

Impact of Service-Learning on the Motivation of Engineering and High School Students*

BELÉN MUÑOZ-MEDINA, SERGIO BLANCO and MARCOS G. ALBERTI

¹ Universidad Politécnica de Madrid, School of Civil Engineering, Spain. C/ Profesor Aranguren, n°3,28040 Madrid, Spain.

E-mail: mariabelen.munoz@upm.es

Service-learning is a pedagogical methodology that enhances student's learning process through a community service experience. Since the first applications of this methodology in Engineering education in the 90s a great volume of evidence has been collected given its benefits in the students' personal learning and civic responsibility. In Spain, its development is relatively recent although there are already successful examples of application in several universities. In this study, a service-learning activity in the School of Civil Engineering of the Technical University of Madrid (Spain) is presented. In such activity, undergraduate and graduate students presented their final degree project to high-school students. Presentations were recorded and peer-reviewed by the university students along with their tutors. The main objectives of the study were: (a) measuring the degree of efficiency of this service-learning experience to boost Sciences, Technology, Engineering and Mathematics (STEM) vocations, (b) evaluating the degree of comprehension from the high-school students with the presentations made by university students, (c) improving the communication skills of the university students and (d) comparing the various feedback obtained from lecturers, teachers and both the high-school and university students. The conclusions showed that this activity was effective in capturing the interest of high-school students in studying STEM degrees. These high-school students actively engaged in the development of the activity showing a high degree of satisfaction. On the other role, university students stated that the activity helped them to improve their presentation skills. They have indicated that the two aspects of the project with the most impact have been: (a) being able to visualize their recorded video presentations and (b) reflecting through the evaluation process of their peers using a correction rubric. This critical reflection on the aspects to be evaluated in an oral presentation, applied to their classmates and to themselves, has been more useful than receiving different feedback from tutor teachers, high-school students and their own university colleagues. We understand that this activity is easily transferable to other technical schools and can benefit the oral communication skills of university students and boost STEM vocations among high-school students.

Keywords: service-learning; generic competences motivation; creativity; high school education; university education; written communication; oral communication

1. Introduction

Service-learning (SL) is defined by Bringle et al. [1] as: 'course-based, credit-bearing educational experience in which students (a) participate in an organized service activity that meets identified community needs and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility'. It is assumed that service-learning must be associated with an academic credit course. That is to say, it must be intentionally designed to meet academic course objectives [2]. According to Ferrari and Chapman [3], service-learning methodology enhances student's understanding of the theoretical aspects of the course through community service experience and reflection on that experience. To be precise, in order to achieve the course goals and obtain deeper understanding of the theoretical principles of the discipline, along with obtaining increased awareness of civic responsibility and personal learning [4], the student must reflect on the service activity [5, 6]. The first model

for service-learning in engineering can be found in 1995 in Purdue University in the so-called Engineering Projects in Community Service (EPICS) [7]. This methodology soon attracted significant attention from academics and researchers, see among others the literature reviews about the service-learning practices, pedagogy and learning outcomes in references [4, 8–11].

Service-learning pedagogies are based on different theories like the experiential learning theory by Dewey [12], the experiential learning cycle by Kolb [13], the expectancy-value theory [14] and, as stated by Salam et al. [4], social – cognitive theory [15, 16] and constructivism theory [17]. Kolb's experiential learning theory works on two levels: a four-stage cycle of learning and four separate learning styles [18]. The learning cycle involves four stages: practical on-site experience, reflection on service-learning experience, abstract conceptualization and active experimentation. Kolb's learning styles are diverging, assimilating, converging and accommodating [19]. Several scholars have claimed that Kolb's experiential learning theory provides strong theoretical foundation for service learning

pedagogy [20–24]. As Jacoby states [25] and Bielefeldt collects in [2] ‘there are three prevalent implications of Kolb’s model that are central to service-learning. First, the course must be structured with continual opportunities and challenges to enable students to move completely and frequently through the learning cycle. Second, Kolb’s model underscores how central and important reflection is to the learning cycle, and third, reflection must follow direct and concrete experience and precede abstract conceptualization and generalization’. On the other hand, the expectancy-value theory postulates that student learning activities are motivated by a combination of students’ expectations for success and subjective task value in the learning process [14]. According to Eccles and Wigfield [26] the expectancy-value theory model includes three types of subjective task values: intrinsic value, utility value, and attainment value. As stated by McLean et al. in [27] ‘in the context of engineering, intrinsic value accounts for how much interest one has in engineering. Utility value measures the degree to which one finds the act of learning engineering to be useful in some way, especially for one’s future. And attainment value captures how much one considers engineering important to one’s identity’.

Service learning methodologies face several challenges in its implementation because of the difficult interaction between all three participants (i.e., students, instructors and community members) [28, 29], and because of the difficult assessment of the connection between learning objectives and actual outcomes of course contents [30, 31]. Despite these difficulties, service learning has been integrated in higher education curriculum in several ways (class projects, extra-curricular activities or research projects) [32]. Specifically, engineering faculties are implementing service-learning projects across its disciplines and throughout a range of engineering coursework [2, 27, 33–37]. Several are the benefits for the engineering faculties as institutions: reduce the attrition rates from university engineering programs [27, 38, 39], enhances course instructors’ teaching ability [40] and improve diversity of its students [27, 41, 42].

