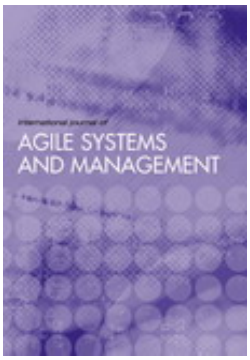

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Abstract: The application of agile techniques is critical to achieve success in the resolution of unique problems in collaborative projects. This article explores the adoption of a project management approach adapted from the Scrum agile method in collaborative research initiatives framed within the Oil & Gas industry. The Scrum features integrated are assessed in six phases to identify how agile principles contribute to the efficiency in research processes related to modelling and understanding geomechanical phenomena in heavy oil reservoirs. Aiming to gather information, the study performs interviews, surveys and the analysis of official documents. Results suggest to foster certain "apprenticeship of observation" from more experienced researchers, a high degree of openness during the adoption of the Scrum framework to develop a collective understanding of novel Scrum practices, exploit improvement opportunities and incorporate agile roles in a flexible manner to strengthen team trust, constructive criticism, efficiency and communication.

Keywords: Scrum framework; agile methods; collaborative research initiatives; agile project management; feasibility assessment; success factors.

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1 Introduction

Since the publication of the Manifesto for Agile Software Development, agile management practices have been widely used to enable industries to deliver products in short time and monitor the management during the activities according to the customer needs (Salas et al., 2005; Moradini et al., 2020).

Scrum is one of the most recognised and adapted agile project management approaches worldwide (Lei et al., 2017). Although currently this framework is mainly used in the information technology (IT) industry and the software development sector, Scrum offers limitless potential to benefit non-software sectors such as the Oil & Gas industry (Schwaber and Beedle, 2001; Abramov, 2020), telecommunications, industrial product design, research initiatives, aircraft maintenance, among other contexts in the industry (Cohen et al., 2004; Hossain et al., 2009; Dyba and Dingsoyr, 2009; Subowo, 2015; Freitas et al., 2020).

In general, both Oil & Gas industry and academia are challenged to work in a continuously-changing environment. On one hand, the Oil & Gas companies have only recently begun to consciously implement agile ways of working to cope with the current industry speed of delivery, competitiveness, and usability of projects (Hamilton et al., 2019). On the other hand, the scientific activity faces many complexities when adopting agile methods for research, an environment where a balance between timing, effort and collaboration is needed to studying and problematising phenomena, setting research questions, providing results or prototyping (Sandberg and Crnkovic, 2017).

The adaptation of Scrum and agile methods is inevitable in the industry–academia research collaboration as means to exploit essential elements and develop skills for team members such as well-coordinated and cross-functional teams, rapid decision-making cycles supported by technology, and a common sense of purpose to get to key decision points faster through iterative steps.

Research projects framed in the Oil & Gas industry might be tailored in such a manner that they fit into agile project management and agile product development (Abramov, 2020). Agile project management concentrates on the overall management of the project based on the implementations of a set of short iterations or Sprints that supports incremental progress

on work priorities. Agile product development concentrates on engineering activities related to the product delivered of a project (White, 2008). These modalities facilitate the fast-paced and coordinated nature of research work, ensuring quality in deliverables, compliance with acceptance criteria and timely feedback (Moradini et al., 2020).

Particularly, this paper presents a case study to identify and understand the main factors, practices and challenges of a Scrum framework adaptation in a research group dedicated to hydrocarbon reservoir engineering and reservoir geomechanics. This study enriches the groundwork related to agile strategies in scientific production and applied engineering product development.

To provide some context, the target research group, assessed in this research, started implementing the Scrum methodology during the development of a project whose main deliverable product was a reservoir simulation software, and once the methodology was implemented, strengths and benefits regarding the team performance were identified as future elements to be exploited in the management of new research projects. The projects developed by this research group have mainly involved two components, a technical component, and the deliverables. The technical component includes activities aimed at providing a scientific response to the main problem addressed by the project, while the deliverables are commitments acquired with the project financial organisations: training of students at the undergraduate or postgraduate level, construction and delivery of new knowledge (articles, books, patents, etc.) and social appropriation of knowledge (presentations, events, workshops, etc.). The projects framed within the Scrum methodology have been usually financed by public entities that promote technological and scientific development in topics of current interest in the industry, such as improved hydrocarbon recovery.

To understand the implications of the Scrum methodology adaptation, this study was guided and structured by the following research question: How has the Scrum methodology been adapted in the context of a research group framed in the Oil & Gas industry and to what extent this adaptation has contributed to successfully cope with research project requirements?

2 Background

2.1 The Scrum framework

According to Salas et al. (2005), Scrum is a flexible framework that helps people, teams, and organisations to create value through adaptive solutions to complex problems. Scrum, as a development process, includes iterations or sprints where the Scrum team is responsible and participates during the planning, scheduling, distribution of tasks, monitoring, decision-making activities, and assessment (Rising and Janoff, 2000).

The Scrum framework is based on three guidelines: transparency, inspection and adaptation. The Scrum members must monitor the relevant aspects of the process according to the standards and agreements. Artifacts and Sprint Goals must be also inspected, and any material or process should be adapted if needed to encounter the planned tasks.

According to Romero-Castro et al. (2018), the Scrum framework is developed in Sprints which are between two and four weeks long. In each Sprint a new version of the product is generated to improve the version of the previous one based on the outcomes of improving the properties of the product parallel to the project progress. At the beginning of the Sprint,

the Scrum Planning occurs to define the tasks and activities to be done. At the end of each Sprint, the Sprint Review and Retrospective meetings are scheduled. During the Sprint, members of the Scrum Team participate in Daily Meetings of 15 minutes long. These daily meetings and other ceremonies such as Scrum Planning, Retrospective and Review Meetings are time-boxed and led by the Scrum Master.

The Scrum framework includes three roles, five events and three artifacts (Salas et al., 2005):

Product owner. Professional responsible for prioritising the requirements of the project scope, maximising the value of the product developed by the Scrum Team.

Scrum Master. Professional responsible for managing and ensuring that the Scrum process is understood and carried out appropriately. The Scrum Master also facilitates the execution of the process and its mechanics.

Scrum Team. Group of three to nine professionals who oversee the development of the project and delivery of the final product. They self-organise and decide what is the best way to deliver an increment Sprint by Sprint.

Product Backlog. This event includes a subset of short-term and long-term user stories and tasks defined by the Product Owner and Scrum Team. These tasks migrate from the Product Backlog to the Sprint task-board to be completed at the end of the Sprint.

Sprint Burndown Graph. This artifact shows the remained tasks to be done for the Sprint over the time of it.

Increment. This feature corresponds to the sum of the items of the Product Backlog that were completed during the previous Sprints. After each Sprint a new increment is added according to the definition of 'Done' given by the Scrum Team.

Sprint Planning Meeting. This event involves the planning of the tasks to be developed by each one of the members of the Scrum Team during the Sprint. This meeting includes the estimation of the time required to develop each task, the dependence between them and potential issues to consider.

Daily Meeting. This event allows all team members to present their plan of the day and address any potential issue that may affect the delivery of the tasks during the Sprint.

Sprint Review. This event involves the Scrum Team and stakeholders who are asked to provide feedback to what has been developed during the Sprint. It is a time-boxed meeting held at the end of the Sprint to share results and inspect them.

Sprint Retrospective. This event implies an opportunity to assess the team's relationships, processes, and dynamics to plan future improvements.

2.2 The Scrum framework and related work in the target Oil & Gas research group

According to Ernst & Young Global Limited (2014), only 20% of the megaprojects worldwide are successful in the Oil & Gas industry. Particularly, in Latin America 57% of these projects face cost overruns and 71% face schedule delays. These overruns are caused by inadequate planning, ineffective project management and human capital deficit that must be well-studied.

Grapenthin et al. (2015) stated that agile methods can be implemented to overcome obstacles and challenges when facing project failure. The Scrum framework is a tested solution for effective cooperation between companies and organisations that minimises capital project risk and maximises return on investment (Schwaber and Beedle, 2001). However, when it comes to collaborative research projects, the Scrum framework requires adaptations and new project management techniques since these research projects face other challenges related to the need for supervision and coordination between peers, hardly unpredictable factors and timely progress assessment (Hidalgo, 2019).

Indeed, large-scale research projects often require a greater dedication to lead and coordinate every process. Research progress can take many forms, such as implementing code, carrying out an experiment, reading or writing a paper, writing up reports, or preparing a talk. Methodologically, these additional complexities in conducting scientific activities represent an evolving interdisciplinary field that requires exploration (Hidalgo, 2019). Some other benefits of adopting agile methods in research are related to the visualisation and sharing of progress in tasks (Sljivar and Gunasekaran, 2018), the accomplishment of tasks and deadlines, the empowerment and definition of next steps and provision of structure and organisation (Tomás et al., 2021) which maximise the chances of success in any of the elements of the iron triangle (Pollack et al., 2018): scope (functionality), cost (resources) and time (schedule).

