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Project Based Learning Meets Service Learning on Software Development Education*

DANIEL LÓPEZ-FERNÁNDEZ, LAURA RAYA, FERNANDO ORTEGA and JOSÉ JESÚS GARCÍA
U-tad: Centro Universitario de Tecnología y Arte Digital, Madrid, Spain. E-mail: daniel.fernandez@u-tad.com, laura.raya@u-tad.com, fernando.ortega@u-tad.com, jose.rueda@u-tad.com

This contribution presents several case studies performed using Project Based Learning and Project Based Service Learning methodologies. The case studies have been carried out for two years in a Software Engineering degree. Qualitative methods like surveys, observations and interviews have been used to investigate both methodologies. The results obtained lead to useful guidelines for those Engineering teachers who intend to use these methodologies in a productive and enriching way. The data indicate that motivation, soft skills and technical abilities of the students are improved using these methodologies. Critical issues like project selection, communication with clients, session performing, conflicts prevention and evaluation methods are addressed. Recommendations to implement successfully these methodologies are stated.

Keywords: active methods; project based learning; service learning; project based service learning; software engineering; software development

1. Introduction

Project Based Learning (PBL) is a methodology highly suitable for Engineering Education. This methodology allows students to take the theoretical concepts into practical projects to solve real problems, which is the purpose of an engineer [1–5, 13]. PBL also facilitates the development of soft skills such as teamwork, leadership and project management, critical in their professional careers [2, 3, 13]. In addition, when using this educational methodology students show high levels of motivation and engagement with the projects [1, 4].

Following its personal, academic and professional remarkable outcomes, PBL has been successfully applied in several Engineering areas. Different research carried out in the field of Industrial Engineering in postgraduate courses show that the use of PBL increases students' interest, and several soft skills are trained [3]. Another study carried out on graduate students concludes that motivation is clearly stimulated using PBL [4]. A case study conducted in Electrical Engineering at a postgraduate level reveals that soft skills such as communication, teamwork or creative thinking are enhanced through PBL [2]. Case studies performed in Mechanical Engineering also at a postgraduate level discloses that PBL improves students' satisfaction, soft skills such as communication, teamwork and time management and the whole learning process [5]. Prince and Felder explored PBL through several empirical experiments performed in several Engineering fields. As a result, they indicate the enhancement of motivation of the students and the increase of their communication and teamworking skills as great benefits of PBL. Additionally, they highlight an improvement in professional practice and in the application of theoretical concepts to real problems [1].

Despite the reported benefits of PBL, there are also some warnings in the literature about its use. [1] describes conflicts between teammates due to unbalanced workloads or differences in opinions. [2] analyzes students' dissatisfaction at the beginning of the projects related to the difficulties of the multidisciplinary work. [3] reports complaints related to the perceived fairness of the evaluation methods and the arising of conflicts between classmates. [4] reveals problems related to tight schedules. [5] studies the negative impact of PBL in the teacher workload and the cost for the institution.

When Service Learning (SL) is incorporated to PBL, the resulting methodology is named Project Based Service Learning (PBSL). This methodology is very similar to PBL but using projects with a social aim. The application of PBSL can boost the positive outcomes of PBL and expand them. PBSL contributes to further increase students' motivation towards the subject and their engagement with the project [6]. Often, when students understand the social needs they are covering with their work and they know the people they are helping, they get more committed to the mission and objectives of the project. Moreover, PBSL contributes to other aspects of their learning such as civic responsibility, stronger ethics or self-esteem [6–8]. These benefits also have an impact in the commitment of teachers, who may find in the social purpose another good reason to make the necessary effort to incorporate

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PBSL into their lessons. In order to achieve these positive outcomes, the mentioned warnings related to PBL should also be considered in PBSL. In addition, some specific aspects must be carefully considered when PBSL is used to generate useful solutions for Non-Governmental Organizations (NGOs) or similar: communication processes, adequacy between the learning needs of the course and those of the organization and participation of the students [9].

