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Scrum in the Classroom: An Implementation Guide

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***Abstract*— Over the years, Agile approaches have been proven successful in industry settings, as documented in the literature. In response to this success, education professionals have developed ways to introduce Agile practices into engineering classrooms with similar success. These practices have been most popular in project-based courses because they enhance student learning and prepare students for using Agile practices in industry after graduation. The Scrum approach is one of the most popular Agile methods in industry and classroom adoption. Modified versions of Scrum are utilized within the classroom to align with student needs, familiarity with Scrum, and the materials presented within the class. As a result of this adaptation, many different Scrum-based implementations are found in classrooms. The popularity of this approach has led to numerous publications detailing individual experiments using Scrum in the classroom, with most of these adoptions occurring in engineering classrooms. This paper presents a literature review of Scrum applied in the classroom. This work explores the advantages of using Scrum in the classroom, providing details on the type and level of university classroom used for implementation. Information on methods of implementation, appropriate class subjects, and student educational levels are provided within this paper. This guide can be used by those looking to utilize Scrum within their classroom as a stand-alone practice. The findings of this paper demonstrate that Scrum can be used in correlation with a wide variety of classroom structures and topics. This paper is intended to guide future educators who wish to implement Scrum into classes and educational programs.**

Keywords—Agile classroom, Scrum in the classroom, Agile approaches

I. Introduction

As Scrum has grown to be the most popular Agile method used in the software engineering industry and project management, the scope of Scrum applications has increased [1]. Its popularity as a project management technique has led it to be adapted in other engineering industry positions. This popularity has trickled down into higher education, where classrooms teach Scrum approaches to engineering and project management students to prepare them for future positions in industry [2, 3, 4, 5, 6]. However, the benefits of Scrum for managing groups of students go beyond preparing them for industry; it has been implemented as a pedagogical method to aid student learning in the classroom. This paper explores the findings from many studies that track the implementation of Scrum in the classroom. As many of these studies focus on an individual class or program, this paper serves as a guide for compiling the practices and findings of other researchers in the industry. This paper thus acts as a practical guide for future adaptations of Scrum in the university classroom.

This paper is organized as follows. Section II gives a background on Agile methods and Scrum. Section III describes related work, describing the findings of other surveys on the applications of Scrum. Section IV presents the possible applications of Scrum in the classroom, both as course content and as a pedagogical method. Section V summarizes the general rules for implementing Scrum in a classroom setting. Section VI presents the conclusions of this research as well as future applications.

II. Background

Scrum has become one of the top Agile methods for organizing projects requiring flexibility and effective team communication. It has proven to be an effective framework for projects in various fields. Scrum combines Iterative and Incremental models in its approach, allowing for the early development of a working product [1]. Due to Scrum's flexible and customizable nature, it has been rapidly adopted in many industries and has quickly grown in popularity.

A. Agile Methods

Agile methods were first introduced in 2001 by Jeff Sutherland and Ken Schwaber through the creation of the Agile Manifesto. This manifesto was created to respond to the issues commonly produced by traditional methods. Traditional waterfall development methods often require the completion of thorough documentation relating to each development phase before the next phase is allowed to begin.

Traditional methods have the potential to become unnecessarily time-consuming and, over time, proved to fall short of modern software development needs. Due to the limitations of traditional methods, the impracticality of its use has exponentially grown as modern software and systems have increased in complexity and size. These new challenges required introducing a development method focused on flexibility, communication, and effective team dynamics. These

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core values are what Agile methods aim to provide to the new age of software development.

As the name implies, Agile methods provide a framework for the quick development of a working product and the fast adoption of changing requirements. In addition, Agile methods encourage frequent communication with the customer and stakeholders. The Agile Manifesto outlines these goals in its core principles listed below [7]:

- "Individuals and interactions over processes and tools."
- "Working software over comprehensive documentation."
- "Customer collaboration over contract negotiation."
- "Responding to change over following a plan."

The first of these principles places a greater importance on expert opinions rather than reliance on processes and tools. The second principle emphasizes the importance of having a working product or feature over the documentation attached to it. Agile differs from traditional methods and can lead to a substantial amount of time saved during development. The third principle introduces effective communication into the development framework. Consistent communication with the customer allows for the elicitation of requirements that adequately reflect the needs and wants of the customer. Incorporating opportunities for communication also allows the customer to provide feedback throughout the development process, which may lead to the implementation of change. This focus on feedback leads to the fourth core principle, which is the ability to respond and incorporate changes, even if it goes against the initial plan.

