APPLYING KANBAN TO PROBLEM ORIENTED PROJECT BASED LEARNING METHODOLOGY

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This study is the next step in a previous case-study research based on the experiences developed in the "Master in Business Innovation and Project Management" of Mondragon Unibertsitatea. An insight into the application of agile PM methods to POPBL learning methodology was gained in the previous research. The current study analyses the result of a new experience carried out through the application of the Kanban method, taking into account the previously achieved findings and conclusions, and applied to a quasi-real problem.

Keywords: Agile project management; Kanban; POPBL; PBL

APLICACIÓN DEL MÉTODO KANBAN A LA METODOLOGÍA PROBLEM ORIENTED PROJECT BASED LEARNING

El presente estudio supone un paso más en la investigación realizada mediante estudio de casos desarrollada en el "Master de Innovación y Dirección de Proyectos" de Mondragon Unibertsitatea. El trabajo anteriormente realizado proporcionó un importante conocimiento acerca de la aplicación de métodos ágiles de gestión de proyectos a la metodología POPBL. Este nuevo estudio analiza el resultado de una nueva experiencia realizada en base a la aplicación del método Kanban, a partiendo de los hallazgos y las conclusiones obtenidas anteriormente, pero aplicándolo a un problema cuasi-real.

Palabras clave: Gestión ágil de proyectos; Kanban; POPBL; PBL

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1. Introduction

The evolution of Project Management (PM) has been widely reported in the literature. From its origins, it has continuously evolved, experiencing an intensive development for the last decades (Kloppenborg & Opfer, 2002). As a result of this growth, diverse approaches and philosophies have emerged recently. Agile PM is one of them, a philosophy which purpose was to find better ways to developing software and characterised by a set specific general features gathered in the "Agile Manifesto" (2001). Diverse methodologies such as Extreme Programming (XP), Scrum or Kanban among others coexist in the Agile PM, different approaches with specific features whereas converging on the general aim (Beck, 2001; Schwaber & Beedle, 2002; Kniberg & Skarin, 2009).

Despite its origin, these methodologies have rapidly expanded (VersionOne, 2016). This broadening has gone beyond software development, reaching several industries, thereby having drawn attention from companies (West & Grant, 2010; PMI, 2013). Consequently, there is a real need for professionals skilled in the use of agile methods (Grout & Bonham, 2012). However, there is a lack of trained agile practitioners.

One of the main objectives of the Master's Degree in Business Innovation and PM (MDBIPM) of the Faculty of Engineering of Mondragon Unibertsitatea is to enhance the PM capabilities of students. Their knowledge and skills are developed based on active education, integrating different methodological approaches. The realization of POPBL (Problem Oriented Project Based Learning) approach based group projects is one of the main features of the programs offered by Mondragon Unibertsitatea. That way, a different project is conducted in each semester, turning a means whereby teams provide an answer to the problem posed by combining knowledge, practice and teamwork. Thus, students can reach learning results that cannot be achieved by traditional learning (Araz & Sungur 2007).

The origin of this research is twofold. On the one hand, there is lack of literature on learning agile methods (Griffiths 2005; Devedzic & Milenkovic, 2011; Lu & DeClue, 2011; Cubric 2013), particularly concerning POPBL contexts. On the other hand, it was decided in 2013 to set agile methods as the basis to manage the project of the first semester of the MDBIPM. This fact and the abovementioned features the master turned it into a good candidate for further research in this topic. Thus, this study is based in the three-year experience conducted so far. The results of the first two years were reported in a previous work, summarising the findings and conclusions reached based on the use of Scrum and Kanban to manage diverse POPBLs (Apaolaza, Gutierrez & Amorrortu, 2015). The present investigation adds a third experience based on Kanban, but also varying certain aspects of the POPBL.

