Chapter 17. Adapting Agile Scrum Methodology for the Subject of Building Project Design in University Teaching

Pedro Fernández-Valderrama [a]*, Daniel Antón [ab], David Marín-García [a], Manuel J. Carretero-Ayuso [c]

a Universidad de Sevilla, Departamento de Expresión Gráfica e Ingeniería en la Edificación, Escuela Técnica Superior de Ingeniería de Edificación, Seville 41012, Spain

b Product Innovation Centre & The Creative and Virtual Technologies Research Lab, School of Architecture, Design and the Built Environment, Nottingham Trent University, Nottingham, UK

c Department of Architectural Graphic Expression, Higher Polytechnic School, University of Extremadura, Cáceres, Spain

* Corresponding author: **pfvalde@us.es**

Abstract

Project management techniques have emerged as useful tools to contribute to the achievement of objectives. In this management context, the Agile methodology is usually used in projects with an adaptive life cycle, in which there are uncertainties in the requirements, the expected results, and the risks that the project will face, but also when change is a constant. The application of Agile typically occurs in combination with other traditional management techniques and adapts to the circumstances of each context. This work proposes an adaptation of the Agile Scrum methodology to the particularities of a university subject where the work proposed to students consists of designing a building and writing its building project. In this subject, students work on the project in small groups; this makes it necessary to adapt the characteristics of the workgroups proposed by Scrum. It also involves an adaptation of team roles and Scrum events, such as the format of daily and recurring meetings. The results of this research show that applying this framework in this type of teaching provides students with resources to work in a decisive, disciplined, and creative way, thus contributing to completing the project, accelerating the fulfilment of the objectives set and enhancing behavioural competencies.

Keywords

Scrum, Project design, Teaching-learning process, Higher Education, Project Management.

1. Introduction

Being limited to the context of university teaching, this work addresses a subject that consists of the preparation of a project for the construction of a building or the adaptation of an existing space for the implementation of a specific activity. Here, Agile project management techniques are implemented into teaching in order to contribute to skill development by students as a complement to the traditional class delivery system. The motivation of this work is to incorporate new resources by students so that the deliverables required to pass the subject are completed in a more organised and efficient way. The cultivation of skills associated with personal relationships is also pursued, which is particularly crucial in today's job market for fostering effective teamwork.

The project management technique is a professional discipline that is usually unknown to university students. It is often not part of the core subjects in the curricula of university degrees involved in the field of project design and execution. On other occasions, it is not even part of the content of university degrees in the field of architecture and building.

According to the Project Management Body of Knowledge (PMBOK) [1], a project is a temporary effort carried out to create a unique result. Project management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements [1]. In broad terms, the different project management approaches can be grouped into traditional and agile, the latter being addressed in this work.

The application of these approaches largely depends on the relationship between the phases that generally occur in a project: conceptual or analysis, design, execution, testing, and delivery. The relationships between these phases can be different: (i) sequential, each phase begins when the previous one ends; (ii) overlapping, the phase begins before the previous one ends; (iii) iterative, the phases are repeated throughout the project producing iterations, where the lessons learnt in the previous iteration are taken advantage of (see Figure 1).

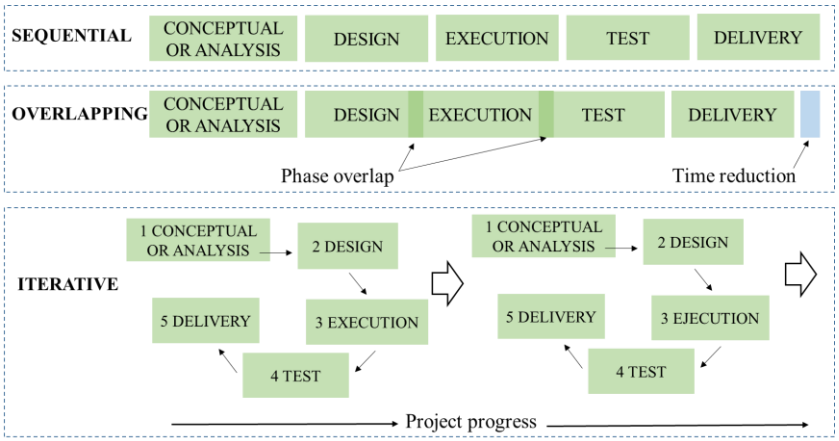

Figure 1 – The three types of relationships between the phases and the phases of a project.