Activities such as scientific research, innovation, invention and software development, typically exhibit constant changes, addition of tasks and complex follow-up (Marchesi et al., 2007) which can be managed by the adaptation of agile methodologies. This process implies modifying agile methods to align them with the needs of different projects and institutional contexts to enhance product quality, efficiency and effectiveness (Munteanuand and Dragos, 2021).

Previous experiences with Scrum adaptation in research projects have been successful. Hicks and Foster (2010) adopted an hybrid agile management approached called SCORE to keep the track of the progress of Ph.D students and collaboratively produce high-quality research results. SCORE, as an adaptation of Scrum to research, implemented three-times-per-week status meetings and one-on-one meetings, scheduled on demand. Regular short status meetings helped to keep every member of the research group up-to-date on how students were doing, and on-demand meetings between the student(s) and adviser(s) allowed the discussion of research questions, methods, technical challenges, obstacles and results. Regarding the main benefits, participants remarked they felt more encouraged to make their progress smoother and more consistent and had better interactions with their advisers and team members as the approach fostered a sense of community and more robust group dynamic.

Rover et al. (2017) implemented a case study on a capstone design project where agile project management was used with students research initiatives. According to the results, Sprints and Meetings fostered communication processes that allowed frequent feedback and established what items could be made in Sprints. The major outcomes originated by these agile practices were teamwork, product quality, customer focus, and iterative development.

Other authors such as Tomás et al. (2021) set out an exploratory case study focused on the perceptions and results related to Scrum project management methods for managing thesis development and supervision. Interviewees reported having group meetings at the beginning and at the end of a Sprint for planning and reviewing the work done. These Meetings provided opportunities for frequent feedback, continuous monitoring and constant updates regarding specific problems which were of great help to check on progress and

exchange experiences. By implementing bi-weekly meetings, students felt motivated to achieve the goals set at the beginning of the Sprint, they acquired a feeling of responsibility and empowerment once accomplished tasks and deadlines, and implemented the division of a large work into smaller parts, avoiding delays.

Hidalgo (2019) provided an analysis of the adoption of agile practices and the Scrum framework at the research centre CECAN. According to the results, integrating agile methods for collaborative research initiatives requires flexibility and 'learn by doing' approaches. The shared leadership, team orientation, motivation, cross-functionality, internal learning processes and team autonomy are key elements of agile management practices for research.

Based on previous studies, this paper main contribution is the development of a hybrid agile approach that resulted from the integration and application of some elements of the Scrum methodology to a case study from a research initiative framed in the Oil & Gas industry. A second contribution is the study and application of the agile approach outside its natural context and identification of the main benefits, novel practices, aspects to reinforce and challenges that lead to much more efficient project management processes.

2.2.1 Research group dynamics before the Scrum framework adaptation

The target research group in this case study has endeavoured to develop research tasks and projects where the scope, time and budget are fundamental pillars when addressing solutions or challenges in the reservoir productivity. At the beginning, the target research group managed and led projects based on a traditional planning scheme (Figure 1). The project development was performed according to the Waterfall model where controlled processes included non-adaptive standards, non-flexible modes of working, and roles not well-differentiated (Trigas-Gallego and Domingo-Troncho, 2012). The delivery of products used to be programmed at the end of the project and practitioners did not assess the positive and negative aspects of the process to identify improvement opportunities. Besides, deliveries were constantly delayed causing re-processing, non-compliance, schedule delay and costs overrun.

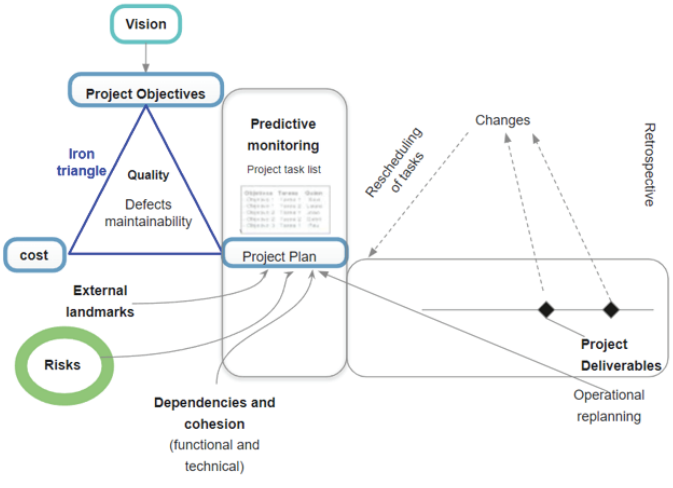
Research projects developed by the target group have faced a lot of hardly predictable factors, that limit the use of classical project management. The current research initiative developed by the group tackles scientific and technological challenges related to the geomechanical assessment and production forecast of heavy oil reservoirs subjected to steam injection processes. The project is divided into several research lines approaching some of the following main goals:

- identify geomechanical factors related to the steam injection processes that impact well productivity and model the evolution of the reservoir stress state during injection and production stages that induce permeability changes
- assess different productivity scenarios and reservoir stress response using an in-house simulator
- formulate and test a methodology focused on heavy oil reservoir management that integrates the assessment of the stress state evolution and production forecast.

Consequently, to cope with the project deliveries and schedule, it has become necessary to include artifacts, modelling and documentation that allow the adoption of Scrum practices in these contexts (Santos et al., 2016). According to Ota (2010), Scrum is a suitable approach

for projects combining academic or scientific research and applied engineering within a product development as it enables iterative incremental deliveries between scientific and engineering tasks for each iteration (usually from 2 to 4 weeks). It allows monitoring and controlling milestones, fostering communication flow, constant scope review and forcing time-boxed deliveries or events to adjust any failures identified, guarantee team cohesion and avoid delays (Lima et al., 2010).

Figure 1 Traditional planning scheme in the research group (see online version for colours)



The studies of López-Martínez et al. (2016) and Eloranta et al. (2016) mentioned some obstacles encountered during the adoption of Scrum which are related to the ones identified in the current case study. The resistance to change and the lack of training and confidence in the process have negatively contributed to the length, and complexity of the project management. Furthermore, the integration of new professionals, who bring customs of handling a traditional methodology with well-defined standards and individual work, caused some resistance to change to agile methodologies, slow-paced collective communication and poor shared learning within the team.

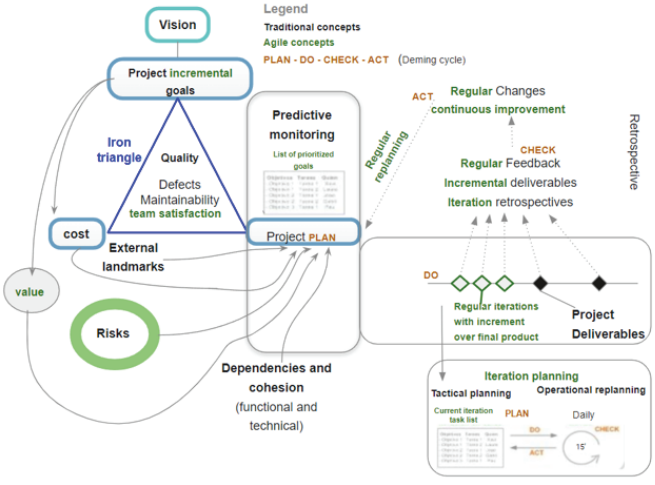
To mediate some of the aforementioned challenges, the group has integrated different activities: Scrum adaptation to allow the construction of the Minimum Viable Product (MVP) with the participation of the research team and stakeholders; parallel phases to assess the technical viability of the project and work on flaw identification; agile management based on Scrum, and continuous strategic assessment to test research hypothesis.

2.2.2 Research group dynamics after the Scrum framework adaptation

For five years, the research group has been committed to agile methodologies, specifically the Scrum framework, achieving flexibility and immediacy to assist the specific circumstances of the context (Figure 2). With the support of specialised consultants, it has been possible to transfer knowledge to the team of collaborators in the target research group. At the beginning of the agile methodology adoption, mixed groups were formed between consultants and direct group collaborators.

In brief, the underlying justification for the selection and adoption of agile methodologies in the research group has been based on the key characteristics of the Scrum framework, such as flexibility, autonomy and self-organisation that allow better control of the processes.