The remaining part of the paper proceeds as follows: the second section gives a brief overview of the background of the Case Studies (CS) previously carried on, also describing the POPBL in which the present experience is based. The third section explains both, the research methodology, and the CSs conducted over the third year, whose results are presented in section 4. These findings are discussed in section 5, taking into account the entire path followed in the three-year research. The most significant conclusions drawn from this research are summarised in section 6.

2. Background of the Case Studies. Objectives and description of the POPBL.

The POPBL project, as means for knowhow acquisition, must include diverse perspectives and objectives. By completing the project, the requirements of the overall learning process must be fulfilled, thereby covering the issues related to each subject. Hence, the results expected are twofold: the outcomes of the project and the competences acquired by each

student. Therefore, the main objective is to guarantee that every student reaches the minimum knowledge level required by each subject. Consequently, the particular objective of the PM subject was the acquisition of certain capabilities related to Kanban PM approach, which is of interest for this study.

From the perspective of the POPBL project the objective was to define a competitive product according to the market opportunity defined by the teachers. For this purpose, the team previously had to perform a market study so as to justify their selection, as well as complete deliverables involving all 5 subjects. The duration of this project was limited to 4 consecutive weeks in which students were full-time engaged in the resolution a problem, organized in teams composed of 4-5 people.

The basis for the design of the POPBL is the experience achieved over the previous two years (Apaolaza, Amorrortu & Gutierrez, 2015). Therefore, some guidelines derive from those conclusions. Firstly, the kind of problem selected is referred to as "F" problem (i.e. fictitious). That way, uncertainty caused by external factors such as dependence on a company is expected to be avoided. Additionally, Kanban was the method selected to manage CSs, as it was considered to be more suitable for Operations Management (OM) activities. Indeed, the current POPBL involved 5 subjects, 3 of which were related to OM, also implying most of the work to be done.

According to the previous conclusions, the inclusion of 5 subjects in the PBL was considered to be a risk. The configuration of a consistent POPBL involving so many problems is not easy. Additionally, its inherent complexity makes difficult for students to solve such a multidisciplinary problem in a limited period and resource-constrained context. Furthermore, managerial background and certain capabilities are required to properly handle a POPBL through a team-based approach. These kinds of capabilities are not likely to be found when, as in the present case, the participants have little or none professional experience.

Taking into account the conclusion of the previous research, as well as the specific characteristics of the preliminary proposal of the POPBL project, some threats were identified. Thus, certain conditions were integrated into the final project:

- A conflict exists regarding the creation of the organizational structure to manage the project: A given (imposed) structure may restrict the learning process, whereas a structure designed by unexperienced participants may be ineffective and lead the project to failure. In an attempt of balancing both sides a preliminary deliverable was set: design pf the organizational model. Then it would be critically analysed by the teacher, and finally the convenient changes would be done to create the final organizational model.

- By the same token, all the teams were required to perform project tracking on a daily basis, using at least a "Burndown Chart" to display the current situation. The documents and information related would be sent to the teacher responsible of the PM subject every day. Thus, adherence to the method was looked for.

- Taking into account the complexity mentioned above it was decided to use a fictitious problem to limit uncertainty (referred to as "F").

- Finally, a retrospective report was required to analyse the whole project, highlighting aspects such as initial objectives, results, process followed, relevant occurrences, etc.

This section has introduced the investigation previously developed, which also serves as the foundation for the forthcoming work. The most relevant aspects regarding the forthcoming study also have been summarized. The next chapter describes the research method used to complete this endeavour, consisting on the new CSs and the analysis of all the results.

3. Research Methodology and description of the Case Studies

The present inquiry follows the logic and principles of the previous research, including the research question posed: *"How can agile PM methods be learned in a POPBL context?"*. Due to the need for comprehensive understanding of the context and the action, based on the observation of people, qualitative approach is suitable (Yin, 2009). According to Robson's perspective (2002) the purposes of the research are twofold, exploratory and descriptive: on one hand it aims at a deep understanding of the phenomenon, identifying key issues and variables. On the other hand, it explores and explains a topic also providing information about it.