The benefits of PBL and PBSL can also be found in the Software Engineering field [10–12]. To ensure the success of PBSL, the design process of the learning experience must pay special attention to the use of appropriate evaluation methods, the relationships between classmates, the selection of adequate projects, the elaboration of a realistic planning, the required technical resources, the implication of third parties involved in the experience, etc. To tackle these issues in Engineering Education, more guidelines and recommendations based on empirical experiences should be provided.

This paper describes several experiences where PBSL has been successfully applied in Software Development Education over the last two years. Our experiments have been carried out in an integrated environment, being the PBL or PBSL methodology used in the 80% of the courses in the study plan. This helps to attenuate one of the main problems found in previous empirical studies: they have been conducted in isolated courses during a short time span. On the ground of this empirical research, our contribution aims to provide recommendations and guidelines for Software Engineering teachers who want to use PBSL in a productive and enriching way.

The rest of the paper is structured as follows: Section 2 describes the research; Section 3 contains the results obtained in the study; Section 4 discusses the results; and Section 5 presents the conclusions and the future work.

2. Presentation

This section presents the descriptive-exploratory empirical study that has been carried out. It details the research framework, objectives, research instruments, the population sample and the projects related to this study.

The study has been performed in *U-tad: Centro Universitario de Tecnología y Arte Digital*, a technical University located in Madrid (Spain). The Department of Software Engineering offers an associate degree on Development of Multiplatform Applications (DMA), a degree on Software Engineering and several post-degrees on computer graphics, virtual reality, big data and cybersecurity. During the two years that lasted the present research, students have mainly used PBL or PBSL methodologies in their courses, although they have also been exposed to Non-Project Based Learning, allowing subsequent comparison. The exposure to PBL or PBSL in different courses favors the understanding and integration of these methods by students for its later evaluation.

Unlike previous empirical studies conducted in isolated courses during a short time span, our experiments have been carried out in an integrated environment during a long period of time (two years). Furthermore, PBL and PBSL methodologies has been used in the 80% of the courses in the study plan. This key feature of our study provides reliable results that can be used to understand the importance of the PBSL methodology in Software Development Education.

This contribution focuses on the analysis of the results of the application of PBSL methodology in the projects made by students in Software Development courses. The specific research objectives of the study are the following: (1) evaluating the suitability and usefulness of PBL in the Software Development field; (2) evaluating the suitability and usefulness of PBSL in the Software Development field; (3) exploring the most motivating elements of PBSL in the Software Development field; and (4) extracting recommendations and guidelines to perform PBSL in a productive and enriching way.

The sample of the study is composed by twenty-six students (twenty-three men and three women, in the 18 to 24 age group), six teachers and five clients. The research instrument used to gather the point of view of the students is a survey, composed by both quantitative questions (see Tables 2, 3, 4 and 5) and qualitative questions (see Table 6). The research instrument used to gather the point of view of the teachers is another survey, composed by both quantitative questions (see Tables 6 and 7) and qualitative questions. In both cases, the surveys were fulfilled after the finalization of the two-year learning experience. The objective of the research was presented to students and teachers, who fulfilled the survey anonymously. The quantitative questions were answered using a Likert scale of five levels, being 1 '*total disagreement*' and 5 '*total agreement*'. The data collection technique was the online surveying. Qualitative methods like face to face interviews were used to elicit the point of view of the clients. The academic results obtained by the students were also considered. This research scenario is depicted in Fig. 1.

In the academic years 2016–2017 and 2017–2018, PBSL methodology has been used in Software Education as a training method in several ways.

