems*) was between 'medium contribution' and 'high contribution' at both schools (46.6% at ETSII, 49.5% at ICAI). The frequency of response of 'very high contribution' was also remarkably high at ETSII (20.5%).

For competence number 6 (a*n understanding of professional and ethical responsibilities*), there is no significant value to be highlighted at either school. Since social responsibility is considered to be a key subject at university to be developed in the future, more careful analysis and countermeasures will be considered based on these results.

FYP contribution to competence number 7 (*an ability to communicate effectively*) was mainly considered to have made a 'high contribution,' with 34.3% and 33% of total ETSII and ICAI responses respectively. It must be noticed that FYP is presented in public sessions at both universities, contributing to the strengthening of this ability.

With regard to competence number 8 (*a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context*), the average response is between 'medium contribution' and 'high contribution,' the latter being selected by 37% and 44% of respondents, respectively.

The average for the ninth competence (*a recognition of the need for, and an ability to engage in, life-long learning*) was very close to 'high contribution,' (43.8% and 49% of responses).

The average rating for competence number 10 (*a knowledge of contemporary issues*) was between 'medium contribution' and 'high contribution.' The latter was selected most often with 38.4% and 44.9% of respondents, respectively. The fact that more than 80% of respondents chose between options 3 and 5 at ETSII and 87.1% at ETS-ICAI for this competence can be explained by the fact that FYP should be conducted on current issues, which requires the student to be always aware of developments in engineering issues to satisfactorily resolve the project's problems or difficulties.

The average response for competence number 11 (*an ability to use the techniques, skills and modern engineering tools necessary for engineering practice*) was very close to 'high contribution,' which obtained 41.1% and 50% of responses, respectively. The least selected responses were 'no contribution at all' and 'low contribution' with 5.5% and 2.3% of respondents, respectively. Around 89% and 94.9% of respondents selected the options 'medium', 'high contribution' or 'very high contribution.' This, like the previous competence is justified by the need when practicing professional engineering to be aware of all of the latest techniques and developments to perform the work. In the case of FYP, it is imperative to develop the project successfully.

The standard deviation for these two last abilities and the fifth competence deviation was noticeably lower at ETS-ICAI than at ETSII.