Figure 2 Agile planning scheme adopted in the target research group (see online version for colours)



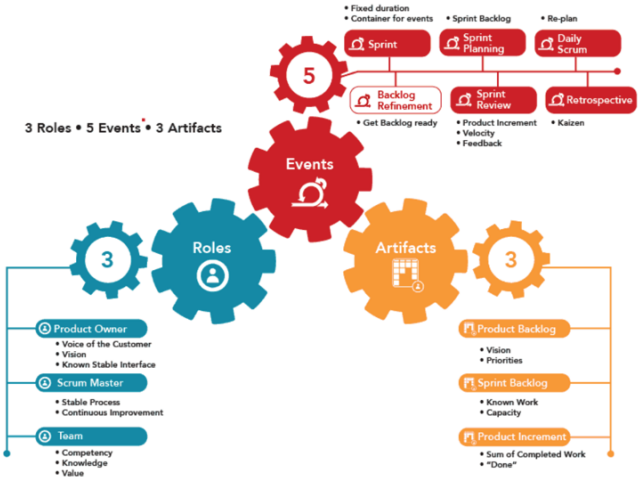
The Scrum framework adapted and implemented in the group (Figure 3) has focused on minimising the risks during the execution of any project through iterations, which usually last two weeks. Implementing short Sprint length lets participants achieve a situation where all tasks are completed at the end of the Sprint (Papadakis and Tsironis, 2018). According to the research group experience, bi-weekly Sprints provide more benefits compared to Sprints of 3–4 weeks as they allow the accomplishment of checkpoints or deadlines and the division of large work into smaller parts. Impediments, conflicts and re-processing seemed to dominate in longer Sprints inducing a poor balance of the workload and efficiency, whereas bi-weekly sprints enhance the team's performance in terms of time, communication and constant work, facilitate flaw remediation and the team's responsiveness seem to be more efficient to react to strategic changes.

Research objectives can be planned in cycles of bi-weekly Sprints. Some typical objectives include understanding new geomechanical phenomena and creating new modelling strategies to assess reservoir performance, based on principles and rules; designing, optimising and predicting production, hydraulic fracturing and oil recovery processes, and developing software or methodologies with strong applied research capabilities to meet industry demands.

Each Sprint represents a small section of the final project that includes all the tasks necessary to implement new functionalities: planning, analysis of requirements, designing, testing, and delivery of documentation. At the end of each iteration and between each one of them, the team reassesses its priorities (Schwaber and Beedle, 2017).

As a matter of fact, the Scrum framework has helped to improve teamwork, task coordination and motivation as it clarifies roles, mediates conflicts thorough negotiation, and ensures that each member of the team contributes to the Sprint Goal (Rigby et al., 2016). Particularly, in this case study some considerations regarding the Scrum features include:

Figure 3 Scrum framework components in the research group (see online version for colours)



- The Product Owner creates a priority list of what is expected to be developed, called the Product Backlog (or product stack).
- During the Sprint Planning, the team selects a few items from the top of this priority list, Sprint Backlog, and decides how to implement these items.
- The team has a certain amount of time to complete the planned work. The team has Daily Meetings to evaluate the progress.
- The Scrum Master constantly keeps the team focused on the goals. He/she is not only focused on command-and-control, but also on providing direction and support to other team members. This Scrum Master is part of the Scrum Team participating as a Scrum Facilitator.
- Tasks are readjusted if necessary, during the Sprint. At the end of the Sprint, the team is ready to deliver in the Review Meeting a brief report about the work developed during the sprint.
- The Sprint ends with the Sprint Review and the Sprint Retrospective. At the start of the next Sprint, the team picks another chunk of remaining activities from the Product Backlog to plan the future tasks.

Based on the Scrum principles and tools that are commonly adopted in the research group, the proposed configuration can be summarised in six phases as shown in Figure 4.

Starting phase. This phase implies the structuring of the main needs the project seeks to solve, as well as the configuration of the teamwork. In this phase, those responsible for the initiative describe in general terms the needs, problems, as well as what is expected to be found as a solution to them. Another outcome of this phase is the identification of the roles of the team members and their responsibilities.

In this initial stage, the first list of priorities is defined in the Product Backlog, the team agrees on the requirements to consider a task as completed (definition of 'Done') and the first user stories are structured. The inputs, tools and outputs of this phase adopted in the research group are shown in Table 1.

Figure 4 Research project phases based on the adoption of the Scrum framework in the research group (see online version for colours)

Table 1 Inputs, tools, and outputs of the starting phase

Project charter		
Entry	*Tools*	*Outputs*
Owner of the initiative Problem or need that gives purpose to the project. Approval and agreement of the stakeholders.	Face-to-face or virtual group meetings. Assessment of experts on the subject Similar project experiences.	Formal configuration of the project. List of roles involved: main promoters, stakeholders, Scrum Facilitator and Scrum Team.
Project identification of requirements		
Formal configuration of the project. Project members involved: main promoters, stakeholders, Scrum Facilitator and Scrum Team.	Face-to-face or virtual group meetings. Focused interviews. User stories workshop. Diagnosis of the current situation.	List of requirements.
Project prioritisation of the product list		
Owner of the initiative Problem or need that gives purpose to the project. Approval and agreement of the stakeholders.	Face-to-face or virtual group meetings. Assessment of experts on the subject. Similar project experiences.	Formal configuration of the project. List of roles involved: main promoters, stakeholders, Scrum Facilitator and Scrum Team.

Planning phase. In this phase, with the project team formally established, more detailed activities are carried out. This phase involves the estimation and diagnosis of the necessary

resources to search for solutions to the research problem. This problem notion evolves from a global idea to a more elaborate one that leads to the formulation of needs grouped in cycles that facilitate focusing the efforts of the team on the Minimum Viable Product (MVP). The planning phase considers the elaboration of user stories with their acceptance criteria, estimation of the effort points for the development of solutions and the work plan for the MVP over the iterative steps. The inputs, tools and outputs of this phase adopted in the research group are shown in Table 2.

Table 2 Inputs, tools, and outputs of the planning phase

Elaboration of user stories		
Entry	*Tools*	*Outputs*
List of requirements. Prioritised product list. Participants: stakeholders, and Scrum facilitator.	Face-to-face or virtual group meetings. User story workshop.	List of user stories.
Task estimation		
List of user stories. Participants: stakeholders, work team and Scrum Facilitator.	Face-to-face or virtual group meetings. Time estimation method.	Task estimation.
Elaboration of the increase cycle board		
Elaboration of the increase cycle board. Participants: Scrum Team and Facilitator.	Face-to-face or virtual group meetings. Incremental cycle workshop.	Incremental cycle board.
Task tracking		
Task estimation. Incremental cycle board. Participants: Scrum team and Scrum Facilitator.	Face-to-face or virtual group meetings. Task monitoring instructions.	Follow-up assignments.

Implementation phase. During the implementation phase, the team centralises its activities on the execution of the tasks identified during the planning phase, constantly updating the increase cycle board and the follow-up of tasks in Daily Meetings. Moreover, the person in charge of the project and other members complete the product list of features to work on the following cycles, compiling important adjustments that must be included in each cycle and formulating the change requests. The inputs, tools and outputs of this phase adopted in the research group are shown in Table 3.

Launch phase. In this phase, the compliance with the increment functionalities, the acceptance criteria, change requests and impediments is formalised by the person in charge of the project. The delivery involves providing details regarding each one of the functionalities, configurations, and applications outside the scope defined in the project's charter. The inputs, tools and outputs of this phase adopted in the research group are shown in Table 4.

Review and retrospective phases. The project development process should be adapted by making room for reflection, learning and improvement opportunities (Moe et al., 2010).

These phases are performed with the purpose of socialising and discussing with the main stakeholders, the successes and failures identified during the execution of the tasks of each increment. To do so, a period at the end of each Sprint is programmed to reflect on the team's performance and the actions that must be undertaken for the next iterations to overcome the obstacles identified in the previous cycle. At the end of the cycle, the acceptance criteria, change requests and impediments are validated. The inputs, tools and outputs of these phases are shown in Table 5.

Table 3 Inputs, tools, and outputs of the implementation phase

Changes requests		
Entry	*Tools*	*Outputs*
List of user stories. List of prioritised products. Participants: stakeholders.	Face-to-face or virtual group meetings. Preparation of request for changes.	Request for changes.
Elaboration of impediments		
Follow-up assignments. Task estimation. Increment cycle dashboard. Team participation.	Face-to-face or virtual group meetings. Instructions to formulate impediments.	Impediments.
Task tracking and increment cycle board		
Follow-up assignments. Task estimation. Increment cycle dashboard. Team participation.	Face-to-face or virtual group meetings. Task execution.	Task estimation (Updated). Increment cycle dashboard (Updated). Task tracking (Updated).

