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LEARNING SCRUM THROUGH PBL

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Every year more than a million project managers are needed worldwide. Therefore, it's crucial that recent graduates have comprehensive knowledge of state-of-the-art approaches in project management. In the case of contexts characterized by uncertainty and change, agile project management is especially appropriate. It is an eminently practical philosophy, based on action and oriented to the rapid achievement of results. Inexperience limits the ability to understand the concepts and importance of agile methods. Therefore, learning methods capable of providing efficiently agile knowledge and practical skills are of particular interest. This study addresses this problem by proposing a training approach to learning Scrum through PBL. We suggest a process that combines self-learning, supervision, and practical application. This approach allows the students to apply agile concepts in a quasi-real environment. Besides, receiving feedback provides students with the opportunity to progressively modify and correct their decisions, gradually improving their knowledge and use of the Scrum framework. The designed process seems to facilitate the achievement of greater capacities for practical application of Scrum project management compared with both traditional learning and previously tested PBL-based approaches.

Keywords: Agile; Project management; Scrum; POPBL; PBL

APRENDIZAJE DE SCRUM MEDIANTE PBL

Cada año se necesita más de un millón de gestores de proyectos en todo el mundo, haciendo imprescindible que los recién egresados dispongan de conocimientos sólidos y de vanguardia en gestión de proyectos. En el caso de los contextos caracterizados por la incertidumbre y el cambio, la gestión ágil de proyectos resulta especialmente apropiada. Se trata de una filosofía eminentemente práctica, basada en la acción y orientada a la rápida consecución de resultados. La inexperiencia limita la capacidad de comprensión de los conceptos e importancia de los métodos ágiles. Por ello, los métodos de aprendizaje capaces de proporcionar conocimientos y habilidades prácticas en gestión ágil a alumnos universitarios de manera efectiva son de especial interés. Este estudio aborda dicha problemática proponiendo un proceso formativo para el aprendizaje de Scrum a través del PBL, combinando autoaprendizaje, supervisión y aplicación práctica. Ello permite al alumnado aplicar los conceptos ágiles en un entorno cuasi real. Además, el feedback proporcionado les permite modificar y corregir progresivamente sus decisiones, mejorando gradualmente su conocimiento y uso del método. Así, se facilita la consecución de mayores capacidades de aplicación práctica en comparación con otros enfoques pedagógicos basados en enfoques tradicionales o en otras propuestas basadas en PBL.

Palabras clave: Ágil; Gestión de proyectos; Scrum; POPBL; PBL

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1. Introduction

As the global economy becomes more project-oriented, there is a widening gap between employers' need for skilled project managers and the availability of professionals to fill those roles. According to the Project Management Institute (PMI), nearly 22 million project management-oriented jobs will be created by 2027 (PMI, 2017).

The traditional project management (PM) approach is rooted in the rationalistic paradigm, which promotes a plan-driven product-line methodology using a standardised, controllable and predictable process (Dyba, 2000; Moe et al., 2010). Thus, it assumes that the team has nearly perfect information about the project requirements, the solutions and the goals (Lei et al., 2017). However, constant and unpredictable change is now the norm in many industries, posing challenges to meeting customers' needs and requiring high adaptability to changing project scopes, deadlines and costs (Futrell et al., 2002). Agile PM addresses the issues of this new context and, thus, Agile methodologies have gained prominence in the last years (Beck et al., 2001; West et al., 2010).

Agile methodologies minimise project risk by focusing on short iterations of clearly defined deliverables to adapt quickly to unpredictable and rapidly changing requirements (Cervone, 2011). Moreover, direct communication with partners is emphasised. However, creating the right relationship with team members and other stakeholders is one of the biggest challenges that project managers face (Bucero, 2004; Pant & Baroudi, 2008; Thamhain, 2004).

To cater to the increasing demand for Agile PM skills and support our students in gaining competencies that are highly valued by the industry, we included Agile PM as core content in the third year of the Bachelor of Engineering in Industrial Organisation programme. While the hard skills of PM might be learned in a classroom setting through simulation and case studies, there are other aspects of the profession that require soft skills (Cervone, 2011). These include interpersonal abilities and understanding the situation and people and then dynamically integrating appropriate leadership behaviours (Strang, 2003). These abilities can only be gained through practice. This is why for the Agile PM educational course, we applied project-based learning (PBL), an active learning methodology that usually involves students in a joint project aimed at solving a problem (Darling-Hammond et al., 2015; Thomas et al., 1999).

Earlier experiences highlight the potential advantages of learning Agile PM through PBL. The main differential benefit of PBL lies in its practical side, as the use of Agile PM approaches in solving problems under quasi-real conditions allows for reaching depth and realism, which are not achievable by traditional means (Araz & Sungur, 2007). However, earlier experiences (Apaolaza et al., 2021) suggest that the design of the pedagogic approach can be determined at the level of the theoretical and practical knowledge that Agile PM students may gain through PBL.