In recent years, evidence of benefits that service-learning pedagogy has for students have accumulated. This methodology have positive cognitive and academic effects on undergraduate students [10, 11, 33, 43, 44]. As stated by Bielefeldt et al. [45], (project) service learning offer ‘rich learning environment for engineering students; one that fosters not only their cognitive development, but provides strong opportunities for social and moral development’, leading to a deeper understanding of course contents. Cannon et al. also say [33] that ‘the

students enjoyed working as real engineers, achieved practical experience and knowledge to identify a problem, learned to work with constraints, and got trained to find a proper way to provide a solution to any problem’. Service-learning also develops communication skills, ability to work independently, teamwork, critical thinking, problem-solving skills, social awareness and sense of civic responsibility [46, 47] along with enhanced social responsibility and civic leadership among students [48]. For a full literature review of service-learning methodology the reader is addressed to the work of Salam et al. [4] and references therein.

In this study, a service-learning activity in the School of Civil Engineering of the Technical University of Madrid (Spain) is presented. In such activity, undergraduate and graduate students presented their final degree project to high-school students. Most of the experiences reported in the literature of service-learning activities are related either to companies or to NGOs. However, the authors believe that the collaboration between the university and the high school can be very fruitful in fields such as the promotion of Sciences, Technology, Engineering and Mathematics (STEM) vocations or the improvement of the self-perception as future engineers of university students. In this case, the oral expression competence in university students was also sought. This basic competence is part of the priorities set by the Technical University of Madrid (transversal skills objectives) to be developed among students (together with written expression, use of information and communication technologies, respect for the environment, creativity, organization and planning, teamwork and leadership). This competence, oral expression, is scarcely present in the development of the educational syllabus and because of that, students struggle to develop such an important competence [49].

From the point of view of secondary education, there are important challenges in communicating and informing students about the educational stages after high school. Although universities have programs that disseminate information about their degrees to high-school students, it is difficult to assess the receptivity of these messages. In addition, the transition from high-school to university is an especially stressful time for most students [50]. If students are unable to adapt and master that transition, they will most likely face some immediate failures. In such a sense, college students, who are only a few years older than high-school students, could become excellent ambassadors for the degrees they are studying. High-school students can easily reflect in the mirror of college students, so this activity can increase STEM voca-

tions and the diversity of the student body (particularly the presence of women).

For this reason, this work aimed to carry out a service-learning experience that would allow a technical university, such as the Technical University of Madrid, to approach secondary school students and that it has also enabled university students to improve their oral communication skills. Both objectives are achieved by presenting final degree projects (FDP) to high-school students by university students. This initiative has allowed the research team to present the fields of application of Civil Engineering and highlight the contribution of this discipline to society. University students belonged to the Bachelor's Degree in Civil Engineering, the Master's Degree in Civil Engineering and the Master's Degree in Engineering of Structures, Foundations and Materials (all of them at the School of Civil Engineering of the Technical University of Madrid).

The main questions that raised before this experience was designed were: would the high-school students receive the main message of the presentations performed by university students? To what extent would the presentations be more effective than those made by university through the official channels? Will that message improve the willingness of the students to study engineer degrees? The significance of this research relies on the mutual contribution of the two educational levels that traditionally have worked separately. This experience could show the possible synergies of nearing the high-school institutions and the universities. Thus, the main objectives of the study were: (a) measuring the degree of efficiency of this service-learning experience to boost STEM vocations, (b) evaluating the degree of comprehension from the high-school students with the presentations made by university students, (c) improving the communication skills of the university students and (d) comparing the various feedback obtained from lecturers, teachers and both the high-school and university students. To evaluate this, evidence was gathered through rubrics carried out by all the agents: teachers and students from both high-school and university. The results obtained have shown important benefits in both institutions, which have consolidated the activity.

2. Presentation

The S-L experience has been developed during several academic courses under the umbrella of competitive calls for educational innovation projects carried out by the UPM and with the collaboration of several secondary education centres in the Region of Madrid (Spain).

Initially, the S-L experience was planned as a two-pronged activity. On the one hand, the S-L methodology should allow the university students to develop curricular and non-curricular competencies with the aim of training them as future professionals. On the other hand, it was intended that secondary education students know what civil engineering is and increase their motivation. In order to achieve that aims, university students will show high school students, with examples through their FDP, which works are developed in the field civil engineering. The final goal is to avoid situations of early abandonment of studies.

For this, the following objectives were initially defined:

- Support for secondary education to improve student motivation and reduce early school leaving (main objective).
- Strengthening transversal skills in FDP university students.
- Dissemination of Civil Engineering activities and professional development among secondary and high school students.
- Establishment of collaboration channels between the secondary schools and the University to promote outreach activities so that the students of the secondary schools know the activities and professional development of Civil Engineering.

The development of the S-L experience had two stages, with two different scenarios. In the first one the FDP students worked on their construction project with the help of their tutor, as detailed below in the development phases of the S-L project. Subsequently, the second stage was carried out in the participating secondary education centres where the oral presentations took place.