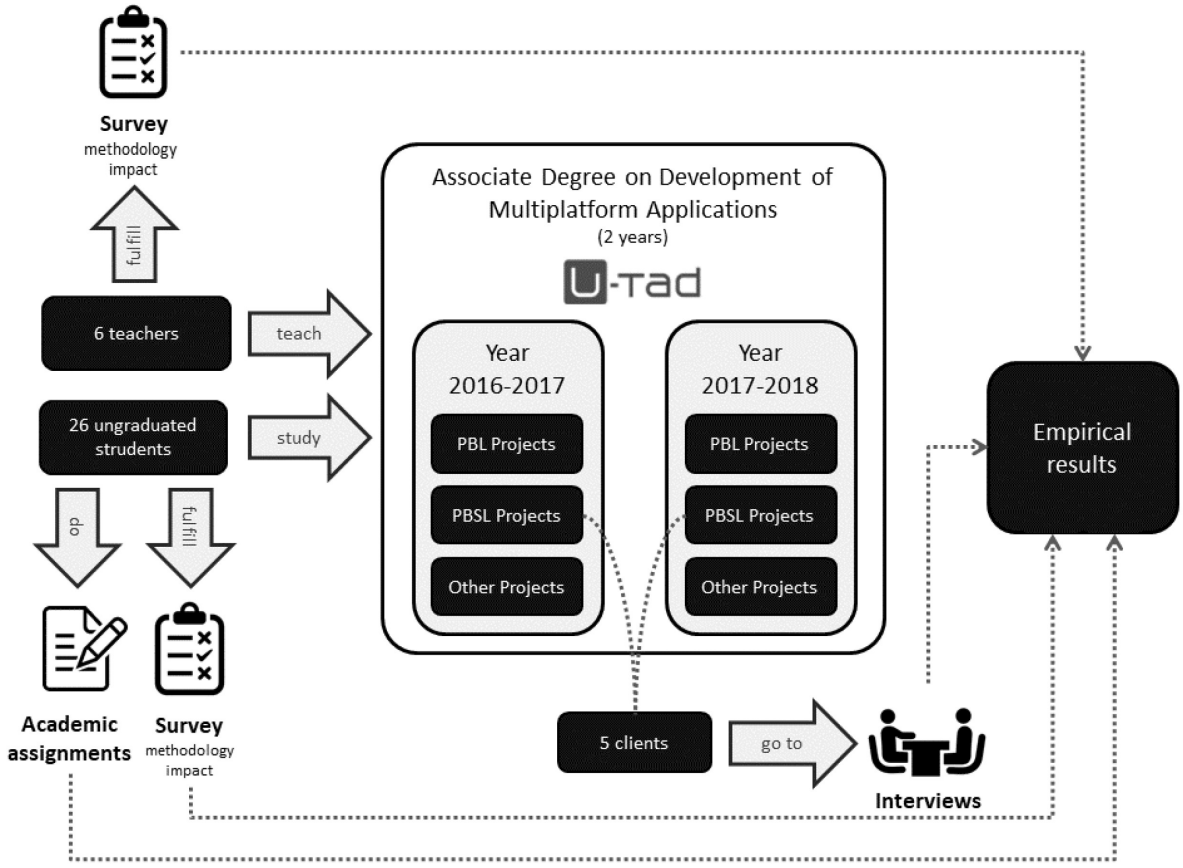

Fig. 1. Research scenario.

Observations for this research have been collected during the two years. The most representative student projects developed during this period are described in Table 1.

3. Results

Both the products developed by the students in their projects and the PBSL methodology used during the development process have been valued very positively by all the actors involved in the study: students, teachers and clients.

To fully understand the students' point of view, the used survey is described next. It is divided into five sections, whose results are presented below. The first two sections aim to detect the opinion of the students regarding the use of the methodologies applied in their projects, after their experience during the course. The average scores indicated by the students are shown in Table 2 for PBL methodology and in Table 3 for PBSL methodology. In the case of PBL, the item '*PBL facilitates the acquisition of soft skills (communication, teamwork, etc.)*' is the best valued with an average score of 4.63 out of 5, followed by '*PBL enhances your motivation*' with an average score of 4.44 out of 5. The worst valued item is the one related to participation in the classroom (3.94). In the case of PBSL, '*The exploitation of the products developed under PBSL stimulates your motivation*' is the best valued with an average of 4.19 out of 5. The item '*The relations with the clients working under PBSL are enriching*' is the worst valued one (3.81).

The third section of the students' survey identifies the most motivational elements to study when using PBSL. To this end, the students were instructed to rank the different elements from 1 to 7 according to their motivation, being 1 the most important element and 7 the least important one. Fig. 2 shows a percentage distribution diagram where students' priorities are displayed. '*The development of a real product*' is the element chosen as first choice by the largest number of students with a 31.3%, followed by 25% of students who indicate that '*The usage of the developed products by the final users*' is a motivating element (see Table 4). '*The usage of real technological ecosystems*' is the least motivating element for students, 43.8% of them chose this element as the less motivating.