Table 4 Inputs, tools, and outputs of the review and retrospective phase

Entry	*Tools*	*Outputs*
Task estimation (Updated). Increment cycle dashboard (updated). Task tracking (Updated). Request for changes. List of impediments and team participation.	Face-to-face or virtual group meetings. Elaboration of increment. Analysis of improvements. Retrospective meeting.	Increment. Actionable improvements. Hindsight.

Suggested phase: lessons learned phase. It is suggested to implement an additional phase in the Scrum framework to guarantee that the adaptation of the Scrum framework is an agile and evolving process with increasing maturity based on the team's expertise. This phase includes an in-depth and formal follow-up of all the project actions as the main input in the starting phase of the following projects. The lessons learned document is constructed by all the team members as a guideline of adaptations for artifacts and events and a compilation of positive and negative experiences considered relevant to be replicated or improved in future projects considering feedback comments. This stage involves processes of monitoring and

scaffolding the adoption of agile practices to identify improvement opportunities (Freire et al., 2018). The inputs, tools and outputs adopted in the research group are shown in Table 6. The lessons learned phase is currently not implemented in the research group but, it is suggested to incorporate it into the Scrum framework adaptation proposal.

Table 5 Inputs, tools, and outputs of the review and retrospective phase

Entry	*Tools*	*Outputs*
Increments. Retrospective. Task tracking (Updated). Participants: people responsible for the project, Scrum team and Scrum Facilitator.	Face-to-face or virtual group meetings. Preparation of deliverables. Retrospective.	Deliverables. Retrospective.

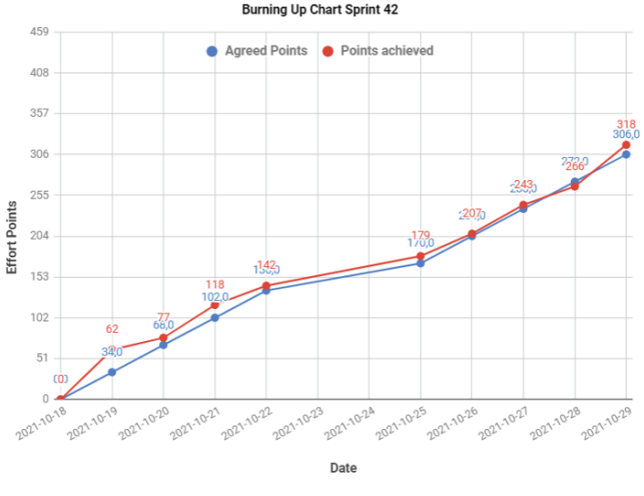
Table 6 Inputs, tools, and outputs of the lessons learned phase

Entry	*Tools*	*Outputs*
Formal formulation of the project. Project Retrospective.	Face-to-face or virtual group meetings. Project closure meeting.	Lessons learned report.

Each of these structured six phases implemented in the research group have been measured by indicators to monitor the satisfactory completion of the projects' tasks.

Burndown chart. This graph shows the amount of work over the time of the Sprint on a daily basis and must be updated by the Scrum Master at the end of each Sprint. The effort points can be expressed as story points, perfect days, team days or any other unit (Figure 5).

Figure 5 Statistics of effort points achieved in a Sprint by the research group (see online version for colours)



Overall progress of the project. This indicator measures the academic-technical progress of the project based on the project's goals. This indicator allows mapping the current performance (83.41%) and deliverables which are allocated in each Sprint as represented in Figure 6 with a circle, triangle, diamond, or box.

Figure 6 Statistical academic – technical progress of the project (see online version for colours)

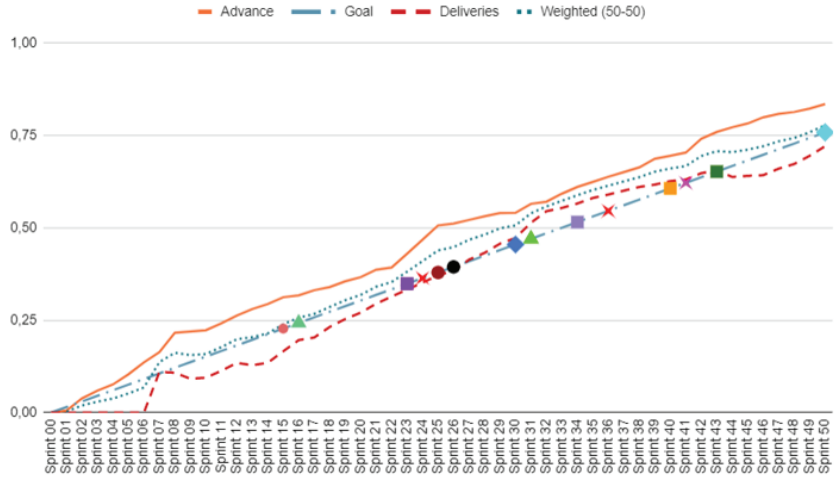
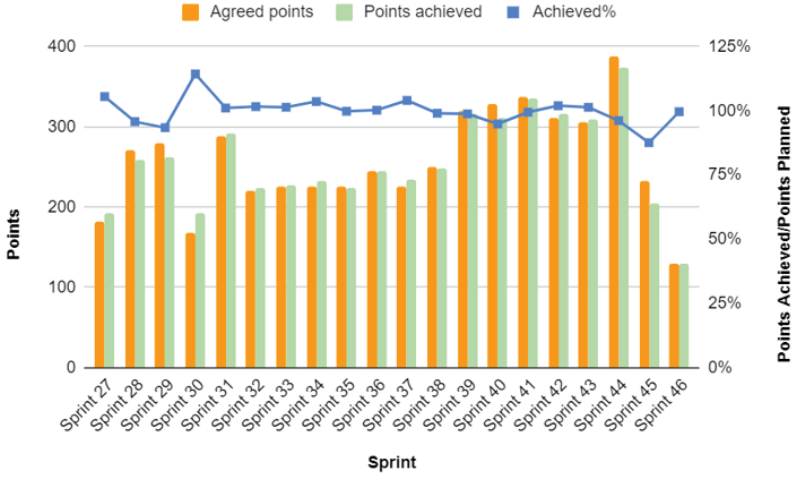


Figure 7 Comparison statistics of estimated and achieved points per Sprint (see online version for colours)



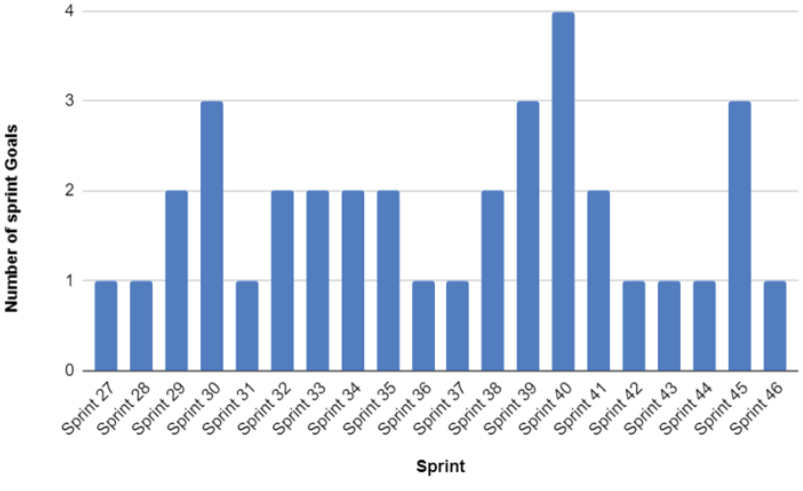
KPIs. This monitoring indicator corresponds to the Business Owner's perception per Sprint. According to the performance assessed by the Business Owner, the average score of the sprints analysed has been 8.6, a high score considering a scale from 0 to 10.

Comparison of estimated and achieved points per Sprint. This indicator allows the analysis of the Sprint execution in terms of estimated points from the Sprint Planning and the points

achieved at the end of it. This indicator is reviewed every six months. Figure 7 shows the percentage of points achieved or estimated during each sprint (an average percentage of 102%). There is a relevant variation of the planned and achieved points since Sprint 39 due to the inclusion of new team members.

Number of sprint goals per sprint. This indicator shows the number of Sprint Goals by sprint. It is assessed every six months. Figure 8 highlights that in multiple Sprints more than one Sprint Goal has been proposed. There have been multiple open and resolved research lines where most of the Sprint Goals have been accomplished.

Figure 8 Number of Sprint Goals per Sprint (see online version for colours)



3 Research methodology

The objective of this case study is to understand the adaptations implemented to adopt the Scrum framework in a research group and the main contributions or challenges faced by this team in terms of the project management. To achieve this goal, the study was developed within three stages: review of the Scrum framework in the research group, inquiry and collection of practitioners' insights, data triangulation and discussion of main results.