2.1 Development Phases

The phases of the project and the actions carried out during each of them were as follows:

PHASE 1. Promotion of the project among FDP students and their tutors

In coordination with the school administration, an FDP selection contest was established among all students (approximately 250 students) of the degree of Civil and Territorial Engineering. Several projects were selected among the different categories, according to the different types of civil infrastructures: roads, ports, dams, urban planning, pedestrian walkways, bridges... At the same time, with the help of the students' tutors and schoolteachers, training sessions were held on the characteristics of the materials to be presented (oral presentation, poster). In this phase, the commitment of the students and the tutors was decisive in order to

finish the experience and achieve the desired objectives.

PHASE 2. Temporary planning of presentations in secondary education centres

Different meetings were held with the secondary education centres to set the calendar for the exhibitions of the students' work. The greatest difficulty of the experience was to set a joint calendar for the exhibitions, considering the tight deadlines that exist in the curricula of the different university degrees and in secondary education.

PHASE 3. Delivery of the works to present

Delivery by the FDP students of the materials prepared (presentation, poster) that contained, regarding the construction project, the following aspects:

- Written and graphic description of the project.
- Summary of the previous conditions and needs to be solved by the construction project.
- Presentation of alternative solutions and difficulties encountered.

PHASE 4. Oral presentations in secondary education centres

In this phase, all the presentations of the construction projects of the FDP students in the secondary and high school participating centres were carried out, according to the schedule set in phase 2. 12 FDP university students and 152 high school students participated in these sessions. The oral presentations of the students were videotaped for later viewing by the teacher-tutors and the university students themselves.

During the development of these presentations, and with the aim of evaluating the student's FDP, as well as the experience of S-L, evaluation rubrics were carried out by the university tutors and high school teachers, by the university students themselves and by the high school students. The content of the rubric has been included in the appendix, and

the results obtained have been analysed in the following section.

PHASE 5. Results and conclusions

In this phase, the analysis of the evaluation rubrics completed by all agents involved in the L-S project (university students, high-school students, university tutors and high-school teachers) was carried out. In case of the university tutors and students, their evaluation was based on the recorded presentations.

3. Results

The results obtained in the L-S activity are presented in this section. In total, fifteen presentations have been made in three secondary education institutes of the Region of Madrid, made by ten undergraduate university students to 152 secondary students on three different days. Each presentation lasted around an hour and consisted of an introduction, the presentation of the final degree project and finally a question and debate session. In the end, a survey was passed among the high school students about their understanding of the information and their assessment of the activity. Subsequent to the presentation, and relying on video recording of the entire activity, the same correction rubric was passed to all participating university students, so that they could evaluate each other, and their university tutors.

The questions in the first group of the rubric (see Table A1 in Appendix A) are related to the technical content of the presentation and the results obtained are summarized in Fig. 1. This group consist of questions related to the technical level of the presentation, the clarity and coherence of the information, the completeness of the exhibition, the adequacy of the answers to the questions asked and the attitude towards the criticisms received. In Fig. 1 we can see the proportions of evaluations A, B and C given by university students among them (left), by the university tutors (centre) and by the high school

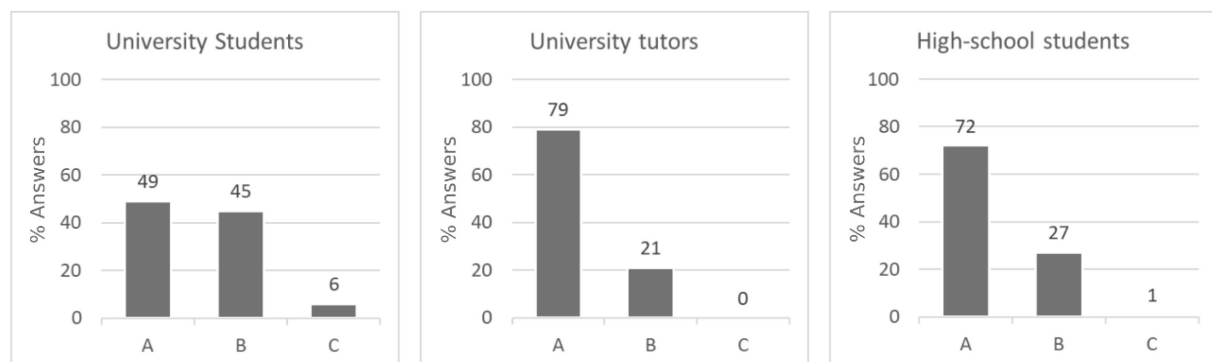


Fig. 1. Evaluations related to the technical content of the presentation.

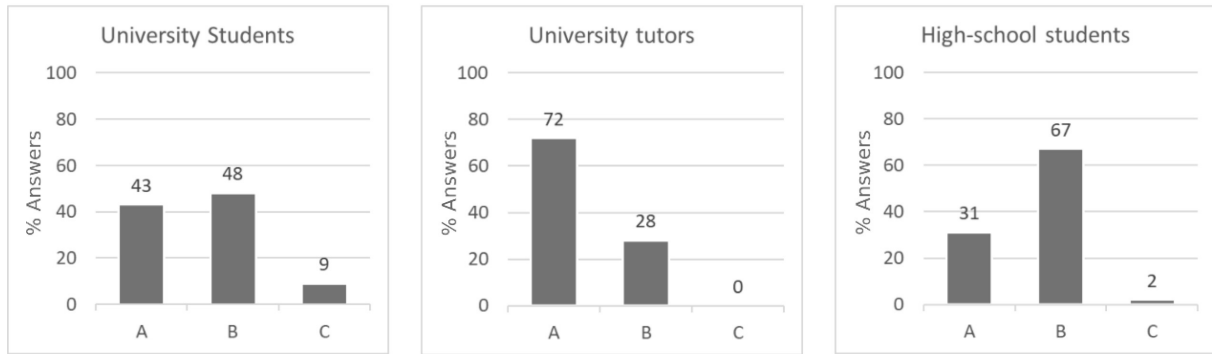


Fig. 2. Evaluations related with the presentation skills.