The fourth section of the students' survey aims to obtain the methodological preference among PBL, PBSL and the absence of both, after having worked during two years with these methodologies (see Fig. 3). Results indicate the preference of students

Table 1. Projects performed during academic courses 2016–2017 and 2017–2018

Product	Client	Context	Organization	Status
Web app to raise people's' awareness to their ecological footprint.	*Fundación Vida Sostenible* [15], a foundation focused on the promotion and development of responsible lifestyles from the ecological point of view.	The app was developed as practical work in the web development subject.	The students were divided into groups of 5 people and each group made the requested app. The product best valued by the client has been finally implanted.	Production [16].
Android app to improve the communication of children with Autism Spectrum Disorders (ASD).	*TEAyudamos* initiative [17], one project of the *Hospital Universitario de Fuenlabrada* focused on the usage of augmentative communication with children population suffering from ASD.	This app was developed as Final Degree Project.	This app was developed by three students.	Deployment phase.
Desktop app to request the application of funding for social projects	Council of Torrijos, a town of Toledo (Spain)	This app was developed as practical work in the programming and databases subjects.	The students were divided into groups of 5 people and each group made the requested app. The product best valued by the client was finally implanted.	Production
Android app to locate canteens, shelters and social centers.	ACCEM [18], an NGO focused on the attention of refugees, migrants and people on situation or risk of social exclusion.	This app was developed as Final Degree Project.	This app was developed by one student.	Deployment phase.
Android app to facilitate the assistance and management of events for non-violence.	Jai Jagat [19], a platform that brings together organizations and people committed with the objective of promoting the JAI JAGAT 2020 in Spain.	This app was developed as Final Degree Project.	This app was developed by one student.	Deployment phase.

Table 2. Average scores of the students about PBL methodology sorted from higher to lower

Item	Score
PBL facilitates the acquisition of soft skills (communication, teamwork, etc.)	4.63
PBL enhances your motivation	4.44
PBL facilitates you the acquisition of technical competences (computer programming, interfaces design, etc.)	4.13
PBL impacts favorably in your learning process	4.06
PBL is a methodology suitable to learn software development	4.06
The incorporation of multi-sources evaluation methods (where teachers, classmates and clients provide feedback) into PBL is effective	4.00
PBL promotes your participation in the classroom	3.94

Table 3. Average scores of the students about PBSL methodology sorted from higher to lower

Item	Score
The exploitation of the products developed under PBSL stimulates your motivation	4.19
PBSL is a methodology suitable to learn software development	4.13
The social component of PBSL favors your engagement with the project	4.06
The incorporation of Service Learning (SL) enriches PBL methodology	3.94
The relations with the clients working under PBSL are enriching	3.81

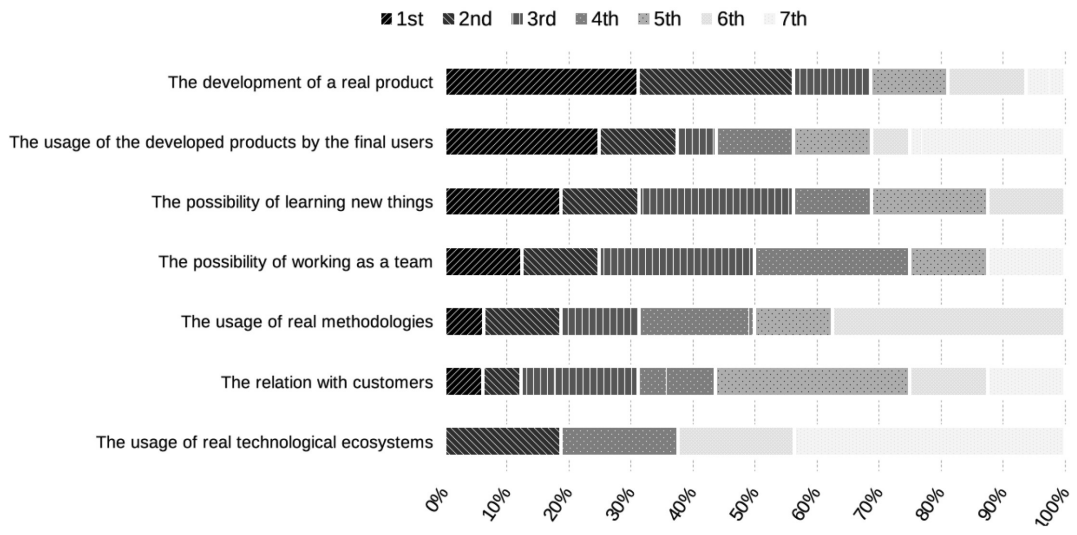

Fig. 2. Distribution of scores related to students choosing each item in a fixed rank position.

