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LEARNING SCRUM: A POPBL-BASED EXPERIENCE.

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Agile project management methods have played a prominent role in recent years. Certain aspects as adaptability or orientation toward action characterize agile methods, making them especially interesting in high uncertainty and unpredictability contexts. Thus, some agile methods have transcended the software development context thereby reaching a remarkable expansion in various industries. It is the case of Scrum, which also requires the participants' know-how. In the case of people without a professional background, the starting point is different. Besides, learning agile methods is aimed at application, which requires practice. Lack of experience and fictitious application context hinder this purpose. Consequently, the learning process must overcome these obstacles. This study addresses the abovementioned problem when it comes to learning Scrum through the Project Based Learning approach. Eight teams of students competed to develop the best solution through a project to be managed with Scrum. As a result, we reached interesting findings and conclusions that we believe may be applicable in other methods beyond Scrum.

Keywords: Agile; project management; Scrum; POPBL; PBL.

APRENDIENDO SCRUM: UNA EXPERIENCIA BASADA EN POPBL

Los métodos ágiles de gestión de proyectos han jugado un papel destacado en los últimos años. Caracterizados por aspectos como la adaptabilidad o la orientación a la acción, son especialmente interesantes en contextos de alta incertidumbre e imprevisibilidad. Así, algunos métodos ágiles han trascendido el contexto original de desarrollo de software, alcanzando una notable expansión. Es el caso de Scrum, requiere además conocimientos por parte de de los participantes. En el caso de personas sin experiencia, el punto de partida es diferente. Además, el aprendizaje de métodos ágiles tiene como objetivo la aplicabilidad, lo que requiere práctica. La falta de experiencia y la el uso de un contexto de aplicación ficticio dificultan este propósito. En consecuencia, el proceso de aprendizaje debe superar estos obstáculos. Este estudio aborda esta problemática para el caso de Scrum, basándose en un enfoque de aprendizaje basado en proyectos. Ocho equipos de estudiantes compitieron para desarrollar la mejor solución mediante un proyecto gestionado con Scrum. Este trabajo ha dado lugar a hallazgos conclusiones de interés que, además, consideramos que pueden ser aplicables en otros métodos, más allá de Scrum.

Palabras claves: Ágil; gestión de proyectos; Scrum; POPBL; PBL.

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1. Introduction

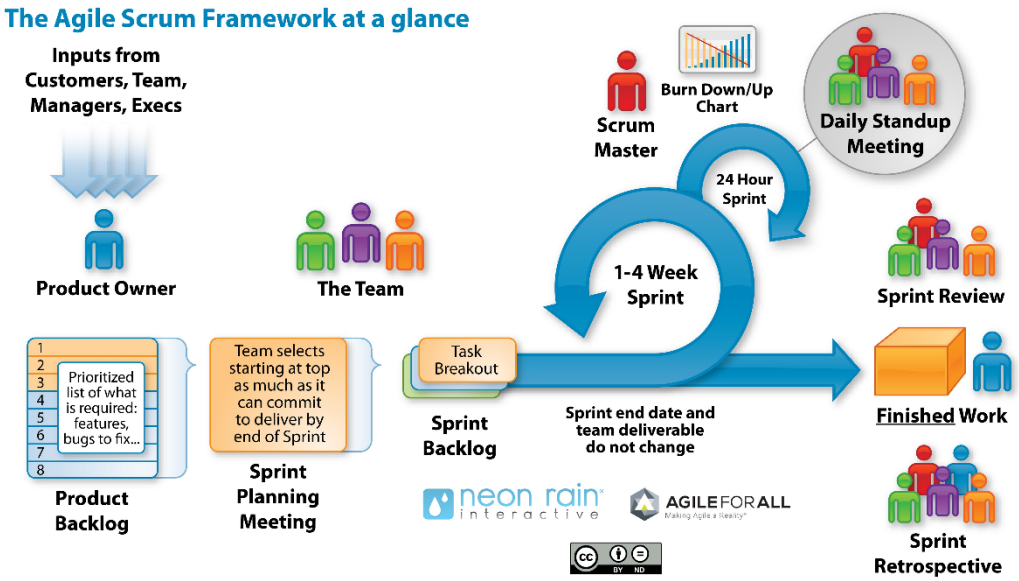
Agile Project Management (PM) emerged as a response to the limitations of the traditional PM methods, which were not suitable for the uncertain and ever-changing conditions in the software programming context (Beck et al. 2001). Thus, a group of practitioners developed different methods within the agile PM philosophy, such as Extreme Programming, Kanban or Scrum. The good results obtained through this new philosophy motivated its rapid expansion to other sectors and activities (Beck et al. 2001; Greening 2010; van Ruler 2015; Streule et al. 2016). One of these new environments in which the use of agile methods continues to spread is the educational sector. For instance, there are specific approaches oriented towards learning Scrum (Bourdeau, Romero-Torres, & Petit 2021). In contrast, other authors have reported experiences with the application of agile methodologies to develop and/or support learning approaches (Sakulviriyakitkul, Sintanakul, & Srisomphan 2020; Vogelzang, Admiraal, & van Driel 2019).