There are several popular agile methods used in the industry today. Some of these methods include extreme programming, kanban, lean development, crystal methods, and Scrum; however, all Agile methods follow these four main Agile principles.

B. Scrum

Scrum has become one of the most widely used Agile methods in many industries today. As previously mentioned, Scrum is an iterative and incremental process. As such, it uses one-to-four-week iterations, called sprints, to incrementally develop working features. Sprints, as well as the six other Scrum process components, are defined in Table 1. The three Scrum roles are defined in Table 2.

The first area of discussion is the Scrum roles. These roles include the Development Team, Product Owner, and Scrum Master. The Development Team should be self-organizing, and roles within the team can vary from sprint to sprint depending on what is needed. The size of Development Teams may vary but usually range between five to ten members.

Furthermore, the Product Owner usually knows what the project entails and how the events should be carried out. The Product Owner is responsible for communicating these expectations to the Scrum Master.

The Scrum Master holds many of the responsibilities usually seen from a project manager, including communication with top management or the Product Owner. In addition to these management responsibilities, the Scrum Master is expected to ensure that the Scrum values are upheld throughout each sprint and that impediments experienced by the Development Team are quickly resolved.

TABLE I. SCRUM PROCESSES [8, 9]

Process Components	**Definition**
Stand-Up Meetings	A daily meeting of approximately 15 minutes where the developers discuss the previous day's accomplishments and today's goals.
Sprint Backlog	The tasks that will be completed during a sprint, as selected from the product backlog.
Product Backlog	A list, in order of importance, of the tasks that still need to be completed for the product.
Sprints	A period of 1-4 weeks in which a certain set of goals is to be accomplished by the Developers.
Sprint Planning Meetings	An initiation of the sprint in which the work goals for the sprint are chosen.
Sprint Reviews	An inspection and demonstration of the work done during the sprint.
Sprint Retrospectives	A review of the efficacy of the sprint and brainstorming for future improvement.

TABLE II. TABLE 2. SCRUM ROLES [8, 9]

Roles	**Definition**
Scrum Team	A team that includes the developers, a Scrum Master, and a Product Owner
Developers	The group of individuals that is responsible for creating the product during Sprints
Product Owner	The person who is responsible for organizing the requirements of a product into a product backlog and thus maximizing the value of the product the Scrum Team creates.
Scrum Master	The person who is responsible for ensuring that the Scrum process is followed.

Additionally, Scrum comprises of several process components in which the roles stated above take part. The first of these processes is the daily meetings. These daily or "stand-up" meetings should include all members of the development team. As the name suggests, these daily meetings are meant to occur every day; therefore, these meetings are often relatively short, usually lasting less than half an hour. The topics discussed within these meetings include what has been done since the last meeting, what will be done before the next meeting, and what impediments to productive work are experienced by team members [10]. Each Scrum team member

should explore these topics before the meeting is concluded. Daily meetings encourage communication between team members concerning what they require from each other in order to meet their goals for a sprint. In addition, these meetings serve as a way for the Scrum master to identify what is getting in the way of the team's progress so they are better equipped to remove those impediments early on.

The next two process components identified in Table 1 are the Sprint and Product Backlogs. The Product Backlog is a prioritized list of requirements requested by the Product Owner. For each sprint a Sprint Backlog is created by listing Product Backlog items that the Development Team can commit to completing by the end of the sprint. Additionally, subtasks are created to identify what steps need to be taken to complete the listed Product Backlog items.

The Sprint Planning Meetings, Sprint Reviews, and Sprint Retrospectives are all used for different purposes. The Sprint Planning Meetings are often between the Product Owner and Scrum Master. In these meetings, the Product Owner communicates to the Scrum Master the expected requirements for the project and discusses each requirement's rank in terms of priority. In a Sprint Review, the Development Team showcases what has been accomplished in the most recent sprint to the Product Owner to display their progress. Lastly, the Sprint Retrospective meetings should not include upper management, including the Product Owner, as this meeting reflects on what went right and what went wrong in the previous sprint. Once problems are identified, the meeting time is used to brainstorm ways to prevent similar issues from occurring in the next sprint. It is often said that the Sprint Reviews are used to identify how well the product is working, whereas the Sprint Retrospectives are used to identify how well the process works.