The objective of this paper is to describe and compare the effectiveness of two different versions of a pedagogic proposal based on the PBL methodology for the development of Agile PM skills using Scrum, as suggested by Apaolaza et al. (2021). The reason for this choice is that Scrum is more restrictive than other Agile methodologies, such as Kanban (Kniberg & Skarin, 2010), which may reduce dispersion amongst students with little or no professional experience (e.g. bachelor's students).

2. Methodology

2.1 Research methodology

The purpose of this research is exploratory and descriptive (Robson, 2002). We carried out two case studies, Year 1 and Year 2, with 8 and 10 units of analysis, respectively. Due to the importance of context characteristics, an action-oriented research approach was adopted (de

Massis & Kotlar, 2014; McCutcheon & Meredith, 1993; Yin, 2013). In order to ensure data triangulation (de Massis & Kotlar, 2014), we consulted several data sources, including documentation, observation and interviews. Table 1 summarizes the sources of information used.

Table 1: Sources of information

Data collection method	Example of application
Observation	The lecturers observed the behaviour and actions of the teams and analysed the coherence between what the students reported they had done and what the lecturers observed.
Documentation	1. The lecturers had access to documentation in which PM monitoring was done. This includes: • Burnup (BU) and burndown (BD) charts • Scrum boards and daily meeting minutes • Review meeting minutes • Retrospective meeting minutes • Weekly meeting minutes. 2. Final report, presentation and individual defence: the latter was especially useful for assessing individual knowledge acquisition and individual engagement.
Interviews	Unstructured and semi-structured meetings between lecturers and individuals/teams: we distinguished two types of meetings: • Project-tracking meetings with the team's coach • Technical meetings with experts in the field.

A mixed methodology that considers both a quantitative and qualitative approach was adopted. We used grades to analyse the evolution of the students' understanding of the subject. Here, it must be noted that the PM grades are not directly comparable, as in Year 2, a hybrid approach that combined predictive (high-level) and iterative (operational-level) PM was implemented. Furthermore, 20% of the grade in Year 2 related to PM reporting during the PBL period.

In addition to the quantitative analysis, we carried out a thematic analysis of the answers provided by the students for the individual defence. The thematic analysis was organised around two questions: (1) what difficulties did the students experience in implementing the Scrum management framework and (2) what actions did they take in the current project or would take in future projects to overcome the identified difficulties? We understand that the answers to these two questions are good indicators of the level of theoretical and practical knowledge the students gained on the subject.

Finally, we complemented the analysis with data obtained from observations. To avoid bias, the impressions we gained from observations were regularly discussed amongst the lecturers' team.

The data analysis aimed to assess whether the changes introduced in Year 2 after the experience gained and the conclusions drawn in Year 1 resulted in improved Scrum PM skill development. For more details on the differences between the pedagogic designs, see Table 2 in the following section.

2.2 The PBL approach

The case studies presented here are PBL experiences in a university environment. They are based on previous experiences (Apaolaza et al., 2015; Apaolaza et al., 2016; Apaolaza et al., 2021; Balve et al., 2017) and intend to improve the educational proposal by maintaining strengths and tackling identified weaknesses. It is important to note that improvements are limited to the university's pedagogical approach, which means that the challenge must be solved in teams and include most semester subjects. Furthermore, these PBL experiences are framed within a limited period, and the results are completely dependent on the teams' managerial capabilities and decisions.

Theoretical background

Literature on previous experiences suggests two main challenges: (1) reducing the risk of dispersing and/or control loss, and (2) narrowing the PM approach (Apaolaza et al., 2021). Ideally, a team that adopts Scrum as a work tool should not do anything special to achieve this goal. Furthermore, this would provide the opportunity to deepen the learning and management of Scrum. To this end, the following main action points were raised:

- Start from a more prescriptive approach—Scrum—and simplify the requirements of the methodology. This is intended to reduce the likelihood of teams becoming disoriented and to release resources and/or capacity for other aspects of the approach.
- Due to the eminent practicality of Agile PM in general and Scrum in particular, the authors decided to include a Scrum simulation workshop in addition to the fundamental concepts.
- Strengthen the supervision of the PM process to better guide the teams in their learning process and detect significant errors and deviations early.

In brief, we looked for greater orientation towards practical use, trying to ensure that teams concentrate their efforts on this. Supervision is an aspect of special interest for this enquiry, as previous works highlighted two key aspects for success: the organisation of the supervision and the availability of supervisors, as they must assist the teams throughout the process. Thus, it is essential to determine the characteristics of the supervision. Consequently, we defined a specific process for this new experience based on the lessons learned in the past. This approach is further described in the following section.

2.3. The cases and pedagogic proposals

The cases consisted of 8 Year-1 and 10 Year-2 teams working on a multidisciplinary project, including knowledge of finance and international commerce, logistics, quantitative methods for industrial organisation, optimisation techniques and tools and PM, between the end of November and beginning of February. Although working on a multidisciplinary project involving different subjects mimics a real-world project relatively well and therefore poses a management challenge, the students' previous experiences highlighted the relevance of a good problem definition (Apaolaza et al., 2016; Apaolaza et al., 2021). Taking this into account, the lecturers tried to align the subjects' sub-objectives to a broader objective. In this case, the project's objective was to redesign a certain company's supply chain to make it more competitive. Moreover, the PBL had the following sub-objectives:

- Identify countries that are the main manufacturers for the proposed company (importer) and discuss their suitability in the current market situation;
- Select the distribution warehouse location and define and optimise the warehouse;
- Explore Power BI as a business intelligence tool for the company.