This inquiry is concerned with learning agile PM using the Project Based Learning (PBL) approach in an educational framework. PBL is an active learning methodology that usually involves students in a joint project aimed at solving a problem (Darling-Hammond et al., 2015; Thomas, Mergendoller, & Michaelson 1999). The nature of PBL requires that students within the same team work together to progress (Johnson et al. 2013). Furthermore, this approach allows for deeper and more practical learning since it fosters team reflection and decision making (Bender 2012; Hallermann, Larmer, & Mergendoller 2011; Krajcik & Czerniak 2014), achieving an in-depth understanding of the concepts (Krajcik & Czerniak 2014). The characteristics of this context can be summarised as follows: the learners lack professional experience and are arranged in teams aiming to complete a multidisciplinary project involving topics and objectives from several subjects.

The starting point of this research is similar studies conducted in the past combining agile PM and PBL approaches (Apaolaza, Amorrortu, & Guallar 2016; Apaolaza, Gutierrez, & Amorrortu 2015; Balve, Krüger, & Tolstrup Sørensen 2017). The authors of these studies have identified significant aspects to consider when designing analogous experiences. One of these aspects is transcendent when designing the project: the limitation of dispersion by learners when designing their management system (Apaolaza et al. 2016, 2015). The aforementioned lack of professional experience is an aspect that works against learners in this regard. Consequently, the selection of a more restrictive method may be helpful in reducing the risk of dispersion in the initial stage. That is why the agile PM selected for this experience was Scrum, which is more prescriptive than other agile methods, such as Kanban (Kniberg & Skarin 2010).

Scrum is one of the most popular agile PM methods due to its clarity and simplicity (Schwaber & Sutherland 2017; Sutherland 1995). Similar to other agile PM methods, its use has transcended the framework of software programming (Greening 2010; van Ruler 2015; Streule et al. 2016; Sutherland 2001). In the context of Scrum, projects are embedded in time-boxed periods called sprints, with a duration that usually varies between one and four weeks (Project Management Institute 2017). Sprints are cycles that are repeated over time and progressively produce value for the customer. One of its main strengths in uncertain environments is its adaptability, as it provides flexibility to the changes common in these environments. The projects are managed by teams whose members have different roles in carrying out the tasks, such as a Product Owner (to prioritize the backlog) and the Scrum Master (team facilitator). Another characteristic of Scrum is the meetings, which articulate the project. These meetings were carried out by different participants at different frequencies and for different purposes (Figure 1 shows the generic Scrum framework used in the project).

Figure 1: The generic Scrum framework used in the project



"The Agile Scrum Framework at a glance" by Neon Rain Interactive is licensed under CC BY-ND 3.0.

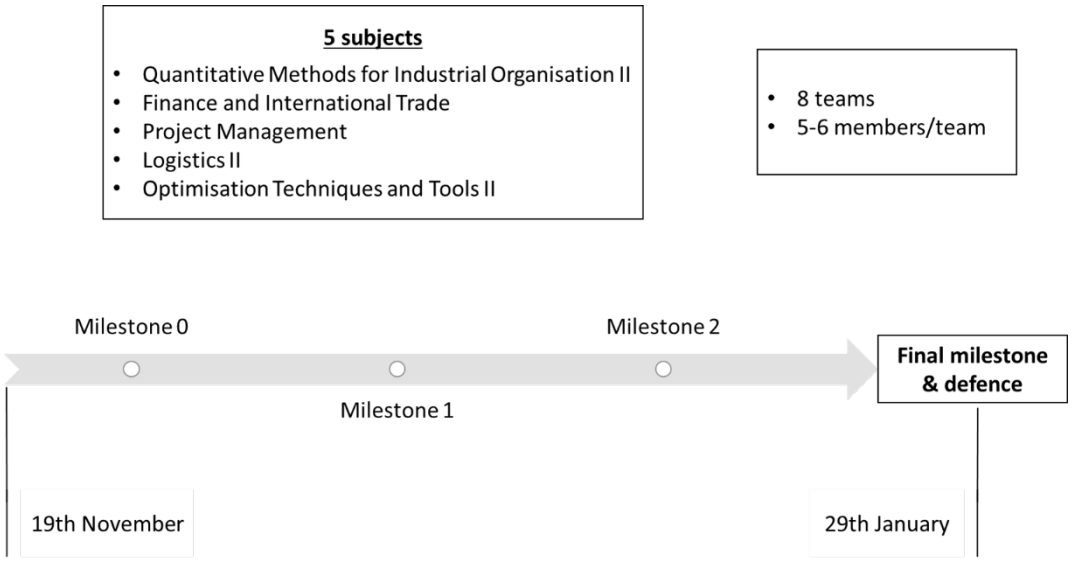
2. Objectives, Background and Design of the PBL Project

In the context of PBL, each team must compete against the other teams to offer the best solution to the problem posed by the teaching team (who also act as experts and customers). The solution must comply with the requirements of all five subjects in a time- and resource-constrained environment, as described in Figure 2. From a learning perspective, the objective is to acquire the expected knowledge and practice levels through the PBL dynamic. According to previous experiences (Apaolaza et al. 2016, 2015), the inclusion of topics from several subjects is a delicate aspect. On the one hand, it provides levels of dispersion and management complexities to mimic real-world problems, thus making the experience more professional. However, this aspect also carries several associated risks. From the organisational point of view of PBL, it is a challenge since it is not easy to elaborate on a multidisciplinary problem compatible with all the associated conditioning factors, such as diverse topics and objectives or the existing limitations in terms of time and resources. This is especially important in a context involving engineering degree students lacking professional experience. The experience of the teaching team is a fundamental aspect of preparing a suitable project for these conditions.

