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Enhancing Employability Skills of Biology Graduates through an Interdisciplinary Project-Based Service Learning Experience with Engineering and Translation Undergraduate Students

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Abstract: We describe an interdisciplinary experience based on the application of the Project-Based Service Learning (PBSL) methodology for six learning outcomes directly related to employability skills. The objective was to assess students' learning outcomes, the level of satisfaction of students and lecturers with the PBSL, and the advantages and disadvantages of the implementation of this learning methodology. Interdisciplinary teamwork of undergraduate science, engineering, and humanities students was required to design real-world projects to develop their transferable skills, through the process of learning by doing. Students perceived that PBSL favored employability skills such as knowledge acquisition, self-directed learning, problem-solving, critical thinking, communication, and teamwork skills. Students and lecturers showed high satisfaction with PBSL and outlined its advantages as an active and experiential learning methodology. In conclusion, the implementation of the collaborative and interdisciplinary PBSL methodology is decidedly recommended to enhance Biology, Engineering, and Translation graduates' learning satisfaction and their future employability.

Keywords: active learning; collaborative learning; employability; soft skills undergraduate

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1. Introduction

During the European Union Ministers Conference held in 2009 in Leuven on the topic of Higher Education in the European Area [1], the search for a Europe of Knowledge showcasing high degrees of innovation and creativity was highlighted as the main objective by the year 2020. This challenge only can be achieved if it maximizes the talents and capacities of its citizens, widening participation in higher education. Students should acquire not only advanced knowledge but also employability skills and professional competencies they will need in a changing labor market [2]. Thus, university education would focus on the students and developing those competencies, understood as the set knowledge, skills, and abilities that are not only academic but also socially relevant.

The acquired skills should enable and ease the process of entering the workforce as the labor market requires increasing levels of job training, which unites both professional and social performance [3]. Besides this, the European Commission also proposed a new European University Initiative in 2020 [4], among several other aims, which will plan a design curriculum where students and academics, taking into account the opinions of stakeholders, can cooperate as interdisciplinary teams to tackle the biggest issues facing Europe. In this framework, "the educational objectives of the official curriculum at the bachelor level will, in general, have a professional focus; in other words, they must provide university training in which basic skills, transferable skills (related to the integral training of persons), and the more specific skills, that enable a professional approach that allows graduates to integrate into the labor market harmoniously" [1,2].

Finally, such employability skills should contribute to graduate students trained at the university being able to adapt to the continuous changes and transformations of all kinds (economic, social, cultural, political, etc.) and, at the same time, build a society more technologically advanced and equitable according to the Sustainable Development Goals [5,6].

1.1. Theoretical Framework: Functionality of Service and Project-Based Learning

Several authors [7–11] have described how service learning (SL) facilitates the development of employability skills in Higher Education and their relationship with the social responsibility of the university since graduates not only acquire knowledge but also social skills to become active citizens. In this sense, SL focuses on the active participation of students' learning by providing services and solving real problems in the community [3,9,12]. That is, all SL experiences performed by the students would attempt to solve community problems through the curriculum contents of the various subjects [13,14]. Students, as pointed out by [15], would have the opportunity to apply the curriculum content to community practice, where they would gain insights into civic participation activities.

SL is defined as intentionally structured activities that engage students in social services to solve problems encountered by community members [11,16]. In other words, SL is a project of a social nature where students participate in social life positively and actively, becoming aware of the social, cultural, and environmental needs, etc., and committing themselves to act on them through the knowledge and skills that they already have and those that they will develop. The SL methodology has been widely employed across multiple disciplines such as engineering, social sciences, humanities, and medicine within higher education, but it remains less prevalent in certain disciplines, such as business [17,18], and is still scarce in Biology higher education programs [19,20].

Project-based learning (PBL), although distinct from SL, is also a collaborative learning method, but in this case, the students should develop personal abilities, such as critical and innovative thinking, decision-making, problem-solving, digital and communication skills, and interpersonal and teamwork collaborative abilities to address a complex problem with multiple solutions [18,21–23]. While PBL is considered more theoretical, SL places students in the real world. Then, the combination of both SL and PBL allows students to live and breathe problem-solving learning experiences in the real world. Here, the term Project-Based Service Learning (PBSL) is used to define this experience, following the most common terminology [12,24,25].

The PBSL methodology in Engineering higher education has become popular over the last couple of decades [26,27]; however, it is uncommon in other university undergraduate studies, such as Biology [28]. Thus, in this study, we focus on identifying the learning benefits, advantages and disadvantages, and satisfaction of students and lecturers with their participation in a new methodology for Biology students, which combines both problem-based and service-learning methods to enhance graduate employability skills, taking advantage of the experience of Engineering and Translation students and lectures.

1.2. Efficiency of PBSL as a Methodology

From a teaching point of view, the PBSL methodology allows bachelor students to optimize academic performance, improve their social and civic skills, promote the freedom to organize the time devoted to learning and their responsibility toward it, and strengthen the social dimension of the University [29–32]. However, experiences with this type of methodology have been carried out in homogeneous groups, usually within the same subject or degree, and with little systematization concerning the difficulties of institutionalizing such methodologies. Only very recently was experimental learning also applied to develop employable skills using the PBSL methodology in the field of Natural Sciences at higher education [28,33]. In contrast, here we describe an interdisciplinary experience based on the application of the PBSL methodology for mastering specific and transversal competencies of undergraduate students of science, engineering, and humanity degrees. In this way, the study aims to demonstrate the effectiveness of the BPSL methodology to assess learning on six outcomes directly related to employability such as knowledge acquisition, self-directed learning, critical thinking, problem-solving, effective communication, and teamwork, as well as students' and lectures' satisfaction with PBSL pedagogy. Thus, the study explored three research questions:

1. What mastery do students achieve in the different learning outcomes (specific competencies and transferable skills) evaluated?
2. What is the satisfaction of students and lecturers with the learning experience based on BPSL?
3. What advantages and disadvantages do students and lecturers report for the implementation of this learning methodology?