Considering the improvement opportunities identified in the previous section, the PBL methodology and, in particular, the contents of PM were modified. Table 2 shows the main differences between the original (Year-1) and the improved (Year-2) approaches.

Table 2: Comparison of the main contents, activities and deliverables of the PBL in Year 1 (original) and Year 2 (improved)

Milestone	Content/activity/deliverable	Team/individual	Year 1	Year 2
0	Agile + Scrum fundamental concepts	Team	X	X
	Scrum simulation practice	Team	-	X
	PM approach design*, initial version + feedback**	Team	X	X
	PM approach design*, improved version (optional) + feedback**	Team	X	X
1	Round table discussion with experts	Team	X	X
2	Overall progress monitoring and control (Logistics II subject)	Team	X	X
3	Upload final document	Team	X	X
	Presentation + debate	Team	X	X
	Individuals: defence	Individual	X	X
Continuous	Weekly progress reporting and regular feedback on it	Team	-	X

Note: the main differences related to the Scrum approach are highlighted in grey. (*) Comparable: the Year-1 deliverable and the Scrum part in the Year-2 deliverable. (**) More detailed feedback in Year 2.

The students had to work in a time- and resource-constrained environment. Considering their lack of experience, the lecturer team defined a framework to guide them throughout the entire period. Before the project kick-off, the students participated in the abovementioned workshop to work with Agile and Scrum fundamental concepts. This workshop included a Scrum simulation practice so that the students could obtain more realistic insight into Scrum. Shortly after the project kick-off, the students had to reach Milestone 0. Two weeks after Milestone 0, they had an optional feedback session (Milestone 1), which had to be requested by the teams. The aim of this milestone was to compare their approach with that of the experts to address the project objective. A couple of weeks before the final milestone, the students had a compulsory feedback session with the logistics experts. The final milestone included a full report and presentation. Additionally, the students had to defend their work in a debate in front of the customers—in this case, the group of lecturers. Finally, the students were subjected to an individual evaluation to assess the individual learning achieved through the project.

The teams had the possibility to consult the experts on the technical aspects of the subjects during the process. This was limited to a maximum of two one-hour sessions per expert, which sum up to 20 hours of optional coaching sessions per group. Apart from this, the PM lecturers

designed a supervision approach to guide the teams throughout the process of designing, applying and improving their methodology, as explained below.

The PM supervision process

First, the teams had to develop their Scrum-based PM proposal in Milestone 0, including:

- The project's overall perspective through a hybrid approach that combines high-level (project life cycle—predictive approach) and operational-level (Scrum—incremental/iterative approach) strategies.
- Complete and consistent integration with the generic managerial approach (definition, planning, execution, monitoring and controlling, and closing).

After receiving feedback, the teams were given the opportunity to improve and resubmit their PM design for a new evaluation and further feedback. This was mandatory for the teams who did not meet the minimum requirements of the deliverable but optional for those who did.

