Conflating SCRUM with micro-Project Based Learning. An HMU Application in an IoT Device Development

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Abstract. *Project Based Learning has been well established in the scientific literature as a useful pedagogy tool. The same is true for SCRUM framework with respect to Industry and Education as well. Recent studies have revealed the potential of applying SCRUM methodology in a PjBL setting with very promising pedagogical results. In this work we provide further support for this active area of research by applying SCRUM in a micro-PjBL setting. It involves a small group of Erasmus Students assigned to develop a meteorological station in a short timeframe using SCRUM but, in this case, applied in a step-by-step approach (micro). The outcome of this quasi-experiment supports the effectiveness of SCRUM once more as an indispensable pedagogy tool for Active Learning purposes.*

Keywords. Active learning, project-based learning, micro-PjBL, SCRUM, IoT

University of Maribor Press

DOI https://doi.org/10.18690/um.4.2023.16
ISBN 978-961-286-783-6

1 Introduction

Active learning, meaning the set of pedagogies that promotes self-directed, student-centered and hands-on experience by engaging students in the learning process, has revolutionized the field of Education. It was conceived as an ambitious educational reform back in the early 1900s and has since then evolved into a coherent corpus of methodologies such as: Problem-based learning (PBL), Project-Based learning – PjBL, Flipped classroom, Collaborative learning, Case-based learning, Game-based learning, Video-based learning, Experiential learning, and Service learning, among the most prevalent ones [1].

In this short report, we follow the micro-Project-based approach adjusted with the application of Scrum methodology to make the case and provide support in the rising bibliographical evidence that Scrum is a profoundly useful pedagogy tool [2][3].

Micro project-based learning (micro-PjBL) shares the same core principles and mechanisms with PBL but features a shorter learning cycle. It is recognized as a lightweight alternative with the desirable characteristics of being short, precise, and highly applicable. In comparison with PBL, micro-PjBL is efficient, flexible, and practical. It retains the advantages of PBL by helping students to develop skills covering collaboration, communication, and problem-solving in collective exploration. Moreover, due to its characteristic of "micro", a micro-PjBL cycle can be completed within a shorter time period relative to a full semester. In education, micro-PjBL is a comparatively new topic. The learning processes of micro-PjBL, such as how to design a mini project which can include the core concept and involve task introduction, implementation, presentation, evaluation and reflection, feedback and adjustment, and effectiveness are depicted also in our study.[3][4]

In particular, the case study involves a team of Erasmus students doing their study mobility at HMU that took on the project to build, in a period of three months. Their project focused on developing a meteorological station able to connect with the Web and able to share information with a web platform via pc or cellphones.

We discuss the results in the final sections of this report.

2 SCRUM methodology and its application in the learning process

Scrum framework is one of various Agile methodologies, that provides a structured approach to project management and collaboration. It is widely used in software development, but its principles and practices are adapted to many other fields, including education.

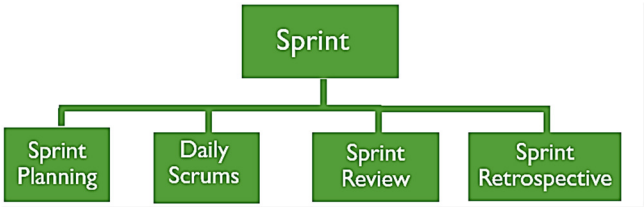

Figure 1. Sprint structure in the Scrum framework

Very briefly, it involves dividing a project into small, manageable pieces called Sprints. Each Sprint typically lasts 1-4 weeks with a specific set of tasks. Each Sprint starts with the Sprint Planning meeting where all the necessary jobs or tasks are written in the Product Backlog. At the end of each Sprint, the team gets together in the Sprint review meeting to review progress, with the feedback of the stakeholders. If the Sprint is successful, then the team has an Increment and can proceed to the next event which is the Sprint Retrospect. In this meeting the team members identify any issues or obstacles and decide on ways of improving their work on the next Sprint. This discovery of obstacles and issues is made every working day during a very short stand-up meeting, the Daily Scrum. Fig. 1 depicts the Sprint structure.