2. Materials and Methods

2.1. Research Context and Experience Design

The competencies linked to the mastery of transferable skills in real environments are vital for the employability of future university students [3,34]. Here, an interdisciplinary experience was carried out with multidisciplinary teams of students from three different academic disciplines, three bachelor's degrees, and in three subjects (Table 1), where the authors of this research had the most load teaching during three consecutive academic years (2015–2016, 2016–2017, and 2017–2018).

Table 1. Academic discipline, bachelor degrees, and subjects selected for the experience and number of students per year.

Discipline	Degree	Subject	Nº Students per Year		
			15–16	16–17	17–18
Sciences	BSc in Biology	Methodology for Projects in Biology	54	62	81
Engineering & Technology	BEng in Industrial Electronics and Automation Engineering	Project Elaboration and Management in Engineering	22	34	33
Humanities	BA in Translation & Interpreting	Introduction to languages of specialization: Spanish	24	31	31
Total			100	127	145

Source: Own elaboration.

Each student team had the option to select from a range of service-learning experiences offered by the teachers or propose a new experience based on their interest in applying the curriculum content in community practices. Specifically, 16, 11, and 20 experiences were conducted in 2015–2016, 2016–2017, and 2017–2018, respectively. Examples of these courses include (1) constructing a greenhouse for an occupational center catering to individuals with disabilities, (2) devising an incubator for a hospital center to mitigate the noise produced by existing ones, and (3) designing a renewable energy station for a rural development association.

This innovative experience arose from the general perception of a low command of transferable skills, such as reflective/critical thinking, self-directed learning, creative problem solving, effective communication, multidisciplinary teamwork, and knowledge acquisition, when lecture (teacher-focused pedagogy) is used instead of learner-focused pedagogies such as service learning or project-based learning [35].

Furthermore, the success rate scores in these bachelor's degrees were significantly lower compared to others from the same university [36]. However, the students with these degrees presented, in general terms, a good overall satisfaction index (57–67%) regarding their undergraduate studies [37], although after graduating, they expressed that their learning outcomes were far from the employable skills required for good job placement. The percentage of job placement was low (<69%), except for the Industrial Engineering Degree, which reached 90% (Table 2). However, it took graduate students 3 to 13 months to secure their first job related to their degree, and their initial net salary was relatively low [37]. This was attributed to their lack of experience and employable skills, as reported by the students themselves. One striking aspect is that the graduate students considered their studies to be useful since more than 78% of the graduates said they would have repeated the same degree at the same university (Table 2).

Table 2. Employment rate, time in finding the first job, net salary per month, and satisfaction level two years after finishing their university studies in Biology (Bio), Industrial Engineering (Eng), and Translation and Interpretation (Tra).

Degree	Employment (%)	Time for the First Job (Months)	Net Salary per Month (€)	Satisfaction with Studies
Bio	46.43	2.37	1057.69	86.36
Eng	89.47	6.95	1161.76	87.50
Tra	68.89	12.83	1050.00	78.13

Source: Espada y Martínez [37].

In this context, transversal competencies or "transferable skills" played a key role, as they were relevant as specifics or even more so in jobs. This gap could justify the prolonged average time the students needed to find their first job as shown in Table 2.

Based on all this, the main objective of the experience was to consolidate the mastery of specific competencies (knowledge acquisition) and transferable competencies (critical thinking, self-directed learning, problem-solving, effective communication, and teamwork) through the PBSL methodology under a multidisciplinary context, as described in Table 3.

Table 3. Summary of the specific and common transversal competencies chosen for evaluation in this interdisciplinary experience per degree: Biology (Bio), Industrial Engineering (Eng), and Translation and Interpretation (Tra) and subjects selected for this experience.

	Degree: (Subject)		
Competences	Bio: (Biology project)	Eng: (Engineering project)	Tra: (Introduction to languages of specialization)
Specific	Biology project	Engineering project	Use of Spanish language in specialized contexts
Transversal	Self-directed learning Problem-solving Critical thinking Teamwork skills Communication and digital skills		

Source: Data from each official degree program at the University of Vigo website.

To achieve these skills, different activities were developed that were common to all subjects, intending to solve a real-context project using PBSL. The specific design of all those activities and deliveries can be found in the Supplementary Material (Table S1).

2.2. Participants

During the three academic years that were analyzed for this study, a total of 372 undergraduate students participated in it, of whom 60.8% were women and 39.2% were men.

The number of participating lecturers was 5 (3 men and 2 women) and they were always the same people during the three academic years (Table 1).

2.3. Method

This is a longitudinal ethnographic case study conducted over three academic years (2015–2016, 2016–2017, and 2017–2018). The study utilized mixed methodologies, encompassing qualitative approaches such as project oral rubrics, project written rubrics, and classroom journals, alongside quantitative methods such as written tests and satisfaction surveys (Table 4). These methods allowed for a comprehensive exploration and understanding of phenomena from the perspective of participants within their natural environment and contextual relationships [38]. As a result, the unit of analysis was conducted within the same educational, social, and cultural environment, enabling informed judgments about the researched reality [39–41].

Table 4. Data-gathering instruments for the experience.

Instrument	Objective	Ponderation (%)		
		Bio	Eng	Tra
Project oral presentation rubric	To evaluate the mastery of the specific and transferable skills.	10	30	20
Project written report standardized grading rubric	To evaluate the mastery of specific and transferable skills	70	40	30
Written test	To evaluate cognitive knowledge acquisition	20	30	50
Satisfaction survey	To gather students' opinions on the efficiency and problems of the learning outcomes with PBSL	0	0	0
Classroom journal (CJ)	To register critical opinion during the PBSL implementation by students. To gather the lecturers' opinions on the evolution and results of the PBSL experience	0	0	0

Source: Own elaboration.