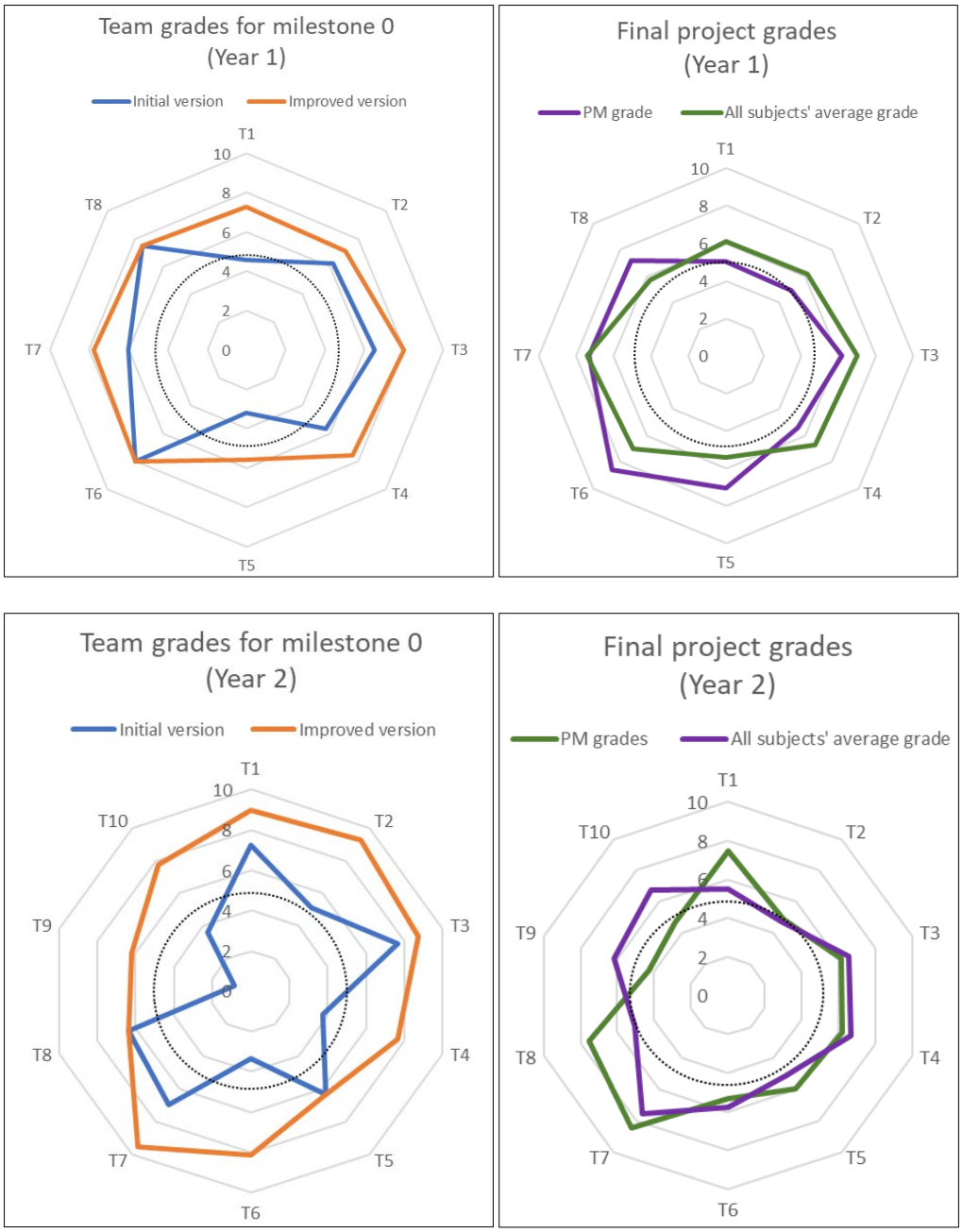
It is considered essential to extend the teams' attention to the project's managerial side beyond Milestone 0. For this purpose, the students had to report to the lecturers their project execution and tracking in a timely manner so that they could receive valuable feedback. Finally, meetings with the teams to facilitate learning were also included in this process, especially regarding communication and understanding.

3. Results

3.1 Quantitative results

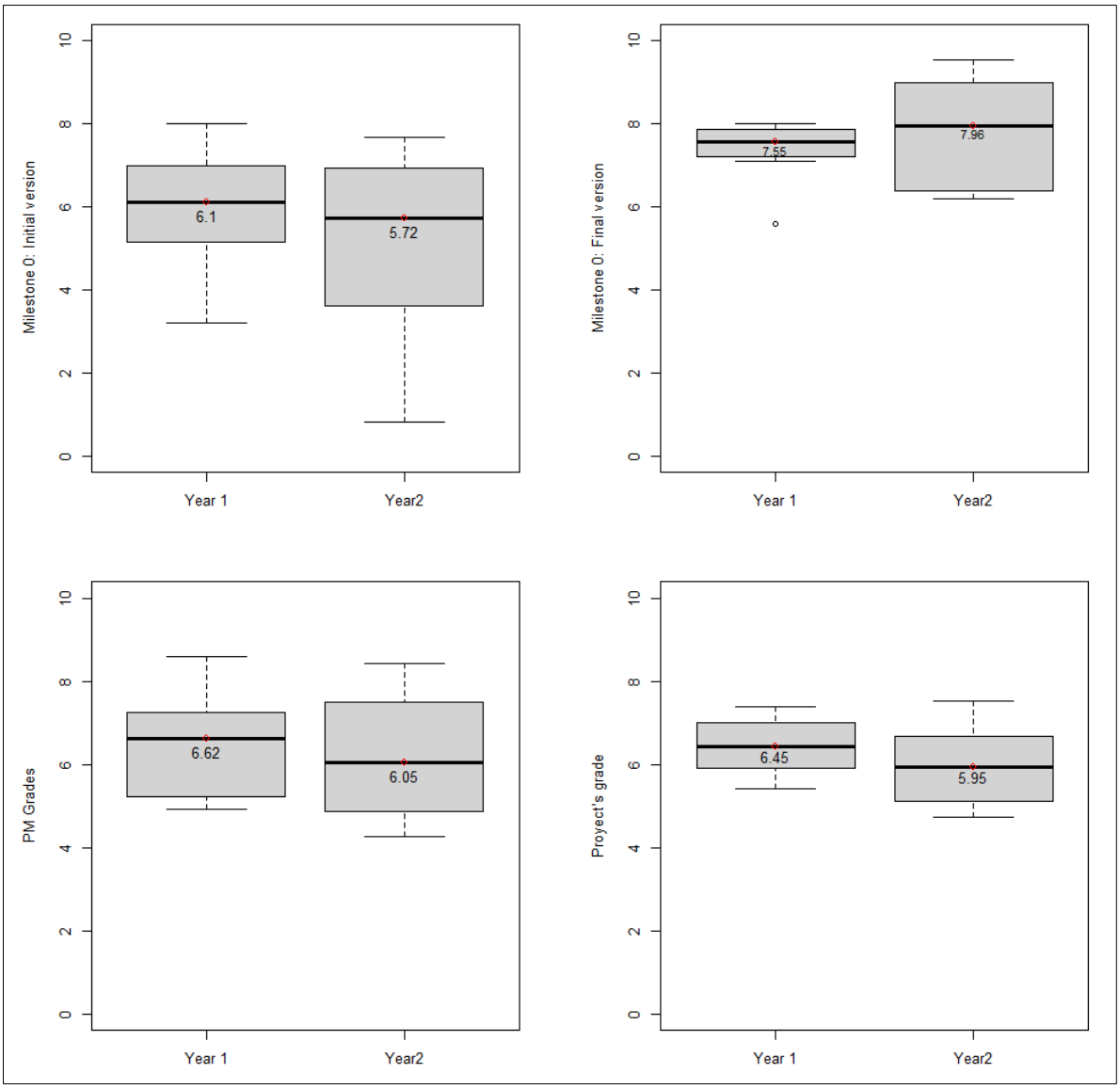
Figure 1 presents the grades that the teams received in Years 1 and 2, and Figure 2 shows the variations in grades. The values show an overall decrease in grades from Year 1 to Year 2, except for the improved PM design delivered in Milestone 0, where the teams obtained higher grades in Year 2. The grades for Year 1 showed smaller variations, i.e. there were smaller differences between the best and worst team grades. In contrast, variations increased in Year 2 and are especially evident in the PM results. Finally, it should also be pointed out that the decrease in the median PM grade is slightly larger than the decrease in the median of all subjects' average grades.