students (right). Label A in this figure means “Excellent: belongs to the top 10%”, B means “Satisfactory: meets the requirements” and C means “Unsatisfactory: does not meet the minimum requirements”. As we can see, the peer evaluations carried out by the university students themselves have been the most critical, with a similar distribution between the evaluations of excellent and satisfactory (49% of evaluations are excellent and 45% of evaluations are satisfactory). On the contrary, the evaluations carried out by the university tutors have been mostly excellent, with 79% of excellent evaluations compared to 21% of satisfactory evaluations. Finally, the evaluations of the high school students have been mostly excellent, with 72% of responses evaluated as such, with the remaining 27% evaluated as satisfactory and 1% residual as unsatisfactory. It should be noted that the only appreciable negative evaluations, judging an unsatisfactory result, have taken place in the peer evaluations that university students have carried out among themselves (6%).

The following group of questions, described in Table A2 in Appendix A, gathers aspects related to oral expression during the presentation and the results are summarized in Fig. 2. Questions were asked about the visual contact between the speaker and the audience, her/his body language, the speed

of exposure, possible grammatical errors, and the degree of interest it arouses. As in the previous case, the left part of the figure shows the results of the rubric of university students (peer-review), the centre the results of the university tutors, and the left part the results among high school students. It is observed that the excellent and satisfactory evaluations are distributed equally among university students (43% and 48% respectively), while the university tutors have mostly evaluated the questions asked as excellent in 72%, compared to 28% of questions evaluated as satisfactory. Surprisingly, high school students have been the most critical group, with 67% of satisfactory evaluations and only 31% of excellent evaluations. Similar to the previous case, the group made up of university students was the only one with an appreciable percentage of unsatisfactory evaluations, 9%, compared to 0% of university tutors and 2% of high school students.

The last group of questions (see Table A3 in Appendix A) are related to the composition and design of the presentation itself. These questions have to do with the exhibition time, the construction of the different slides and the structure in which they have been arranged. These results are summarized in Fig. 3, in which again the left part of the figure shows the results of the rubric of university

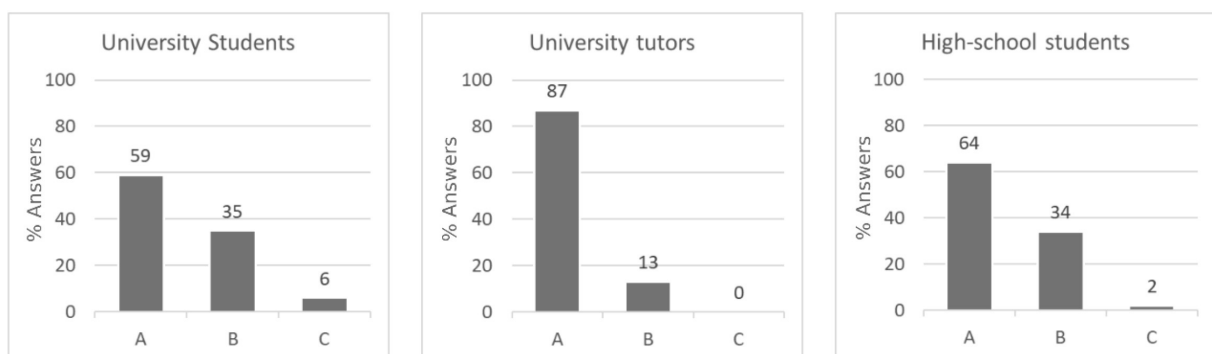


Fig. 3. Evaluations related with the composition and design of the presentation.

Table 1. Activity assessment statements

Statements	Yes	No	I don't know
It was easy for me to answer the evaluation rubric, I had the right answer to each question	23.5%	29.4%	47.1%
I liked the activity, I found it interesting	100%	0%	0%
After seeing the presentations I have a better understanding of the activities of the Civil Engineer	88.2%	0%	11.8%
I had not thought to study engineering, but after the presentations I am considering it	35.3%	17.6%	47.1%
I had thought about studying engineering, but after the presentations I have doubts about doing it	0%	76.5%	23.5%
I had thought to study engineering and after the presentations I have even more desire	29.4%	35.3%	35.3%
I had not thought about studying engineering and the presentations have not made me change my mind	29.4%	47.1%	23.5%

students, the centre that of the tutors and the left part the results among the high school students. As can be seen in the figure, the three groups have mostly issued excellent ratings in this category, with a clear predominance among university tutors with 87%. Satisfactory evaluations are similar among university and high school students (35% and 34% respectively) and somewhat lower in university tutors (13%). Finally, unsatisfactory evaluations are appreciable among university students (6%) and null or residual among university tutors and high school students.