As for the team, it consists of three distinct roles, the Product Owner, the Scrum Master, and the Developers. The Product Owner has the sole responsibility for the outcome of the project. The Scrum Master makes sure the Scrum events are held and helps the working team (the Developers) to embrace the pillars and values along with removing any possible obstacles. The Developers, a term borrowed from the software development industry, are the people doing the actual hands-on work to develop the final product. The Scrum framework establishes this way, in an apt manner, collaboration, communication, and self-organization among team members [2]

We have already tested the use of Scrum as a pedagogy tool and soft skills development, in teaching Physics II course in HMU. The results and conclusions can be found in another publication of our research group [5].

The use of Scrum methodology in a project-based learning setting brings notable innovations. Scrum methodology, originally developed for software development projects, has gained popularity and proven to be effective in various domains, including project-based learning (PBL) settings. Scrum's iterative and incremental approach, focus on collaboration, and emphasis on delivering value align well with the goals and requirements of PjBL. Specifically:

1. Improved Project Management: Scrum provides a structured framework for managing projects, enabling students to better plan, organize, and track their progress. It emphasizes the use of user stories, product backlogs, and sprint planning, which helps students break down complex projects into manageable tasks and prioritize them effectively.[7]
2. Enhanced Collaboration: Scrum promotes collaboration among team members, which is a crucial aspect of PjBL. It encourages frequent communication, transparency, and cross-functional teamwork. Students work together in self-organized teams, sharing their knowledge, skills, and responsibilities, which leads to better learning outcomes and a sense of ownership. [6]
3. Adaptability and Flexibility: PBL often involves addressing complex, ill-defined problems that may require frequent changes and adaptations. Scrum's iterative nature, with short development cycles called sprints, allows students to respond to changes and incorporate feedback effectively. It fosters a mindset of continuous improvement and adaptability, which is valuable in dynamic project settings. [8]
4. Empowered Learning Environment: Scrum empowers students by giving them autonomy and accountability over their projects. They have the freedom to make decisions, self-organize, and take ownership of their learning journey. This sense of empowerment fosters intrinsic motivation and active engagement in the learning process. [9]

In brief, we argue that the Scrum methodology can be applied by dividing the project into sprints. Each sprint is then focused on a specific aspect of the project, such as research, design, or documentation. It would be useful here to refer to the term "micro-Pjbl", regarding each component of the project that needs a different problem-solving approach(step-by-step). The short learning cycle of the project and the need for high precision makes this approach even more suitable [3]. Scrum methodology fits in PjBL environments so well since many aspects of the projects are highly unpredictable, with various degrees of uncertainty, and Scrum manages to diminish high -risk perception by dividing into smaller and more attainable tasks [6].

3 Using Scrum in a PjBl setting at HMU with Erasmus Students

The students were required to develop a meteorological station under the Internet of Things-IoT concept with a specific description regarding the use of the final product, but with no technical details on how it is supposed to be built, leaving therefore the technical aspect of the project to be solved by the team, along the process. The given deadline was three months, and the requirement was to use commercially available components (off the shelf). The result of their work is shown in Fig. 2.

The structure of the weather station separates the system into three working fields: sensors, PV-battery-system and online connectivity. The main component is the Raspberry Pi. The weather station features sensor BME280 for measuring the air humidity, temperature and air pressure. An analog sensor for the wind speed is connected to the Raspberry Pi using an analog-digital-converter. A rainfall sensor measures the amount of precipitation. Three solar panels are connected to the battery using a respective self-built unit.

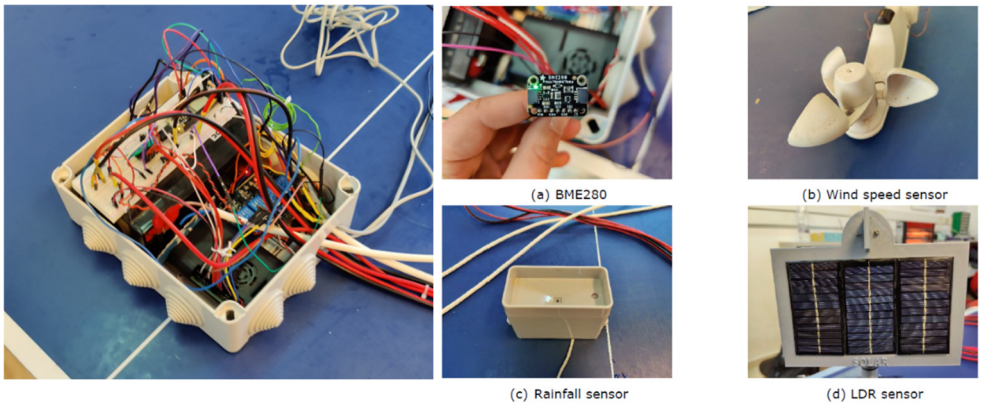

Figure 2. The completed device and the sensors

The raw measurement data from the sensors is uploaded and stored in a database which connects to a website, where the user can access the data in visualized graphs. The Raspberry Pi is powered via a normal power socket. For easy mobility and during outages the backup power will be delivered by the PV-charged battery of the system.