2.4. Procedure and Data Analysis

The research questions were formulated to find out the impact that the PBSL methodology has on the mastery of specific and transferable competencies of the students of the three bachelor's degrees throughout three academic periods and to verify the level of satisfaction experienced by both students and lecturers. For that purpose, the following data collection instruments were used (Table 4):

(i) To identify the benefits of PBSL: project oral presentation, project written report, and written test.
(ii) To measure the level of satisfaction: students' survey.
(iii) To assess advantages and disadvantages: classroom diary (Table 4).

Each of these assessment tools was employed after the teaching–learning process to evaluate students' proficiency in the assessed skills and knowledge. Consequently, the rubric for assessing oral project presentations involves multiple teachers and occurs on the day of the public presentation. An evaluation using rubrics for the written project report and the written test was conducted by the respective subject teachers (Biology, Industrial Engineering, and Translation and Interpreting). The class diary was utilized throughout the learning period to document critical incidents and rectify any discrepancies in the curriculum design.

The data analysis procedures were different depending on the research question to be answered. Graphs have been used to represent the evolution and subsequent comparison of the magnitudes under study, descriptive statistics, and an analysis of means using Student's *t*-test and variance analysis (ANOVA) followed by Bonferroni's post-hoc test ($\alpha = 0.05$).

3. Results

3.1. Level of Mastery of the Learning Outcomes (Competencies)

As shown in Table 5, there are differences ($p < 0.05$) in the levels of learning outcomes (competencies) acquisition in the three bachelor's degrees under study, measured as average grades obtained by the students.

Table 5. Average (A) and standard deviation (DS) of three yearly scores obtained in each assessment test by bachelor. ANOVA F and p-values and post-hoc Bonferroni Test at $\alpha = 0.01$.

	Bachelor	N	A	DS	F	p Value	Bonferroni
Project oral presentation	Bio	198	9.40	0.91	62.19	0.000 *	Bio-Eng = 0.000
	Eng	88	8.00	1.20			Bio-Tra = 0.000
	Tra	86	8.80	0.79			Eng-Tra = 0.000
	Total	372	7.29	3.25			
Project written report	Bio	198	8.77	1.16	29.37	0.000 *	Bio-Eng = 0.05
	Eng	88	9.31	1.05			Bio-Tra = 0.000
	Tra	86	7.80	1.84			Eng-Tra = 0.000
	Total	372	7.41	2.97			
Writing test	Bio	198	8.89	0.92	49.81	0.000 *	Bio-Eng = 0.000
	Eng	88	8.05	1.04			Bio-Tra = 0.000
	Tra	86	7.53	1.42			Eng-Tra = 0.006
	Total	372	8.36	1.29			

* $p < 0.01$. Source: Own elaboration.

The science (Bio) students showed a higher level of acquisition of efficient communication and digital skills in the project oral presentation, followed by humanities (Tra) students and, lastly, Engineering (Eng; $p < 0.05$; Table 5).

However, in the written report project that evaluated specific skills, the Engineering students achieved the highest level, followed by the Biology students and, lastly, Translation. There are also significant differences between the groups ($p < 0.05$).

Taking into account the scores from the written tests, measuring the conceptual contents, the academic performance of the Biology students stands out, followed by Engineering and, lastly, Translation ($p < 0.05$).

In general, women performed better than men in communication and digital skills measured in the project's oral presentation test ($p = 0.000$) and in other transferable skills scored in the written report project ($p = 0.017$) but no differences between the sexes were found in knowledge acquisition scored in the written test ($p = 0.200$; Table 6).

The analysis disaggregated by degree reveals that Biology follows this trend: men's performance was lower in communication and digital skills acquisition scored through the project oral presentation test ($p = 0.008$). Regarding the mastery of written skills and the development of the project, there are no differences between the sexes in any of these bachelor's degrees. In Table 6, we can also verify that the Engineering degree is still mostly male, while Translation is mostly female.

Average scores were high for all assessments throughout the three consecutive years studied, although significant differences between years were detected ($p < 0.05$; Table 7). Interestingly, the scores in the project oral presentation were higher in the first course than in the following one, but not in the third ($p < 0.05$). However, the scores given to the project's written report and the written test tended to be higher in the third year. This could be due to the training of the lectures in the use of these evaluation techniques since they had not been used previously, particularly in the Biology and Translation degrees.

Table 6. Average (A) and standard deviation (DS) of three yearly scores obtained in each assessment test by bachelor. Student's t-test at $\alpha = 0.05$ and $\alpha = 0.01$.

	Bachelor	Gender	N	A	DS	t	p Value
Project oral presentation	Bio	Female	143	9.50	0.78	2.69	0.008 **
		Male	55	9.12	1.13		
	Eng	Female	15	8.27	1.08	0.892	0.375
		Male	73	7.95	1.28		
	Tra	Female	68	8.69	1.02	0.336	0.738
		Male	18	8.59	1.15		
	Total	Female	226	9.18	0.98	5.86	0.000 **
		Male	146	8.47	1.32		
Project written report	Bio	Female	143	8.80	0.83	0.470	0.639
		Male	55	8.71	1.06		
	Eng	Female	15	9.40	.94	0.337	0.739
		Male	73	9.29	1.04		
	Tra	Female	68	7.79	1.48	−0.084	0.933
		Male	18	7.83	1.22		
	Total	Female	226	8.53	1.24	−2.39	0.017 *
		Male	146	8.89	1.14		
Writing test	Bio	Female	143	8.93	1.10	1.64	0.101
		Male	55	8.70	1.30		
	Eng	Female	15	8.56	1.05	2.13	0.360
		Male	73	7.94	1.06		
	Tra	Female	68	7.52	1.84	−0.168	0.867
		Male	18	7.58	1.91		
	Total	Female	226	8.48	1.45	2.34	0.200
		Male	146	8.18	1.36		

*, ** $p < 0.05$, 0.01. Source: Own elaboration.