Figure 1: Team grades in Year 1 (top) and Year 2 (bottom)



Note: the grade scale ranges between 0 and 10, where 0 is the lowest and 10 is the highest grade. The minimum grade to pass is 5. This is indicated in the graph by the dashed circle.

Figure 2: The variation in team grades between Year 1 and Year 2



3.2 Qualitative results

The thematic analysis of the students' answers in the individual defence yielded 99 comments regarding the difficulties the students experienced in implementing features of the Scrum framework in Year 2. We asked them to identify and describe two difficulties. However, some students introduced more or less than two difficulties. The difficulties lie in various categories:

Product Backlog Item (PBI) definition (27/99). Estimating the PBI size was the most commonly reported difficulty (20/99). Many teams found that they had underestimated PBI sizes, whereas others also pointed out their 'unrealistic' expectations on productivity during the set working hours. A few students (7/99) went a step further by noticing an insufficient number of specifications for PBIs, either regarding the acceptance criteria or the breakdown of tasks to be carried out and their scope.

Meetings in the Scrum framework (24/99). Holding high-quality meetings or even holding them at all was the second most referred difficulty (18/99). Some students mentioned that

'this method [the Scrum framework] requires a very big commitment', which was not always present, especially as the project went on and delays on project activities and approaching deadlines posed pressure on the team, leaving meetings on a lower priority level.

Some students also mentioned that they had difficulties in understanding the difference between review and retrospective meetings (4/99) and in sticking to pre-defined meeting durations (1/99). Finally, one student found that they had too few reviews and retrospective meetings (1/99) during their project, which is in conflict with the view of another student, who proposed holding fewer daily meetings as a solution to the difficulties encountered regarding meetings as part of the Scrum framework.

PM control and reporting (21/99). Several students mentioned difficulties in using and updating burndown/burnup (BD/BU) charts (9/99) and the Scrum board (2/99) and in filling in project reporting documents (1/99). Others mentioned issues in delivering timely and high-quality PM reporting (5/99). Time was a constraint for this (exacerbated by the fact that some underestimated the time needed for control and reporting in the Scrum framework (3/99)), together with the lack of a systematic (and well communicated) way to name and store project reporting files. Another student found a lack of integration and consistency between operational and high-level PM control (1/99).

Implementing the Scrum master and product owner roles (14/99). The students found it difficult to implement the product owner role (7/99) due to insufficient understanding of the acceptance criteria, the challenge of 'finding errors in [their] own work or in [their] teammates' work' and time constraints. Implementing the Scrum master role (5/99) was also found to be difficult and sometimes required the support of other team members, which led to difficulties in sticking to the pre-defined roles (2/99).

The iterative and customer-oriented approach of Scrum (8/99). The adaptive character of Scrum was pointed out as a difficulty, especially regarding the updates of, e.g. backlogs and acceptance criteria (5/99), where the issue of adapting to iterative planning (1/99) was also highlighted. In addition, the wrong prioritisation of PBIs in the project backlog was mentioned (2/99).