The particular features of the research, related to management, led to the conclusion that CSs are the more suitable approach according to several authors (McCutcheon & Meredith 1993; Easterby-Smith, Thorpe & Lowe, 2002; De Massis & Kotlar, 2014). In particular, Yin (2009) claims that *"CS-s investigate a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident"*. Other authors assert that CS approach gives direct access to information, enhancing knowledge and overcoming other methods' limitations (Rowley, 2002; Wacker, 1998). Robson (1993) states that if in these conditions there is access to people involved, CS-s is the best approach.

The investigation under consideration is an extension of an initial research (Apaolaza, Gutierrez & Amorrortu, 2015). Taking into account the specific features of this inquiry, an embedded Multiple-CS approach is adopted for the whole research, composed of six holistic CSs conducted through 3 consecutive years (See figure 1), in 2 different locations. As a result 6 CSs compose the investigation (1 CS for each location and year).

Figure 1: Overview of the research
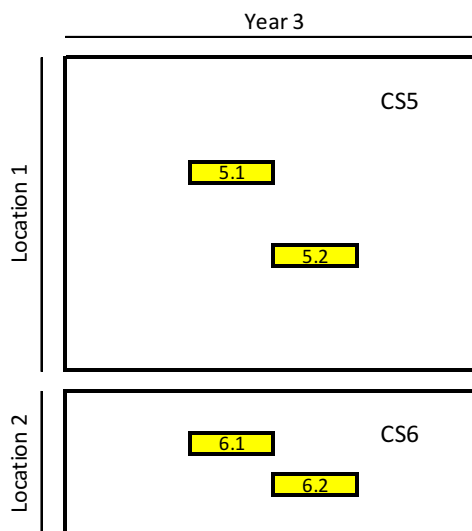
Case Studies 5 and 6, developed through year 3, extend the previous research.

The specific details of each CS are presented in table 1. The description of the general characteristics of the cases includes year, location, unit of analysis, management method used, number of participants and kind of problem posed (see legend below table 1).

Table 1: Characteristics of the case studies

	CS5		CS6	
Year	3	3	3	3
Location	A	A	G	G
Unit	1	2	1	2
Method	K	K	K	K
Participants	5	4	5	5
Problem	F	F	F	F

Year: year of execution of the CS within the period of observation.
Location: the MIP is taught in parallel in two locations. Therefore, there are 2 possible choices: A (loc.1), G (loc.2).
Unit: study unit (team) inside each embedded research unit.
Method: specific agile PM method used: K (Kanban).
Participants: number of participants in each team.
Problem: type of problem: F (fictional, quasi-real).

The replication approach suggested by Yin (2009) is adopted, aiming the analytic generalisation of results to broader theory. In particular, literal replication is used here. The individual CS corresponding to the third year is first analysed. Founded in the theoretical framework developed, the cases were conducted expecting to achieve predicted similar results. These results as well as the previously achieved results and conclusions are the input for the discussion and conclusion of this inquiry, presented in sections 5 and 6. The framework of the CS is shown in figure 2.

Figure 2: Summary of the research framework
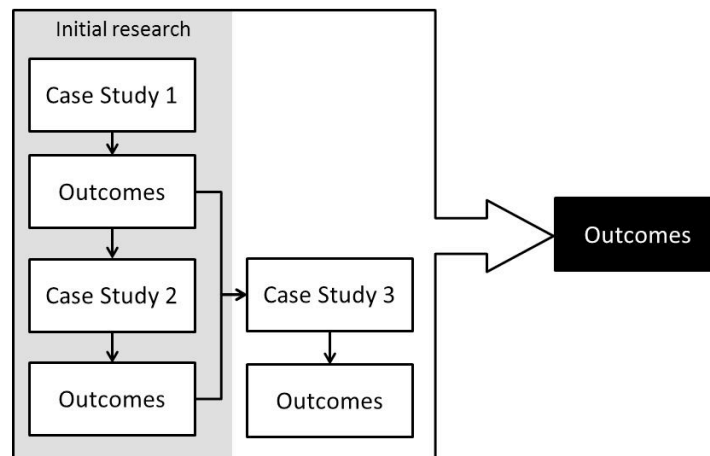
Another characteristic of this inquiry is the use of multiple data sources, thus enabling triangulation and therefore enhancing data credibility (De Massis and Kotlar, 2014). Indeed, in a qualitative research data may be collected by different means. The availability of multiple sources of evidence gives access more historical and behavioural issues. In CS research observation, interviewing and analysis of documents and records are typically involved (Robson, 1993), providing rich and varied information. The data sources used in the present study as well as specific examples are shown in Table 2.