Once these process components and roles are established, the Scrum method is expected to occur as described in Fig. 1. Scrum begins when the Product Owner receives input from upper management. A Product Backlog is then created using requirements gathered from the Product Owner. The Scrum Master then leads the Sprint Planning Meeting and helps develop the Sprint Backlog. Once this is done, Sprint Backlog items and tasks are assigned to different members of the Development Team. The Development Team then works on these Sprint Backlog items for the duration of the sprint. Within the sprint, Daily Standup Meetings are held to help each team member progress with their tasks and to help eliminate anything getting in the way of that progress. During each sprint, the Scrum Master oversees the process and helps eliminate distractions whenever possible. After each sprint is concluded, a Sprint Review and Sprint Retrospective are held. The sprint cycle continues until a working product that satisfies all backlog items is created.

III. Related Work

Several other papers have surveyed the use of Scrum in industry, education, or some other setting. To establish a cognizant basis for this paper, this section presents a brief overview of related Scrum studies and surveys. Most surveys and studies on this topic present the issues, challenges, or problems associated with Scrum usage in various settings that are followed up with proposed practices or solutions that purport to mend the given impediments.

A study on the use of Scrum in two companies, one, a digital content agency, and the other, an automobile systems firm, found that there are several common issues in Scrum implementations, such as code quality, teamwork disruption, managing backlog items, and more.; it was also observed that conducting proper Scrum training alleviated many of these issues [11]. An early Systematic Literature Review (SLR) of primary studies using Scrum in Global Software Development (GSD) found various challenges with Scrum in GSD, including synchronizing communication, effectively collaborating, communication bandwidth, and tool support, with attendant solution practices, e.g., synchronized work hours, key documentation, multiple communication modes, and proactive resource management, respectively [12]. A Web-based survey collected data about Scrum usage from ScrumAlliance, Project

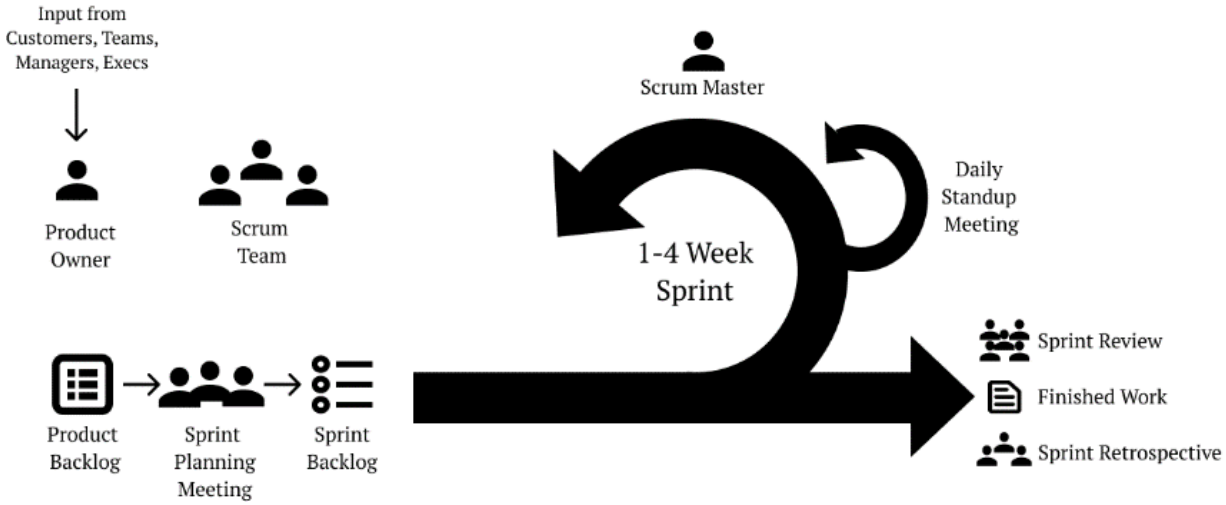

Fig. 1. A depiction of the Scrum Process, adapted from [8]

Management Institute (PMI), and several high-maturity organizations [13]. Some of the key findings are given below:

- Scrum was the most frequently used development method
- Scrum found most of its use in the financial, telecommunications, and healthcare sectors
- Scrum team size from 4-9 members was most common
- Average sprint length was from 2-4 weeks
- Scrum products were rated as having higher quality
- Scrum products were rated as having greater customer satisfaction

A large 2022 SLR investigated *why* and *how* Scrum was modified in actual practice by taxonomizing the review into nine modification objectives. The nine most common objectives for modifying traditional Scrum were to improve the performance of the product development life cycle, to make Scrum fit better into particular development contexts or fields, to emphasize architecture artifacts, to let Scrum coexist with other frameworks, e.g., lean development, to effectively manage distributed teams, to grant better managerial control, to allow greater incorporation of end-user feedback into the product development process, to improve collaboration between multiple Scrum teams and to increase software security [14].