Others (5/99). Some students experienced difficulties in the distribution of workload between the team members (2/99); in some cases, resources had to be divided to work on more activities in parallel to avoid delays; in others, team members had no work to do, as activity dependencies had not been adequately identified. Others also mentioned difficulties in deciding on an adequate sprint size (2/99). Finally, one student experienced insufficient understanding of the Scrum framework (1/99) as a difficulty.

Table 3 provides an overview of the difficulties students in Year 2 experienced in implementing the Scrum framework. The reported difficulties provide interesting insights into the varying (individual and team) learning levels achieved by the students. The reported problems can refer both to situations overcome by the team and to problems that were not solved.

We observed significant differences in the types of comments collected. While some refer to doubts about basic concepts, others are related to the practical application of the method. It is in relation to the latter group of difficulties and the proposed solutions to overcome those difficulties (see Table 4) that we observe improvements in the Year-2 students over the Year-1 students. It is relevant to note that the number of difficulties reported (99) is exactly three times higher than the number of solutions proposed (33), showing varying degrees of depth reached in the subject by different students.

Table 3: Difficulties encountered by the Year-2 students regarding the implementation of the Scrum PM framework

Category of identified difficulties	No. of students	Sub-category of difficulties	No. of students
PBI definition	27	PBI size estimation	20
		PBI definition was too general: either the acceptance criteria or the activity breakdown	7
Meetings	24	Holding good quality meetings or even holding them at all	18
		Understanding the differences between review and retrospective meetings	4
		Sticking to the set meeting durations	1
		Too few retrospective and review meetings	1
PM control and reporting	21	The use and updates of the BU/DB charts	9
		Timely and good quality PM reporting	5
		The update of the Scrum board	2
		Time estimation for the implementation of Scrum PM	3
		Understanding how to fill in the documents for PM reporting	1
		Adequately integrating Project Life Cycle and Scrum during project implementation, especially for monitoring and control	1
Implementing the Scrum master and the product owner roles	14	Sticking to the roles	2
		Implementing the product owner role	7
		Implementing the Scrum master role	5
The iterative and customer-centred approach in Scrum	8	Iterative character of Scrum, especially the updates of, e.g. backlogs and PBIs' acceptance criteria	5
		Priorities were not adequately considered in the project backlog	2
		Changing the classical planning approach with the adaptive approach, where planning is done for each sprint.	1
Other	5	Distribution of workload between the team members	2
		Insufficient understanding of the Scrum framework	1
		Deciding on sprint size	2

Table 4: Proposed solutions to the problems reported by the Year-2 students

Sub-category of difficulties	No. of students	Proposed solutions	No. of students
PBI size estimation	20	Consider time for implementing feedback.	3
		Do not expect 100% productivity during working hours (e.g. include breaks).	1
		Do estimations based on statistical data from previous years.	1
		Improve PBI size estimations as knowledge of the project tasks is gained.	1
		Improve activity breakdown.	1
Holding high-quality meetings or even holding them at all	18	Stress the importance of PM.	2
		Reduce the number of daily meetings.	1
		Schedule/plan meetings.	1
PBI definition was too general: either the acceptance criteria or the activity breakdown	7	Get a clearer understanding of the clients' requirements early in the project.	2
		Stress the role of the product owner.	1
		Take advantage of the daily meetings.	1
		Improve the definition of the tasks to carry out.	1
Adaptive character of Scrum, especially the updates of, e.g. backlogs and PBIs' acceptance criteria	5	Stress the role of the product owner.	1
		Write down the necessary updates, e.g. in PBIs' acceptance criteria so that these may be taken into account when planning new sprints.	1

4. Discussion

Our quantitative results indicate a positive impact from providing much more detailed feedback after handing in the initial version of the PM approach in Milestone 0, resulting in better grades for the Year-2 students in the improved version. The larger variation between team grades in Year 2 could be explained, to some extent, by the fact that the teams in Year 2 seemed to feel satisfied with lower grades. As in Year 1, in Year 2, two teams decided not to provide an improved version of the PM approach in Milestone 0; however, their grades were lower (7.5 and 8 in Year 1 compared with 6.33 and 6.39 in Year 2). When taking these two teams from

Year 2 from the calculations, the difference in the median grades for the improved version of the PM approach delivered in Milestone 0 increased by 12.7% and 11.66% in Year 2 and Year 1, respectively. Hence, we can conclude that detailed feedback promotes significant improvements.

In contrast, our quantitative results suggest that adding the Scrum simulation practice and the regular reporting and feedback on it did not provide any advantage to the Year-2 students over the Year-1 students, since the grades were lower for both initial version of Milestone 0 and PM. Nonetheless, the qualitative data gathered through the analysis of documents, observations and interviews suggest that learning results were better in Year 2.