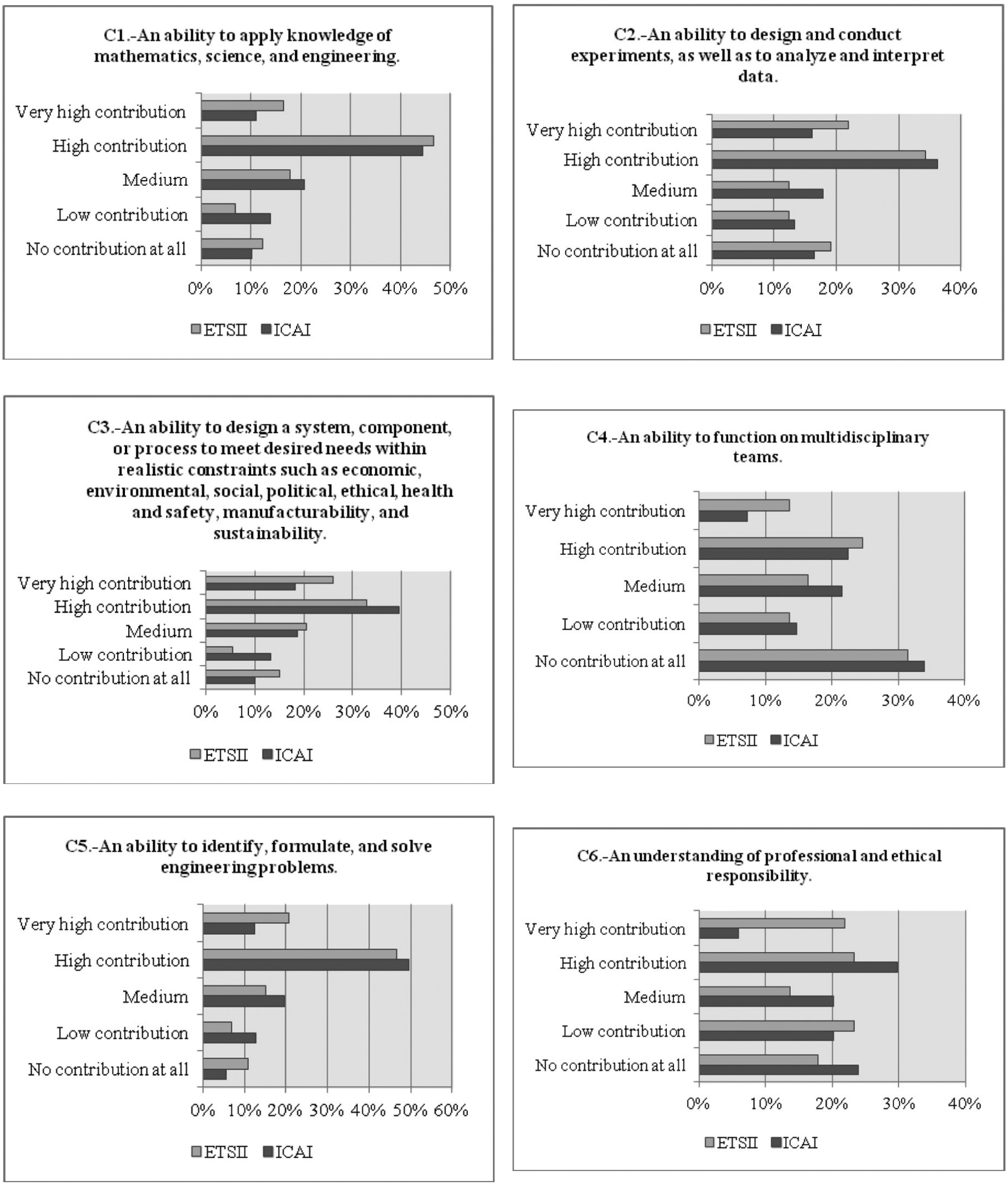

Fig. 1. Frequency distribution of competences by school.

These responses mean that completing the FYP contributed positively in most cases to students' acquisition of important skills necessary to be an engineer. However, C9 competence (*a recognition of the need for, and an ability to engage in, life-long learning*), and C11 competence (*an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice*), are considered to be those that were most strengthened by the two groups of students. On the other hand, C4 competence (*an ability to function on multidisciplinary teams*), was considered to be the least important in contribution. This is understandable, since FYP must be undertaken as an individual work project.

In addition, both Student t and Levene hypotheses tests were performed in order to compare the mean and variance by university group (the p-value considered was 0.05), when analyzing the contribution of the FYP to the strengthening of ABET competences.