The literature highlights the difficulty of articulating a PBL project involving agile PM methodologies. One critical aspect is the construction of an appropriate methodology for the case. It is essential to consider that in addition to the lack of professional experience, the students approach the project with basic notions of agile PM, which should be enhanced during the project. Consequently, past research shows that, in general, students are not expected to have the ability to design a team management system appropriate for the case. An outstanding aspect of previous experiences is the inclusion of an initial milestone for the supervision and correction of the operating system designed by the team. However, despite being highly valued, it was found that initial milestone delivery may not be enough to guarantee satisfactory results at this level. Thus, Scrum was selected as the management method for this experience (the PM subject will be referred to as the PM-Scrum for the remainder of this article). As this is a more prescriptive method than other agile methods, it is much more restrictive regarding the design of the methodology, thus limiting the risk of mistakes and/or dispersion of the team.

Besides, the Scrum approach also requires a daily monitoring system as a general rule. This way, all the teams have to report their progress and decisions during the execution period of the project. Thus, all teams must report their daily progress and decisions during the project execution phase. Moreover, all the teams use the same software called Triskell (https://www.triskellsoftware.com/) for project planning and tracking, combined with the burnup and burndown charts. Besides, the team is required to permanently store the daily meeting reports and ensure their ease of accessibility. Finally, a retrospective project analysis for the entire period should be carried out highlighting aspects such as initial objectives, results, the process followed and relevant problems, etc. These results and conclusions should be reported in a brief final document.

Figure 2: Overview of the project



The PBL framework involving five subjects and eight teams was designed, as shown in Figure 2. The team size may range between five and six members. The main milestones of the project and their characteristics are briefly described below:

- Milestone 0: Mandatory PM-Scrum milestone to check and correct the managerial approaches suggested by the teams.
- Milestone 1: Optional meeting with the experts to ask questions, clarify doubts and check progress.
- Milestone 2: Mandatory Logistics II milestone to check the status of the group work.
- Final Milestone: Includes several tasks and activities to be completed within nine days, comprising delivery of the final report, presentation of the proposal developed, debate with the other teams and individual defences of the work.

3. Research Methodology

This study is based on the same approach used in previous inquiries with similar objectives (Apaolaza, Amorrortu, & Guallar 2016; Apaolaza, Gutierrez, & Amorrortu 2015). Given the characteristics of the contexts described in the preceding section, the research involved a single case study composed of eight units of analysis (the teams) embedded in the same context (Yin, 2009). Furthermore, the characteristics of the context (management research and contemporary action within its real-life context) recommended the use of an action-oriented

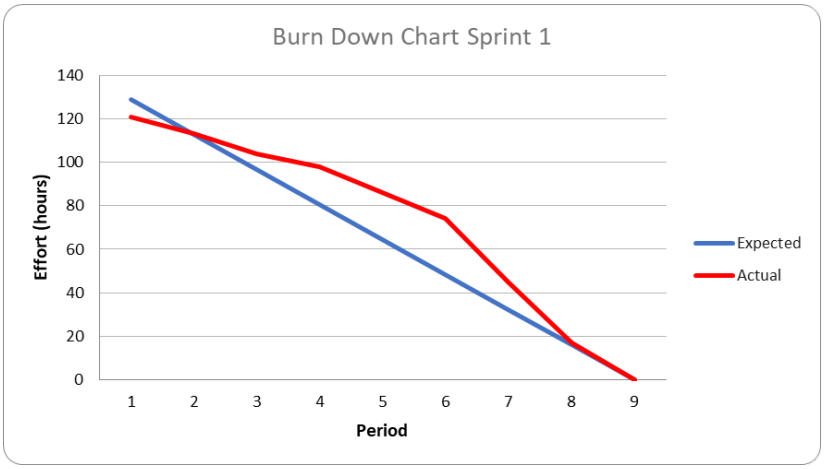
research approach involving a case study (McCutcheon & Meredith 1993; Easterby-Smith, Thorpe & Lowe, 2002; Yin, 2009; De Massis & Kotlar, 2014). Furthermore, because of the need for a deep understanding of the context and the action, observation is expected to be one of the main sources of information. This way, the researchers would have direct access to the information (Wacker, 1998; Rowley, 2002). This case study-based approach is consistent with Robson (1993).

In addition, the purpose of this research is exploratory and descriptive (Robson 2002). It aims to explore and explain a topic, which also requires a profound comprehension of the topic and its context. Another characteristic derived from the context of the research is the need for multiple data sources. This way, triangulation is enabled, thereby enhancing credibility (De Massis & Kotlar, 2014). The use of multiple evidence sources provides more diverse data. Table 1 summarises the data sources used in this inquiry, and Figure 3 shows an example from team T6.

Table 1. Data sources

Source	Examples of application
Observation	In person and virtual meetings: project tracking meetings (tutor of the team) and technical meetings (field expert)
Interviews	Formal: arranged and semi-structured (meetings with tutors and experts); Informal: Unstructured, random contacts.
Documents	Surveys (satisfaction surveys of students and teachers), deliverables (documents with specific scope to be delivered at certain dates), monitoring reports (timely information regarding the status of the project), final report (gathers all the work done by the group), documents for the presentation and defence of the work and written personal defences (very useful in assessing acquired knowledge and individual involvement of students)
Other sources	PM software, burnup and burndown charts (permanent access), presentations and oral defences, e-mails and other communications (source of informal and often 'unexpected' information, which can reveal contradictions, uncover personal perspectives, etc.)