Table 7. Average (A) and standard deviation (DS) of three yearly scores and total, ANOVA F and p-values, and post-hoc Bonferroni Test at $\alpha = 0.05$ and $\alpha = 0.01$.

	Year	N	A	DS	F	p Value	Bonferroni
Project oral presentation	15–16	101	9.11	0.95	3.90	0.021 *	15–16/16–17 = 0.020
	16–17	126	8.68	1.38			15–16/17–18 = 0.836
	17–18	145	8.94	1.11			16–17/17–18 = 0.198
Project written report	15–16	101	8.31	1.79	7.24	0.001 **	15–16/16–17 = 0.101
	16–17	126	8.60	1.46			15–16/17–18 = 0.001
	17–18	145	8.99	0.98			16–17/17–18 = 0.003
Written test	15–16	101	8.42	1.49	5.88	0.003 **	15–16/16–17 = 0.001
	16–17	126	8.08	1.19			15–16/17–18 = 0.355
	17–18	145	8.57	0.95			16–17/17–18 = 0.002

*, ** $p < 0.05$, 0.01; N = 372. Source: Own elaboration.

Finally, a correlation analysis of the scores obtained among the assessment tests was revealed as significant positive (Table 8). The greatest correlation appears between the scores of the written test and the project's written report assessment tests (0.708) and the written test with the project's oral presentation scores (0.618). The correlation was small between the project's written report and oral presentation tests (0.305).

Table 8. Correlations between grades obtained per assessment. N = 372.

		Project	Writing
Oral	r	0.305 *	0.618 **
	Sig. (bilateral)	0.000	0.000
Project	r		0.708 **
	Sig. (bilateral)		0.000

*, ** $p < 0.05, 0.01$. Source: Own elaboration.

3.2. Satisfaction of Lectures and Students

The level of satisfaction of the students was high (95%). In all the degrees, the involvement of more than 90% of the students was reached. The involvement of the lectures in the PBSL experience was also valued as highly satisfactory (94%), together with the adequacy and coherence between the specific competencies and transferable skills to be acquired and the total ECTS credits assigned to each subject.

Through the survey, students expressed the great usefulness of the PBSL methodology for learning essential competencies in their future working lives, highlighting the importance of acquiring both multidisciplinary knowledge and transferable skills that could improve their future employability. As can be seen, the average score for each of the "items" is relatively high, reaching higher than 3 out of 5 in all cases (Table 9).

The acquisition of learning outcomes related to critical thinking and self-directed learning skills was the most highly valued by students (Table 9). They are more willing to appreciate the discussion of the different points of view (4.11), the effort needed to reach agreements by changing and accepting new ideas (4.08) and better adapt to new situations, and integrate the information and ideas of different topics to improve self-learning (4.04; Table 9).

Problem-solving and teamwork skills were also highly scored (3.7–3.9), noting that PBSL improved students' ability to use knowledge, not opinions, to solve problems (3.8) and correlate multidisciplinary information and ideas to solve them better (3.9). Furthermore, PBSL increases students' confidence to deal with a variety of people and be an effective member of a team (3.7), even in interdisciplinary contexts (Table 9).

Likewise, the experience was equally satisfactory regarding the interdisciplinary relationships built between the humanities, scientific, and technological disciplines, which are traditionally unyielding in terms of student collaboration in these disciplines.

The PBSL methodology was also demonstrated to be very good for improving digital and communication skills (3.6) and specific knowledge acquisition (>3.6). Students perceived that they had learned a huge amount of useful knowledge and had developed a good understanding of most concepts of their specific subject (Table 9). Overall, they believe that they improved their employability skills.

Finally, in the student's opinion, although the PBSL methodology has facilitated the relationship between lecturers and students compared to other subjects that use the lecture methodology (2.96) and improved the understanding of the course contents (3.06), it has greater room for improvement up to a maximum of 5 points with which it can be assessed.

Table 9. Survey to evaluate students' learning outcomes and satisfaction with the PBSL experience.

	Average		
Items	**Woman**	**Men**	**Total**
Critical thinking:			
I have developed my critical thinking skills in making reasoned judgments from opposing perspectives.	3.67	3.57	3.61
I am more willing to consider another point of view to evaluate how strong or valid it is.	4.15	4.08	4.11
Faced with a difficult problem, I can usually find a new way of solving it.	3.72	3.65	3.67
PBSL encourages you to examine questions or problems differently.	3.54	3.75	3.67
I am more willing to change and accept new ideas.	4.08	4.02	4.04
Self-directed learning:			
I feel I must take responsibility for my learning.	3.97	3.88	3.91
I am more trusting in my abilities to face new learning challenges.	3.95	3.83	3.88
With PBSL methodology, I have learned to adapt better to new challenges.	3.79	4.18	4.04
Problem-solving:			
I have improved my capacity to use knowledge to systematically solve problems.	3.85	3.8	3.82
I can correlate information and ideas from different fields to solve problems.	4.03	3.86	3.92
Knowledge acquisition:			
I believe this project's subject contents have improved my skills for a future job market and career development.	3.72	3.68	3.69
I learned a huge amount of useful knowledge in this project subject.	3.72	3.63	3.66
Until now I have developed a good understanding of the main concepts of this subject.	3.72	3.78	3.76
Communication and digital skills:			
So far, the PBSL has helped in develop my skills in effectively communicating with others.	3.62	3.55	3.58
My oral presentation skills have improved after the PBSL.	3.46	3.66	3.59
Teamwork skills:			
I learned to be an effective member of teamwork.	3.64	3.82	3.75
I am confident I can deal with a wide range of people.	3.92	3.62	3.73
Student satisfaction with PBSL methodology:			
In my opinion, teachers use a wide variety of teaching methods in this degree.	3.00	2.98	2.99
With the PBSL method, we had the opportunity to participate in the classroom more directly.	3.49	3.65	3.59
Generally, teachers made an effort to make us understand the content of the course.	3.15	3.22	3.19
In this degree, teachers designed the classes so the students had a better understanding of the contents of the course.	3.05	3.06	3.06
Using PBSL, when I had problems with the content, the teachers were there to help.	3.64	3.62	3.63
The teachers were efficient when I had problems understanding the course material.	3.44	3.48	3.46
In most subjects was a close relationship between teachers and students.	2.79	3.06	2.96
In this degree, there was easy and good communication between teachers and students.	3.13	3.28	3.22

Source: Own elaboration.