All the issues and remedies discussed are also witnessed in educational settings employing Scrum. A 2021 primary study employing Scrum for an undergraduate software engineering course presented very positive results when the students were surveyed about their experiences [15]. Students reported positive outcomes regarding team communication, the definition of sprint goals, and daily standup meetings. In the same year, another primary study found that using Scrum in project-based university classes improved student learning and performance because of Scrum's emphasis on project management, task assignment, performance monitoring, and regular feedback [16].

IV. Findings

This section provides a survey of studies that used Scrum in the classroom. There are many similar studies with similar results. Due to the length limitations of this work, a full systematic literature review was not performed. To reduce the overwhelming number of citations, papers were chosen with preference to the quality of the study, the recency of the study, and the novelty of the study. This selection process allows the most thorough and contemporary discussion of implementing Scrum in the classroom. However, all papers were found using the following search term: "(scrum) AND (adoption OR pedagogy OR academia OR classroom OR research OR education OR students)" or cited within the papers found using the above search.

A. Teaching Scrum

The majority of the adaptations of Scrum for the classroom focus on the idea of teaching the Scrum process to students. The goal is to introduce the students to the Scrum method because they will eventually use it in industry. Therefore, the first category of Scrum in the classroom involves teaching Scrum explicitly to students as a part of the methodology.

1) Class Type

When teaching Scrum as a method, it is most common that the class aligns with an industry that commonly uses Scrum. For example, Scrum is commonly used in Software Engineering jobs and is thus taught in a Systems Analysis and Design Course [2], various capstone courses [3], and project management courses [4]. Using Scrum is beneficial for developing projects, learning the Scrum process, learning project management, and learning effective teamwork [5]. Other work has specifically encouraged Scrum for project-based learning classes [6].

Most of the strategies discussed are studied in one-off classroom settings. Additionally, Scrum is taught the most in upper-level courses. This usage is sensible because lower division courses, such as first-year courses, face the problem of adapting students to the university-level coursework, so adhering to proper project management would pile another expectation on them [17]. Other work explicitly details an approach that introduces students to Scrum in a freshman-level course but builds on that knowledge through four consecutive courses throughout the degree program [5].

2) Scrum Training

For many of these courses, it was not assumed that students had prior experience using Scrum. In that case, they explained the Scrum process before the students replicated it in their projects. Some approaches recommend giving a few hours of upfront instruction and training and continuing short training sessions to reinforce specific concepts and ensure the method was followed with discipline [2].

There are alternatives to training that do not involve discussions and lectures. In one case, in a project management course, Scrum was implemented to manage a LEGO building challenge; through this, students could effectively learn the Scrum process [18]. The LEGO experience has been used as a part of the lecture series to expose students to Scrum before they apply it to their capstone project [3].

3) Team Organization

The decision to split a class into groups will likely influence the individual students' experience. Teams often are split in an attempt to balance experience and skill levels [2].

Another vital role is the Product Owner. In some cases, the product owner is someone outside the class (such as a professor or a local business owner) [2, 19]. An interesting implementation is that if the Product Owner was not responsive to a team and did not give the necessary feedback, the students were switched with to new product owner [2]. The Product Owner can be a natural occurrence when students in the class were developing for real industrial clients [3].

The role of the Scrum master can be rotated between students [2]. The goal is to keep the students involved in the process and give each of them a taste of the experience of being

the Scrum Master while preventing one singular student from being excluded from the technical expectations of the class. Alternately, other approaches choose not to rotate the role of the Scrum master and instead give the role to the student who is most familiar with Agile methodologies methods [20].