The relationships between sequential and overlapping phases enable both projects with a predictive life cycle and the iterative relationship to projects with an adaptive life cycle. However, practical requirements imply that project life cycles are often mixed predictive and adaptive (see Figure 2). This means that companies and organisations need to have a starting point for the duration and cost of the project.

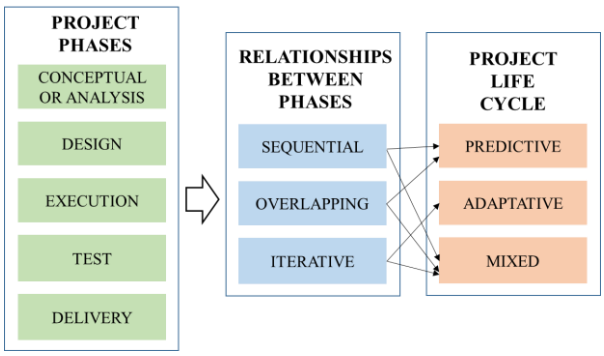

Figure 2 – Relationships between project phases and types of project life cycle to which they give rise.

The predictive life cycle occurs in projects that are developed in known contexts with stable requirements and where there is extensive experience of similar cases. In this way, the execution phases are sequential, as one phase ends and the other begins. However, as indicated above, the phases can also overlap. Planning these projects with a predictive life cycle involves a traditional approach, that is,

establishing their scope and, based on this, determining the costs and deadlines of the project. In these cases, detailed execution planning is of special significance, which involves generating and providing exhaustive documentation.

The adaptive life cycle occurs in environments of high uncertainty. This uncertainty refers to a lack of certainty about the requirements, scope, and whether the project objectives will be viable. It also means not knowing a significant number of the risks that may arise throughout the process, as well as the set of factors that determine the project's context and affect its result. This is what Steve McConnell [2] referred to as a cone of uncertainty. In the initial stages of the project, the uncertainty is high; there is usually little knowledge about these factors that determine the results. As the project progresses, the cone of uncertainty narrows; that is, more knowledge is obtained about the context, the requirements, the scope, and the viability of the objectives are defined, and there is more clarity about the risks that may affect it. In short, the uncertainty is reduced. This is the management environment of Agile approaches, which implies permanent feedback from stakeholders. The project is developed iteratively by increments in the work done, with traditional planning and exhaustive documentation of the process taking a backseat.

The Agile methodology emerged explicitly and formally in 2001 in the USA. A group of 17 software businessmen debated the principles that should guide software development in short execution times and that require flexibility to adapt to continuous changes. The result, the Agile Manifesto [3] gives the greatest value in this type of work to (i) individuals and the interactions between them versus processes and tools; (ii) running software versus generating complete documentation; (iii) collaboration with the client against the negotiation of the contract; and (iv) the response to change versus following a previously outlined plan. For its part, Scrum is an Agile framework that provides a series of rules, techniques, and methods to guide relationships between project stakeholders.

The Scrum Guide [4] describes the fundamental elements that characterise this work philosophy: the team, events, and artefacts. The Scrum team is a small group of 10 or fewer non-hierarchical individuals who are internally self-managed, empowered by the organisation, and pursue the Product Goal. The team is responsible for everything necessary to generate the product through a series of events that revolve around the fundamental event, the Sprint. Through Sprints, increases in Done work are produced iteratively. Each Sprint has a goal, an amount of product work to achieve, and a plan that can be accomplished. This process of increasing the result is helped by artefacts or sets of pending work to be done, which represent key information that allows measuring the rate of progress of the work. These fundamental elements that characterise Scrum are shown schematically in Table 1.

Table 1 – Fundamental elements that characterise Scrum.

Element	Component	What is
Team	Developers	Team members who focus on producing increases in Done work
	Product Owner	The sole person who maximises the value of the product. They develop and communicate the Product Goal
	Scrum Master	Person at the service of both the team and the organisation and is responsible for the Scrum implementation
Events	Sprint	Events lasting less than one month planned to achieve the product objective
	Sprint Planning	Establishment of the work to be done in the Sprint
	Daily Scrum	Meeting of a maximum duration of 15 minutes where the progress of the Sprint is inspected
	Sprint Review	Inspection by the Scrum team and stakeholders of the Sprint outcome
	Sprint Retrospective	Analysis after the Sprint on what worked well, the problems encountered and how they were resolved
Artefacts	Product Backlog	Backlog of work to complete and improve the product
	Sprint Backlog	Set of product backlogs that are selected for the Sprint.
	Increment	Work conducted with the required quality standard and that represents a step in achieving the product's objective

1.1. Similar cases in the literature

A bibliographic search was carried out for scientific works that address the application of Scrum in the context of university teaching and, in some specific cases, in undergraduate teaching. The research was mainly based on scientific journal articles. In this literature review, emphasis was placed on verifying how beneficial applying Scrum in teaching is. Likewise, special attention was paid to verifying in which different fields of university education this methodology has been applied.