This study was framed in a case study with an embedded mixed method design (qualitative and quantitative) to capture the knowledge of practitioners (Benbasat et al., 1987). Information was collected only once, and it was non-experimental (Rising and Janoff, 2000). Sampling strategy was non-probabilistic and by convenience.

Data was collected from the experience of 11 participants, including the current and former participants of the projects in the research group who had played roles as Scrum Master, Product Owner, Business Owner, and Scrum Team. Participants varied by field of expertise, educational background, and experience with the Scrum framework; some of them were master's students, oil industry professionals, doctoral students, and directors of the research group.

Particularly, this case study followed guidelines proposed by two approaches: Appreciative inquiry and Likert methodology. Appreciative inquiry is an organisational development process that involves people in an organisation trying to discover what is working well in order to enhance it, achieve renewal and improve performance (Muga-Naredo, 2014). This approach involves four stages (Table 7).

Table 7 Appreciative Inquiry stages

Stages	
Discovery	Identification of what works well, the strengths.
Dream	Visualisation of what needs to be achieved.
Design	Formulation of the goal in a context-situated scenario and current challenges or limitations.
Destination	Implementation of the design. Specific responsibilities and commitments are assumed. The interviewees refine and give feedback regarding the changes in the processes and factors to adapt and obtain better results.

The Likert scale is a measurement method used by researchers with the aim of evaluating the opinion and attitudes of people (Emerson, 2017; Matas, 2018). When responding to an item on the Likert scale, the user responds specifically based on their level of agreement or disagreement (Table 8). This methodology was implemented in the survey composed of multiple-choice questions distributed in four components: teamwork, application of practices, group support for the application of the methodology and effectiveness of the Scrum practices. The survey was submitted online using Google Forms.

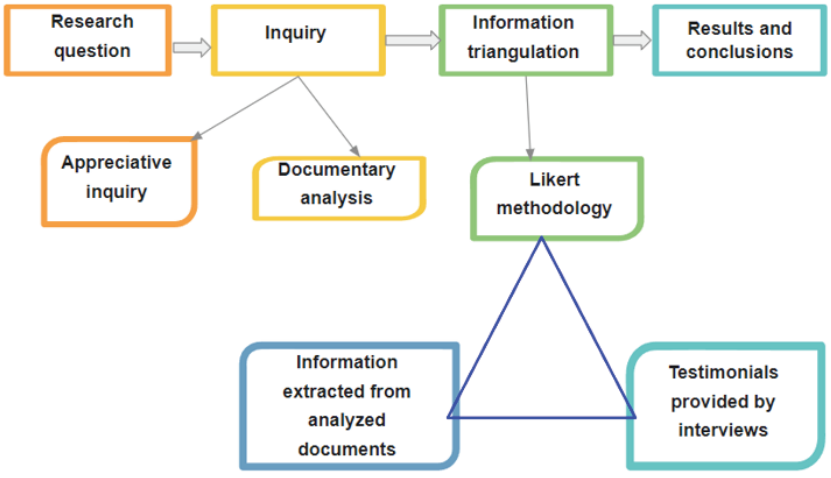
Table 8 Frequency ranges included in the survey

Perception	*Never*	*Rarely*	*Sometimes*	*Usually*	*Always*
Rank	1	2	3	4	5

As for data collection techniques to gather information, the study analysed available documentation in the research group, surveys and semi-structured interviews. The semi-structured interviews were formulated as question-driven conversations concerning practices in the Scrum framework, teamwork, and research activity. The interview questions were developed with the goal of gathering different perspectives from researchers' experiences as practitioners of the Scrum framework in conjunction with four factors of interest: roles, events, artifacts and improvement opportunities. Lastly, the analysis of the documents of the reviewed projects considered the collection of the most relevant and significant elements related to scope, time, budget and Scrum practices.

After gathering the data, the triangulation of the different sources of information occurred (Figure 9). The main objective of this triangulation was to analyse the context-situated practice of the Scrum framework to acquire greater understanding of the adoption of this method in conjunction with the main factors of analysis. To carry this out, this research employed an inferential approach (Cisterna-Cabrera, 2005) to identify the common aspects or divergences related to the proposed Scrum categories: roles, events, artifacts, and improvement opportunities.

Figure 9 Flow of analysis and interpretation of the information collected in the case study (see online version for colours)



4 Results

This section intends to provide a description of the basic characteristics of the Scrum framework adapted in the target research group and future areas to be improved. From the selected sample, five participants have played the role of Scrum Master (45.5%), four people have been Product Owner (36.4%), eight participants have been members of the Scrum Team (72.7%) and finally one person as Business Owner (9.1%).

Concerning the main contributions of the adoption of the Scrum framework, quality and speed of the deliverables, flexibility, simplicity, efficient teamwork, and improved communication are considered of vital importance in the project development as evidenced in Table 9. These results are in line with Ciric et al. (2018) and the top benefits of agile methods stated by Begel and Nagappan (2007).

4.1 Scrum roles

4.1.1 General competences and skills

Reported competences (Figure 10) needed for each one of the Scrum roles in a research project were addressed by asking to the participants their expected competences for all roles based on their experience in the research group and inviting them to self-assess their previous performances when playing any Scrum role. The degree of relevance of each competence (analytical capacity, decision making, professional expertise and continuous learning) is illustrated in Figure 10 in a scale from 0 to 100%, according to the answers of the survey participants. From 0 to 25% refers to a competence to be developed, from 25 to 50% indicates the competence is carried out as a regular practice, but it occasionally requires supervision and support, from 50 to 80% remarks a developed competence with elements to be improved and behaviours to strengthen, and from 80 to 100% refers to a developed competence carried out autonomously and habitually.

First, to adopt and implement the Scrum framework, professionals should acquire *analytical capabilities* to perform roles such as Business Owner, Scrum Master and Product

Owner. It is important to remark that these roles must be capable of setting clear objectives for the analysis and processing of information in compliance with the needs of the project. The Business Owner, Scrum Master and Product Owner must think outside the box (Shastri et al., 2021) and discuss in a truthful and timely manner the results of the analysis of the execution of the projects as input for decision-making activities.

Table 9 Participants answers in the interviews

Excerpts from the semi-structured interviews	
Participant A [role as Scrum Master]	*"(...) it has enabled us to plan, define small tasks to meet an objective, define schedules, verify compliance with them and, if necessary, adjust the objectives. Being part of a work team through cooperative planning."*
Participant H [role as Scrum Master]	*"Before, projects were an act of faith, there were rare follow-up meetings. An agile method has allowed us to have active and non-intuitive control of the development of research tasks over time."*
Participant C [role as member of the Scrum Team]	*"Now I can do things without a problem, in an agile way without major reprocesses, without inconveniences that make me stop everything, restart everything and plan everything again almost from scratch."*
Participant I [role as member of the Scrum Team]	*"The Scrum framework gave us the ability to disaggregate tasks and move forward incrementally."*
Participant E [role as Product Owner]	*"Agility has enabled efficient teamwork."*
Participant J [role as Business Owner]	*"I identify agile work in the group as a way to focus, facilitate optimisation and opportunism."*

Figure 10 Competences identified by role in the research group (see online version for colours)

Professional expertise should be developed at a very high level in the research group in the roles of Business Owner, Scrum Master, Product Owner and Scrum Team. At any assigned role, professionals should be capable of articulating their background knowledge to carry out timely actions aimed at satisfying the resolution of the project's challenges, where each of these roles has as prerequisite to inspire great trust and credibility in co-workers.

This finding is consistent with Rubin (2018)'s conclusion addressing trust as a pre-requisite for shared leadership, communication, feedback, coordination, team learning and team distribution.

Continuous learning is a competence that should be developed in an average value of 78%. The team is in constant and incremental learning as source to promote changes and keep updated the manner of approaching the different problems.

Team leadership is a competence that the group has to develop specifically for the roles of Product Owner and Scrum Master. Teams should be assembled considering the potential contribution of each participant to the different research tasks (Hidalgo, 2019).

Even though there is no competence to be developed at 100% for every role, some target competences such as analytical capabilities and team leadership are developed at a high degree (above 75%) for most of the roles. The Scrum Master in the agile project management should play the role as team articulator with high interpersonal capabilities, problem-solving skills, communication and systemic thinking. The Scrum Team should be capable of mapping tasks with some analytical competences and expertise. The Product Owner should be asked to promote teamwork, analytical capabilities and communication among the team members, which is also consistent with Tomás et al. (2021). Indeed all these competences should be oriented to enhance Scrum pillars and principles in the research group by providing learning opportunities and training an agile leader on human factor management to guide and strengthen the team's competences.