Table 4. Percentage of students who choose each item in a fixed rank position

Item	1st	2nd	3rd	4th	5th	6th	7th
The development of a real product	31.3%	25%	12.5%	0	12.5%	12.5%	6.3%
The possibility of learning new things	18.8%	12.5%	25%	12.5%	18.8%	12.5%	0
The possibility of working as a team	12.5%	12.5%	25%	25%	12.5%	0	12.5%
The usage of the developed products by the final users	25%	12.5%	6.3%	12.5%	12.5%	6.3%	25%
The usage of real methodologies	6.3%	12.5%	12.5%	18.8%	12.5%	37.5%	0
The relation with customers	6.3%	6.3%	18.8%	12.5%	31.3%	12.5%	12.5%
The usage of real technological ecosystems	0	18.8%	0	18.8%	0	18.8%	43.8%

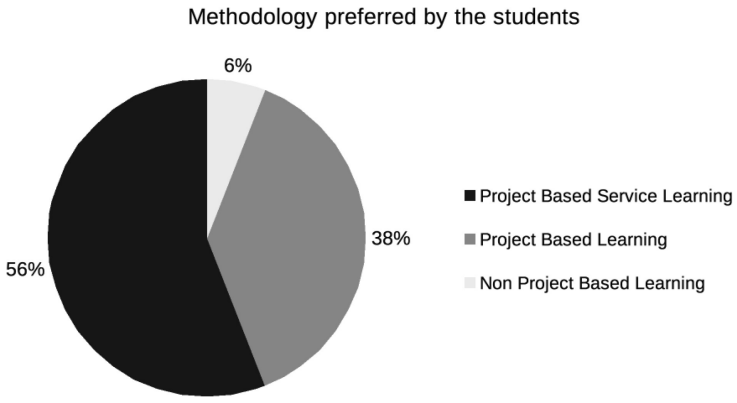

Fig. 3. Methodology preferred by students.

to use methodologies based on projects rather than not using them, highlighting PBSL with 56%.

The last section of the questionnaire corresponds to open comments indicated by the students, shown in Table 5.

To understand the teachers' point of view, the used survey is described next. It is divided into four sections, whose results are presented below. The first section attempts to detect the teacher perception about the impact of PBL and PBSL methodologies on the students (see Table 6), meanwhile the second one attempts to do it on the teachers themselves (see Table 7). All the items are above 4 (out of 5), which indicates that from the teacher viewpoint the impact of these methodologies on both students and teachers is high.

The third section of the teachers' survey explores through open questions the point of view of the teachers about three issues. The first part is related to the advantages and benefits of PBL and PBSL, with statements like "*Students learn working methods very similar to those they will use in their professional career*", "*Students are strongly focused on their goals and increase their*

Table 5. Comments of the students about their experience with PBSL during the course

Aspects that the students liked most about having worked through PBSL	Aspects that the students liked least about having worked through PBSL
"Motivation and involvement in the project and the possibility of encountering real problems."	"Work harder than other teammates but share the same note."
"Teamwork learning, personal realization, practical and real methods."	"Working with different people (different working methods and thoughts), conflicts arising from teamwork, the ethics of some projects."
"Motivation."	"Conflicts that may arise, delivery times."
"Working with real problems, normally in the most guided practices you are not lucky enough to run it. This makes you ready for anything and programs thinking of all possibilities."	"Lack of control of the teacher. It is especially important if the teams are random."
"Teamwork."	"Conflicts."
"Living my first experience with clients and real projects, but under a learning context."	"Deadlines becomes too stressful."
"Real projects."	"Deadlines."