As a final exercise, a series of general questions were asked to assess the level of effectiveness of the activity carried out among high school students. In order to do so, they were asked questions regarding the degree of difficulty experienced in answering the rubric, their degree of satisfaction with the activity and how their perception of the profession of Civil Engineers has evolved. The questions and the results obtained are summarized in Table 1. As can be seen, the high school students experienced a high degree of uncertainty when answering the correction rubric, with almost half of the students evaluating that they did not know if answering the rubric had been easy or difficult. However, all of them liked the activity carried out (presentations, questions and subsequent debate). Regarding how this activity has influenced their assessment of the civil engineering profession, it should be noted that 35% of the students valued studying engineering for the first time and that in 30% of the cases this previous desire was reinforced.

4. Discussion

The numerical results included in Table 1 from the survey of high-school students show that the initial research objective of increasing the number of STEM vocations among students has been achieved. In this regard, 88% of high-school students stated that after viewing the presentations, their knowledge about the activities of the Civil

Engineer had been increased. Also, 35% stated that they had not thought to study engineering, but after the presentations, they were considering it. One issue to highlight is that the presentation did not dissuade any of the high-school students who were already thinking about studying engineering, as 76% stated that the presentation of the university students had not changed their initial vocation, on the contrary, it had been reaffirmed.

There has been a high degree of satisfaction of all the participants in the project, high-school students, university students and tutors. This has made it easier for university students to acquire the desired skills in the presentation of their FDP. In addition, this activity has allowed university tutors to help their students effectively prepare their imminent presentation of the FDP in front of a tribunal.

University students have shown a critical spirit of self-evaluation of their own competence and that of their peers, favouring reflection and judgment regarding their learning strategy and the identification of those points of personal improvement. These students have received a double feedback: on the one hand from their university tutors and on the other hand from their own classmates. This wealth of judgment elements allows them to effectively assess the aspects of their presentation that need to be improved. In turn, high-school students have received motivational exposure from students not much older than themselves with whom it is easy for them to identify and be receptive to their message. This identification allows these students to visualize themselves taking technical degrees in their academic future and to motivate themselves to face the future changes they will experience when entering higher education.

The involvement of university students in the development of the activity, adopting a role of responsibility towards high school students, has allowed them to strengthen their teamwork skills and their commitment to achieving the project's objectives. In this S-L experience, university stu-

dents, in addition to achieving the skills indicated by Bielefeldt et al. [45] and other authors in previous research [10, 11, 33, 43, 44], have significantly improved their oral communication skills by having to adapt the presentation of a technical and professional project to interlocutors who do not know these technical terms and also by making the activity interesting for them.

Among the limitations of the research, it is worth noting that although the number of high-school students participating has been high (152 students), only 12 university students participated in the project (15 presentations). It would be desirable to increase the number of university students involved in the project. It should be also mentioned that no gender distinction has been made as to whether the motivation and increase in vocations for STEM disciplines occur equally in boys and girls. Similarly, the activity was carried out among high-school students in a public school, and it would be interesting to compare the results with those obtained in a private school. These aspects should be addressed in future research.

Moreover, it would be of great interest to follow up on the students who after the activity expressed their interest in studying engineering if they eventually enter an engineering degree at university. This aspect is difficult to perform since the surveys were conducted anonymously due to identity protection measures. To improve this, the School of Civil Engineering carries out an analysis of the high-school of origin of the new students. As result, it is possible to see a slight increase in the number of new students from the high school where the S-L activity has been carried out.

5. Conclusions

The service-learning activity presented in this study has allowed participating university students to develop their oral presentation and exposition skills, while promoting the motivation of high school students to study engineering degrees. This methodology is easily implementable, favouring a successful collaboration between the university and secondary schools, which allows creating a

common workspace in which activities arise that benefit both university students (development of generic skills such as oral communication) and high-school students (promotion of vocations in science, technology, engineering and mathematics careers).

If the initial objectives established when this project was defined regarding high-school students are assessed, it can be concluded that the degree of efficiency of this service-learning activity in increasing interest in studying STEM degrees, in particular vocations to study civil engineering, has been high. This shows that this activity, in which university students present their final degree projects to high school students, has been effective in capturing the interest of the latter. High-school students' comprehension of the presentations (made by university students) has also been significant, as was found from both the responses to the questionnaire carried out, and by the active participation in a debate that took place after the presentations. Moreover, if the objectives set for university students are analysed, all of them have stated that the activity has helped them improve their presentation skills. They have indicated that the two aspects of the project with the most impact have been: (a) being able to visualize their recorded video presentations and (b) reflecting through the evaluation process of their peers using a correction rubric. This critical reflection on the aspects to be evaluated in an oral presentation, applied to their classmates and to themselves, has been more useful than receiving different feedback from tutor teachers, high-school students and their own university colleagues.

The authors believe that this activity, already consolidated in the Civil Engineering School at the Technical University of Madrid, it is transferable to other technical schools and it can be an effective tool in the strategy of strengthening the studies of Sciences, Technology, Engineering and Mathematics.