Figure 3: Example of a burndown chart (Team T6, sprint 1)

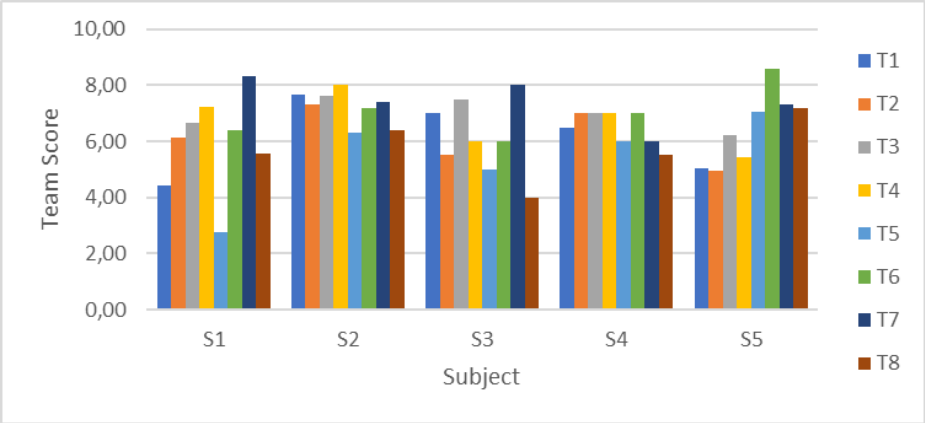


4. Results

In this section, we analyse the results of the teams. We first show the quantitative results of interest for this study. This information, in combination with the qualitative data gathered throughout the observation period, will serve as the basis for the discussion. The quantitative data (i.e., marks) are ranked from worst (0) to best (10) and deployed into two levels: team (PBL and PM-Scrum) and individual (only the PM-Scrum defences). Figure 4 and Table 2 show the marks obtained by each team for each subject and on average. Similarly, Figure 5 shows the marks achieved for the deliverable 0. Finally, Figure 6 and Table 3 displays the marks for the personal defences of PM-Scrum, where the Scrum learning marks are specifically analysed. Starting with the numerical results shown in the previous section, we proceed to their interpretation, considering the rest of the available sources of information.

4.1 PBL

Figure 4: Team PBL marks by subject



Note: Subject 5 (S5) is PM-Scrum.

Table 2: Team PBL marks by subject

Team	Subject					Average
	S1	S2	S3	S4	S5	
T1	4,44	7,65	7,00	6,50	5,02	6,12
T2	6,11	7,30	5,50	7,00	4,94	6,17
T3	6,67	7,60	7,50	7,00	6,20	6,99
T4	7,22	8,00	6,00	7,00	5,44	6,73
T5	2,78	6,30	5,00	6,00	7,04	5,42
T6	6,39	7,20	6,00	7,00	8,60	7,04
T7	8,33	7,40	8,00	6,00	7,30	7,41
T8	5,56	6,40	4,00	5,50	7,20	5,73

Note: Subject 5 (S5) is PM-Scrum.

The group marks of the PBL displayed in Figure 4 and Table 2 show the performance of each team from a general perspective. In this case, there are several notable aspects:

- Team 7 was the one with the best marks, with an average of 7.41/10 points. Teams T6, T3 and T4 achieved similar marks, close to 7/10 points. Among these, team T3 achieved the

most homogeneous results, with a variation of 1.4/10 points between the minimum (6.2) and the maximum (7.6).

- The performances of the rest of the teams were weaker, especially in the case of teams T5 and T8. The differences in the marks between the subjects showed heterogeneous results in the case of T5 and T8: in the case of team T8, the variation was 3.2/10 points (maximum of 7.2 and minimum of 4), while in team T5, the variation shot up to 4.26/10 points (maximum of 7.04 and minimum of 2.78).
- Four teams failed to reach 5/10 points in one subject: T1 (S1 - 4.44/10), T2 (S5 - 4.94), T5 (S1 - 2.78) and T8 (S3 - 4.00). Besides, these teams showed a large variation between their marks, except for team T2.
- Team 2 is a special case; it has one of the smallest variations between marks, with their average results below the mean of the teams' marks.

These results are consistent with the observations and additional evaluations carried out by the teachers involved in the PBL. These aspects were analysed in the cross-evaluation meetings, during which there was general agreement that the team with the highest performance throughout the entire project was T7, followed by teams T6, T3 and T4. The teachers also agreed that the performances of the rest of the teams were heterogeneous and below their potential. Two possible causes were identified: a lack of ability to overcome problems and low team performance.

4.2 PM-Scrum

Regarding PM-Scrum, there are several aspects to analyse. On the one hand, it is important to study the evolution of the marks and the team's behaviour over time. On the other hand, it is important to analyse both group and individual perspectives.

Teams' marks

Figure 5: Team PM marks for deliverable 0

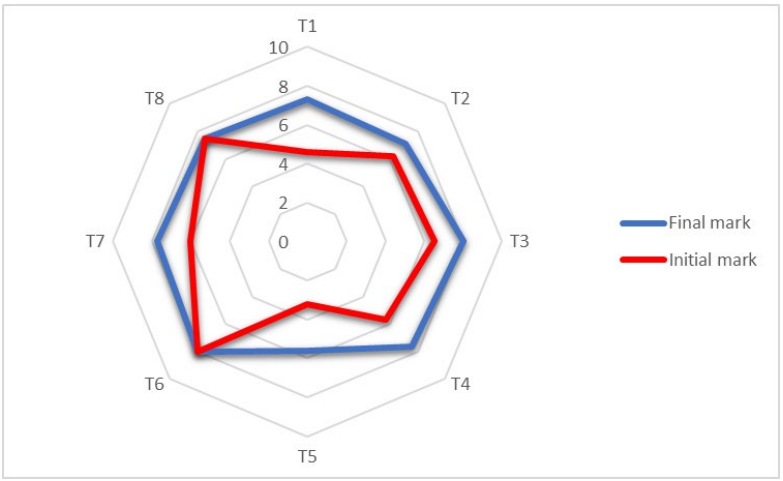


Figure 5 shows the evolution of each team for deliverable 0. There are several aspects to highlight:

- The initial marks for deliverable were very diverse.
- Most of the teams improved their performance mainly due to the corrections and improvements made in the initial approach.