3.3. Advantages and Disadvantages of PBSL

The use of this type of collaborative learning methodology has offered global benefits regarding the students' acquisition of specific and transversal competencies. On the one hand, the fact that the project was incorporated into the subject evaluation tests meant that the students were interested in the optimal achievement of the objectives since this is directly reflected in the overall course grade. On the other hand, the classroom diary shows a few entries referring to complaints or incidences in the development of PBSL, in addition to the problems detected in the internal coordination of teamwork established among themselves and/or with the person responsible for the external collaborating institutions. Normally, these difficulties were related to two issues: the long time it takes to manage the groups and how to manage (prioritize, assign, and schedule) the project phases.

The benefits of interdisciplinarity and teamwork are immediately recognized since they contribute not only to the development of attitudes of companionship but also to the achievement of better specific knowledge of the different academic disciplines, values, and problems [42]. Taken together, PBSL is a continuous teaching adaptation and a series of adjustments in the curriculum that progressively improve with each implementation, especially in aspects related to organization, calendar, and homogeneity in the rubrics (among the courses and disciplines).

The classroom diary prepared by the lectures involved in the experience was very useful in revealing the main benefits and drawbacks detected in the PBSL in the framework of higher education. In the overall assessment requested once the experience was over, the lectures recorded in the diary stated that this type of methodology allows the mastery of transversal competencies, particularly adaptability and innovative critical thinking, self-directed learning using real-world analysis and problem-solving, or communication, management, and teamwork skills, which are otherwise very difficult to develop within the context of a lecture. The lectures also mentioned the high knowledge mastery of the different aspects of each subject's curriculum, as well as the coherence between the level demanded from the lectures and the final score reached by students, and between what was performed in the PBSL and what the job market requires.

However, the classroom diary also shows the need for more training in the use of PBSL assessment methods by lecturers and greater homogeneity at the training level required in each subject of the different degrees.

Finally, the data collected in the classroom diary show that the PBSL experience has been very positive for lecturers due to the high level of consolidation of students' skills and the exchange of ideas that had naturally occurred during the development of the different project phases and seminar sessions. However, lectures have been perceived as negative, and the high number of hours dedicated to organizing the different activities and supervising the multiple tasks performed by the students stand out, which has not been reflected in their teaching load.

4. Discussion

This PBSL experience was designed to provide an interdisciplinary opportunity to connect theory to real-world challenges to students from three different knowledge disciplines: science, humanities, and engineering. We hypothesized that a multidisciplinary project, in a real context, would serve as the key factor to unite students from different disciplines to solve a complex real-world challenge, thus enhancing their employability skills. To reach this objective, students should acquire not only their specific knowledge but also cross-disciplinary ones and transferable skills such as efficient communication (oral and writing) skills, multidisciplinary teamwork culture, innovative critical thinking, and solving problems, under the deep conditions of self-directed learning [42–44].

The results show that the PBSL methodology facilitates student acquisition of specific and transversal competencies that are important for graduates' employability [30,32,45]. Even though this methodology has achieved a wide documentary base, especially in American or Asian Higher Education Institutions [18,23,46], it presents a lack of critical analysis of its effects on learning outcomes [47–49], and there is still not enough scientific evidence of the link between learning design patterns and the effectiveness of the service-learning methodology [15,50]. These constraints come, in part, because implementing new experiential learning methodologies is not easy because of the reticence more on the lecturer's side than on the student's side [29,44]. Faced with the dichotomy between continuing in a stable academic world or facing the challenging real world, in most cases, the classic model of lecture (teacher-focused pedagogy) is maintained instead of introducing learner-focused pedagogies such as PBSL [35]. In this sense, it is highly recommended to provide extra support before, during, and after PBSL implementation, not only for students [18,51] but also for lecturers.

Currently, the skepticism about using the PBSL methodology is still considerable, despite the published reports on its effectiveness for the academic, social, ethical, and vocational development of Higher Education students [52,53]. However, the students appreciate PBSL because of (i) the opportunities it offers to increase their skills in personal citizenship [54]; (ii) its reflective and critical components [55,56]; (iii) the fact that it allows them to master employability skills [3,43], and (iv) it boosts their personal and professional development [50]. In this study, students perceived PBSL as a new learning methodology that is very useful for mastering specific competencies and, more deeply, transferable skills acquisition.

In addition to the development of marketable skills for personal and professional development, this study was carried out in an interdisciplinary fashion between students of different disciplines favoring multidisciplinary teamwork and collaboration to solve a common and real-world problem [42].

In this experience, concerning some of the variables analyzed such as sex, although there are no significative differences between the written skills acquired by women and men, there seems to be a significant tendency for women to obtain better academic results in the project's oral presentation and written report test, revealing that woman showed greater learning outcome acquisition of both specific and transversal competencies using PBSL, particularly those assessed through the project's oral presentation and written report rubrics. This may be, as [54] pointed out, because there is a significant difference between men and women in the value that students attribute to learning services.

In this study, the high level of student satisfaction is significant, and they emphasized that the experience made them more willing to take into account different points of view, change and accept new ideas, and, in general, better adapt to new situations. This same conclusion has been reached in other similar studies, which provide scientific evidence on the subject [57]. The students also highlighted that the PBSL experience offered them the chance to learn social realism. Similarly, in the study by Caspersz and Olaru [54], the students valued SL precisely for the opportunity it provided to increase their citizenship skills. In our study, the PBSL enabled students to consolidate their learning from the coursework, but it also helped them feel more connected to the surrounding community and improve their communication and problem-solving skills for their professional careers, as described elsewhere [58]. Finally, students also demonstrated the richness of the exchange of ideas between colleagues from different degrees, which provoked reflection and critical analysis, as well as the effort required to reach agreements and master different concepts sometimes far afield from the degree they were studying. Therefore, once experienced, the students generally recommend these types of activities [59].