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References

1. R. G. Bringle and J. A. Hatcher, A Service-Learning Curriculum for Faculty, *Michigan Journal of Community Service Learning*, **2**, pp. 112–122, 1995.
2. A. R. Bielefeldt, K. G. Paterson and C. W. Swan, Measuring the value added from service learning in project-based engineering education, *International Journal of Engineering Education*, **26**(3), pp. 535–546, 2010.
3. J. R. Ferrari and J. G. Chapman, *Educating students to make a difference: Community-based service learning*, New-York, Haworth, pp. 1–3, 1999.
4. M. Salam, D. N. A. Iskandar, D. H. A. Ibrahim and M. Farooq, Service learning in higher education: A systematic literature review, *Asia Pacific Education Review*, **20**(4), pp 573–593, 2019.
5. R. G. Bringle and J. A. Hatcher, Implementing service learning in higher education, *The Journal of Higher Education*, **67**(2), pp. 221–239, 1996.

6. T. D. Mitchell, Traditional vs. critical service-learning: Engaging the literature to differentiate two models, *Michigan Journal of Community Service Learning*, **14**(2), pp. 50–65, 2008.
7. E. J. Coyle, L. H. Jamieson and W. C. Oakes, EPICS: Engineering projects in community service, *International Journal of Engineering Education*, **21**(1), pp. 139–150, 2005.
8. E. Tsang, *Projects that matter: Concepts and models for service-learning in engineering*, American Association for Higher Education, Washington, DC, pp. 10–21, 2000.
9. J. D. Geller, N. Zuckerman and A. Seidel, Service-learning as a catalyst for community development: how do community partners benefit from service-learning?. *Education and Urban Society*, **48**(2), pp. 151–175, 2016.
10. R. M. Rutti, J. LaBonte, M. M. Helms, A. A. Hervani and S. Sarkarat, The service learning projects: Stakeholder benefits and potential class topics. *Education & Training*, **58**(4), pp. 422–438, 2016.
11. P. L. Yorio and F. Ye, A meta-analysis on the effects of service-learning on the social, personal, and cognitive outcomes of learning, *Academy of Management Learning & Education*, **11**(1), pp. 9–27, 2012.
12. J. Dewey, Experience and education, *The Educational Forum*, **50**(3), pp. 241–252, 1986.
13. D. A. Kolb, *Experiential Learning: Experience as the source of learning and development (Second edition)*, Pearson Education, Inc., Upper Saddle River, New Jersey, pp. 15–24, 2015.
14. A. Wigfield and J. S. Eccles, Expectancy – value theory of achievement motivation, *Contemporary Educational Psychology*, **25**(1), pp. 68–81, 2000.
15. R. L. Carson and A. L. Raguse, Systematic review of service-learning in youth physical activity settings, *Quest*, **66**(1), pp. 57–95, 2014.
16. L. Kohlberg, The cognitive-developmental approach to moral education, *The Phi Delta Kappan*, **56**(10), pp. 670–677, 1975.
17. C. Galvan and M. Parker, Investigating the reciprocal nature of service-learning in physical education teacher education, *Journal of Experiential Education*, **34**(1), pp. 55–70, 2011.
18. J. E. Stice, Using Kolb's Learning Cycle to Improve Student Learning, *Engineering Education*, **77**(5), pp. 291–96, 1987.
19. D. A. Kolb, David A. Kolb on experiential learning, <http://www.infed.org/biblio/b-explrn.html>, Accessed 20 January 2021.
20. H. O. Ali, A. A. Rahman and W. Z. Abidin, Service learning: An investigation into its viability as a strategy to achieve institutional goals, *Procedia-Social and Behavioral Sciences*, **56**(8), pp. 388–395, 2012.
21. S. Hart, Engaging the learner: The ABC's of service-learning, *Teaching and Learning in Nursing*, **10**(2), pp. 76–79, 2015.
22. N. Musa, D. H. A. Ibrahim, J. Abdullah, S. Saeed, F. Ramli, A. R. Mat and M. J. A. Khiri, A methodology for implementation of service learning in higher education institution: A case study from faculty of computer science and information technology, UNIMAS, *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, **9**(2–10), pp. 101–109, 2017.
23. E. Petkus Jr, A theoretical and practical framework for service-learning in marketing: Kolb's experiential learning cycle, *Journal of Marketing Education*, **22**(1), pp. 64–70, 2000.
24. S. L. Roakes and D. Norris-Tirrell, Community service learning in planning education: A framework for course development, *Journal of Planning Education and Research*, **20**(1), pp. 100–110, 2000.
25. B. Jacoby, *Service-Learning in Higher Education: Concepts and Practices*, The Jossey-Bass Higher and Adult Education Series, Jossey-Bass Publishers, San Francisco, pp. 3–25, 1996.
26. J. S. Eccles and A. Wigfield, Motivational beliefs, values, and goals, *Annual Review of Psychology*, **53**(1), pp. 109–132, 2002.
27. M. Mclean, J. Mcbeath, T. Susko, D. Harlow and J. Bianchini, University-elementary school partnerships: Analyzing the impact of a service-learning freshman engineering course on students engineering values and competence beliefs, *International Journal of Engineering Education*, **35**(5), pp. 1415–1424, 2019.
28. R. L. Toporek and R. L. Worthington, Integrating service learning and difficult dialogues pedagogy to advance social justice training, *The Counseling Psychologist*, **42**(7), pp. 919–945, 2014.
29. A. S. Burke and M. D. Bush, Service learning and criminal justice: An exploratory study of student perceptions, *Educational Review*, **65**(1), pp. 56–69, 2013.
30. K. A. Peters, Including service learning in the undergraduate communication sciences and disorders curriculum: Benefits, challenges, and strategies for success, *American Journal of Audiology*, **20**(2), pp. 181–196, 2011.
31. T. Schoenherr, Service-learning in supply chain management: Benefits, challenges and best practices, *Decision Sciences Journal of Innovative Education*, **13**(1), pp. 45–70, 2015.
32. B. A. Nejmeh, *Service-learning in the computer and information sciences: Practical applications in engineering education*, John Wiley & Sons, New Jersey, pp. 3–22, 2012.
33. B. Cannon, S. Deb, L. Strawderman and A. Heiselt, Using service-learning to improve the engagement of industrial engineering students, *International Journal of Engineering Education*, **32**(4), pp. 1732–1741, 2016.
34. B. Ropers-Huilman, L. Carwile and M. Lima, Service-learning in engineering: A valuable pedagogy for meeting learning objectives, *European Journal of Engineering Education*, **30**(2), pp. 155–165, 2005.
35. M. J. Picket-May, J. P. Avery and L. E. Carlson, 1st year engineering projects: a multidisciplinary, hands-on introduction to engineering through a community/university collaboration in assistive technology, *ASEE Annual Conference Proceedings*, Anaheim, CA, June 26–28, 1995, pp. 2363–2366, 1995.
36. C. W. Swan, C. S. Han and J. F. Limbrunner, Service learning on an international scale: The experiences of Tufts University, *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition*, Portland OR, June 12–15, 2005, pp. 10.1109.1–10.1109.8, 2005.
37. E. Tsang, J. Van Haneghan, B. Johnson, E. J. Newman and S. Van Eck, A report on service-learning and engineering design: service-learning's effect on students learning engineering design in Introduction to Mechanical Engineering, *International Journal of Engineering Education*, **17**(1), pp. 30–39, 2001.
38. B. N. Geisinger and D. R. Raman, Why they leave: Understanding student attrition from engineering majors, *International Journal of Engineering Education*, **29**(4), p. 914, 2013.
39. X. Chen, *STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001*. National Center for Education Statistics, NCES, IES, U.S. Department of Education, Washington, DC, pp. 1–51, 2013.
40. V. Kinloch, E. Nemeth and A. Patterson, Reframing service-learning as learning and participation with urban youth. *Theory into practice*, **54**(1), pp. 39–46, 2015.