Table 6. Average scores of the teachers about PBL and PBSL impact on the students

Item	Score
Facilitate the learning process	4.60
Enhance the motivation towards the subject	4.80
Contribute to the improvement of technical skills (programming, interface design. . .)	4.20
Contribute to the improvement of personal skills (communication, teamwork. . .)	4.80
Facilitate the achievement of learning goals	4.40

Table 7. Average scores of the teachers about PBL and PBSL impact on themselves

Item	Score
Enhance your motivation	4.40
Contribute to improve your teaching skills	4.20
Enrich you professionally	4.80
How much effort implies the usage of PBL and PBSL	4.20

motivation", "*Students improve their motivation and commitment, as well as personal competences*" and "*Students are more confident in the usefulness of what they are learning*". The second part is related to the disadvantages and obstacles of PBL and PBSL, with comments like "*These methods are not quite applicable in very theoretical subjects*", "*If the project is imposed, the motivational effect could disappear*", "*Some students prefer more passive methods*" and "*From the teacher side, it is required a great amount of work, planning and coordination*". The third part explores differences between PBL and PBSL in terms of motivational impact on the student, with remarks like "*With PBSL they get the same benefits of PBL, but they also perceive they are contributing to make a better world*", "*Many students show a very high involvement in social projects*" and "*Students become better citizens*".

The last section of the teachers' survey asked them if they would use PBL, PBSL or both methodologies in the future. All the teachers replied that they will continue using both methodologies.

Finally, the client's point of view was gathered using face to face interviews. They emphasized the motivation, commitment and professionality of most of the students. They highlighted that the students showed an adequate knowledge of the profiles involved in software development and seemed to be used to participating in real projects, as if they had actual professional experience. In some cases, the students continued their work on the projects even after the end of the course. This was very appreciated by the clients, who also remarked the social compromise of the students.

In addition to these results, there are also academic results that are worth analyzing. The final average mark of the 26 students under analysis is 7.24 out of 10. In comparison, the students enrolled in previous academic years obtained lower grades. In the academic years 2015–16 and 2016–17 the students' final average mark was 6.48, and in the academic years 2014–15 and 2015–16 was 6.82. These last students used very less intensively PBL and did not use PBSL. It cannot be fully guaranteed that the improvement in academic results is due only to the use of the methodologies under study, but everything suggests that these contributed to their improvement.

4. Discussion

The obtained results indicate that both PBL and PBSL methodologies are very appreciated by the actors involved in Software Engineering Education (students, teachers and clients).

The results obtained through the students' survey related to PBL (see Tables 2 and 5) and through the teachers' survey (see Table 6 and open comments) confirm some of the conclusions obtained in other studies about the PBL methodology [2–5, 10, 11, 13]. Our results indicate that PBL helps students to acquire technical skills related to software development and favors the learning process in this Engineering field as also indicated in [10-12]. However, the most prominent benefits shown by our students are related to the improvement of their motivation and the training of soft skills such as communication and teamwork, as described in [2–5, 13]. The latter is an essential improvement, as soft skills are very critical in an engineer's career [14]. Other important results to be noted are that the worst rated item by the students is related to classroom participation, and that some teachers comment about the preference of some students for more passive learning methods. This is something to be considered when using these methodologies. Additionally, some conflicts between teammates have been reported through the survey. This highlights the importance of the caution mentioned in [1–3] about the difficulty of teamwork and conflicts that may arise.

In relation to PBSL methodology, the students' survey results of (see Table 3, Table 4 and Table 6), teachers (see Table 6 and open comments) and clients confirm several conclusions obtained in other studies [6–9, 12]. In addition to the increase of students' motivation and the better acquisition of technical skills, provided by PBL, the development of a real product with a social purpose and its subsequent usage by people who really need it clearly strengthens the students' motivation [6, 12]. Working with a real product close to end users is another of the features most mentioned by our students. Furthermore, both teachers and clients commented favorably on the development of student civic responsibility pointed in [6–9], a personal aspect whose growth is also important.

