APPLICATION OF THE AGILE METHOD OF PROJECT MANAGEMENT IN EDUCATION OF IT STUDENTS

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Abstract:

Scrum is one of the agile process frameworks used for better planning, organization and prioritization of work. Implementing the Scrum methodology in the educational process enables active student participation, teamwork, and the cultivation of problem-solving skills. The paper presents the basics of the Scrum framework, defines roles in the Scrum team, explains Scrum events and artifacts. The problems that may arise during the implementation of Scrum in the teaching process are analysed. The advantages of applying this agile method are emphasized and explanations are given on how the implementation of Scrum in teaching can improve the quality of teaching and learning, as well as the motivation of students.

Keywords:

Agile, IT education, Project-based Learning, Project management, Scrum.

INTRODUCTION

The needs of modern society have caused extremely rapid technological progress. Intensive changes are occurring in all spheres of society and therefore changes in the education system are also needed. One of the current priorities in higher education is fostering the development of soft skills in students through the implementation of project-based learning [1].It is a very powerful learning strategy and is developed by stimulating teamwork to solve problems. At the same time, developing students' ability to navigate successfully in new situations is one of the most important educational goals [2].

With the traditional way of teaching, students acquire excellent theoretical knowledge, but they do not sufficiently develop soft skills, which are poorly represented in the educational process [1]. One potential solution to this issue is the adoption of the Scrum methodology in the teaching process [3]. Scrum is one of the agile process frameworks used for better planning, organization and prioritization of work. Research shows that by implementing the Scrum method in teaching, students achieve better results and manage their work more efficiently [4].

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Scrum methodology was originally used in software development as a flexible and agile way of project management [1]. An agile approach, as an alternative to traditional project management, enabled project teams to respond to changing market conditions using incremental and iterative work [5]. The implementation of agile methodologies has facilitated continuous project assessment throughout its lifecycle, achieved through sprints or iterations. This approach has enabled the development of a product that aligns effectively with project objectives. Scrum is the most commonly used agile framework, and more than half of IT companies in Serbia use the Scrum method for project management [6]. Today, this methodology is applied in various fields, including in education. Project management-based learning uses real-world problems and motivates students to apply research concepts [4].

The paper presents the basics of the Scrum framework, defines roles in the Scrum team, explains Scrum events and artifacts. The aim of the work was to investigate the application of Scrum in the education of future IT specialists. In the central part of the paper, the methodology of applying Scrum in teaching is explained. The advantages are highlighted and the problems that may arise when implementing Scrum in the teaching process are listed. The methodology employed in the preparation of the work is qualitative, incorporating theoretical and methodological analysis alongside information analysis.

2. THE IMPORTANCE OF TEAMWORK IN THE EDUCATIONAL PROCESS

The primary aim of higher education is for students to cultivate competencies essential for their academic pursuits and future professional endeavours. To foster general competencies such as organizational skills, planning, leadership, evaluation, self-assessment, and teamwork, active learning methods are indispensable [5]. Research shows that students often resist cooperation with peers. Several factors contribute to this phenomenon, including a lack of interest in the project, a lack of trust in one's peers, and a deficiency in understanding what genuine intellectual and productive collaboration entails [7].

Teamwork is crucial in developing the skills needed to succeed in Education 4.0. The focus of Education 4.0 is digital literacy, critical thinking, communication and collaboration. By encouraging teamwork in higher education, students are prepared for active participation in modern society, and not only for success in their academic and professional careers [8]. By working in a team, students learn to communicate effectively, resolve conflicts, negotiate and make decisions, develop leadership skills, as well as to take responsibility for their work and the work of their team. In addition, working in a team implies the exchange of experience and knowledge, which certainly contributes to the development of new ideas and innovative solutions.