Table 2. Data sources used

Source	Examples of use
Observation	Visits to the location/place the team is working at. Project tracking meetings (tutor of the team). Technical meetings (expert in the field)
Interviews	Formal: arranged and semi-structured (meetings with tutors and experts). Informal: random chances, not appointed. Unstructured.
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), Document for presentation and defence of the work, Written personal defences (very useful in assessing acquired knowledge and individual involvement of students)
Other sources	Presentations and oral defences. E-mails and other communications (source of informal and often "unexpected" information, which can reveal contradictions, uncovering personal perspectives different from the group's, etc.).

4. Results of the Case Studies

The result obtained was satisfactory from the general perspective of the learning process. Based on the Kanban approach, the objectives of the POPBL projects were reached in all projects and subjects. All the deliverables were submitted on time, thereby meeting the requirements. The consequent result met the minimum marks required by of all the subjects involved, including PM (see Figure 3). Therefore, the evaluation of the group presentations and oral defences of the work performed, as well as the individual-written defences, showed that all the objectives were attained.

Figure 3: Average evaluation results of the POPBL projects for each team and subject.
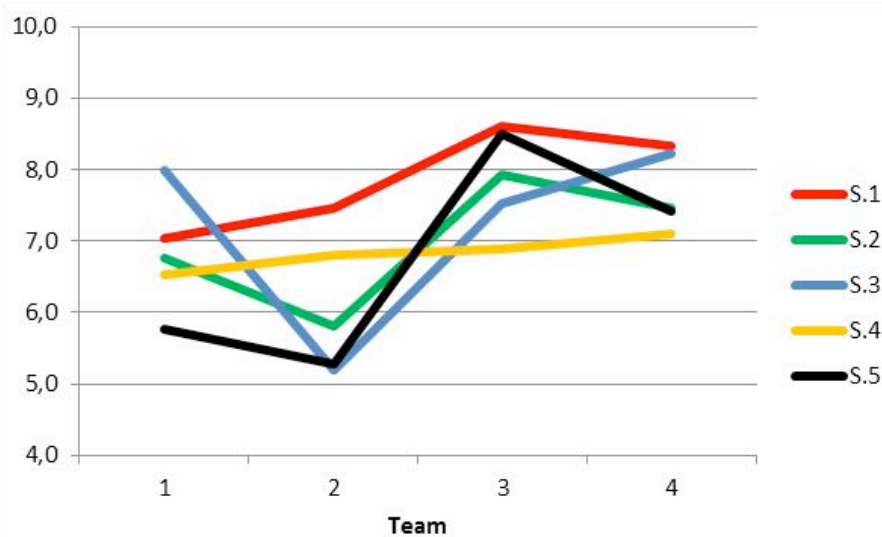
Values between 1 and 10. Horizontal axis: Teams. Vertical axis: Subjects.

Apart from the quantitative evaluation, a comprehensive analysis of the PM subject was done. The frameworks developed by teams and amended by teachers in general succeeded

in supporting the management of the POPBL. Nevertheless, other significant results and issues, relevant from a qualitative perspective, were found. The main findings are summarized below:

- The initial proposals for PM required some amendments to guarantee a robust response to the needs of the POPBLs. Even if all of them were formally correct, limitations related to 2 issues were identified in almost all the proposals: they were incomplete and/or unsuitable for the context. However, the amendments required were simple and were easily implemented, thereby achieving the performance conditions looked for.