According to Vila-Grau & Capuz-Rizo [5], one way to apply Scrum in the classroom is to adapt and adopt the Scrum framework to the classroom, and the second way is to work with eduScrum. This model was created in 2011 by Willy Wijnands and was adopted and standardised for the field of teaching based on Scrum. According to Ivetić & Ilić [6], Agile approaches can be successfully implemented in different areas of universities, such as governance, curriculum design or teaching. In the present work, the focus is on the first approach referred to by Vila-Grau and Capuz-Rizo, that is, on applying the Agile Scrum framework in the teaching of a university subject. Here, making the application of Scrum more flexible to the context of the subject was considered more appropriate. In this sense, Masood et al. [7] noted that applying Scrum in teaching often entails challenges for students, thus making it necessary to implement adaptations to standard Agile practices, in turn making them easier to use in university contexts. In this same sense, Baham [8] explained that studies on Scrum implementation exclude certain parts of this methodology when applying it.

A great part of Scrum studies in teaching have been carried out in the teaching of software engineering and computer science ([9], [10], [11], [12], [13], [14]). This seems to be due to the very origin of Scrum as a framework for software development. In works such as those by Hadi et al. [15], Scrum was used not only to learn certain subjects but also for the very purpose for which it was created, that is, software development. In this case, the authors used it to develop an augmented reality mobile application to learn accounting ethics at the university. However, beyond computer science, Scrum has also been successfully used in other areas of higher education.

Khalfan et al. [16] adopted Scrum in the delivery of a project management course and concluded that Scrum enabled improvements in collaboration, communication, and value delivery to students. Scrum was also implemented into project management teaching by Rush and Connolly [17] with the objective of maximising student learning with respect to the traditional system, as well as the development of behavioural competencies that characterise the success of Scrum teams and that are difficult to teach by traditional teaching systems. That is, Scrum becomes a good teaching framework for acquiring these types of skills associated with relationships between people. In this context of improving teamwork, Turcios-Esquivel et al. [18] used Scrum for this purpose in higher education subjects. For Pope-Ruark [19], projects developed in collaborative teams provide learning benefits but represent a challenge since the educational system encourages individual achievement. Therefore, Scrum is an appropriate tool to manage these team projects.

Barros et al. [20] used Scrum combined with Project Based Learning (PBL) to teach Artificial Intelligence to undergraduate students. The results of the study indicate that students used it appropriately and developed skills in problem solving, communication, teamwork, and critical thinking.

Pócsová et al. [21] implemented the Scrum framework with an experimental group of students to teach mathematics in the engineering degree. The results of the study also showed that the Agile approach contributes to increasing the efficiency of the educational process. Scrum was also applied to a small group of students teaching the subject of physics in an electronic engineering school by Lourakis and Petridis [22]. The authors verified the impact that this technique has on students' success and understanding of the course.

Another application of the Agile framework in university teaching, in this case in business schools, is that by Cubric [23], who used it to teach Agile project management. The author concluded that this framework also increased the employability of students. In this same sense, the work by Akhmetshin et al. [24] on modern approaches to teaching in the business field revealed that employers were interested in those workers who knew the Agile approach, which reflects the need to teach techniques such as Scrum in higher education.

In other fields of university education, such as the humanities, cases of successful application of Scrum can also be found. In work by Belyaeva et al. [25], students selected Scrum as one of the best methods for teaching foreign languages in the context of humanitarian professions.

This review of bibliographic sources shows that, although there is a diversity of Scrum application studies, it is not one of the disciplines most frequently addressed in scientific research. A recent study by Barros et al. [20] reported that research on Scrum in education is currently limited. Despite of this, there is unanimous agreement among scientific research about the benefits this methodology offers. Therefore, new experiences in this field should be drawn on to continue research in this line. In this way, this work is supported by the hypothesis that implementing Scrum in this context will enhance the acquisition of technical and behavioural skills by students.