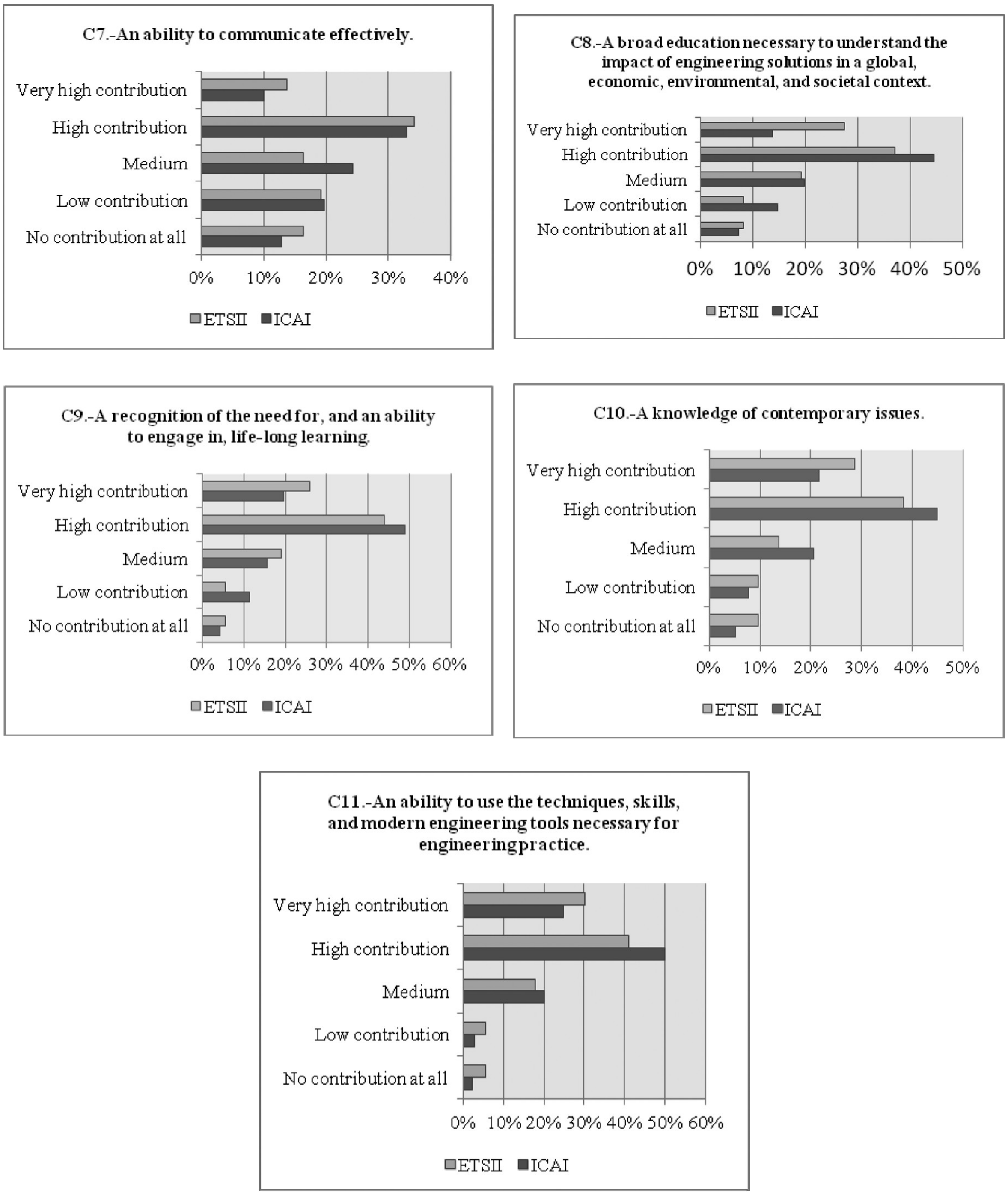

Fig. 1. (*continued*)

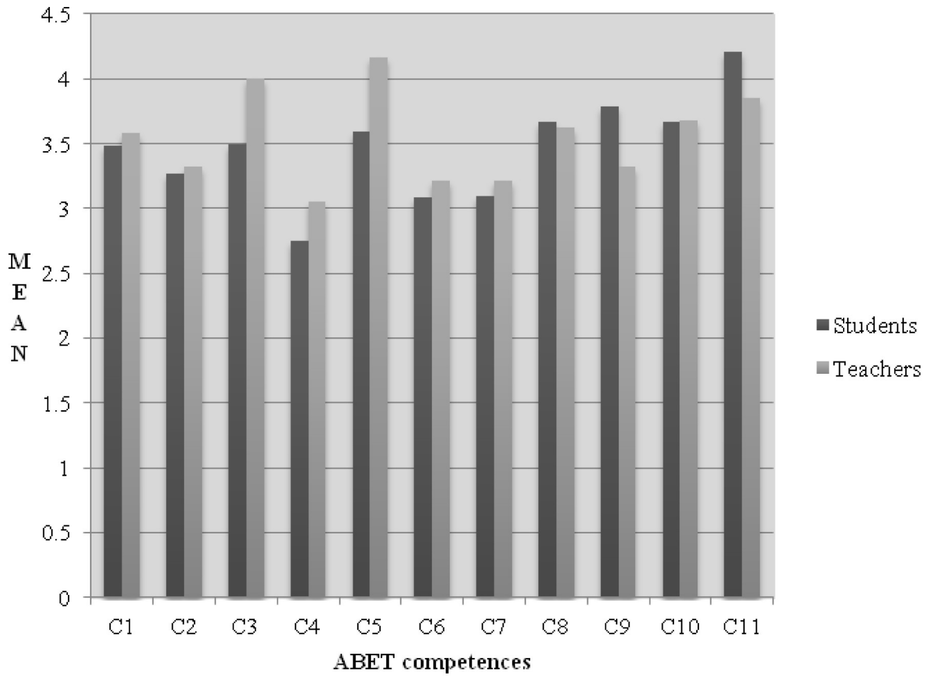

Fig. 2. The mean ranking of each competence, by students and teachers from ETSII.

According to the tests, there are significant differences by competence when the p-value is <0.05 (5% error type I). That is not the case in the 11 ABET competences that were analyzed in this work.

4.2 Comparative analysis. Surveys of instructors and students

The same self-administered questionnaire that was submitted to the students was submitted to the instructors in order to contrast the perceptions of the levels of satisfaction of the 11 ABET competences model. The mean perception by competence is shown in Fig. 2.

Although some significant differences can be found when considering the mean scores of each group, the perceptions of the two groups follows a similar pattern. The maximum mean gaps correspond to C3 (*an ability to design a system, component, or process to meet desired needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability*), and C5 (a*n ability to identify, formulate, and solve engineering problems*), 0.5 and 0.55 points respectively.