A more negative aspect challenging the success of PBSL would be the time the students had to spend organizing with team members and co-workers of the collaborating institutions, mainly due to scheduling conflicts. Similar limitations were pointed out elsewhere [58], referencing time limitations, working with real clients, and technical limitations.

Therefore, we conclude that this methodology has allowed the students to be aware of what has been learned and also contributes to critical reflections favoring the achievement of the learning objectives needed for academic, as well as personal, growth [56].

We can also highlight in our study the great satisfaction of the lecturers who were able to verify the mastery of the skills performed in the classroom, as well as the conceptual mastery of the different curriculum subject matter of each of the degrees involved without previous experience in this kind of learning methodology. The lecturers also highlighted the educational enrichment observed by the students, which also shows coherence between the level of requirement and the final qualification and between what was performed in the classroom and what the labor market demands. Other studies have also demonstrated the effectiveness of the PBSL methodology for mastering not only knowledge but also social skills, autonomy, and study organization [31,32,43].

Furthermore, it is an experience easily transferable to different disciplines (other bachelor's degrees) of the university since it is feasible to replace some tasks and assessment tests on specific subjects with more global projects that integrate common or specific transversal competencies specific to each subject as parts of that global project. However, in our opinion, it would be important to design evaluation rubrics with very precise indicators to facilitate the qualification and eliminate the possible biases that are established between the qualifications of the different disciplines.

After analyzing the experience, we can conclude that the PBSL methodology facilitates the acquisition of transversal and specific competencies, although it is also clear that lecturer training in the use of assessment methods to more rigorously measure the learning outcomes of each curriculum is highly recommended before implementing any new PBSL experience. The study by Wenham and co-workers [60] also reported the difficulty of lecturers and academic tutors in supervising the tasks of students and indicated the need for concrete training in the case of PBSL projects and specific training for those tutoring the group.

Therefore, it is recommended to increase the effort towards the implementation of this type of PBSL methodology in universities to (i) promote the connection between theory, practice, and employability; (ii) motivate the collaborative and interdisciplinary spirit among disciplines [42]; and (iii) facilitate the professional performance of graduate students as set out in the European guidelines, which has already been implemented in some Asian educational systems [3]. Despite the limitations of this study, these results support the success of learning process design patterns using a PBSL social methodology.

5. Conclusions

Based on the findings, the following three conclusions can be drawn:

1. The effectiveness of the PBSL for the consolidation of specific knowledge and transferable skills essential for employability by the students was demonstrated.
2. The study outlined the students' and lecturers' high satisfaction with the PBSL experience since it allows the mastery of transversal competencies, particularly those related to self-directed learning, problem-solving, critical thinking, communication, and teamwork skills.
3. Advantageously, PBSL favored the exchange of ideas and specific knowledge among students from different disciplines (degrees) and facilitated the critical and constructive reflection of the theoretical contents, allowing them to realize what competencies have been gained in real contexts, particularly those demanded by the labor market. However, the long time required to manage all tasks and the assignment and scheduling of the different phases were some of the PBSL disadvantages outlined by students and lecturers.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/educsci14010095/s1, Table S1: Schedule activities and deliveries carried out in this study during the course (15 weeks).

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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References