2. Methodology

The research methodology was based on two preliminary activities described in the introductory section of this work. The first one consisted of a bibliographic review of the scientific literature on Scrum in teaching and of the conceptual foundations of this technique through the Scrum Guide and other publications. The second preliminary activity was based on this analysis and consisted of inventorying the characteristic elements of Scrum with the aim of being applied in the teaching of a university subject. For this application, the characteristics that define the context in the selected subject were analysed, and the Scrum methodology was adapted to the work methodology of said subject. From this point, Scrum was implemented in said teaching, continuously monitoring the work progress to

determine the advantages and disadvantages enabled by Scrum. Finally, a discussion session was conducted with the students about the experience, and conclusions were drawn.

2.1. Selection of the university subject in which Scrum will be applied

This technique was implemented in the subject Technical Projects I, which belongs to the third year of the Degree in Building at the Higher Technical School of Building Engineering of the University of Seville. This work was conducted during a part of the first quarter of the 2023-24 academic year. The classroom sessions on this subject take place on one day of the week with a duration of four hours.

This subject is divided into three fundamental blocks. First, various drawings are developed to address the current state of a space where a construction project will be undertaken to accommodate a purpose different from its current use; specifically, the new use is a Port Centre. This construction project is divided into two new blocks: one is a design project of the renovated state (second block of the subject), and the other is complementary to the previous one and is where the finishes, completions, and certain types of facilities are implemented in the project (third block). Given the time constraints of the subject, the scope of the project is also limited. In the second block, the challenge is for the students to design the distribution of the new use according to the requirements of a needs programme, regulatory compliance, and the specific requirements of a Master Plan, which is the guide for a broader set of urban planning actions that are intended to be developed in the port environment where the project is located. With respect to regulatory compliance, the aspects of Fire Safety and Accessibility are of particular importance for the development of the subject since these regulations have a wide impact on the final distribution of spaces.

Specifically, the application of Scrum was carried out in the second block of the subject, that is, during the design of the Reformated State of the new use. This block lasted approximately seven weeks.

As indicated above, the project management environment with Agile approaches such as Scrum is characterised by high uncertainty in the final requirements, scope, objectives, and risks of the project. In the project proposed in the subject, students generally face this type of situation for the first time in their studies in which they act as designers. This novelty causes students to be unaware of the project process, and they have to complete this part of the subject in a very short time. In this sense, considerably tight project development deadlines constitute another characteristic of the application context of Agile approaches.

2.2. Adaptation of the Fundamental Elements of the Scrum methodology to the Subject

After the analysis of the fundamental elements of the Scrum methodology, the adaptation of these elements to the work methodology of the subject was carried out in its second block. As indicated before, this block consists of the design of the Reformated State and the preparation of the project document that defines this design. This document to be written by students consists of a report and graphic documentation consisting of distribution plans for the new use, bounded plans, plans to justify compliance with Fire Safety and Accessibility regulations, as well as construction plans, elevations, and sections.

Table 2 describes the adaptation to the teaching of the subject of the fundamental elements of Scrum indicated in the Scrum Guide [4].

Table 2 – Adaptation to classroom work of the fundamental elements that characterise Scrum.

Element	**Component**	**Scrum in Scrum Guide**	**Scrum in classroom**
Team	Developers	Ten or fewer individuals	Two persons
	Product Owner	A person who can represent the needs of many stakeholders	The lecturer, who represents the needs of the promoters of the Master Plan and the teaching subject
	Scrum Master	A person at the service of the team and organisation	The lecturer
Events	Sprint	Less than a month	One week
	Sprint Planning	Eight hours for a month's Sprint	Half an hour for the weekly Sprint
	Daily Scrum	Maximum fifteen minutes	Approximately five minutes
	Sprint Review	Four hours for a one-month Sprint	Approximately two hours for weekly Sprint
	Sprint Retrospective	Three hours for a monthly Sprint	Approximately fifteen minutes for a weekly Sprint
Artefacts	Product Backlog	Product backlog. Product details, descriptions, and	Descriptions and details on what the product should be,

Element	Component	Scrum in Scrum Guide	Scrum in classroom
		attributes, among others	basic needs programme, details of the Master Plan on building characteristics
	Sprint Backlog	Product Backlog selected for the Sprint	Fraction of the design and writing process of the project document selected for the Sprint
	Increment	Work Done towards the product and usable	Work or part of the work Done during the Sprint with sufficient quality

2.3. Implementation of Scrum in the Classroom

After the adaptation of the Scrum methodology to the classroom context, its implementation was carried out throughout the seven weeks of the design block of the new use and writing of the project document. Scrum application was carried out with an experimental group of four work teams of two members each, a total of eight people. Once the project work was completed, a joint session was held to analyse the students' experience of implementing Scrum in the classroom, and conclusions were drawn.