41. D. Baker, S. Krause, Ş. Yaşar, C. Roberts and S. Robinson-Kurpius, An intervention to address gender issues in a course on design, engineering, and technology for science educators, *Journal of Engineering Education*, **96**(3), pp. 213–226, 2007.
42. I. J. Busch-Vishniac and J. P. Jarosz, Can diversity in the undergraduate engineering population be enhanced through curricular change?, *Journal of Women and Minorities in Science and Engineering*, **10**(3), pp. 255–281, 2004.
43. K. A. Smith, S. D. Sheppard, D. W. Johnson and R. T. Johnson, Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education*, **94**(1), pp. 87–101, 2005.
44. R. A. Rhoads and J. Neururer, Alternative spring break: Learning through community service, *NASPA Journal*, **35**(2), pp. 100–118, 1998.
45. A. Bielefeldt, K. Paterson and C. Swan, Measuring the value added from service learning in project-based engineering education, *International Journal of Engineering Education*, **26**(3), pp. 535–546, 2010.
46. M. Barth, M. Adombent, D. Fischer, S. Richter and M. Rieckmann, Learning to change universities from within: a service-learning perspective on promoting sustainable consumption in higher education, *Journal of Cleaner Production*, **62**(1), pp. 72–81, 2014.
47. A. Fullerton, V. L. Reitenauer and S. M. Kerrigan, A grateful recollecting: A qualitative study of the long-term impact of service-learning on graduates. *Journal of Higher Education Outreach and Engagement*, **19**(2), pp. 65–92, 2015.
48. L. Weiler, S. Haddock, T. S. Zimmerman, J. Krafchick, K. Henry and S. Rudisill, Benefits derived by college students from mentoring at-risk youth in a service-learning course, *American Journal of Community Psychology*, **52**(3–4), pp. 236–248, 2013.
49. J. C. Mosquera, M. G. Alberti, F. S. Guerra and I. C. Carrasco, Exploring blended learning techniques for competency-based learning in STEM disciplines, from section: Learning, innovation and cooperation as drivers of methodological change, *Actas del V Congreso Internacional sobre Aprendizaje, Innovación y Cooperación, CINAIC*, Madrid, October 9–11, 2019, pp. 561–566, 2019.
50. J. D. Parker, L. J. Summerfeldt, M. J. Hogan and S. A. Majeski, Emotional intelligence and academic success: Examining the transition from high school to university, *Personality and Individual Differences*, **36**(1), pp. 163–172, 2004.