Instructors perceptions exceed 3 points (out of five) in every competence of the ABET model. In other words, the instructors understand that FYP is a teaching tool that has at least a medium contribution to reinforcement of the students' competence. The above mentioned C5 was the highest ranked competence by them, 4.15 points as a mean, over the lower limit of the high contribution.

5. Discussion and Limitations

The development and strengthening of students' competences is a complex, broad and challenging issue that has been included recently in the Spanish universities' study plans and programs, in line with the new Bologna framework. While the Heads of the institutions are adopting new initiatives, conducted by multidisciplinary teams of instructors, we propose a preliminary study of the perceptions by students and instructors of the FYP and its influence in this new educational context. We have chosen the FYP for two reasons: a) it embraces in its realization a wide number of different engineering aspects that the student needs to successfully develop, and b) it is an area within the authors' responsibility.

There have been two main limitations to study that need to be mentioned. The first is related to its scope, just a single approach included under the umbrella of the above mentioned global process, but very important in the sense of its originality, the teaching tool selected (FYP), and the jointly consideration of the students and instructors perceptions.

The second limitation is related to the extent to which students have acquired such general skills in the FYP process. Although this issue has certainly not been studied in depth due to the lack of a well-structured rubric, we understand that the triangulation methodology used with instructors' opinions, gives consistency and valuable results. As the Heads of the universities proceeds with the design of specific rubrics by competence that will be definitively used in further research, this study provides very useful preliminary information to be contrasted with similar, (but more standardized) experience.

6. Conclusions

The results above lead to three main conclusions.

The first is that, despite the differences between the FYP concepts at the two universities, students' ABET competences are reinforced in a similar manner. No evidence of a significant difference has been found among any of the eleven competences. This might be explained by the fact that the UPM and Comillas centres share orientations and curriculum concepts that are fixed by governmental education regulations. Although such a conclusion cannot be generalized, it is especially relevant since the two universities selected are among the most important ones in Spain.

The second conclusion, but no less important, is that C9 competence (*a recognition of the need for, and an ability to engage in, life-long learning*), and C11 competence (*an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice*), are considered to be those that are most strengthened by the two groups of students. On the other hand, C4 competence (*an ability to function on multidisciplinary teams*), is considered to be the least important in contribution, which is quite reasonable since FYP is to be undertaken as an individual work project.

Although competences C3 *(an ability to design a system, component, or process to meet desired needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability*) and C5 (*an ability to identify, formulate, and solve engineering problems*) obtained the highest rankings for instructors, there are no significant differences when comparing the results from both surveys. This is an important fact for further research and study design purposes. In other words, instructors and students have similar perceptions of how FYP might strengthen ABET engineering competences.

Finally, and as a summary last conclusion to be highlighted, is that, when considering ABET competences, FYP is a great value-forming tool. The answers by students at both schools of engineering, which were validated by the survey of instructors, reflect the importance of FYP's contribution to their individual strengthening competence process.

Further research could be undertaken that would focus on the type of specialization in which students have been instructed. The purpose is to find significant differences among the various groups to provide a clearer view of the ABET competences in relation to the FYP.