In the project where students were introduced to Scrum repeatedly at different levels, the role of Project Owner and Scrum Master changed throughout the progression of courses [5]. The roles were not assigned for the freshman level, allowing the whole team to serve as both roles. In the sophomore year, upper-level students exemplified the Scrum Master role. In the next course, the students on the team choose a Scrum Master (and can choose to rotate), and an instructor becomes the Product Owner. In the final stage of this progression, their capstone course, a faculty member is the Product Owner and represents the industry client. At this stage, the Scrum Master remains a student.

Some projects [15] implement a role found in some industry implementations of Scrum [21, 22] and introduce for the classroom experience known as the Agile Coach [23]. The Agile Coach facilitates the student experience, helps resolve problems and conflicts, and aids the students in their collaboration process. Unlike the mentorship that a Scrum Master traditionally provides, the Agile Coach does not act as a part of the team and only interferes when necessary, thus introducing a hierarchy that is intended not to be present in Scrum. In the classroom model, the Agile Coach could be a professor or an outsider with experience in Scrum to help students adhere to the method [15].

4) Sprints and Retrospectives

The length of sprints in the Scrum process varies. In industry, Sprints are expected to last one to four weeks. Some projects have the sprints be one week long, except for when the students did not have class, in which case they were two weeks long [2]. Some suggest that one week can be too short based on how much time students can dedicate to a single class in a week, in which case two-week sprints are more suitable [24]. However, focusing on shorter sprints seems to be a trend to keep students engaged in the process. On top of that, academic semesters are limited to three to four months. The longer the period of the sprint, the fewer sprints can be completed.

In addition, changing the daily stand-up meeting to occur less frequently allows students to get some work done between meetings, such as the amount of time it will take students to contribute an equal amount that they could contribute in a singular eight-hour workday [24]. However, some work includes stand-up meetings frequently (as the class schedule allows), having them up to 4 times a week [5].

5) Scrum adaptations in the classroom

In some projects where there are two class meetings per week/sprint, one class was used for a meeting, work time, and a short training session, while the other allowed for a sprint review, retrospective, and planning of the next sprint [2]. An important consideration when including Scrum in the classroom is that lecture time is lost to handle Scrum events during class [24]. Therefore, some approaches suggest introducing reviews and retrospectives after students have become familiar with the process [5]. It is common to have Scrum processes be completed during the scheduled class period, as it guarantees that all team members will be available to meet and contribute.

Another aspect of adapting Scrum to the classroom setting is the need to assign students grades. In some classrooms, all students on the team received the same grade based on evaluations from clients and coaches and the project's final results [3]. This approach is meant to simulate industry in that the final product is what matters. However, other traditional methods of group work grading are appropriate, such as considering individual efforts and peer reviews.

6) Adapting Scrum

The fact remains that this is implemented in a classroom, not an industry setting. It is nearly impossible to replicate an industry setting exactly. However, it is up to the individual implementors to determine how much they want to adapt and change the Scrum process to fit their needs.