1. European Union Ministers Conference. The Bologna Process 2020-The European Higher Education Area in the New Decade Communiqué of the Conference of European Ministers Responsible for Higher Education. Leuven and Louvain-la-Neuve, Belgium 28 and 29 April 2009. 2009. Available online: https://ehea.info/media.ehea.info/file/20090223-Ostend/54/2/BFUG_Board_CZ_19_4_draft_communique_200209_594542.pdf (accessed on 13 October 2020).
2. Alanazi, A.S.; Benlaria, H. Bridging Higher Education Outcomes and Labour Market Needs: A Study of Jouf University Graduates in the Context of Vision 2030. *Soc. Sci.* **2023**, *12*, 360. [CrossRef]
3. Chan, S.C.; Ngai, G.; Kwan, K.P. Mandatory service learning at university: Do less-inclined students learn from it? *Act. Learn. High. Educ.* **2019**, *20*, 189–202. [CrossRef]
4. European Commission. Education and Training. 2020. Available online: https://ec.europa.eu/education/education-in-the-eu/european-education-area/european-universities-initiative_en (accessed on 13 October 2020).
5. UNESCO. *Education for Sustainable Development Goals. Learning Objectives*; United Nations Educational, Scientific and Cultural Organization: Paris, France, 2017; ISBN 9789231002090.
6. Jelonek, M.; Urbaniec, M. Development of sustainability competencies for the labour market: An exploratory qualitative study. *Sustainability* **2019**, *11*, 5716. [CrossRef]
7. Jacoby, B. (Ed.) *Building Partnerships for Service-Learning*; John Wiley & Sons: Hoboken, NJ, USA, 2003.
8. Crabtree, R.D. Theoretical foundations for international Service-Learning. *Mich. J. Community Serv. Learn.* **2008**, *15*, 18–36.
9. Deeley, S.J. Service-learning: Thinking outside the box. *Act. Learn. High. Educ.* **2010**, *11*, 43–53. [CrossRef]
10. Waterman, A.S. (Ed.) *Service-Learning: Applications from the Research*; Routledge: Oxfordshire, UK, 2014.
11. Culcasi, I.; Venegas, R.P. Service-Learning and soft skills in higher education: A systematic literature review. *Form@ Re-Open J. Per La Form. Rete* **2023**, *23*, 24–43. [CrossRef]
12. Pino Juste, M. Metodologías activas como clave en los procesos de innovación en la escuela. In *Éxito Educativo: Claves de Construcción y Desarrollo*; Santos Rego, M.A., Valle Arias, A., Lorenzo Moledo, M., Eds.; Editorial Tirant Lo Blanch: Valencia, Spain, 2019.
13. Pruett, J.L.; Weigel, E.G. Concept Map Assessment Reveals Short-Term Community-Engaged Fieldwork Enhances Sustainability Knowledge. *CBE—Life Sci. Educ.* **2020**, *19*, ar38. [CrossRef] [PubMed]
14. Wong, M.M.; Lau, K.H. E-service-learning is equally effective as traditional service-learning in enhancing student developmental outcomes. *Interact. Learn. Environ.* **2023**, *19*, 1–5. [CrossRef]
15. Gerholz, K.H.; Liszt, V.; Klingsieck, K.B. Effects of learning design patterns in service learning courses. *Act. Learn. High. Educ.* **2017**, *19*, 47–59. [CrossRef]
16. Yang, M.; Luk, L.Y.Y.; Webster, B.J.; Chau, A.W.L.; Ma, C.H.K. The role of international service-learning in facilitating undergraduate students' self-exploration. *J. Stud. Int. Educ.* **2016**, *20*, 416–436. [CrossRef]
17. Ayers, L.; Gartin, T.L.; Lahoda, B.D.; Veyon, S.R.; Rushford, M.; Neidermeyer, P.E. Service Learning: Bringing the Business Classroom to Life. *Am. J. Bus. Educ.* **2010**, *3*, 55–60. [CrossRef]
18. McDonald, S.; Ogden-Barnes, S. Problem-Based Service Learning with a Heart: Organizational and Student Expectations and Experiences in a Postgraduate Not-for-Profit Workshop Event. *Asia-Pac. J. Coop. Educ.* **2013**, *14*, 281–293.
19. Santas, A.J. Reciprocity within biochemistry and biology service-learning. *Biochem. Mol. Biol. Educ.* **2009**, *37*, 143–151. [CrossRef] [PubMed]
20. Kulesza, A.E.; Imtiaz, S.; Bernot, K.M. Building Connections to Biology and Community through Service-Learning and Research Experiences. *J. Microbiol. Biol. Educ.* **2022**, *23*, e00082-22. [CrossRef] [PubMed]
21. Allen, D.; Tanner, K. Approaches to cell biology teaching: Learning content in context—Problem-based learning. *Cell Biol. Educ.* **2003**, *2*, 73–81. [CrossRef]