3. Development of work, results, and discussion

3.1. Regarding the Scrum team

The Scrum team consisted of the Scrum Master, the Product Owner, and the developers. As indicated in Table 2, in this work, the role of the developers corresponded to the students, and that of the Product Owner and Scrum Master corresponded to the lecturer. This dual role of the lecturer is one of the particularities of the Scrum implementation carried out. This way of acting presents differences from other related works, such as that by Fernandes et al. [26], where this role was played randomly on a weekly basis by one person from each workgroup. The way of acting in this research was motivated by the fact that the application of Scrum occurred in a block of the subject (the design of the reformed state and writing of the project) constrained by a very tight period, seven weeks. Added to this circumstance are two additional difficulties; firstly, designing is new for students. Secondly, the application of this type of project management approach is also an important innovation for the students of the subject and the Building Degree. In this

degree, there is only one optional subject of Project Management, so, at the time of taking the subject, students are unaware of this type of professional project management activity. Therefore, it was considered necessary to ensure the correct implementation of Scrum, assigning the role of Scrum Master to the lecturer, one of their functions being that Scrum is applied as indicated in the Scrum Guide.

The Product Owner (the lecturer) established a Product Objective, which was specified in the new use to be implemented in the workspace. It was also specified in a need programme that the students could complete. Another Product Owner's task was to achieve the greatest value from the team's work. This was achieved through weekly monitoring and resolution of queries in tutorials and follow-up sessions with students. In this continuous monitoring of the work by developers (students), clear communication of the pending elements to complete the product was established. This pending work had to be clearly established and understood during the implementation carried out in this chapter's research. The detection of pending work was achieved through different verifications by the lecturer: (i) compliance with the requirements of the needs programme; (ii) introduction of functional requirements of the building not indicated in the programme but necessary for the correct functioning of the building, for example, technical premises for installations or maintenance or waste rooms; (iii) regulatory compliance; (iv) coherence in the design carried out by the students. As a result of these verifications, the lecturer established the indications of pending work for the product.

The Scrum Master has the fundamental task of ensuring that Scrum is implemented as indicated in the Scrum Guide. In this aspect, the role of the lecturer as Scrum Master has a special meaning with respect to the team of developers (students). One of the responsibilities of the Scrum Master is to make the Scrum team effective. The lecturer must strive to give visibility to the fundamental elements of the Scrum methodology so that they can be verified and implemented, thus making the differences with conventional group work visible. In this sense, the Scrum Master (lecturer) must make every effort to ensure that all Scrum events occur in a timely manner.

In this regard, at the beginning of the sessions where Scrum was implemented (seven weeks), the lecturer taught some notions of Scrum. Subsequently, after the class sessions, the lecturer emailed the teams a document indicating (i) the final objective of the project, which consisted of writing the design project document for the new use to be implemented in the workspace (this objective was established by the lecturer in their role as the Product Owner). (ii) Certain functional requirements that the design had to consider. (iii) List of weekly events that would take place in the seven weeks of the project: Sprint Planning (in class); Daily Scrum meetings between members of each team (outside of class); weekly intermediate review meetings with the lecturer (online); Sprint Review (in class); validation of the

Increment of the work that met the definition of done, that is, whether the work was of sufficient quality (in class); Sprint Retrospective and the weekly work dynamics (in class). (iv) Weekly Sprint Goal or Sprint Backlog. (v) Sprint Goal, or ultimate objective pursued by the weekly Sprint.

Another characteristic of the team in the Scrum technique was the reduced number of participants. In the work context of the subject, one of the conditions was that each work team had to be made up of two people. With this minimum number of participants, the aim was to achieve greater participation and attention of students to the different tasks that are part of the work to be completed. In this regard, adequate functioning of the team was observed, compared to other larger teams where Scrum was not applied. Having two individuals meant greater involvement in the execution of the design, the writing of the report, and the preparation of the plans that made up the project document.