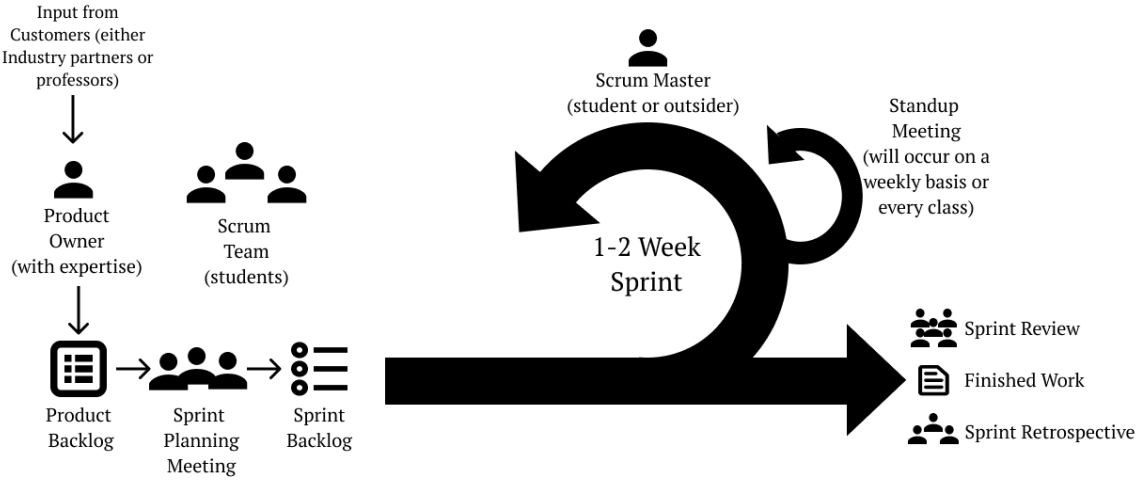

Fig. 2. Teaching Scrum as a Methodology

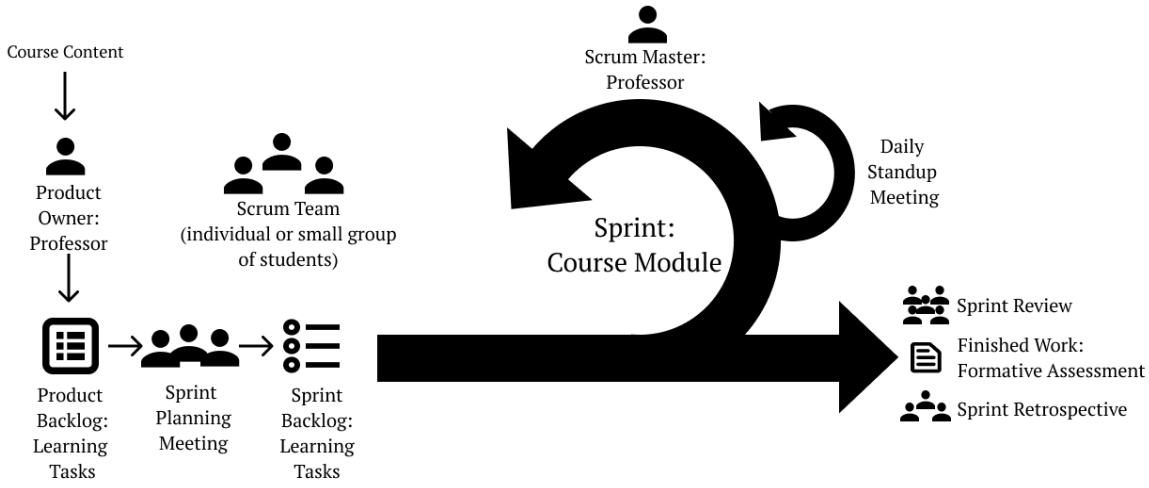

Fig. 3. Using Scrum as a Pedagogical Tool

Some work attempts to remain as faithful as possible to the Scrum method [2]. However, other work notes that adaptations must occur because students are participating in an academic course, not a 40-hour-a-week industry position [24]. Either approach seems to be effective. Too many adaptations can weaken the benefits of Scrum, yet too few adaptations would make the process unreasonable for students.

7) Results

Disseminated recommendations and descriptions come from overseeing over 50 projects in the classroom [2]. Students reported at the end of this study that the hands-on Scrum project allowed them to enhance their knowledge and comfort with Scrum.

Simplified recommendations from these studies are:

- Students should be asked to deliver an actual project [2, 3, 4]
- Students should acquire a legitimate product owner [2, 19]
- Students should be trained on the Scrum process [2, 5, 3]
- Scrum should only be adapted when necessary [2, 24]
- Reduce the occurrence of scrum meetings [19, 24, 3]

The student perspective of Scrum is not always positive. Students have reported negative reviews of the Scrum process yet contradictorily rated their group project as a positive experience [25]. There are certainly some challenges to adapting Scrum in the classroom. The adaption of Scrum into correct usage can be difficult [26]. In that case, students may be utilizing a waterfall process while going through the motions of a Scrum process. This issue shows the tradeoff between ensuring the Scrum Master is experienced enough to steward the process effectively and letting students rotate as Scrum Master to introduce them to the experience.

B. Scrum as Pedagogy

The popularity of Scrum has kept it from being limited to project-based engineering classes. Some researchers have used Scrum in the classroom without the attempt to teach Scrum as a process. In doing so, they reap the benefits of Scrum outside of the domain where learning Scrum is essential to student's future careers.

Scrumage (SCRUM for AGile Education) manages multiple pedagogical approaches to teaching the same material [27]. Rather than the deliverable being a piece of software at the end of each sprint, students present mastery of a learning goal. This method follows Scrum closely, using sprint planning, standup meetings, reviews, and retrospectives. Students can choose the approach to learning the material that works best for them. The Scrumage approach was shown to improve student ability to learn course material and create a positive impact on the students' feelings about their ability to learn course content [28].