22. Allchin, D. Problem-and case-based learning in science: An introduction to distinctions, values, and outcomes. *CBE—Life Sci. Educ.* **2013**, *12*, 364–372. [CrossRef]
23. Sackett, S.C.; Alicea, S.K. Problem-Based learning and service learning approaches in the undergraduate classroom. In *High Impact Teaching for Sport and Exercise Psychology Educators*; Coumbe-Lilley, J.E., Shipherd, A.M., Eds.; Taylor & Francis: New York, NY, USA, 2020.
24. Zarske, M.S. Impacts of Project-Based Service-Learning on Attitudes towards Engineering in High School and First-Year Undergraduate Students. Ph.D. Thesis, University of Colorado Boulder, Boulder, CO, USA, 1 January 2012.
25. Narong, D.K.; Hallinger, P. A Keyword Co-Occurrence Analysis of Research on Service Learning: Conceptual Foci and Emerging Research Trends. *Educ. Sci.* **2023**, *13*, 339. [CrossRef]
26. Palmer, B.; Terenzini, P.T.; McKenna, A.F.; Harper, B.J.; Merson, D. Design in Context: Where do the Engineers of 2020 Learn this Skill? In Proceedings of the 2011 ASEE Annual Conference & Exposition, Vancouver, BC, Canada, 26–29 June 2011.
27. Scherrer, C.; Sharpe, J. Service Learning Versus Traditional Project-Based Learning: A Comparison Study in a First Year Industrial and Systems Engineering Course. *Int. J. Serv. Learn. Eng. Humanit. Eng. Soc. Entrep.* **2020**, *15*, 18–32. [CrossRef]
28. Berchiolli, B.; Movahedzadeh, F.; Cherif, A. Assessing student success in a project-based learning biology course at a community college. *Am. Biol. Teach.* **2018**, *80*, 6–10. [CrossRef]
29. Butin, D.W. The limits of service-learning in higher education. *Rev. High. Educ.* **2006**, *29*, 473–498. [CrossRef]
30. Bringle, R.G.; Hatcher, J.A. Innovative practices in service learning and curricular engagement. *New Dir. High. Educ.* **2009**, *147*, 37–46. [CrossRef]
31. Carnicelli, S.; Boluk, K. The promotion of social justice: Service Learning for transformative education. *J. Hosp. Leis. Sport Tour. Educ.* **2017**, *21*, 126–134. [CrossRef]
32. Barrera, D.; Willner, L.N.; Kukahiko, K.I. Assessing the development of an emerging critical consciousness through service learning. *J. Crit. Thought Prax.* **2017**, *6*, 2. [CrossRef]
33. Hernández-Barco, M.; Sánchez-Martín, J.; Blanco-Salas, J.; Ruiz-Téllez, T. Teaching Down to Earth—Service-Learning Methodology for Science Education and Sustainability at the University Level: A Practical Approach. *Sustainability* **2020**, *12*, 542. [CrossRef]
34. Kindelán, M.P.; Martín, A.M. Ingenieros del siglo XXI: Importancia de la comunicación y de la formación estratégica en la doble esfera educativa y profesional del ingeniero. *Arbor* **2008**, *184*, 732. [CrossRef]
35. Garnjost, P.; Lawter, L. Undergraduates' satisfaction and perceptions of learning outcomes across teacher-and learner-focused pedagogies. *Int. J. Manag. Educ.* **2019**, *17*, 267–275. [CrossRef]
36. Transparency Portal of the University of Vigo. Taxa de Éxito e Avaliación. 2020. Available online: http://dwsid.uvigo.es/MicroStrategy/servlet/mstrWeb?src=mstrWeb.3140&evt=3140&share=1&documentID=0597B99311E68A1D24CB0080EF651154&Server=DW-P-B.UVIGO.ES&Port=0&Project=DataWarehouse+UVI& (accessed on 13 October 2020).
37. Espada, L.; Mártinez, V. *Estudio Sobre a Situación Preofesional das Persoas Tituladas da Universidade de Vigo*; Consello Social-Universidade de Vigo: Vigo, Spain, 2015.
38. Hernández Sampieri, R.; Fernández Collado, C.; Baptista Lucio, P. *Metodología de la Investigación*, 5th ed.; McGraw-Hill: Mexico City, Mexico, 2010.
39. Grandon, T. *Book Informing with the Case Method*; Informing Science Press: London, UK, 2011.
40. Stake, R.E. *The Art of Case Study Research*; Sage: Newcastle upon Tyne, UK, 1995.
41. Yacuzzi, E. El estudio de caso como metodología de investigación: Teoría, mecanismos, causales, validación. *Inomics* **2005**, *1*, 296–306.
42. Tripp, B.; Voronoff, S.A.; Shortlidge, E.E. Crossing Boundaries: Steps Toward Measuring Undergraduates' Interdisciplinary Science Understanding. *CBE—Life Sci. Educ.* **2020**, *19*, ar8. [CrossRef] [PubMed]
43. Quitadamo, I.J.; Kurtz, M.J. Learning to improve: Using writing to increase critical thinking performance in general education biology. *CBE—Life Sci. Educ.* **2007**, *6*, 140–154. [CrossRef]
44. Tripp, B.; Shortlidge, E.E. A framework to guide undergraduate education in interdisciplinary science. *CBE—Life Sci. Educ.* **2019**, *18*, es3. [CrossRef]
45. Vreeke, L.; Huijding, J.; Branje, S.; Hibbel, B.; Van der Ham, J.; Dielwart, I.; Mulder, H. Enhancing students' preparation for the professional field: A quasi-experimental study on a new community service learning module for first year pedagogical sciences students. In Proceedings of the Sixth International Conference on Higher Education Advances, Valencia, Spain, 2–5 June 2020; Volume 162, pp. 1269–1277.
46. Spring, K.; Grimm, R., Jr.; Dietz, N. *Community Service and Service-Learning in America's Schools*; Corporation for National and Community Service: Washington, DC, USA, 2008. Available online: https://files.eric.ed.gov/fulltext/ED506728.pdf (accessed on 13 October 2020).
47. Crabtree, R.D.; Sapp, D.A. International Service-Learning. In *The Wiley International Handbook of Service-Learning for Social Justice*; Lund., D.E., Ed.; John Wiley & Sons: Hoboken, NJ, USA, 2018; pp. 319–352.
48. Nurbatra, L.H. Challenges in International Service Learning. *Engl. Educ. J. Tadris Bhs. Ingg.* **2018**, *11*, 162–175.
49. Pratiwi, V.D.; Wuryandani, W. The Effect of Problem Based Learning (PBL) Models on Motivation and Learning Outcomes in Citizenship Education Learning in Middle School. *JPI J. Pendidik. Indones.* **2020**, *9*, 401–412. [CrossRef]
50. Hebert, A.; Hauf, P. Student learning through service learning: Effects on academic development, civic responsibility, interpersonal skills and practical skills. *Act. Learn. High. Educ.* **2015**, *16*, 37–49. [CrossRef]

51. Schaffer, S.P.; Xiaojun, C.; Xiumei, Z.; Oakes, W.C. Self-efficacy for cross-disciplinary learning in project-based teams. *J. Eng. Educ.* **2012**, *101*, 82–94. [CrossRef]
52. Allen, D.E.; Donham, R.S.; Bernhardt, S.A. Problem-based learning. *New Dir. Teach. Learn.* **2011**, *2011*, 21–29. [CrossRef]
53. Green, P.M.; Johnson, M. (Eds.) *Crossing Boundaries: Tension and Transformation in International Service-Learning*; Taylor & Francis: Abingdon, UK, 2023.
54. Caspersz, D.; Olaru, D. The value of service-learning: The student perspective. *Stud. High. Educ.* **2017**, *42*, 685–700. [CrossRef]
55. Keen, C.; Hall, K. Engaging with difference matters: Longitudinal student outcomes of co-curricular service-learning programs. *J. High. Educ.* **2009**, *80*, 59–79. [CrossRef]
56. Barnes, M.E.; Caprino, K. Analyzing service-learning reflections through Fink's taxonomy. *Teach. High. Educ.* **2016**, *21*, 557–575. [CrossRef]
57. Berasategi, N.; Alonso, I.; Roman, G. Service-learning and higher education: Evaluating students learning process form their own perspective. *Procedia-Soc. Behav. Sci.* **2016**, *228*, 424–429. [CrossRef]
58. Lee, S.J.; Wilder, C.; Yu, C. Exploring students' perceptions of service-learning experiences in an undergraduate web design course. *Teach. High. Educ.* **2018**, *23*, 212–226. [CrossRef]
59. Dienhart, C.; Maruyama, G.; Snyder, M.; Furco, A.; McKay, M.S.; Hirt, L.; Huesman, R. The impacts of mandatory service on students in service-learning classes. *J. Soc. Psychol.* **2016**, *156*, 305–309. [CrossRef]
60. Wenham, K.E.; Valencia-Forrester, F.; Backhaus, B. Make or break: The role and support needs of academic advisors in work-integrated learning courses. *High. Educ. Res. Dev.* **2020**, *39*, 1026–1039. [CrossRef]