- The two teams with the best marks for the initial round (T6 and T8) showed minimal improvement. This is likely due to their focus directed toward other subjects, thus resulting in a lack of additional efforts for improvement.
- The teams that improved their initial marks did so almost proportionally and maintained similar respective positions. The exception was the T1 team, which showed the biggest improvement (from 4.6/10 to 7.3/10 points).
- The T5 showed the second biggest improvement compared to their initial results. The poor initial performance motivated them to work on improvement with the help of expert supervision. However, despite the efforts made, the final result was not as good as the team expected, positioning itself at the average level for deliverable 0 compared to the rest of the teams.

Team marks

Figure 6 and Table 3 display the individual marks obtained by each member for the PM-Scrum defence, grouped by team. The defence consisted of two questions of a theoretical-practical nature within the framework of the project carried out by each team.

Figure 6: Individual marks of the PM-Scrum defence grouped by team

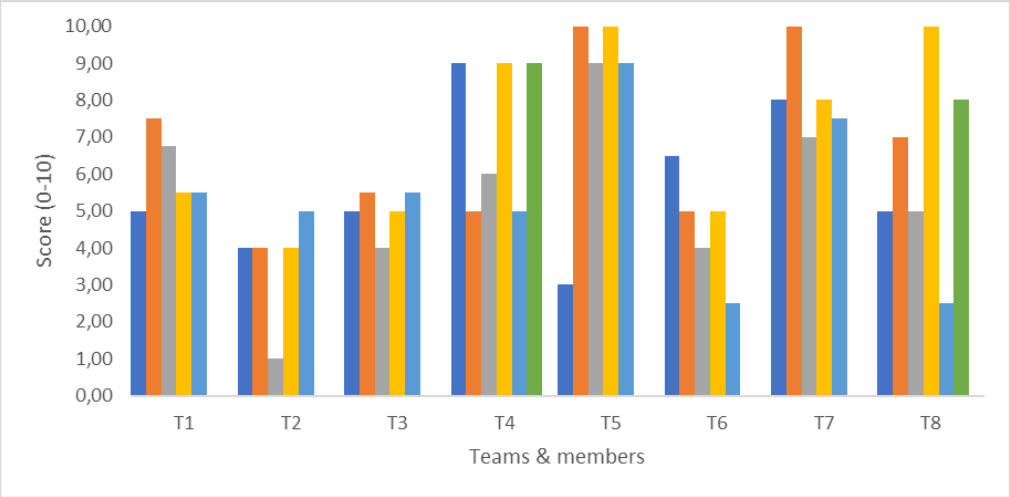
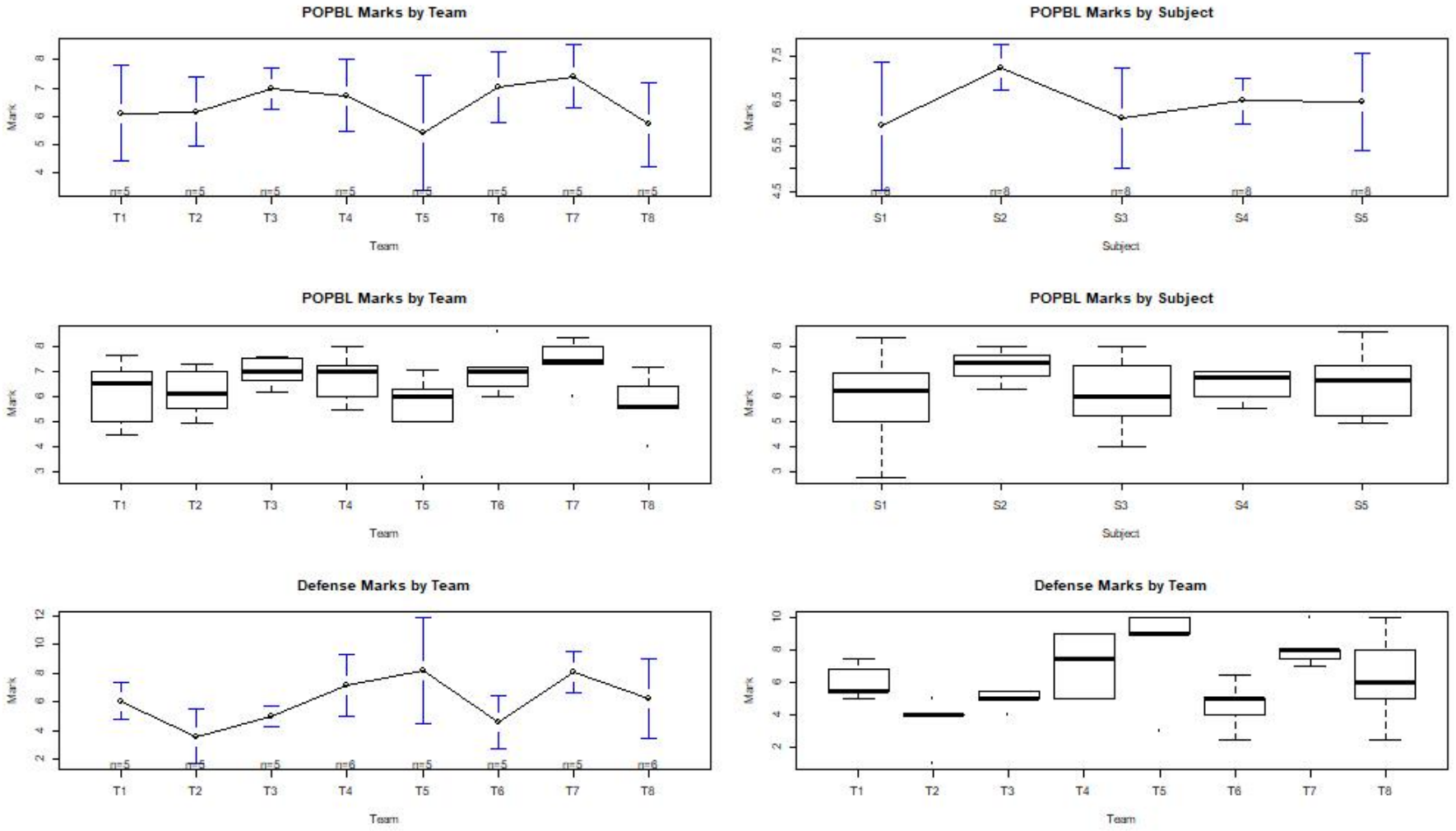