A different approach also used Scrum to manage student ability in the classroom [29]. In a weekly/biweekly sprint, students are given a backlog. Items are rated by difficulty, and tasks with a higher difficulty were associated with a higher grade. In addition, the tasks were not graded, but the students were provided with feedback until the task was marked as "complete." This approach was beneficial for self-regulated students who appreciated the feedback. However, a lack of change in pass rates suggested that it did little to encourage the motivation of disengaged students.

Scrum was also adapted to guide students through their master's thesis [30]. The roles of Product Owner, Scrum Master, and team member were dropped. However, the frequency of meetings and the tracking of incremental progress via backlogs were adopted. This project management technique positively affected students' ability to accomplish a large project and successfully pass their thesis.

Scrum has been used as a classroom pedagogy in a wide variety of classrooms, such as chemistry courses [31], as a method of writing in academia and industry [32], in any project-based course [33], and to manage group work in the humanities [34].

One of the main benefits of Scrum as a pedagogy seems to be students' engagement in the learning process. Scrum concepts were used for online learning as a way of supporting the self-regulation abilities of learners and were successful in helping with goal planning [35]. For group work, allowing students to determine and manage a project via Scrum increases their sense of self-efficacy [34].

The Scrum strategy of breaking down a problem into small tasks and further breaking down those tasks into sprints is effective in many educational domains [31]. At the end of the sprint, the goal of students in project-based classes is to complete self-determined goals [34]. In domains where the students have less structure to determine their progress, the goal at the end of a sprint is to complete a formative assessment [31].

Students are expected to reflect on the learning process between sprints to improve during the next cycle, much like a Sprint Review and Retrospective [31]. This reflection is an integral part of the learning process and is conveniently built into the Scrum process. For some students, the focus on self-efficacy and control over their learning increased their motivation; for others, the lack of obligation presented above, like in a traditional classroom setting, decreased motivation [34].

With Scrum as a pedagogy, the product is usually mastery of course knowledge. This product limits the implementation of the roles of Product Owner and Scrum Master. The product owner is the teacher, who manages what knowledge needs to be mastered by students in their course [33]. The Scrum master is another person of authority [33]. Usually, this will fall to the course instructor, or perhaps a TA, who can ensure that students adhere to the process correctly.

Reducing the group size is important classes where group work is maintained [34]. Groups of approximately four students are practical for ensuring that all students have an equal opportunity to engage in the final product [31]. Much like the recommendations for teaching Scrum methodology, it is important to organize teams based on experience [27]. The ability to self-organize is a component of the official Scrum process, yet not balancing teams can leave inexperienced students behind.

It is worth mentioning that outside of the classroom, Scrum has been implemented in academic research teams [36, 37, 38, 39] and for managing change in engineering departments [40].

V. Findings

Fig. 2 and Fig. 3 summarize the applications of Scrum in the classroom.

Fig. 2 shows the implementation of teaching Scrum methodology to students. When teaching Scrum as a methodology, the most significant decisions surround the roles played and the time frame. Using industry partners as a customer, choosing a product owner outside the university, and utilizing a singular Scrum Master can mimic realistic scenarios for students. Alternatively, using a professor as a product owner or allowing students to rotate the role of Scrum Master may allow them to engage more thoroughly in the Scrum process and have a better learning experience.

In Fig. 3, the implementation of Scrum as a pedagogy is implemented. The most significant change in this situation is that there tend to be fewer requirement changes. Since course content is pre-established, Scrum is used for content delivery. As such, the course instructor takes on the influential roles of a Scrum Master and Product Owner. The main benefit of Scrum as a pedagogy is that it breaks down learning goals into tasks that seem less daunting for students. The self-organizing aspects of Scrum are used to encourage students to take more control over their own learning experiences.

VI. Conclusion

Scrum has been implemented widely in industry. The effectiveness of Scrum extends beyond its original purpose and has found its way into classrooms, both as course content and as a pedagogical method. In both cases, Scrum has seen benefits in the ability of students to manage the workload and complete seemingly daunting projects. For students that will work with Scrum in industry, this allows them to begin to experience the demands of Scrum and makes them better prepared for their future careers.

Scrum is effective as a technique but is not universally beneficial to all students as a pedagogy. Future research should focus on combining Scrum with other educational techniques for engaging students with low skill or motivation.

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