There are several ways to encourage teamwork among students, some of which are:

- group assignments - joint work on a project enables students to practice communication and problem solving in a team;
- multidisciplinary approach - if solving a team task requires the application of several different disciplines, then this leads to the development of new perspectives and solutions;
- evaluation of teamwork - if the evaluation of teamwork affects the formation of a student's grade, then it emphasizes the importance of this component for their academic success;
- inclusive atmosphere – open communication and diversity of opinion improves teamwork and contributes to achieving better results;
- assignment of clear roles and responsibilities - if each team member has a clear role and responsibility in the project, then this encourages a sense of belonging to the team and contribution to a common goal; and
- support and monitoring - students need to be supported during team work and constantly given feedback so that they can improve their skills and understand the importance of cooperation.

All the mentioned ways can be implemented in the teaching process using the Scrum methodology. Research indicates that assigning team tasks and consistently monitoring progress are identified as the primary advantages of employing Scrum, contributing positively to student development and performance [1].

3. THE SCRUM FRAMEWORK

The basic idea of the Scrum framework is very simple. It is based on that one complex task or project is divided into smaller parts that are executed in multiple iterations. Time frame i.e. an iteration in Scrum is called a sprint. It is necessary to determine how much the team can do in one sprint, what exactly needs to be done and how problems can be solved if they arise during the execution of the sprint goals. Following each sprint, a product increment is delivered, representing a distinct, operational, and visibly enhanced portion of the product that satisfies well-defined criteria [5]. Each increment is developed to a standard of quality referred to as "Definition of Done".

3.1. SCRUM TEAM

The basic unit of Scrum is the Scrum team. There are no sub-teams or hierarchy within a Scrum team. It is a team of professionals simultaneously focused on only one goal. Scrum teams are cross-functional. This means that all team members have the necessary skills to deliver value from each sprint. The teams organize themselves and share tasks among themselves. Self-organization achieves a high degree of flexibility, creativity and efficiency. A typical team size is 7-10 people [9].

Working in sprints at a defined pace improves the focus and consistency of the Scrum team. The entire team is responsible for creating valuable, useful increments in each sprint. Scrum defines three specific responsibilities within the team: software developers, Product owner and Scrum master.

The role of the developer in the Scrum team is to create useful sprint increments that lead to the creation of a potentially deliverable product. Developers are responsible for: creating the sprint plan (Sprint backlog), adhering to the Definition of Done and for adjusting the plan according to the sprint goal.

There is only one Product owner in the Scrum team and he conveys the overall vision of the product that the team is building. It is usually the leader who is authorized to make decisions. In addition to working with the team, he is dedicated to researching the needs of customers and following the changes happening in the market. The Product owner defines the product vision, understands the customers and actively involves his team in ideas and continuous improvements. He bears the responsibility of enhancing the value of the product and the efforts of the development team. Additionally, he is tasked with communicating with stakeholders and gathering product-related requests.

The Scrum master is responsible for establishing Scrum within the team and organization and his task is to introduce the team to the theory and practice of Scrum. He guides team members in self-management and helps the team focus on creating high value products. Their responsibility includes removing obstacles hindering the team's progress and ensuring that all Scrum activities adhere to the designated timeframe. The Scrum master builds a relationship of trust between the team and the Product owner.

3.2. SCRUM EVENTS

The Scrum process is divided into precisely defined time periods within which the development increment is added, the result of which is a deliverable product with new functionalities or eliminated defects. The basic time period is called a sprint and within it the necessary planning, development and analysis of achieved goals is carried out. Sprint events can be classified into five categories: Sprint Planning, Daily Scrum meetings, Product Development, Sprint Review-Analysis, and Sprint Retrospective. Figure 1 shows the Scrum framework development process diagram.

The length of the sprint is constant and lasts 2-4 weeks. At the beginning of each sprint, goals are set that should be achieved in that time period and they must not change during the work. Throughout the sprint, no alterations are introduced that could compromise the sprint's integrity or diminish its quality. Each sprint can be viewed as a short project. A new sprint commences promptly following the completion of the preceding one. A sprint can be cancelled if the sprint goals become outdated. Only the Product owner has the authority to cancel a sprint.