4.1.2 Scrum Team

Agile teams are mainly characterised by two things: short iterations and self-organisation. Based on Figure 11, it is possible to conclude that participants agree the Scrum Team members are usually self-organised (36%), which translates into an evident opportunity for improvement towards the consolidation of a more self-managed and self-disciplined team. Another result to highlight is the delivery of progress in an iterative and incremental way (46%) which translates into effective cooperation and collaboration among the members of the group, which minimises project risks in terms of budget, schedule, costs and maximises efficiency.

4.1.3 Product owner

This crucial role in the project is responsible for maximising the value delivered in each iteration, prioritising the Product Backlog and mediating the interaction between the development team and the main stakeholders.

According to the results related to the perception of the performance of the Product Owner (PO) role, Figure 12 shows that professionals who have assumed the PO role usually strive to ensure that projects are developed in a sustainable manner, providing guidelines on the items from the Product Backlog to keep it visible and updated in a transparent manner. The participants agree with Sverrisdottira et al. (2014) regarding the role of PO to provide guidance and assistance, decide what to implement and make decisions when the results do not meet the expectations of the stakeholders.

Figure 11 Scrum Team assessment (see online version for colours)

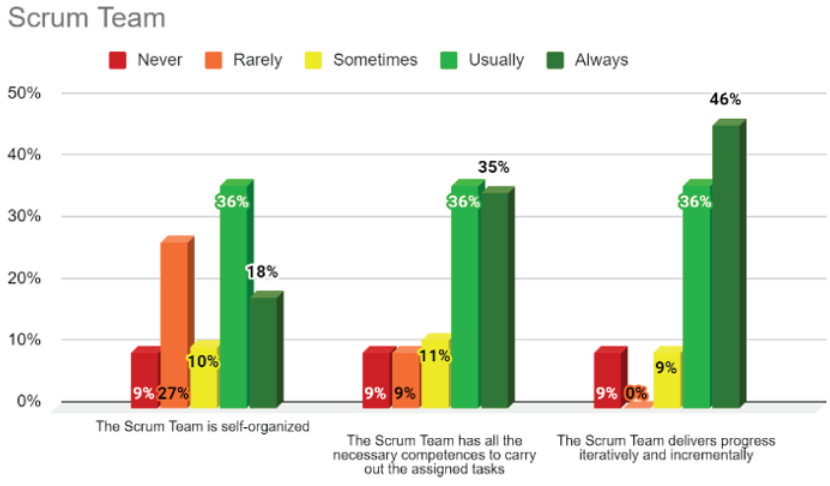
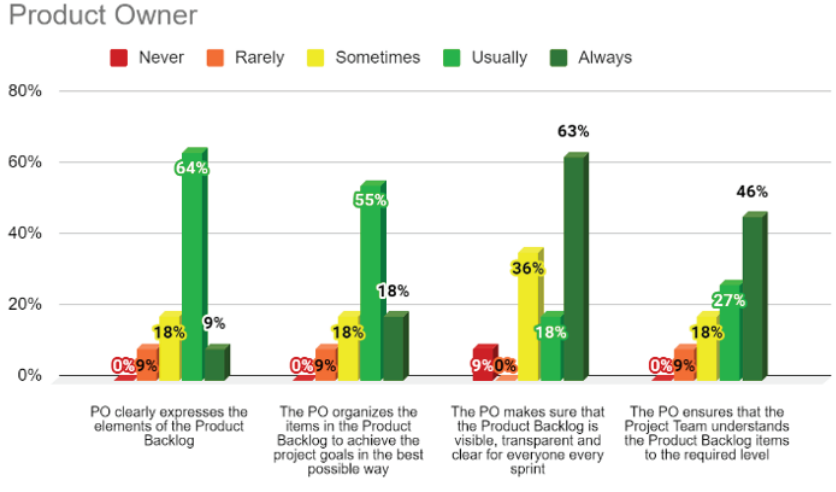


Figure 12 Product Owner assessment (see online version for colours)



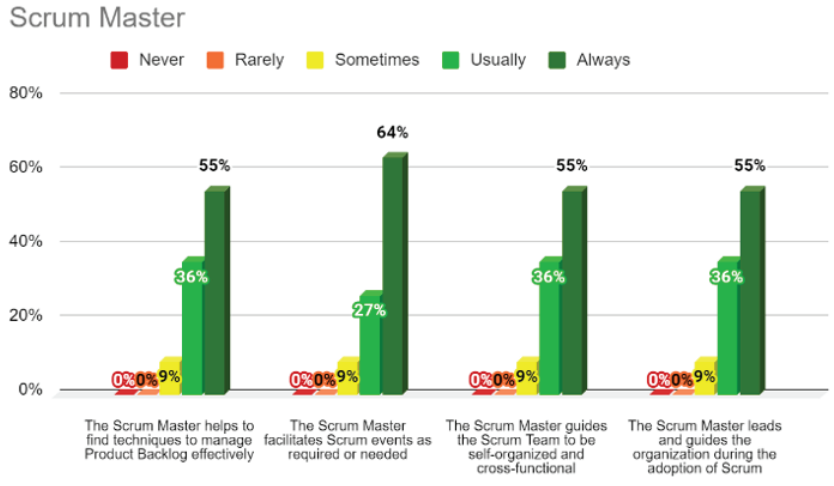
However, the lack of clarity of the Product Backlog is identified by 36% of those survey participants. As a consequence the team might be lacking vision of the valuable elements of the product and more Product Backlog meetings would be needed to order it (Eloranta et al., 2016).

4.1.4 Scrum Master

The role of Scrum Master is the one in charge of leading and guiding the group during the adoption of Scrum. In the research group, the role of project manager is performed by the same person who is Scrum Master and Scrum Team member. According to Figure 13, 91% of the participants mentioned that the Scrum Master always or usually helps to find techniques to manage the Product Backlog effectively. The Scrum Master is in charge of

tasks of supervision of the team's performance and the execution of the different processes to ensure efficiency.

Figure 13 Scrum Master assessment (see online version for colours)



The Scrum Master role always (64%) facilitates the Scrum events as required or needed. It is suggested this role has a full and not part-time dedication to achieve greater effectiveness. The Scrum Master must assume the role of a true and agile leader who is focused on the actions that allow him or her to guide the members to become a self-managed and multifunctional team.These findings supports the notion of the Scrum Master as a mentor and a facilitator (Shastri et al., 2021) who is capable of empowering the team, easing the transition to scrum and facilitate team functioning.

4.2 Scrum events

4.2.1 Sprint Planning

The Sprint Planning is an important and integral part of executing a Sprint effectively as it directly impacts the project schedule. The goal of Sprint Planning is quite simple: define the scope and purpose of the next Sprint (Sprint Goal).

According to Figure 14, the entire Scrum team actively participates in the Sprint Planning. The results show that 91% of survey participants recognised that the Scrum Team participates in the Sprint Planning to prioritise tasks as an opportunity to solve questions or concerns and fulfil the project objectives while not compromising the speed of delivery (Haughton, 2011; Conforto et al., 2014). Al-Zubaidi et al. (2018) stated that poor planning can have a negative impact in terms of time, costs, and budget in the project as it constraints the flexibility and resilience to manage its complexity.

4.2.2 Daily Scrum meeting

As shown in Figure 15, 37% of the Scrum practitioners agreed that the entire team usually participates in Daily Scrum Meetings as an opportunity to engage the teamwork, reallocate work and identify impediments. The project team has a strong involvement in

the Daily Scrum Meetings which always last 15 minutes (37%). However, being aware of the agreements regarding the duration of the ceremonies can be considered an aspect to be improved. This event must be mainly focused on specific needs and requirements for daily activities, minimising the meeting's duration and problems.