On the other hand, when Scrum events were held in classroom sessions, especially Sprint Reviews, the different teams functioned very satisfactorily as one. This was because the lecturer directed these reviews in his role as the Product Owner, and the four teams participated around a table, producing very effective, constructive, and at the same time critical and sincere feedback on the work developed by each team. Acting in this way allowed the participants to debate the different solutions and incorporate shared criteria, although the design solutions were different in the four cases.

Regarding the skills required by developers in Scrum, these must be broad. In the context of applying Scrum to this subject, the skills available to the students as developers were sufficient to achieve the proposed objective of the product. This subject where Scrum was implemented is from the third year of their studies, so the starting skills were sufficient to face the challenge posed to the students.

3.2. About Scrum Events

The main Scrum event is the Sprint. It is one of the main means for the product's objective to be carried out. Normally, Sprints in Scrum last for a maximum of one month. In this case, the duration of the Sprints was significantly shortened to one week. Hence, as the duration of the second block of the signature where Scrum was implemented (the design of the new use) was seven weeks, seven Sprints were carried out. This weekly sequence coincides with the work by Khalfan et al. [16], where weekly Sprint planning and challenge meetings were held. As the Scrum Guide indicates, shorter Sprints can be used to generate more learning cycles and limit risk to a smaller time frame. In this way, it is possible to monitor the status of the Scrum application, taking into account that the class sessions of the subject are carried out one day of the week, and it is complex for the lecturer to do a more continuous monitoring of the work unless that is motivated by questions from

students in tutorials or intermediate review sessions.

In each weekly class session, a Sprint Planning was produced, taking into account the global prior planning of the subject that is established in its programme. In this way, Sprint Planning adapted the requirements of the initial programme to the real circumstances that teaching faces after completing the initial block (first block of drawing up plans). In Sprint Planning, the Product Owner (lecturer) explained why the Sprint was important within the context of the design of the new use. Next, the Scrum method established that developers must discuss with the Product Owner what will be included in the Sprint of the Product Backlog. However, in this application of Scrum to teaching, it was the lecturer who established the content of the Sprint, which made the team of developers adapt the said forecast throughout the week. This determination of the content of the Sprint by the lecturer (Product Owner) and without special debate with the students (developers) was because they do not have previous experience regarding their past performance in this type of work, since as a general rule, it was addressed for the first time. Likewise, this lack of prior experience in these building design tasks made it difficult and even impossible to decompose the pending work elements of the product into smaller parts. In general, the Scrum Guide establishes a duration of eight hours at most to plan a monthly Sprint. Since the Sprint is weekly and there is no debate about the lecturer's forecast of the work to be completed in the Sprint, for the reasons indicated above, the duration of the Sprint Planning was significantly reduced to approximately thirty minutes.

In Scrum, the progress of the Sprint work is monitored by developers in daily Scrums or short meetings lasting no more than 15 minutes. In them, not only is the pending work reviewed, but the plan to produce it is adjusted. All this is in addition to other meetings that may be held during the day with similar objectives. In the weekly class sessions, the lecturer, in their role as the Scrum Master, placed special emphasis on the importance of these daily meetings. To do this, they proposed a meeting structure in which the developers (students) asked themselves what they did the day before to help achieve the Sprint objective, what they planned to do in the present day, and what prevented them from doing it. With all this, it was verified that these Daily Scrums were sometimes not carried out. This was due to the high teaching load of the students, and that often, the members of each team did not physically coincide on a daily basis. Despite this circumstance, an adequate duration of the sprints was observed, one week, since it allowed students to have weekly objectives adjusted to the reduced total period of the project, seven weeks. This contributed to ensuring that there were no lost weeks on the part of the students, as they had clear objectives set in the sequential process of the project.

On the other hand, another set of the contents of the weekly work sessions consisted of a review of the Sprint, the Sprint Review. Here, the students presented the result of the weekly Sprint work to the lecturer in their role as the Product

Owner. The results were analysed to determine whether any changes have occurred in the project's work context. Here, the students exposed possible unexpected difficulties, and the lecturer also highlighted any other circumstance that implied adapting the pending work of the product, such as delays in the development of the design. Besides, the Product Owner (lecturer) validated the work carried out and defined it as an increase in the work done. In general, the duration of a Scrum Review is 4 hours for a monthly Sprint. However, it was less in this teaching context, although it was one of the most extensive activities in the weekly class sessions. In fact, the duration of these reviews took up a significant part of the time of the classroom sessions, approximately two hours out of a total of four.