Sprint planning involves a maximum 8-hour meeting (for a 4-week sprint) whose goal is to define the work that will be done in that sprint. The input parameters of this meeting are the results of the previous sprint and the table of remaining tasks (Product Backlog). Based on previous experiences, the goals of the new sprint are defined. The result of a sprint is an increment - a potentially deliverable product. The selection of tasks for the Product backlog is decided by the Scrum team with the help of the Product owner, who should clearly present each task from the list. The development team should adopt a way of solving the set tasks and how they will

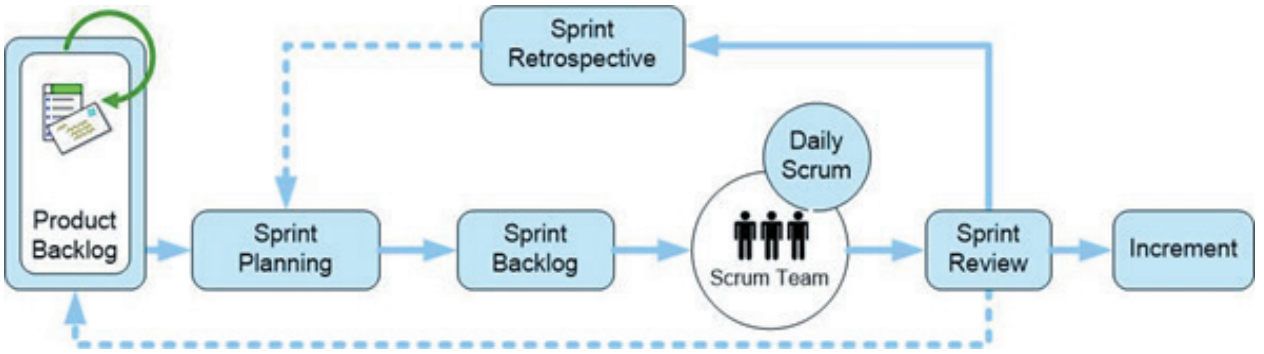

Figure 1. Scrum framework development process diagram.

fit into a potentially deliverable product. It is of great importance to define the conditions that need to be met in order to consider that the task has been successfully completed (Definition of Done).

The Daily Scrum is a brief meeting, lasting no more than 15 minutes. In this meeting, the Scrum team reviews the achievements or analyzes the problems that arose the previous day in order to decide how to proceed. Typical questions answered by all team members are: *What was done yesterday?; Did any obstacles arise?; What will be done today?* These questions are very important because based on the answers received, the performed tasks are controlled, the completion of the next tasks is planned, and potential risks are identified and adequate solutions are found. The Scrum master is responsible for regularly conducting daily meetings.

At the conclusion of each development cycle, a Sprint Review is conducted. The primary goal of a Sprint Review is to review the status of all sprint goals. Also, at this meeting, the table of remaining tasks is adjusted to the new situation. At this meeting, the members of the Scrum team present what was done during the sprint to the stakeholders, and based on the results, ways to optimize the work are analyzed. Sprint Review length is limited to a maximum of 4 hours for a one-month sprint.

The main goal of the Sprint Retrospective is to plan how to increase quality and efficiency in the next sprint. The Scrum team engages in discussions regarding the successes and challenges encountered during the sprint, exploring the reasons behind any unresolved issues A Sprint Retrospective concludes the sprint. It is time-limited to a maximum of 3 hours for a one-month sprint.

3.3. SCRUM ARTIFACTS

Scrum artifacts embody work or value that fosters transparency of critical information and facilitates control and adjustment. The Scrum master has the responsibility to promote the values of Scrum and that all team members properly understand artifact transparency.

The Product Backlog serves as a repository of tasks associated with the product. It's an artifact that delineates an ordered list of requirements that must be addressed. The Product Owner is responsible for this table. The list contains a description of the product's functionality, detected errors, possible improvements, adjustments to the market and client requirements. This table is arranged according to the priority set by the Product owner. The Product Backlog is a constantly changing table. This table can be supplemented with new tasks or already defined tasks can be described with a greater degree of specificity. During the life cycle of the product, this table is constantly increasing.

The Sprint Backlog is a subset of the Product Backlog. This table defines the tasks that should be done within one sprint development cycle. This table is created by the development team during sprint planning. It contains tasks with a greater degree of detail in the requirements description and represents the definition of sprint goals.