Figure 14 Sprint Planning meeting assessment (see online version for colours)

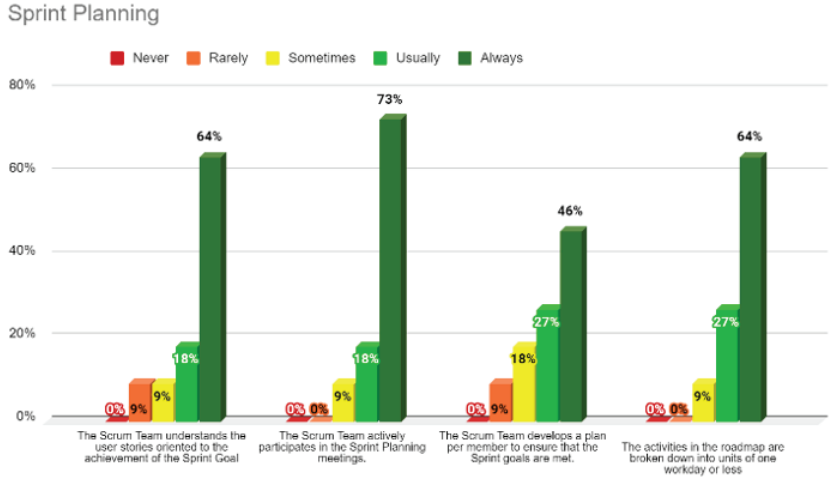
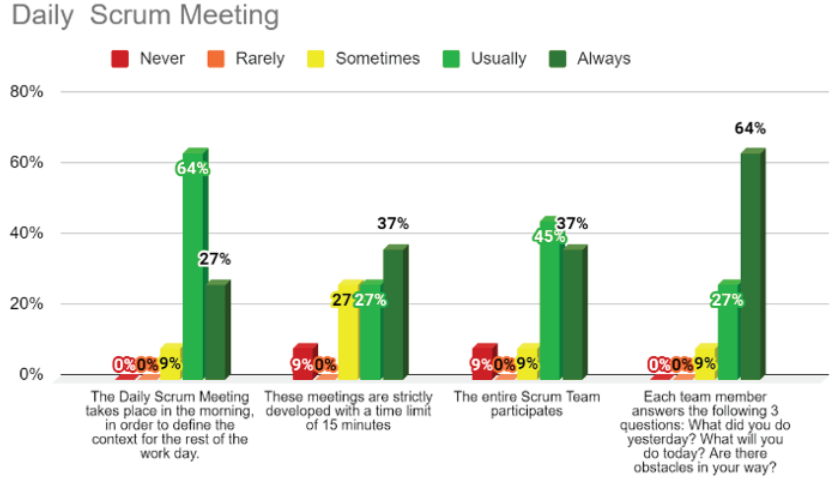


Figure 15 Daily Scrum Meeting assessment (see online version for colours)



Hence, Dorairaj et al. (2014) emphasised the importance of Daily Scrum Meetings to bringing teams closer, allowing them to identify and close the gaps related to agreements and commitment with the requirements of the projects, which has positively impacted in terms of progress, costs, awareness and collective understanding of the project team.

4.2.3 Sprint Review and Retrospective

The Sprint Review has been the meeting par excellence of the assessed research projects. During the Sprint Review, the research group highlights the transparency in the process regarding the increment during the project. In this event, the Product Backlog is inspected and adapted. As can be seen in Figure 16, most participants (91%) indicated that the research group always reviews the Sprint Backlog and socialises the progress of the projects measuring the fulfilment of the stakeholders' needs. Solinski and Petersen (2016) maps learning, feedback and confidence as main benefits of this event.

Figure 16 Sprint Review meeting assessment (see online version for colours)

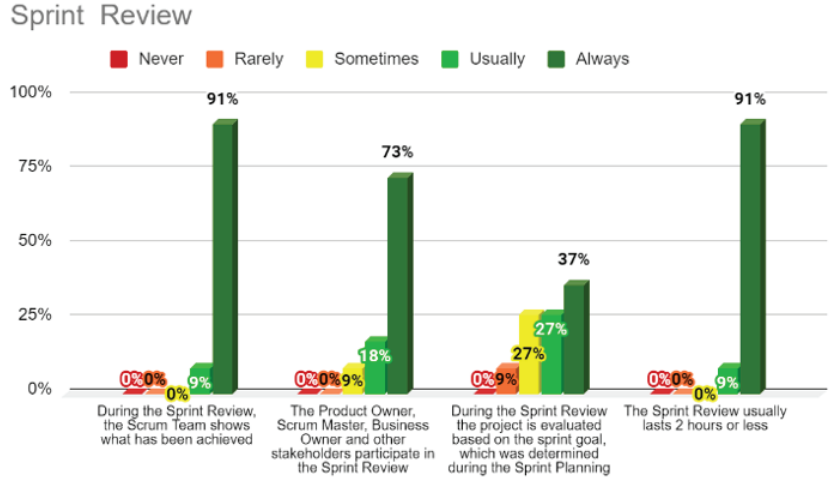
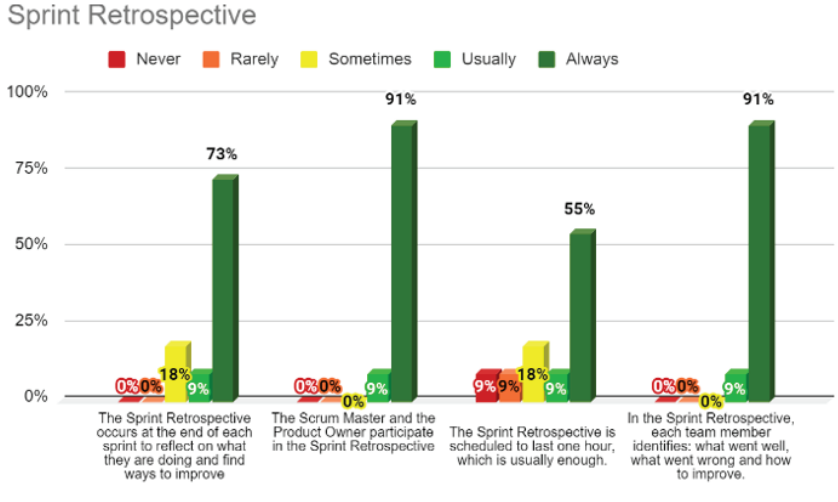


Figure 17 Sprint Retrospective meeting assessment (see online version for colours)



At the end of each Sprint Review meeting, the Scrum Team of the research group conducts a Retrospective meeting to find out what went well, what could have been improved, and

what actions could be taken to do so. According to the data obtained (Figure 17), 82% of the participants indicated that this ceremony is executed in an adequate manner, in agreement with the duration agreed for the ceremony. Sprint Retrospective is a practical tool for improving the project speed (Andriyani, 2017). This event has allowed the research group to evaluate the results of the Sprint Review meeting and prepare for the next Sprint Planning meeting, maximising the opportunity to improve the team's work, and designing an action plan to incorporate the emergent suggestions.

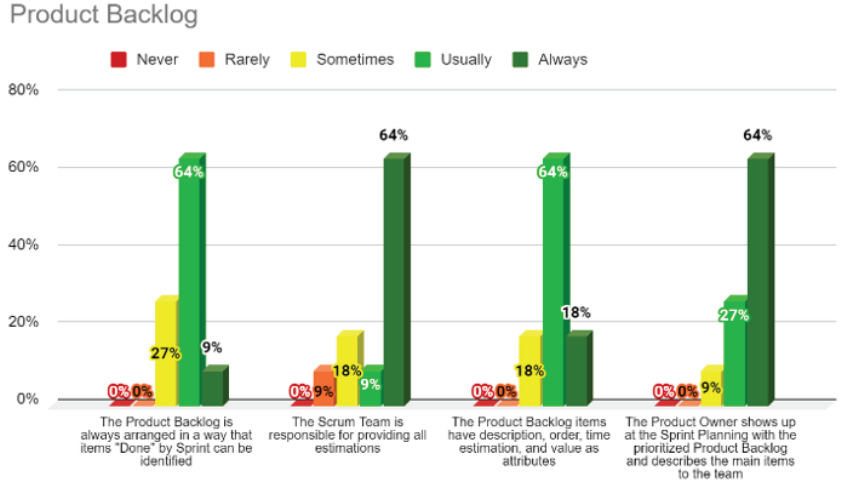
4.3 Scrum artifacts

4.3.1 Product Backlog

The Product Backlog compiles all the goals and desired outcomes within the development of a product. This artifact includes the specific tasks a team aims to complete according to the requirements of the product in the project.

As can be seen in Figure 18, 73% of the participants made reference to the Product Backlog as an organised and structured artifact. However, 'Done' elements must be easily identified to be more effective in the Sprint, leading to the optimisation of time, costs, and project budget.

Figure 18 Product Backlog assessment (see online version for colours)



4.3.2 Sprint Backlog

The Sprint Backlog compiles a subset of features of the Product Backlog that must be visible for the entire team, since it aims to provide transparency on the status of the work planned for the Sprint. The Sprint Backlog includes the Sprint Goal created during the Sprint Planning which helps to enhance cohesion and focus on the work being performed in the research group.

Figure 19 depicts the Scrum practitioners' perception regarding this artifact. 73% of the team members considered the Sprint pending list of items and project's roadmap as always

visible; however, there are scenarios where this situation does not occur and constrains the task of permanently keeping updated and visible to all the team members this artifact.

The Sprint Backlog must be detailed to understand and visualise the on-going progress in the Daily Scrum as stated by 91% of the survey participants (Figure 19). To improve the adoption of this artifact, it is suggested to ensure the updating and availability of the roadmap in a daily basis since this practice maximises the level of self-organisation and communication to solve problems and create increased value in research projects.