- The students found difficulties when dividing the work requested from each subject into suitable tasks. In particular they didn't know how to proceed to obtain appropriate tasks for Kanban methodology, as well as for preventing scope loss. The main difficulty was related to task size. Thus, the resulting tasks tended to be too big, consequently remaining in progress for long time periods.

- The Burndown charts were timely updated by the teams, thereby providing an accurate perspective of the current situation.

- Conversely, teams had problems making decisions based on performance information. However, teams speculated with the weekends, an extra capacity available in case it was required.

- Similarly, teams found difficult to work within the Work in Progress (WIP) limits, often exceeding them. When problems arise, they tend to launch more activities instead of solving the problems and unblock the situation.

- All these reasons caused a misuse of the information given by the Burndown chart, often followed by an accumulation of work in the last part of the project, next to the deadline.

- In addition, the teams often experienced difficulties when facing retrospective meetings, as well as to suggest improvements.

5. Discussion:

One of the main concerns from the PM perspective was the design and implementation of an organizational structure capable of handling the problem posed in it specific context. The initial difficulties were related to the lack of practical experience of the students, particularly regarding agile PM. The insertion of a preliminary deliverable, a design of an approach to help the team managing the project, allowed the students to deal with the problem of creating a Kanban context. The results uncovered the problems derived from such and endeavour, in carried out time-constrained conditions and lacking knowledge and experience. However, the simple changes that had to be introduced also demonstrate that the teams were able of creating good initial proposals, which once corrected provided a proper support. Additionally, the PM learning process was completed by using the approach designed by the team for the remainder of the project. It was found that the additional know-how provided by this second step can only be acquired by practice.

The lack of real-world experience mentioned above, as well as Agile PM culture, became evident. In general, teams and students rarely were proactive from this perspective, and tended to be reactive, waiting for requests and instructions. This behaviour was reflected also in other situations. For instance, the use of project tracking on a daily basis and supported by a Burndown chart was essential to display the project status. That way, the essential information to prompting decisions was easily obtained. Thus, the underlying logic of this chart is to estimate and graphically show the situation with respect to the end of the project, instead of looking at what has already been done. In addition, the simplicity of this

procedure allows daily information updates, thereby enabling to stay aligned towards the objective. Indeed, this was the foundation for daily meetings, in which analysis and decisions were made from a global perspective. Nevertheless, the teams didn't properly use these advantages. In contrast, it is concluded that Burndown chart was considered to be a deliverable rather than a valuable tool to supporting PM.

The main cause for this behaviour was the lack of pressure the students felt. Teams knew that they could work overtime and, if necessary, also work in weekends. In addition, the use of this additional capacity didn't penalize the project as it would happen in a real-world context. Therefore, teams speculated with this additional capacity. The direct result was that a certain delay was accepted without any reaction. That way, even when the Burndown chart provided early warnings, immediate reactions weren't prompted. Furthermore, as a result of this relaxation, certain tendency to return to the traditional perspective was observed. This led to distributing tasks to work independently, causing some disregard for WIP management and limits. In brief, the potential for flow improvement through WIP reduction aimed by Kanban was not completely reached.

On the other hand, the use of a fictitious problem guaranteed lower uncertainty levels if compared to previous experiences. As expected, the remaining uncertainty sources were only internal. This gave a lot of independence to teams, which were focused exclusively on managing their projects without the problems derived from dependency on customers. On the contrary, the inexistence of a customer reduced the managerial difficulties caused by the criteria, conditions, changes, delays, etc. typically introduced by customers. From this perspective, the complexity of the projects and the sense of reality were lower. This aspect also contributed to enhance the behaviour towards Kanban management mentioned above.