Teachers and clients also highlighted how students get a better knowledge of the necessary roles within a development team and they are more prepared for their professional career. However, some students complained about the stressful deadlines arising from the relationship with the client entity. The students also indicated that the relationship with the client has not been as strong as they would have liked, although they did not seem to consider it a most important drawback in the use of the methodology. Even so, as noticed in [9], the communication processes between students and clients must be cared to get the most of PBSL. It does seem very important the relationship with the end user, as it makes the students to be aware of the usefulness of the product they are developing, and how it will solve a problem for real users. The certainty that their work in the classroom is focused to develop a real product with a social aspect is the engine that moves our students to work.

After two academic years working with PBL, PBSL and Non-Project Based Learning methodologies, the students have clear preferences in relation to which methodology they are most comfortable with when it comes to learning (Fig. 3). Most of them prefer PBSL as learning method, although a high percentage also recommend learning with projects without a social aim. Very few students prefer working with Non-Project Based Learning methods. Furthermore, the academic records from 2014 to 2018 reveal that students who worked using very intensively PBL and PBSL obtained better marks than others who did not. From the teacher side, it is also mentionable that results related with the methodology impact on the teachers (see Table 7 and open comments) indicate that PBL and PBSL enhance their motivation and enrich them. However, the application of these methodologies also implies a great effort on their part. Anyway, this effort seems to be worthy because all the teachers indicate that they will continue using PBL and PBSL in the future.

These empirical results seem to confirm the main findings obtained in several case studies carried out in Engineering Education: PBL and PBSL are highly suitable in Engineering Education [1–5, 7, 8, 10–13]. In addition, this empirical study reveals that the social component of PBSL provides added value for PBL, as mentioned in [7, 8, 12], and therefore, it is favorable to incorporate PBSL in the classroom.

Based on this empirical research, carried out through qualitative research instruments like surveys and interviews, as well as on the experience acquired in the two years of study, we have elaborated a set of recommendations about critical issues that should be cared when incorporating PBSL in Engineering education, particularly in Software Engineering Education.

(a) *Project selection*: Many NGOs and associations need software products to make their work easier. In our experience, there are more projects than available teams. In fact, several project proposals were not selected. This fact is positive for the PBSL success because students and teachers have a wide variety of

projects to choose. A choice close to the interests of the students is one of the aspects that has proved as crucial after these two years. It is recommended to select a project: (a1) with an appropriate scope, it should be achievable in the available time; (a2) that can be done with technologies aligned with the curriculum of the course; (a3) driven by a strong and clear social need; (a4) that allows to bring the project's beneficiaries to the classroom.

(b) *Communication with clients and end users*: Using the real-life scenario provided by PBSL, students can participate in and develop projects that can be used by NGOs and associations. Real projects with a value-added for their curriculum and with real life causes and requirements. Knowing firsthand the needs of someone who needs help has greatly motivated our students during the projects. It is very good that the students have a direct communication with the clients, who usually receive the work from students with a high degree of gratitude. It is recommended to ask clients for the following compromises: (b1) full description of the system functionalities, (b2) periodic meetings to review the results with clients and end users, (b3) testing of the application; (b4) any other tasks that can be necessary during the project development.

(c) *Provision of technical resources*: Software Engineering projects may require less resources than Engineering projects in other fields, but they still require critical resources such as servers, software licenses, hardware devices, etc. Working with PBSL, it can be easy to request and eventually receive funding both from private and public sectors public. The following actions are recommended: (c1) apply for grants from foundations and/or public calls; (c2) dissemination of the project in the media; (c3) carry out crowdfunding campaigns.

(d) *Sessions performing*: Using PBSL involves a lot of work outside the classroom, but also during the class. In our experience, teachers highly skilled and motivated with PBSL are strongly necessary to get the most from this learning method. It is recommended to conduct the following activities during the sessions: (d1) training, teacher gives theoretical lessons about the technologies or methods to be used; (d2) self-training, students continues studying the technologies or methods needed; (d3) working, students advance in the development on the project; (d4) follow-up, teacher reviews the students' work, solve questions and give feedback; (d5) demonstration, clients and stakeholders are invited to review a demo of the application and provide feedback.