An online database was built to host all the measurement data from the sensors of the weather station. The provider used is called phpMyAdmin. The database "weatherstation" hosts the seven parameters "temperature", "humidity", "pressure", "light", "rainfall", "windspeed" and "date". This database was interlocked with the open-source program "Grafana" which is an application that displays graphical representations of raw data from online databases. The user tailored website for the weather station redirects the user to "Grafana" where the relevant graphs are show. This includes the following parameters : Light intensity (%), Temperature (°C), Pressure (hPa), Windspeed (km/h), Rainfall (ml/m^2) and Humidity (%).

The team was also required to develop the project using the Scrum framework. The framework was introduced by the PhD student, having the role of the Scrum Master in a four-hour session. The supervising Professor had the role of the Product Owner, and the students were respectively the Developers.

The duration of the project was divided into three sprints of 20 days each and lasted from November 4th 2021, until the 26th of January 2022. The timeframes of work were flexible each week accommodating for other student engagements. There were on average three working timeframes per week, lasting on average five hours each. The separate Scrum events such as Sprint Planning, Sprint Review and Sprint Retrospect were held according to the Scrum Guide [7] at the start and at the end of each sprint and lasted on average half an hour each.

The student engagement was constant throughout the project because each working timeframe produced an incremental step towards the final product. The observation was done by the Scrum Master who monitored the daily scrums and by the Product Owner who verified the production of the Increments on each Sprint Review.

After the completion of the project, the student's opinion was asked in the form of an anonymous questionnaire, in order for the researcher – PhD student – to track the effect of Scrum on the micro- PjBL format.

The micro-PjBL approach helped them fulfill all the necessary aspects of the product such as Research, Development and Documentation. The Scrum framework specifically helped them manage their deadlines, collaborate smoothly with their peers and present aptly their work as it is shown in Fig. 3.

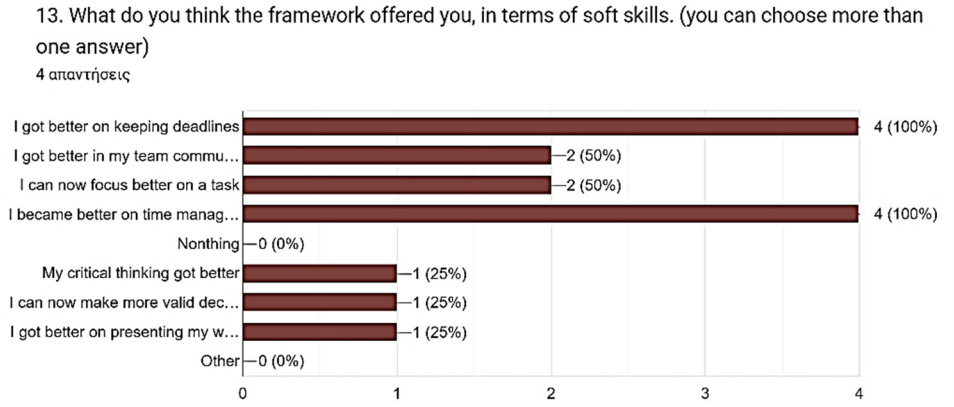

Figure 3. Students' responses on the question of how much the Scrum framework, helped them to get better in soft skills like time management and communication.

Although the students didn't have experience in project management, the overall impression was that Scrum is easy enough to apply, provided you have a Scrum Master and the time to familiarize with the framework described in the Definitive Scrum Guide [6].

4 Conclusion

The application of the Scrum methodology to PrBL, analyzed into micro-PjBl steps as defined and showed above, can provide a better structured and organized approach to project management and collaboration, helping students to develop necessary skills and achieve their learning goals.

Our work argues in favor of deepening the role of the Scrum framework in the learning process especially in highly technical and innovative fields such as applied physics, engineering, electronics, computer science, and STEM in general. Further research and classroom tests are going to enhance the effectiveness of these pedagogy tools.

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