The last Scrum event was the Sprint Retrospective. In this event, the team holistically reviewed how the last Sprint worked, that is, what went well and what went wrong, and how these last issues were resolved. This event is what, in relation to traditional project management, the PMBOK [1] identifies as a project knowledge management process, which involves generating learnt lessons about what happened during the progress of the work. In Scrum, the duration of the Sprint Retrospective is a maximum of three hours in a monthly Sprint, reducing it significantly in this work to approximately fifteen minutes.

3.3. Regarding Scrum artefacts

The Product Backlog is the set of work elements to produce the design of the new use and the project document that reflects this design and its justification. This first artefact of Scrum is usually specified in a list of pending works to be done. In this teaching context, this Product Backlog included two types of products, one related to the design work and another related to the writing of the document.

Regarding the writing of the project document, the students were provided with a list of the formal content of the final delivery to be made after seven weeks, which broke down each of the deliverables that need to be completed. These referred to both the graphic documentation of the project and the content of the project report with their respective normative and functional justifications.

With respect to design, as it was a new work for the students so far, explanations were previously provided in the theoretical classroom sessions about the necessary steps of the design process. In Ochodek's research [27], theoretical lecture sessions were also combined with laboratory classes through a reduced project within the context of a subject. In this research, the steps of the design process explained in the theoretical sessions were complemented with the necessary regulatory justifications for the product, especially those related to Fire Safety and Accessibility. Real cases of similar buildings within these previous theoretical explanations were also studied. These examples of similar cases served to provide examples of future states of the building product, that is, examples of what we want

to achieve. These future states are what the Scrum Guide defines as the Product Goal, which is the commitment associated with the Product Backlog. In Scrum, each artefact contains a commitment that translates into information with which to measure progress. That is, it is about achieving a building that, with a particular design, is capable of providing and satisfying the intended use of the building.

The second of the Scrum artefacts is the Sprint Backlog, which specifies the work that developers plan to complete in the Sprint. In the context of the subject, this Sprint Backlog was detailed weekly in the classroom sessions, and throughout the week, the students updated it and adapted it to the real circumstances of the progress of the work as they acquired knowledge. The commitment associated with the Sprint Backlog is the Sprint Goal. In the context of the subject and apart from the pending work of the Sprint, in each Sprint there was an ultimate objective or ultimate purpose of each work week. In some cases, it was closing a programme of needs and in others, for example, sizing the spaces or defining a distribution of spaces. These objectives were defined when the Sprint was planned and explained to the students in writing on a weekly basis.

The third artefact is the Increment. Different increments were added to produce the final product. For the work to be considered an Increment, it must meet the commitment associated with this artefact: the definition of Done. This means that the work meets the established quality requirements. This is one of the issues that were verified in the Sprint Reviews, where the lecturer validated the work effectively considered Done. If this definition of Done was not met, in the next Sprint it was necessary to modify those circumstances that prevented an Increment from being produced.

3.4. Consultations with students on the implementation of Scrum

Once the block of the subject where the implementation of Scrum was carried out was completed, a work session was held with the students with the aim of analysing how this experience turned out. To do this, participants were encouraged to express themselves freely and sincerely, indicating the positive and negative aspects. Before and throughout the course, the lecturer paid special attention to fostering a sincere and collaborative work environment. This climate aimed to achieve the acquisition of skills by the students and for them to express themselves honestly at all times about the difficulties and advantages of the methodology followed, thus improving the reception of adequate feedback on the implementation of Scrum.

The results of this session of consultations with the students provided satisfying feedback about the use of Scrum, which was generally expressed as a positive experience for different reasons. Establishing a weekly Sprint with a Sprint Backlog was very helpful in structuring and managing work more efficiently. It was also

helpful in maintaining a constant focus on the project work during the seven weeks of developing the experience. The Sprint Backlog helped us know where to focus on the weekly work. This type of work carried out in the subject was new for the students, so having a clear image of the work to be done during the week allowed them to work with concreteness. In the same sense, the students stated that, in turn, this Sprint Goal and the subsequent Sprint Review implied a specific commitment for which they would have to be held accountable on a weekly basis. This circumstance served as an incentive for constant work. At the same time, collaborative Sprint Reviews between all groups meant joint participation in the work, which was motivating. It was also indicated that applying Scrum meant obtaining results more quickly. In fact, both students and lecturers observed faster progress in the groups where Scrum was implemented compared to those in which the group work dynamic was traditional. It is not in vain that this type of technique is applied to products that have an aggressive time to market. Another issue that was positive for the students was the improvement of relationships between participants, with this Scrum work context being a link between them. This was true not only between the two people who formed each work group but also between the four groups in which Scrum was applied since a good part of the in-class work, especially the Sprint Review, was done jointly and around a work table.