Table 3: Individual marks of the PM-Scrum defence grouped by team

Member	Team							
	T1	T2	T3	T4	T5	T6	T7	T8
1	5,00	4,00	5,00	9,00	3,00	6,50	8,00	5,00
2	7,50	4,00	5,50	5,00	10,00	5,00	10,00	7,00
3	6,75	1,00	4,00	6,00	9,00	4,00	7,00	5,00
4	5,50	4,00	5,00	9,00	10,00	5,00	8,00	10,00
5	5,50	5,00	5,50	5,00	9,00	2,50	7,50	2,50
6				9,00				8,00
Average	6,05	3,60	5,00	7,17	8,20	4,60	8,10	6,25

Figure 7: Boxplot diagrams



5. Discussion

This section presents the analysis carried out based on the results described in the previous section. To facilitate understanding and provide a broad vision we display the results in a boxplot format (see Figure 7). The analysis was carried out from a triple comparative perspective. First, we compared the group marks of both PBL and PM-Scrum to identify possible relationships. Second, we analysed the marks achieved in the PM-Scrum both in the PBL and on average in the defences. The intention here is to analyse the behaviour and learning of the groups throughout the entire process. Finally, we compared the individual marks obtained by the team members on PM-Scrum defences with the average results of their groups. This approach will help to understand the extent of learning achieved on a personal level.

5.1 PBL vs PM-Scrum

The combined analysis of the marks does not allow us to establish a direct relationship between PM performance and the marks obtained. From this perspective, the marks can be misleading and apparently contradictory. The observations and assessments made based on the comparison of the group marks of the PBL and PM-Scrum are explained below.

- Teams T6 and T7 obtained the best results in both management and technical subjects. These are the teams that have best managed the project from an organisational and monitoring perspective throughout the entire period.
- Teams T8 and T5 finally achieved similar results in the PM-Scrum. Nevertheless, it did not allow them to achieve comparable marks in the PBL. In the case of team T8, this was due to the inability to respond correctly to the needs of the rest of the subjects. In contrast, the management problems led team T5 to put in extra effort to improve the initial managerial approach, thereby reducing their dedication to other subjects.
- Team T2 was at the opposite extreme. Despite having significant shortcomings in their PM approach, they have managed to rank in the middle. The team had to make significant extra efforts to achieve this.
- The remaining teams (T1, T3 and T4) scored similar marks for both areas (near 5/10 points); so conclusive deductions cannot be obtained.

Given these results, Scrum seems to be helpful to the teams that have used it properly (T6 and T7). However, this does not guarantee that the results will be good, as there are other key factors (T8). Likewise, it can be concluded that the incorrect or partial use of the method does not necessarily prevent the achievement of acceptable results, although it requires significant effort and ability to cope with uncertainty.

5.2 PM-Scrum PBL vs Defences

Regarding the learning of Scrum, the comparison between the marks of PBL and the defences provides a complementary vision. We found significant differences when comparing the PM-Scrum group marks and the average marks of the defences of each group:

- Team T6 obtained the best result for PBL in PM-Scrum. However, their average result for the defence fell by 4/10 points (4.6/10 points); they had the second-worst group result for the defence, and the marks for all individual team members except one were mediocre. This result is surprising and apparently contradictory since the team that demonstrated better practical handling of the method (which requires theoretical knowledge) obtained low marks for the defence. One possible explanation for this is the prioritization of other subjects when preparing for defences and relegating PM-Scrum to the background, to the

extent of abandoning it. It is also possible that one person had fully assumed responsibility for Scrum-related activities. Consequently, it is concluded that the Scrum learning and/or the analysis of the work carried out from a management perspective was neglected by almost the entire group.