First, the difficulties reported provide interesting insights, as we observe significant differences in the types of comments collected, which reveal varying (individual and team) learning levels amongst students. While some difficulties refer to doubts about basic concepts, others are related to the practical application of the method. Difficulties with basic concepts (e.g. differentiating between review and retrospective meetings or the use of BD/BU charts) denote insufficient preparation for an acceptable level of familiarisation with the Scrum framework before the start of the project. These concepts were explained in class and applied in the simulation practice. In addition, there was a lot of training material available for self-study. Doubts when applying these concepts should have prompted further study and/or a request for support from the experts; however, this was the case only for some students.

Some difficulties regarding the practical application of the Scrum framework (e.g. implementing the product owner and Scrum master roles) could be explained by the students' limited experience and similar profiles, meaning that there was no (outstanding) 'expert' (neither in technical aspects nor in PM facilitation), while other difficulties (e.g. those related to the PBI definition or the iterative and customer-centred approach of Scrum) support our argument that a broad understanding of the framework is not sufficient for its smooth implementation; in other words, practice is essential to acquiring Scrum PM skills. The weekly report and regular feedback on it made the teams keep their attention on PM beyond Milestone 0. In Year 1, a clear loss of attention was observed, as the students concentrated on the rest of the subjects. This was not the case in Year 2. The level of follow-up and its quality were remarkably better in general, and only some groups were the exception. As a result, 82 out of 99 comments referred to difficulties regarding the practical application of the Scrum framework, corroborating the high effectiveness of the changes introduced in the pedagogic design of Year 2.

Second, the proposed solutions to overcome the difficulties regarding the practical application of the Scrum framework (see Table 4) suggest important improvements between Year 1 and Year 2. Almost all the proposals could be foreseen, as they are rooted in common generic problems. However, it was the application that raised specific questions. The interesting point here is that the directions of the proposals are specific. Furthermore, even if some of the proposals are concrete ideas or actions, others point to specific problems but fail when specifying solutions. This shows the difficulty of overcoming the reported problems, corroborating the importance of application in learning. Finally, it is relevant to note that the number of difficulties reported (99) is exactly three times higher than the number of solutions proposed (33), again showing varying degrees of depth reached in the subject by different students. The reason for this is that the pedagogic approach is crucial for fostering higher or lower learning levels between students but is always dependent on students' dedication and effort.

Overall, we can conclude that the three changes introduced in Year 2 resulted in significant learning improvements over Year 1. Given that the study is based on a natural experiment, meaning there are factors that are not controllable (most importantly, students' capacities and willingness), we should not expect to obtain the exact same results if we run the study again on new units of analysis. However, we think that the general results would remain the same,

i.e. the implementation of the Year-2 pedagogic approach will provide significant improvements in learning results over the Year-1 pedagogic approach, as well as over traditional pedagogic methods. We realise that the application of the improved pedagogic approach to the development of Agile PM skills through PBL to other grades within and outside our university may be limited by the specific semester design. Nonetheless, we believe that the improvements we propose (i.e. a Scrum practice simulation, weekly reporting and regular and detailed feedback) can be adapted to diverse contexts to yield positive results in students' learning levels. The dedication required for the supervision task was one of the main concerns. The present study shows that it is possible to provide adequate supervision with reasonable dedication. This fact gives the method greater potential for use.

5. Conclusion

Learning Agile PM (in this case, Scrum) through the PBL approach offers a clear opportunity to achieve higher levels of learning than through traditional methodologies. This study demonstrates that students who managed the PBL project consistently with the Scrum method developed capabilities that went beyond those achievable through theoretical training. In this sense, facing unexpected situations that require quick responses is especially noteworthy. This type of experience provides practice-based learning, thereby developing know-how based on application, which cannot be acquired through traditional learning.

The training method used in this study is founded on previous experiences and. To address the identified shortcomings of previous experiences, this method includes three improvements: (1) a Scrum simulation practice as support for the initial training, (2) more detailed feedback on the PM design and (3) weekly progress reporting and feedback on it. The simulation practice proved valid in facilitating the rapid assimilation of the concepts, thus accelerating application capabilities. In addition, 'forcing' the application of the Scrum framework during the entire project to ensure learning through practice and improved, more regular feedback were crucial for improving learning results from Year 1 to Year 2.

While the pedagogic approach may not be directly applicable in other contexts, we believe that it could be possible to adapt the main characteristics of this improved pedagogic approach to the specific needs and requirements of the semester to improve learning results.

Finally, it is important to note that our method offers an opportunity for improvement but does not guarantee the results. The proper use of Scrum is an essential condition for achieving higher learning levels. In other words, the students' degree of involvement has a significant influence on the learning level achieved.

5.1 Limitations and future

In summary, the improvements added to the original learning method as presented in this document satisfactorily responded to the needs raised. Therefore, we consider that the improved method constitutes a tool capable of effectively providing high learning levels and reaching the application level. However, despite having overcome some of the limitations reported in the literature, other aspects remain unsolved. Some of these limitations have not been addressed in this study, the main one being the dependence of the learning outcomes on the students' involvement. Participation in this type of PBL (i.e. in groups, with the simultaneous participation of multiple subjects) does not guarantee the necessary involvement level of all the students in PM. We therefore consider that the search for ways to guarantee the students' level of involvement at the level necessary to produce the aforementioned superior learning results should be a topic of interest for future analyses.