The CSs analysed in this new investigation support the general conclusion reached in the previous research. In summary, regarding agile PM, POPBL methodology allows learning with a depth and realism that is not achievable by traditional teaching. Team members have to collaborate to reach a common objective, including activities such as analysis, negotiation, decision making, etc. The conditions set by this approach (i.e. teams working in time-constrained contexts) require to handle these situations and problems in quasi-real contexts, beyond the theoretical knowledge required. Therefore, it is corroborated that "POPBL allows learning with a depth and realism that is not achievable by traditional teaching".

One of the foundations for the design of such a POPBL project is the selection of a fictional or a real problem as the basis for a POPBL project. It is controversial. Real problems are attractive for different reasons. From the perspective of the learning process, the project is a means to learn through experience, achieving a result that can't be obtained by traditional teaching. For students, it is an excellent opportunity to put in practice theoretical knowledge and to acquire certain practical knowhow. However, due to the time constrained nature of POPBL projects, the high dependence on the customer is a source of uncertainty.

Fictional problem-based projects are another valuable option. The results show that even if this approach is not so close to reality and involves less uncertainty, it is also worthwhile. Additionally, its strengths are better process control and more autonomy for teams. In brief, it is concluded that real problems are preferred when the minimum conditions to progress without stoppages or interruptions caused by reasons external to the POPBL project are granted. On the contrary, when these conditions can't be guaranteed, fictional problem-based projects are more suitable.

In contrast with the CSs conducted in the past, the present CSs lacked learners with significant professional experience. It was found that fictional problems are especially suitable in these conditions. The maturity and professional experience of learners was another influencing factor identified in the previous research. It was then concluded that those teams with experienced participants tended to perform better than those whose

members lacked a professional background. However, the absence of experienced participants must not be viewed as a negative aspect. The methodology is designed to ensure the conditions required to develop competences and capabilities regardless of the initial professional background. On the contrary, the participation of students with real-world experience is an opportunity to achieve objectives beyond the standard objectives.

In previous experiences, availability and involvement of teachers in the project was considered to be another relevant factor for the project. This was also confirmed in these CSs. It is proven that a real risk of deviating from the targets exists. Therefore, supervision is needed to prevent this kind of consequences. On the one hand, supervision of teachers is essential to prevent teams from getting lost. On the other hand, teachers' overacting may also restrict the experience, limiting the contribution of the project to the student's knowhow. This dilemma is overcome by combining intermediate deliverables and corrections. The insertion of a preliminary milestone enabled the development of the definitive approach used by each team, once the changes were implemented. That way, teams autonomously developed their own approaches, and teachers contributed to reach the minimum conditions required to properly manage the projects.

6 Conclusions

POPBL approach is suitable for Kanban PM learning. One of the main features of agile methods is their orientation towards action, and the context provided by this kind of methodology is especially appropriate for this purpose. In general, when dealing with Operations Management, flow-management oriented methods without sprints such as Kanban are best. However, it is difficult to faithfully reproduce full real-world conditions in an artificial environment, thereby making difficult to create an agile culture in such a short period of time. This fact leads to situations that must be properly faced in order to take advantage of the opportunity provided by the POPBL approach. In that way, this methodology provides an excellent way to learn how to manage a project through an agile method. By blending theory and practice, the knowhow, skills and capabilities of students are enhanced towards a real-world use of the underlying concepts. The new insight provided by this study can be summarized as follows:

- The value of the insertion of a preliminary deliverable including the design of a suitable organizational arrangement is twofold: first, it allows learners to design and test their own approaches. Additionally, it strengthens the educational process through practice in quasi-real conditions.

- The lack of experience and the availability of cost-free extra capacity (i.e. weekends) are examples of the obstacles to reproduce full real-world conditions in this context. To achieve more valuable results, mechanism for encouraging teams to fast react according to the early warnings should be found.

- The use of fictional problems as the basis for POPBLs is best when low uncertainty levels are required. It gives independence to teams, allowing them to concentrate on the development of managerial capabilities. However, to certain extent, it also implies to move away from real-world problems and situations.

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