- Team T7 showed great robustness here too. Their marks were the second best in both cases, and this was the team with the least variation between their marks (7.3 and 8.1/10).
- The case of team T5 is striking for its apparent consistency and performance, similar to team T7. However, there are important differences between the two cases. The main difference was that team T7 was able to maintain similar performance levels throughout the project. This allowed them to further develop their practical learning. In contrast, the T5 team started from a noticeably weaker situation, and only at the end of the project were they able to reach a relatively high performance level. This delay prevented them from achieving superior practical learning. In summary, the learning achievement of team T5 occurred mainly at the conceptual level, whereas that of team T7 was complete.
- Team T4 suffered a situation radically inverse to that of team T6. Starting from the third-worst position for the average group PBL result of PM-Scrum, their average result in defence increased to 7.17/10 points, with a percentage increase of more than 30%. The mediocre marks in the application of the method contrasted with the level of theoretical knowledge and the work carried out by almost all its members.
- On the other hand, team T2 obtained the worst marks in the PM-Scrum for both the project and defences. Their average marks were always below 5/10 points, and the marks obtained for the rest of the subjects showed that their efforts were focused on other activities. Consequently, the Scrum learning level achieved was basic on both the theoretical and practical levels.
- The rest of the teams obtained similar marks for their projects and defences. In the case of team T1, the marks for the defences were superior to their PBL PM-Scrum marks, and the opposite happened with teams T3 and T8. However, their results were within a 1/10-point margin, with team T8 being the best.

5.3 Average vs Individual Defence Marks

To facilitate the understanding of the subsequent analysis, it is important to explain that a good defence result implies both theoretical understanding and knowledge of the work carried out by the team. However, a bad result may be due to a lack of theoretical knowledge, knowledge of the work carried out by the team or both. From the analysis of the aforementioned information, the following conclusions can be formulated:

- The T7 team obtained the second-best result and demonstrated homogeneous marks. This result is consistent with the previous ones, demonstrating that all the members of this team performed at their best at all levels throughout the project.
- The T5 team obtained the best average result. Four of its members achieved an outstanding result, but one of them failed (3/10 points). This result is striking because, as stated in the previous section, this team performed the worst among all the teams at the group level. The observations made by the expert have allowed us to conclude that this team achieved a higher level of conceptual learning than the average due to the effort made during the project phase to improve the bad result of deliverable 0. However, the level of learning at the application level is not that high.
- On the other hand, in teams T4 and T8, unequal results were observed among the members. This means that although the average is good, the levels of learning of the subject and/or knowledge of the work carried out were very different at the individual level.

Thus, half of the members of the T4 team barely reached 5/10 points, while the other half obtained excellent marks. In the case of team T8, the marks were even more heterogeneous.

- The marks of the T2, T3 and T6 teams were lower than the rest, showing generally low levels of learning. We conclude that these teams have oriented their efforts toward other subjects to the detriment of PM-Scrum performance.
- Finally, the case of the T1 team was atypical. Both the average result and that of most of the members were near 5/10 points. However, the two people who dedicated the most time to PM and the relationship with the PM-Scrum expert obtained good marks compared to the rest of the team. This pattern was also observed in other teams in which the members in charge of the management tasks achieved the best marks.

5.4 Final remarks

The purpose of the PBL project is to learn based on problem-solving through a project, so it is an eminently practical approach. In this case, Scrum learning was framed as one of the participating subjects. Other subjects act as a means to achieve the rest of the objectives and PM-Scrum acts as an integrator. This experience has shown that the role of this subject is an important aspect since it entails significant threats. As it was the only subject in the first part of the project, the students initially devoted effort and attention to it. However, once the rest of the subjects were introduced after the completion of deliverable 0, the efforts were oriented towards these subjects instead of PM-Scrum, which was neglected in some cases.

In brief, the opportunity to acquire more comprehensive, in-depth and practical learning through this approach is real and makes sense. However, it may lose an important part of its potential. If so, the efficiency of the method remains in the hands of the will and interests of the participants. When competing with subjects whose objectives are tangible and associated with milestones, attention tends to be prioritised in favour of other subjects. We have observed similar realities in real-world experiences in professional contexts, where resource conflicts usually occur between management improvement projects and other technical activities. In professional contexts, the responsibility for prioritising efforts falls on company managers. However, this approach is not valid in the case of groups of students, so it is necessary to look for additional solutions.

The results of this analysis are consistent with the literature and reinforce the idea that it is important to both supervise the configuration of the operating system and limit the decision-making margins of the teams in this regard. Furthermore, the restrictive nature of Scrum compared to other methods has contributed to reducing errors and dispersion in this regard, but even so, the existence of the remaining risk has been evidenced. For this reason, to improve the level of learning in the management approach, it is considered essential to design a mechanism that allows safeguarding the integrity and interest of this subject throughout the entire project.

6. Conclusion

Learning Scrum through multidisciplinary group projects within the framework of PBL has both strengths and weaknesses. Theoretically, this approach has ideal characteristics to enhance Scrum learning. On the one hand, it provides a practical environment comparable to a professional context, where a team must achieve various objectives for a deadline. On the other hand, the prescriptive nature of Scrum limits the risks associated with a non-experienced team when it comes to the construction of an efficient approach. Furthermore, the total versatility of team members should facilitate decision-making and management. Under these conditions, the use of a management method such as Scrum should help to improve the team's

performance and increase its probability of success in terms of meeting objectives. In the context of PBL, the team faces situations that require a combination of technical and managerial skills for resolution. This is a good opportunity to learn Scrum since it is worth from the perspectives of both skill development and practical knowledge

However, the uneven results achieved at the group and individual levels show that despite being true, the above does not necessarily have to materialize as expected. On the one hand, a lack of professional experience and the shortcomings related to the practical use of the method represent an added difficulty when applying an agile PM approach. On the other hand, the teams' decisions regarding how to focus and distribute their capacity among different objectives and subjects are crucial aspects that strongly influence the effectiveness of the method and, consequently, the learning performance. When attention is focused on technical subjects (i.e., project objectives), the team tends to lose control of the project, and the learning level achieved is limited, especially from the application perspective. However, the groups that properly adopt the method are capable of managing their projects with solvency, progressively improving their managerial capabilities and keeping the project under control.