Finally, a limitation was that the implementation of the main elements that define Scrum was not so possible. Particularly, it was observed that Daily Scrums were hardly put into practice on a continuous basis. After the weekly Sprint Retrospective sessions, the students stated that it was difficult to carry out this type of meeting. This was because the components that formed the Scrum workgroups had problems being present at the same time due to having different schedules. In other cases, regardless of possible coincidences, the heavy learning load on students favoured not holding a daily Scrum and further concentrating the work in certain sessions. Despite this, the rest of the events and artefacts applied compensated for this difficulty, implying a positive experience with the implementation of Scrum in this teaching context.

4. Conclusions

In this research, Scrum was implemented in the teaching of a subject (Technical Projects I, in the Degree in Building) where students developed novel work in their studies so far. Besides, this experience was carried out throughout one of the thematic blocks of the subject that lasts seven weeks, a short period for a work with a wide scope. Projects where this technique is usually applied are characterised by aggressive market launch times and high degrees of uncertainty about the requirements, objectives, and risks that the project will face. The circumstances indicate that a priori, the proposal presented to the students in this subject block—primarily the design of a building—was a highly suitable context for implementing Scrum. The results of the experience and its contrast with the students showed that

this hypothesis was correct. Scrum allowed students to focus on the work that needed to be addressed to meet weekly objectives in a context of very high uncertainty for them. The Scrum event that gained the most strength in this teaching context, the Sprint Review, strongly contributed to overcoming uncertainties and allowed the building design to be completed based on iterations. When these reviews were carried out in the different phases of the building design and this design did not meet the definition of done, a new iteration began that led to the improvement of the final product.

Furthermore, this way of working has meant reinforcing the group feeling, not only among the people who formed the work teams but also between the different teams and the lecturer. Scrum became a tool that everyone used to advance together toward the final goal of students to acquire skills. One of these transversal skills proposed in the subject is teamwork. The values of Scrum, its roles, events, and artefacts were a new way of giving consistency to this competence with respect to the traditional group work that students had already been developing in their studies. In fact, it was observed that those groups that were lagging in the early stages of the project were carried along by the Scrum spirit and managed to complete the work satisfactorily. All this was due to the cohesion between the different groups, which, during the class work sessions, worked as one. One of the circumstances that reinforces this observation was that in the different Sprint Reviews, the teams took design ideas from each other; however, the final designs were all different in each of the teams. This way of working in cohesive subgroups in a larger group during Scrum sessions significantly reinforced the final results.

As mentioned earlier, the Sprint Review was the most significant event in this educational context. Contrarily, the Daily Scrum turned to be more challenging for students to complete and for the teacher to verify. The main reason is that this event must take place every day, outside the scheduled class sessions, which occur only once a week. The lack of daily physical coordination at the university or elsewhere among the members of the working groups, coupled with their heavy academic workload, made it more difficult to conduct the Daily Scrum.Consequently, future implementations of the methodology in this teaching context are necessary to sort out this issue and look for satisfactory alternatives. It is also worth noting that weekly online review sessions and tutorials were not enough to compensate for the poor implementation of Daily Scrum.

With regards to the roles in Scrum, one of the particularities was that the lecturer played the role of Product Owner and Scrum Master. Once the results were compared, it seemed to be a successful option since the lecturer, in their role as Scrum Master, was able to reinforce the application of this technique as described in the Scrum guide. However, placing the role of Scrum Master on students themselves should be researched in order to assess the impact of assigning this role among student representatives in the different teams.

Similar to Scrum's work, this work followed an empiric approach. The conclusions obtained were based on the observation by the teaching team of what was happening during the work progress, as well as on the feedback from students through discussion, both in the Sprint Retrospective and in the final session of queries.

The application of Scrum in this context made it possible to accelerate the obtaining of results by reducing the uncertainties that arise throughout the process of the building design project and also by increasing the involvement of the students in the subject. Likewise, Scrum contributed to uniting work teams and participants. Therefore, it can be stated that Scrum is an effective support tool in the subject mentioned above and has great potential in teaching in this context. Future research on these experiences would reinforce the literality in its implementation. Increasing prior conceptual training in Scrum by students at the beginning of work will undoubtedly contribute significantly.

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