(e) *Conflicts prevention*: The conflicts between classmates may due to perception of unbalanced workloads, differences in opinions, stressful deadlines and so on. In any case, these conflicts can dynamite the success of PBSL. During the two years, different situations have arisen where we have learned that it is important: (e1) a carefully selection of the team members; (e2) performing of retrospectives at the end of each work cycle to found personal problems and its solutions; (e3) provision of training in feedback techniques to communicate assertively their opinions.

(f) *Evaluation methods*: When teachers are the only evaluators, the evaluation system may be perceived as unfair or incomplete by the students. In PBSL, teammates, clients and other stakeholders are usually highly involved in the evaluation process providing useful and accurate feedback. Normally it occurs informally, but it could be useful to gather systematically these feedbacks. The difference observed these two years of student feedback and learning when we applied 360 evaluation to when we didn't, is notorious. A 360 degrees evaluation system is exhaustive and could be enriching for students. So, it is recommended to include in the evaluation process the assessment of: (f1) teachers; (f2) teammates; (f3) clients, (f4) stakeholders; (f5) the student himself.

5. Conclusions

After the experience gathered during the two years of teaching with these methodologies, the observations made during the classes and the empirically obtained data in this research, the main conclusions found in this contribution are as follows:

- The student's motivation and the development of their soft skills are improved through PBL.
- PBL helps students to acquire technical skills related to Software Development.
- The management of PBL is critical due to the difficulty of teamworking.
- The development in PBSL of a real product with a social purpose is highly motivating.
- PBSL helps to develop student's civic responsibility and social values.
- The management of PBSL is critical to improve communication between students and clients.
- Software Engineering students prefers learning methodologies oriented to projects (social or not).
- The social component of PBSL adds value to PBL, consequently PBSL is even more recommendable.

- PBL and PBSL seem positive for the academic performance and the grades of the students.
- PBL and PBSL increase the effort of the teachers, but they think it is worthy because of the benefits.

Moreover, several recommendations about the following issues have been provided: project selection, communication with clients, provision of technical resources, sessions performing, conflicts prevention and evaluation methods.

However, this case study has several limitations that must be considered. The size of the sample forces us to take previous conclusions with prudence. It hinders the establishment of a causal link between Project Based methodologies and positive learning outcomes. Nevertheless, this empirical research, together to previous studies, invite to think that the principal conclusions of this contribution are correct: PBL and PBSL methodologies are highly suitable in Software Engineering education and PBSL can expand the benefits of PBL.

Finally, as Future Work, the PBL and PBSL case studies that have being carried out in the academic courses 2017–18 and 2018–19 period will be presented to continue the research. Also, PBL and PBSL case studies that have been performed in the Software Engineering degree and post-degrees will be described. 360 degrees evaluation methods will be incorporated to several case studies and its impact will be evaluated. These empirical researches will strength the conclusions presented in this contribution and will allow the expansion of the elaborated guidelines to perform PBSL in Software Engineering Education.

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Daniel López-Fernández is Software Engineer graduate and Software & Systems PhD by the Universidad Politécnica de Madrid and Coaching master by the Universidad Camilo José Cela. He is the coordinator of Development of Multiplatform Application associate degree and teacher of Software Engineering degree of U-Tad. His main research interests include the application of active learning methods and the study of motivation in Engineering Education and the usage of agile methodologies in professional environments.

Laura Raya is MS degree in Computer Science, MS degree in Computer Graphics and PhD degree in Computer Science from Universidad Rey Juan Carlos. She is professor and researcher at U-tad. She is the head of the master's degree and the manager of Virtual Reality projects. Her primary research areas are virtual reality, haptics devices, data visualization, gamification and the benefits of virtual immersion in health.

Fernando Ortega is Software Engineering graduate and Computer Sciences PhD by the Universidad Politécnica de Madrid. He is professor and researcher at U-tad. His main research fields are machine learning, data analysis and artificial

intelligence. He has published several papers in the most relevant international journals. He also actively collaborates in various projects with technology companies.

Jose Jesus García is B.S. degree and master degree in telecomunications engineering and PhD degree in telematics, in 2002, from the Universidad Politécnica de Madrid. Currently, he is the head of data programs and research coordinator at U-tad. His main research fields are educational technology, virtual worlds and virtual reality. He has also been an external advisor for technology companies.