In brief, the results of this experience indicate that this framework offers suitable conditions for learning the method in quasi-real environments. However, these conditions are not sufficient to guarantee the desired higher levels of learning in all cases. Consequently, it is necessary to modify the process to provide it with the necessary mechanisms to guarantee the achievement of these objectives by avoiding the impact of the temporary interests or priorities of the team over Scrum learning performance.

6.1 Limitations and Future Research

We believe that this study provides interesting findings related to learning the Scrum methodology in the context of students with little or no experience. However, the work has a series of limitations, so we invite other researchers to conduct additional studies to address these limitations.

First, this experience was carried out in a very specific context: a PBL framework consisting of a multidisciplinary project involving five subjects to be performed by a team. Based on the results and the analysis performed, we consider that additional experiences with different conditions can contribute to enhancing the learning of Scrum. For instance, reducing the number of subjects involved could lead to groups paying more attention to the management methodology.

The prescriptive nature of Scrum seems to be an advantage when designing the managerial approach. However, it is not enough to guarantee the proper use of the method in the daily reality of the project. This is a critical aspect in learning how to apply the method and consequently in developing practical knowledge and managerial skills. Intensive direct supervision of each team would allow for the identification and correction of shortcomings on the fly. However, this may not be feasible due to the high level of dedication it requires. We therefore consider that, from this perspective, additional and more sustainable alternatives can be valuable in enhancing the potential of this learning approach.

Communication aligned with the Sustainable Development Objectives

References

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., 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

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

Bender, W. N. (2012). *Project-based learning: Differentiating instruction for the 21st century*. Thousand Oaks, CA: Corwin Press.

Böhm, K., & Unnold, Y. (n.d.). Agile learning loops–combining agile approaches in higher education programs. In M. Baptista, P. Isaías, & P. Powell (Ed.) *International Conference on Mobile Learning proceedings* (177-184). IADIS Press.

Bourdeau, S., Romero-Torres, A., & Petit, M.-C. (2021). Learning Scrum: A LEGO®-Scrum Simulation. In *Agile Scrum Implementation and Its Long-Term Impact on Organizations* (pp. 169–189). IGI Global.

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.

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.

Easterby-Smith, M., Thorpe, R., & Lowe, A. (2002). *Management Research: An Introduction*. London: Sage.

Greening, D. R. (2010). Enterprise scrum: Scaling scrum to the executive level. *2010 43rd Hawaii International Conference on System Sciences*, 1–10.

Hallermann, S., Larmer, J., & Mergendoller, J. R. (2011). *PBL in the elementary grades: step-by-step guidance, tools and tips for standards-focused K-5 projects*. Buck Institute for Education.

Johnson, D. R., Renzulli, L., Bunch, J., & Paino, M. (2013). Everyday Observations: Developing a Sociological Perspective through a Portfolio Term Project. *Teaching Sociology*, *41*(3), 314–321.

Krajcik, J. S., & Czerniak, C. M. (2014). *Teaching science in elementary and middle school: A project-based approach*. New York, NY: Routledge.

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

Robson, C. (2002). *Real World Research: A Resource for Social Scientists and Practitioner-Researchers*. Blackwell Publishers.

Rowley, J. (2002). Using Case Studies in Research. *Management Research News*, *25*(1), 16–27.

Sakulviriyakitkul, P., Sintanakul, K., & Srisomphan, J. (2020). The design of a learning process for promoting teamwork using project-based learning and the concept of agile software development. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(3), 207–222.

Schwaber, K., & Sutherland, J. (2017). The scrum guide. In *Scrum Alliance* (p. 19). https://www.scrumguides.org/docs/scrumguide/v2017/2017-Scrum-Guide-US.pdf#zoom=100

Streule, T., Miserini, N., Bartlomé, O., Klippel, M., & de Soto, B. G. (2016). Implementation of scrum in the construction industry. *Procedia Engineering*, *164*, 269–276.

Sutherland, J. (2001). Inventing and Reinventing SCRUM in five Companies. *Cutter IT Journal*, *14*, 5–11.

Sutherland, J. (1995). Business object design and implementation workshop. *Addendum to the Proceedings of the 10th Annual Conference on Object-Oriented Programming Systems, Languages, and Applications (Addendum)*, 170–175.

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

van Ruler, B. (2015). Agile public relations planning: The reflective communication scrum. *Public Relations Review*, *41*(2), 187–194.

Vogelzang, J., Admiraal, W. F., & van Driel, J. H. (2019). Scrum Methodology as an Effective Scaffold to Promote Students' Learning and Motivation in Context-Based Secondary Chemistry Education. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(12).

Wacker, J. G. (1998). A definition of theory: research guidelines for different theory-building research methods in operations management. *Journal of Operations Management*, *16*(4), 361–385. https://doi.org/10.1016/S0272-6963(98)00019-9

Yin, R. K. (2009). *Case Study Research: Design and Methods*. Thousand Oaks, CA: SAGE Publications.