An increment is a set of all goals that were successfully realized in a sprint together with all values from previous sprints. An increment represents all items from the Product Backlog list that have met the Definition of Done condition.

4. SCRUM IN EDUCATION

The application of the Scrum methodology in teaching creates an environment that allows students to develop their creativity and to constantly have insight into the progress of learning through successfully completed sprints. Using a process of inspection, adaptation and transparency, Scrum becomes a framework for learning [4,5].

A Scrum framework specifically tailored to the educational environment is called eduScrum. EduScrum is built upon the project management methodology of Scrum and incorporates effective techniques from active learning, such as peer learning and embracing corrections [10]. It was first applied in secondary education in the Netherlands [10]. It can be applied in any context where the realization of group projects and team problem solving is required [9]. To date, no singular educational approach has proven universally applicable across all courses. Nevertheless, the methodology suggested by EduScrum can be adapted with slight modifications to suit the majority of practical and laboratory classes in technical sciences. Several technical European universities have modeled whole classes according to eduScrum which provides a basis for teamwork throughout the semester [9]. Also, there are researches on the implementation of Scrum in subjects from social and humanities where excellent results have also been achieved [8].

To introduce the Scrum methodology into an academic setting, it's essential to precisely delineate the context of its application. This implementation entails two phases. The initial phase involves establishing how the agile process will be integrated into the teaching process. The subsequent phase entails identifying the outcomes or artifacts of the process.

The agile classroom is structured around five elements that can be integrated in various combinations. These elements include [5]:

- visible class: a visual learning management system;
- learning rhythm: a comprehensive and iterative learning cycle;
- collaboration: a model that enhances collaboration capacity and delineates the learning dynamics among students;
- empowerment: a model that enhances empowerment capacity, outlining the learning dynamics and boundaries of choice between teachers and students; and
- journey: refers to the gradual evolution of any classroom towards self-organization.

The primary roles in EduScrum include:

- Product owner: the instructor responsible for overseeing and defining the Product Backlog;
- Scrum master: either the instructor or a team member tasked with coaching the team to adhere to the principles of EduScrum accurately; and
- Development team: comprised of students tasked with delivering the product.

The teacher assumes the role of the Product Owner, bearing responsibility for the curriculum content that students must grasp. Additionally, they oversee and enhance the quality of learning outcomes, with a keen focus on the subject matter. Encouraging collaborative efforts among teams, the teacher establishes acceptance criteria to monitor the quality of learning. One of the items in the Definition of Done is that all students have understood the material [3].

Groups of students can be formed at the beginning of the semester. It is recommended that the team has up to 7 students. The group of students should be the same until the end of the semester, except in cases where some of the students drop out or if poor teamwork requires changes. Teachers can form teams but this is not recommended by eduScrum. Student organization and multidisciplinary team composition consistently yield better outcomes. Students in a team may have specific skills, but the responsibility for achieving learning outcomes is shared by the group. It is possible to form temporary groups in order to perform a single task, but this is not a good practice because each team needs a certain amount of time to be productive. Unlike Scrum, in eduScrum the sprint cannot be cancelled, but it is possible to add special tasks in order to achieve the expected results [5].

In accordance with EduScrum, every sprint should include the following components: objectives (a selection of subject outcomes), to-do list (comprising exercises, problems, user stories, etc.) and acceptance criteria (for each task, there should be a defined set of criteria for assessing and evaluating students' work).

Throughout the sprint, students engage in activity development and distribute tasks among team members. These activities may be subdivided into multiple tasks, each assessed for the effort needed for completion. Often, the Fibonacci sequence is employed for estimation, assigning complexity and time requirements to each task [10]. Students then select tasks accordingly. Initially, during the first sprint when students are acclimating to the Scrum process, teachers may propose weights for the activities or tasks. Each team independently determines the timing and methodology for executing the activities or tasks during the sprint.