Figure 19 Sprint Backlog assessment (see online version for colours)

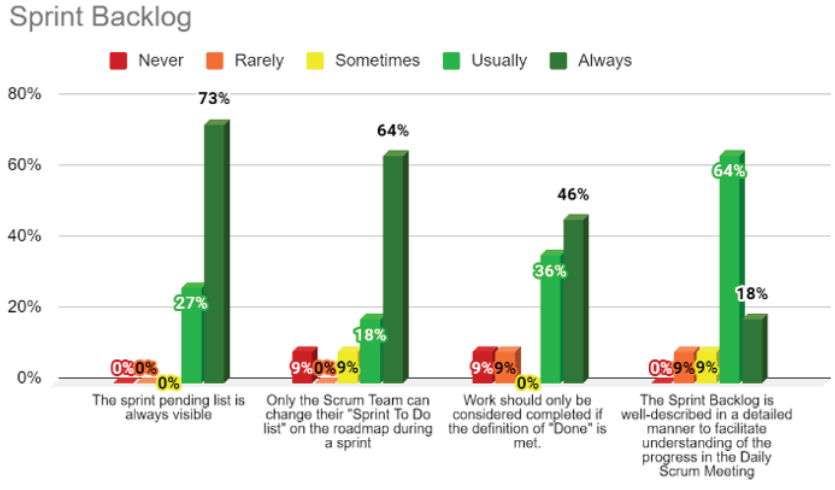
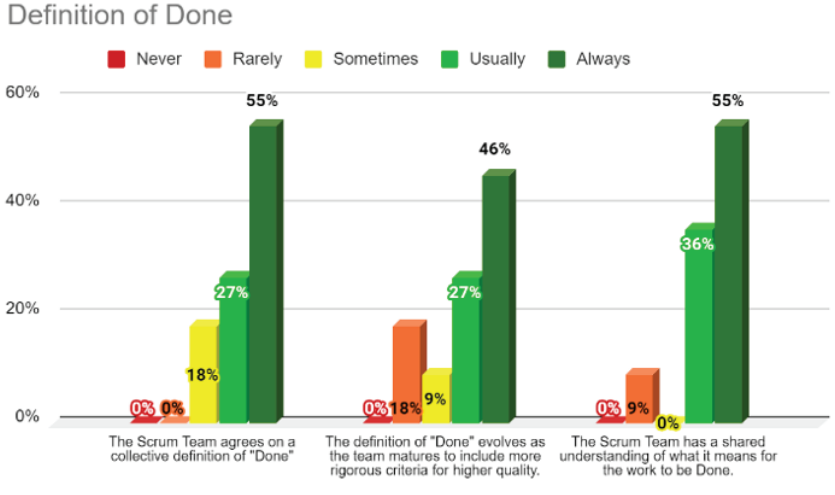


Figure 20 Definition of 'Done' assessment (see online version for colours)



4.3.3 Definition of 'Done' (DoD)

All research projects must have DoD as a resource to enhance the functionality and maturity of the team. This DoD must provide a common understanding of a task completion to

facilitate its monitoring. According to Figure 20, most of the participants stated that the definition of 'Done' usually (46%) evolves according to the team's maturity and discernment to include more rigorous criteria and higher work quality. Defining the DoD is fundamental to provide instruction among the members and prevent risks that have been previously experienced in other projects in terms of costs, budget, and schedule.

4.4 Scrum features to be improved

In terms of the roles assumed by the Scrum practitioners in the research group, results show the research team is multifunctional and each one of the professionals is aware of the objective and functions of each other's role being capable of adequately developing the project requirements and tasks of each Sprint as well as responding efficiently to any change. However, the 'Done' is not always accomplished by the team during the Sprint due to a deficit in the follow-up process developed by the Scrum Master. This finding agrees with Shastri et al. (2021) who identified positive correlation between the DoD, planning, project speed, and the performance of the Scrum Master.

Regarding these challenges, a proposal of actions of improvement is suggested:

- The Product Owner must map the main requirements of the project once the Review Meeting is finished.
- The Scrum Master must provide rich coaching, constant feedback, and clarity in the presented reports (Venkatesh and Rakhra, 2020). He/she should also ensure that the agreed points are fully accomplished, and that the refinement resource is properly used.
- The Scrum Team must maintain a sustaining pace and be capable of solving problems quickly at an early stage. The team should be encouraged to accomplish the "Done" during the Sprint.

By analysing the information gathered concerning the Scrum events, the main strengths identified present similarities with the study of Hicks and Foster (2010): (a) the events have relevance during the development process in the research project, (b) events offer opportunities that allow planning in a structured manner as an aid to set goals and empower the team creating a sense of community and accomplishment, and (c) the usefulness of meetings leads to achieve desired results and inspect the progress keeping status apart from research outcome.

As stated by Lima et al. (2010) and Hidalgo (2019), some Scrum practices must be preserved such as the communication cycle, the scope review, intermediate deliveries to receive feedback and the concept of time-boxed events. It is necessary the Product Owner and the Scrum Master understand the project's risks and degree of uncertainty when prioritising the user stories during the Sprint Planning.

Concerning artifacts within the Scrum framework, they must guarantee the transparency, updating, reporting and supervision of the fundamental information reported during the Scrum implementation in the research group as they are the resources that underpin productivity and quality. In addition to the six-month plan for the Product Backlog, it is suggested to implement an event where a prioritisation process is aimed based on the observations of the Review meeting. This proposal allows the Product Owner and Scrum Master to provide observations with clarity prior to the Scrum Planning on which they must focus their effort.

The results of this case study are aligned with the analysis of Venkatesh and Rakhra (2020) concerning the proper management of the schedule and updating the Product Backlog as useful tools to handle the needs of the project and the distribution of workload within the team.

Lastly, some limitations of this study include the intermediate level of maturity of the team, the rapidly changing strategies to adjust the workflow of the Scrum methodology to the specific needs of the research project, the convenience sampling and small number of people assessed and invited to participate in the current study that might induce some bias to the quality of answers. Furthermore, there is no parallel comparison with other agile practices implemented in the research context of different universities and the limited period of time assessed for this study, since there was no structured data to measure the impact of the methodology during a long-term period. All these aspects might limit the generalisability of the results and analysis.

5 Conclusions

Migrating and changing the way of working from a traditional approach to an agile one, requires a reorientation of the team practices to a self-managing mode which implies resources and time investment (Moe et al., 2010). The adoption of the Scrum framework helps to identify factors to improve through appreciation and perception of the practitioners, therefore this study suggests to include as a Scrum practice a phase of Lessons Learned to enrich the on-going and future research initiatives adopting Scrum principles.

Although a possible lack of skills, trust and rigid mental models might occur, it is necessary to establish actions to strengthen the agility in the research group to continue obtaining innumerable benefits from this methodology to fulfill the objectives outlined in the research projects with greater efficiency and with better control of factors such as: cost, time and scope. According to the results from this study, some actions that should be considered when transitioning to agile methods in research project management include:

- formulating strategies to moderate the degree of individual autonomy that may weaken the team orientation and efficiency
- developing a collective understanding and progressive process of adaptation of incremental research results following the agreements regarding research tasks
- enhancing the role of the Scrum Master as an intermediary and facilitator guided by shared goals
- ensuring the Product Backlog is well-described and validated to strengthen communication, coordination of tasks and the possibility of giving feedback
- setting team rules and enhancing a collective understanding of the Scrum principles and roles to define how team members should interact, communicate, reallocate their work and manage the expectations of each role
- promoting a sense of trust between the team members to empower them and create opportunities to express experiences, feedback and concerns regarding the agile strategies, team performance and working progress

- promoting awareness of the limitations of the context (scientific research) to coordinating the activity, the institutional culture of the research group and the time and resources constraints
- compiling and keeping a record of lessons learned to reconsider the suitability of the Scrum framework for other research initiatives.

It is important to consider that the Scrum methodology adapted to research initiatives mainly targets the management of research tasks and the successful progress in scientific production according to deliverables (paper submission, plan activities leading up to a document deadline or enriching the groundwork for new initiatives). Even though, the suggestions and Scrum practices proposed in this exploratory case study are framed in the specific context of research initiatives in the Oil & Gas industry which does not have a great amount of references in literature, these set of guidelines might also be suitable for management of some kinds of projects combining academic/scientific research and engineering within product development (Hicks and Foster, 2010; Tomás et al., 2021; Ota, 2010).

Finally, it is necessary to remark how the adoption of agile practices in research projects provide opportunities for team members to increase communication, cohesion, monitor processes and scaffold the progress of the transition from traditional approaches. Instructing all the team members into common mental models may facilitate communication, monitoring and team orientation. Nonetheless, some prerequisites for practitioners based on the current case study include the openness to adopt new principles and directions, foster trust, co-creation, communication and be aware of the feedback and improvement opportunities.

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