References

Apaolaza, U., Gutierrez, A., & Amorrortu, I. (2015). Agile project management learning by POPBL methodology: A two-year experience in Mondragon Unibertsitatea. In AEIPRO *19th International Congress on Project Management and Engineering* (2305–2314). Granada: AEIPRO.

Apaolaza, U., Amorrortu, I., & Guallar, F. J. (2016). Aplicación del método Kanban a la metodología Problem Oriented Project Based Learning. In AEIPRO *20th International Congress on Project Management and Engineering* (86–95). Cartagena: AEIPRO.

Apaolaza, U., Lizarralde Aiastui, A., Soto-Gordoa, M., & Kortabarria, A. (2021). Aprendiendo Scrum: Una experiencia basada en POPBL. In AEIPRO *25th International Congress on Project Management and Engineering* (2305–2314). Alcoy: AEIPRO.

Araz, G., & Sungur, S. (2007). Effectiveness of problem-based learning on academic performance in genetics. *Biochemistry and Molecular Biology Education, 35*(6), 448–451.

Balve, P., Krüger, V., & Tolstrup Sørensen, L. (2017). Applying the Kanban method in problem-based project work: A case study in a manufacturing engineering bachelor's programme at Aalborg University Copenhagen. *European Journal of Engineering Education*, *42*(6), 1512–1530. https://doi.org/10.1080/03043797.2017.1350143

Beck, K., Beedle, M., Van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., & Jeffries, R. (2001). *Manifesto for agile software development*. Retrieved from: https://agilemanifesto.org/

Bucero, A. (2004). Smart emotions. *PM Network, 18*(11), 22.

Cervone, H. F. (2011). Understanding agile project management methods using Scrum. *OCLC Systems & Services: International Digital Library Perspectives, 27*(1), 18–22. http://dx.doi.org/10.1108/10650751111106528

Darling-Hammond, L., Barron, B., Pearson, P. D., Schoenfeld, A. H., Stage, E. K., Zimmerman, T. D., Cervetti, G. N., & Tilson, J. L. (2015). *Powerful learning: What we know about teaching for understanding*. San Francisco, CA: John Wiley & Sons.

de Massis, A., & Kotlar, J. (2014). The case study method in family business research: Guidelines for qualitative scholarship. *Journal of Family Business Strategy*, *5*(1), 15–29. https://doi.org/10.1016/j.jfbs.2014.01.007

Dyba, T. (2000). Improvisation in small software organizations. *IEEE Software, 17*(5), 82–87.

Futrell, R. T., Shafer, D. F., & Shafer, L. (2002). *Quality software project management*. Upper Saddle River, NJ: Prentice Hall Professional.

Kniberg, H., & Skarin, M. (2010). *Kanban and Scrum: Making the most of both*. Retrieved from: https://www.infoq.com/minibooks/kanban-scrum-minibook/

Lei, H., Ganjeizadeh, F., Jayachandran, P. K., & Ozcan, P. (2017). A statistical analysis of the effects of Scrum and Kanban on software development projects. *Robotics and Computer-Integrated Manufacturing, 43,* 59–67. https://doi.org/10.1016/j.rcim.2015.12.001

McCutcheon, D. M., & Meredith, J. R. (1993). Conducting case study research in operations management. *Journal of Operations Management*, *11*(3), 239–256.

Moe, N. B., Dingsøyr, T., & Dybå, T. (2010). A teamwork model for understanding an agile team: A case study of a Scrum project. *Information and Software Technology, 52*(5), 480–491. https://doi.org/10.1016/j.infsof.2009.11.004

Pant, I., & Baroudi, B. (2008). Project management education: The human skills imperative. *International Journal of Project Management, 26*(2), 124–128. https://doi.org/10.1016/j.ijproman.2007.05.010

PMI. (2017). Project management. Job growth and talent gap 2017–2027. Retrieved from: https://www.pmi.org/learning/careers/job-growth

Robson, C. (2002). *Real world research: A resource for social scientists and practitioner-researchers*. Oxford: Blackwell Publishers.

Strang, K. (2003). Achieving organizational learning across projects. *PMI® Global Congress 2003—North America, Baltimore, MD*. Newtown Square, PA: Project Management Institute.

Thamhain, H. J. (2004). Linkages of project environment to performance: Lessons for team leadership. *International Journal of Project Management*, *22*(7), 533–544. https://doi.org/10.1016/j.ijproman.2004.04.005

Thomas, J. W., Mergendoller, J. R., & Michaelson, A. (1999). *Project based learning: A handbook for middle and high school teachers*. Novato, CA : Buck Institute for Education.

West, D., Grant, T., Gerush, M., & D'Silva, D. (2010). Agile development: Mainstream adoption has changed agility. *Forrester Research, 2*(1), 41.

Yin, R. K. (2013). *Case study research: Design and methods*. Thousand Oaks, CA: SAGE Publications.

Comunicación alineada con los Objetivos de Desarrollo Sostenible