Task management during the sprint relies on the utilization of the Scrum board, which typically comprises four columns: "Not started," "In progress," "Finished," and "Accepted." At the onset of the sprint, all tasks reside in the "Not started" column. The distinction between "Finished" and "Accepted" holds significant importance within the methodology, as only work approved and assessed by the Product Owner (i.e., teacher) can be deemed "Accepted." Any task that remains incomplete or fails to receive a positive evaluation from the teacher regresses to the "In progress" phase. Additionally, the assessment or acceptance of tasks by the teacher may involve querying the team about the task or activities.

The Sprint assessment typically consists of three components [10]:

- evaluation of tasks completed: involves calculating a weighted average of accepted activities;
- assessment of students' individual contributions through analysis of the team's Scrum board; and
- integrative sprint review (optional): Students are expected to respond to questions or tackle a practical task related to the sprint. It's recommended that the teacher employs a straightforward rating scale (e.g., scale of 1-5) for this purpose.

Following the conclusion of the sprint, each group of students is expected to compose a brief analysis and respond to three questions pertaining to the team's performance during the sprint: “What went well?”; “What went wrong?”; “What should be improved in the next sprint?”.

5. CHALLENGES IN THE APPLICATION OF SCRUM IN THE FIELD OF IT EDUCATION

The cultivation of engineering competencies necessitates the practical application of technical knowledge within contexts relevant to professional practice [4]. Application of the Scrum method can be applied during the teaching of all IT subjects. The reason for this is that learning outcomes can be presented as project goals. The possibilities of teaching in this way are numerous. For example, programming lessons can be implemented by having students deliver a specific application written in the appropriate programming language as the final product. Teaching computer networks can be realized by having students design a network with specific requirements by applying knowledge in the field of network equipment, IP addressing, cabling, etc.

The Scrum method helps students prepare for the real world, where teamwork and an agile approach are of great importance for success in the IT industry. The implementation of Scrum in higher education allows students to actively engage in the learning process, work in teams, and develop their problem-solving and critical thinking skills. Simultaneously, the instructor can tailor the teaching approach to accommodate the individual needs and preferences of the students, aligning with the objectives of the study program.

Scrum solves many more problems that are characteristic of the traditional way of teaching. For example, students who miss some of the classes have the option to manage their work during a multi-week sprint. Also, until the advent of Scrum, a particular challenge was represented by heterogeneous student teams. However, this problem is now solved because Scrum naturally encourages peer learning and evaluation. In this way, it was possible for students with lower achievements to fit into the group [10].

Scrum offers straightforward yet powerful instruments for planning and overseeing student endeavours. The integration of Scrum into education has fundamentally altered the paradigm of student evaluation. In this framework, incorrect or unfinished work isn't penalized. Following Scrum principles, it's preferable for a student to have half of their assignments or papers well-structured than to submit all assignments, many of which may contain errors. In this way, the quality of work is naturally promoted, and students are encouraged to develop into valuable team members [10].

In order to fully see all the advantages of introducing Scrum into the teaching process, it is necessary to solve certain problems. Research indicates that educators are still hesitant to embrace active learning, which grants students autonomy in charting their own educational journey [10]. Also, a large number of teachers focus on individual assessment of students and ignore the positive effects of peer learning. Therefore, when expanding edu-Scrum, special efforts should be made to train teaching staff.

6. CONCLUSION

The Scrum method allows teachers to develop an agile and flexible way of teaching that can be adapted to the individual needs and demands of students. The implementation of this method in the educational process allows students to actively participate in the learning process, work in teams and develop problem-solving skills. Applying this agile method has the potential to enhance the quality of teaching and learning, along with boosting student motivation.

Incorporating agile methodologies into the educational process necessitates adaptation to both the teaching context and the institutional setting. Organizing teams to work according to the Scrum methodology requires time and dedication of the teacher, but as a result it gives efficient and successful projects.

Further research will be focused on the direct application of the Scrum methodology in the implementation of teaching in several IT subjects. The subject of the next paper will be the analysis of success in mastering the material among students who followed the traditional way of teaching and students who were part of the Scrum team. The goal of future research will be to confirm the hypothesis that by implementing the Scrum method in teaching, students achieve better results and manage their work more efficiently.

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