References

1. K. U. Koskinen, P. Pihlanto and H. Vanharanta, Tacit knowledge acquisition and sharing in a project work context, *International Journal of Project Management*, **21**, 2003, pp. 281–290.
2. I. Ortiz-Marcos et al. Evolution of Final Year Projects at the Universidad Politécnica de Madrid, *International Journal of Engineering Education*, Ed. **26**(1), 2010, pp. 162–168.
3. K. R. Bartkus, Skills and Cooperative Education: A Conceptual Framework, *Journal of Cooperative Education*, **36**, 2001, pp. 17–24.
4. C. Berggren and J. Söderlund, Rethinking project management education: social twists and knowledge co-production, *International Journal of Project Management*, 2008, **26**, pp. 286–296.
5. J. Jawitz, S. Shay and R. Moore, Management and Assessment of Final Year Projects in Engineering, *International Journal of Engineering Education*, Ed. **18**(4), 2002, pp. 472–478.
6. S. Patrick, K. Chua, The initiation, organisation and logistics of Part-time Final-year Projects, *International Journal of Engineering Education*, Ed. **17**(3), 2001, pp. 248–254.
7. I. Ortiz-Marcos and F. J. Sánchez Alejo, El proyecto Fin de Carrera. Normas de realización, presentación y defensa. ISBN: 84-7484-182-8. Madrid, 2005.
8. J. R. Herkert, Sustainable development, engineering and multinational corporations: ethical and public policy implications, *Science & Engineering Ethics,* **4**, 1998, pp. 333–346.
9. D. G. Johnson, Ed. *Ethical Issues in Engineering*, Englewood Cliffs, NJ: Prentice-Hall 1991.
10. E. J. Woodhouse, Overconsumption and Engineering Education: Confronting Endless Variety and unlimited quantity, *International Journal of Engineering Education.* **19**(1), 2003, pp. 124–131.
11. ABET, inc. Criteria for accrediting engineering programs. Effective for Evaluations during the 2009–2010 accreditation cycle.
12. M. Besterfiel-Sacre, L. J. Shuman and H. Wolfe. Modeling undergraduate engineering outcomes, *International Journal of Engineering Education*, Ed. **18**(2), 2002, pp. 128–139.
13. J. McGourty, L. Shuman, M. Besterfield-Sacre, C. Atman, R. Miller, B. Olds, G. Rogers and H. Wolfe, Preparing for ABEC EC 2000: Research-Based Assessment Methods and Processes, *International Journal of Engineering Education* Ed. **18**(2), 2002, pp. 157–167.
14. P. Wellington, I. Thomas, I. Powell and B. Clarke, Authentic assessment applied to engineering and business undergraduate consulting teams, *International Journal of Engineering Education.* **18**(2), 2002, pp. 168–179.
15. J. M. Williams, The engineering portfolio: communication, reflection, and student outcomes assessment, *International Journal of Engineering Education*, **18**(2), 2002, pp 199–207.
16. R. S. Adams, C. J. Atman, R. Nakamura, G. Kalonji and D. Denton, Assessment of an international freshmen research and design experience: a triangulation study, *International Journal of Engineering Education*, **18**(2), 2002, pp. 180–192.
17. E. Nault and J. Hoey, Trust: the missing ingredient in assessment, *International Journal of Engineering Education*, **18**(2), 2002, pp. 117–127.
18. A. Kaw, G. Besterfield and J. Eison, Assessment of web-enhanced courses in numerical methods, *International Journal of Engineering Education*, **21**(4), 2005, pp. 712–722.
19. B. Steward, S. Mickelson and T. Brumm. Continuous engineering course improvement through synergistic use of multiple assessment, *International Journal of Engineering Education*, **21**(2), 2005, pp. 277–287.
20. G. Mitchell and J. Delaney, An assessment strategy to determine learning outcomes in a software engineering problem-based learning course, *International Journal of Engineering Education*, **20**(3) 2004, pp. 494–502.

21. L. Howell, G. Roach, D. Clark and J. Cox. Use of explicit instructional objectives to achieve program outcomes and facilitate assessment: a case study, *International Journal of Engineering Education*, **19**(6), 2003, pp. 828–835.
22. L. A. Shay, K. L. Huggins, J. R. S. Blair and B. L. Shoop, Approaches to increasing the efficiency of an effective outcome assessment process, *International Journal of Engineering Education*, **24**(5), 2008, pp. 884–892.
23. D. Franquesa, J.-L. Cruz, C. Alvarez, F. Sánchez, A. Fernández and D. López, The Social and Environmental Impact of Engineering Solutions: from the Lab to the Real World, *International Journal of Engineering Education*, **26**(5), 2010, pp. 1144–1155.
24. D. Kilgore, A. Jocuns, K. Yasuhara and C. J. Atman, From beginning to End: how Engineering Students Think and Talk about Sustainability across the Life Cycle, *International Journal of Engineering Education*, 2010, **26**(2) pp. 305–313.
25. H. Iino, Introductory and Engineering ethics education for engineering students in Japan, *International Journal of Engineering Education*, **21**(3), 2005, pp. 378–383.
26. A. Colby and W. M. Sullivan, Ethics Teaching in Undergraduate Engineering Education, *Journal of Engineering Education*, July 2008, pp. 327–338.
27. T. O'Donoghue and K. Punch, Qualitative Educational Research in Action: Doing and Reflecting. Routledge. 2003, p.78.
28. H. Altrichter, A. Feldman, P. Posch and B. Somekh, Teachers investigate their work; an introduction to action research across the professions, Routledge, 2008, p. 147 (2nd edition).
29. R. Likert, A Technique for the Measurement of Attitudes, *Archives of Psychology*, **140**, 1932, pp. 1–55.

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