Appendix A. Evaluation questionnaire

Table A1. Evaluation questionnaire. Technical content

Criteria	Unsatisfactory: does not reach the minimum requirements	Satisfactory: reaches the requirements	Excellent: belongs to the top 10%
Technical content	(C) Unsatisfactory	(B) Satisfactory	(A) Excellent
1	The work presented is not at the level of a professional work, being deficient in terms of reliability and completeness	The work presented boosts the level of a professional work	The technical level of the work presented is excellent and would even be an outstanding solution in a professional environment
2	I did not understand the project properly and I would not be able to explain it to another partner	I understood the project properly and I would be able to explain the main ideas to another partner	I perfectly understood the project and I would be able to explain it in detail to another partner
3	It is not clear to me what was the problem to be solved in the project	The problem to be solved by the project is clear to me and I would be able to express it	The problem to be solved by the project is clear to me and I would be able to identify analogous situations where the same solution could be applied
4	It is not clear to me what restrictions, laws or approaches may limit the proposed solution	I understand the restrictions, laws or approaches that the project should meet in order to consider it feasible	I understand the requirements that the project should meet and I could propose alternative examples
5	I have the feeling that the most relevant parts of the project have not been explained	I feel that all the relevant parts of the project have been explained	I understood all the relevant aspects of the project and I could count them in detail
6	Our questions have been inadequately answered	Our questions have been adequately answered	Our questions have been clearly answered and I would like to know more about the project
7	I think the critics have been answered inadequately	I think the critics have been answered adequately	The critic have been clarified and an effort was made to help me understanding them, defending the point of view and recognising possible improvements

Table A2. Evaluation questionnaire. Presentation skills

Criteria	Unsatisfactory: does not reach the minimum requirements	Satisfactory: reaches the requirements	Excellent: belongs to the top 10%
Presentation skills	(C) Unsatisfactory	(B) Satisfactory	(A) Excellent
1	The student barely looked to the audience and it seems like if she/he would not be speaking to me (looks to the sheet or a wall)	There was eye-contact with the audience, and it seems to be speaking to me during the speech	The student captures the audience, making me feel like part of a conversation reaching the complete attention of the public
2	The body language is uncomfortable, and I become distracted; it is not appropriate	The body language was correct	The body language was outstanding showing control and self-assurance
3	The student was not able to continue when she/he made a mistake	Mistakes did not have any impact on the presentation	The student continued unaffectedly after a mistake
4	The student spoke too fast or too slow	The student speaks at an acceptable pace, sometimes a bit fast/slow, but correct in general	The pace of the speech was correct during the whole speech
5	Some grammatical mistakes could be appreciated	No grammatical mistakes could be appreciated though the vocabulary was poor	I was delighted with the language she/he used. Precise sentences helped me understanding the concepts
6	The way of speaking was boring and I lost the attention almost from the beginning	The student kept the attention of the audience, although I had to make an effort to follow the presentation	With the way of speaking the student has maintained my attention without any effort
7	The presentation was too difficult (too easy) for the audience	The presentation was congruent with the audience though some parts were too difficult (too easy)	The presentation was perfectly congruent with the audience

Table A3. Evaluation questionnaire. Composition and design

Criteria	Unsatisfactory: does not reach the minimum requirements	Satisfactory: reaches the requirements	Excellent: belongs to the top 10%
Composition and design	(C) Unsatisfactory	(B) Satisfactory	(A) Excellent
1	The presentation was too short/long (less than 10 minutes or more than 20 minutes)	The presentation was adjusted accordingly to its allotted time (+/- 4 min)	The presentation lasted its allotted time
2	The slides were poor: too much or too low detail, difficult to understand, small characters and figures, messy	Adequate slides	Outstanding slides: clear, good image, well structured
3	The structure of the presentation was poor (missing parts, unintelligible order, I forgot parts of the presentation)	There was a coherent order in the presentation although I miss some parts of it	There was a very good order in the presentation. The sequence of the structured seemed to be easy and natural, easy to follow

Belén Muñoz-Medina is Lecturer of Applied Economics and Final Degree Project at Technical University of Madrid. She received MS in Civil Engineering from the University of Granada, Spain in 1998. Her research interests focus on student-centred and collaborative approaches to increase motivation through service-learning methodology.

Sergio Blanco is Senior Lecturer in the department of Continuum Mechanics and Theory of Structures at the School of Civil Engineering in the Technical University of Madrid. He teaches Classical Mechanics, Continuum Mechanics and Numerical Methods. He conducts educational research about engineering learning in the degrees of Civil Engineering and Biomedical Engineering. In addition to engineering education, his research focuses on damage models in continuum mechanics. He received his PhD from the Technical University of Catalonia in 2007.

Marcos García Alberti is Senior Lecturer in the department of Civil Engineering: Construction at the School of Civil Engineering in the Technical University of Madrid, where he obtained his PhD in Engineering. He is responsible for the modules Smart Construction and Building Information Modelling (BIM), Construction Management, Projects and Final Degree Project and he is also lecturer of Special Concretes and Reinforcement Materials. His research lines are wide and productive in the field of concrete and concrete structures, sustainability and durability, BIM and other topics related with numerical models for engineering. Regarding educational research, he is remarkably active in a wide range of Innovation Projects, and he has mainly focussed on service-learning activities, online and distance learning, flipped classroom, gamification, design-thinking initiatives, automatization, and STEM vocations. Such experience has derived in a considerable number of contributions and conferences that can be found in published literature.