

PAEE/ALE'2018 FULL PAPERS SUBMISSIONS (ENGLISH)

Submissions accepted for the PAEE/ALE'2018 papers sessions in English.

Making PBL teams more effective with Scrum

José Dinis Carvalho¹, Sandra Fernandes², Rui M. Lima¹, Diana Mesquita³

¹ Centro Algoritmi, Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal

² Portucalense Institute for Human Development - INPP, Portucalense University, Porto, Portugal

³ Research Centre on Child Studies, University of Minho, Braga, Portugal

Email: dinis@dps.uminho.pt; sandraf@uportu.pt; rml@dps.uminho.pt; diana@dps.uminho.pt

Abstract

Scrum is a project management methodology very popular in the software industry with good results in terms of team work effectiveness. Scrum is based on important team work values such as commitment, courage, focus, openness and respect and can be described in three different dimensions: Scrum team; Scrum Events; and Scrum artefacts. This paper aims to analyse the implementation of scrum approach in a project based learning context in higher education. The scrum approach was applied in the fourth year of the Industrial Engineering and Management (IEM) degree program, where teams of students developed a PBL project in an industrial context during the first semester. The research methodology focused on a qualitative approach. Semi-structured interviews were carried out to the Scrum Team (scrum master, product owner and the student team). Scrum Events were analysed through direct observation and Scrum Artefacts (Product Backlog, Sprint Backlog and Increment) were analysed based on a document analysis. The results of this study contribute to understand the effectiveness of the application of Scrum to complex PBL learning environments. The results presented in the study provided important inputs to improve the way PBL student teams manage themselves as well as their projects.

Keywords: Project-Based Learning (PBL), Scrum, Project Management, Teamwork, Engineering Education.

1 Introduction

Project Based Learning (PBL) has been present in the Industrial Engineering and Management degree at the University of Minho for the last 10 years (Lima, Dinis-Carvalho, Sousa, Alves, Moreira, Fernandes, and Mesquita, 2017) with very positive results for most of the stakeholders (students, companies and university staff). The most worthy PBL experiences are the projects taking place in real context, usually in industry. One of the complex issues is the way student teams manage themselves and manage their projects. A very typical problem is that student teams end up having most of the work taking place just few days before the milestones (due dates defined for deliverables including final presentation and final report). The quality of the deliverables could be even better and student anxiety and stress could be reduced if student teams managed their work in more effective ways. The nature of these projects held in industry, complex and open, with unpredictable results, are virtually impossible to plan in reasonable detail, so traditional project management methodologies are not applicable.

Scrum itself is a simple framework for effective team collaboration on complex products (Schwaber, 2004) as well as being focused on managing projects where it is difficult to plan ahead, where feedback cycles are the core of the management technique that are used in opposition to traditional command and control management. Scrum is a project management methodology very popular in the software industry with positive results in terms of team work effectiveness and quality results. It is based on important team work values such as commitment, courage, focus, openness and respect and can be described in three different dimensions: Scrum team; Scrum Events; and Scrum artefacts.

The objective of this paper is to analyse how the Scrum methodology can be effective when applied in a project based learning context in higher education. This methodology was applied as the core project management methodology in two PBL teams in the fourth year of the Industrial Engineering and Management (IEM) degree program, where teams of students develop a PBL project in industrial context during the first semester.

2 SCRUM

Traditional project management is developed as a sequence of steps that the project team will perform. Most of the times, advancing from one phase to the other, requires that the previous phase is completely closed. This approach has several drawbacks, namely: the need to create a detailed and closed set of requirements at an early stage of the project; the client will have to accept the early negotiated results, even though he/she may want a different result at the end; project teams are most of the times separated by specific technical knowledge and this may result in integration problems.

In order to reduce these potential problems, during the 1990's, groups of project managers, mainly from the software industry, started developing new approaches. These approaches got a major boost in 2001 when seventeen experts of the software industry decided to meet to discuss the so-called "light processes". This led to the "Agile Manifesto", which stated the common values and principles of software production in an agile way (Beck et al., 2001). This manifest states the following values:

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

Scrum is the most known Agile Project Management approach. This approach is based in three main dimensions: team roles, ceremonies and artifacts (Schwaber & Sutherland, 2013). The team is composed of the Scrum Master (project manager), product owner and team members. There are three main ceremonies, sprint planning, daily scrum and sprint review. Finally, the Scrum approach includes three main artifacts: product backlog, sprint backlog and Burndown chart.

Sutherland (2014) refers, in his book, the opportunity to use Scrum for the improvement of educational results, describing some examples. The same author (Sutherland, 2012) refers the implementation of the so-called eduScrum in a school of The Netherlands (Delhij, Solingen, & Wijnands, 2015).

In the last years, the research community published a few papers on the implementation of Scrum approaches to improve learning in higher education. An example reporting better results on development of leadership competences obtained when students enrolled in the modified Scrum based class in an introductory engineering class (Stawiski, Germuth, Yarborough, Alford, & Parrish, 2017). Another example of the use of scrum in the classroom refers to the use of two pedagogical approaches, Lean Teaching and Learning and eduScrum, in engineering courses (Dinis-Carvalho, Fernandes, & Filho, 2017). Both approaches have characteristics of pull learning, with high student autonomy and responsibility. Finally, the authors present a set of recommendations for improvement of teaching and learning processes. Other works are focused on software related courses (Bruegge, Krusche, & Alperowitz, 2015; Mahnič & Časar, 2016; Rodriguez, Soria, & Campo, 2016), mainly associated to capstone projects.

The analysis of the literature showed that most of the publications that have simultaneously the term Scrum and education are related to the process of learning Scrum. The works referred in the previous paragraphs shows that, when Scrum is used with the intention to give support to the learning process, is mainly in software related courses. Thus, considering that Scrum is, nowadays, highly used and effective in project management practices, it is important to understand what could be the effectiveness of Scrum, if used in higher education courses, to support project-based learning.

3 Context of the Study

This study takes place in a Project Based Learning oriented semester in the fourth year of the integrated master's degree in engineering and industrial management at the University of Minho. This Project Based Learning (PBL) initiative involves all the curricular units of the semester and a company where the project takes place. Each team of students carries out a different project since a different company is assigned to each team of students. One particular curricular unit, designated as "Integrated Project in Industrial Engineering and Management II" (IPIEMii), assumes the leadership of the project and manages the communication between all

curricular units, student teams, companies, tutors and teachers. The curricular units included in the semester are: (i) Manufacturing Systems Organization II, (ii) Integrated Production Management, (iii) Production Information Systems, (iv) Ergonomic Study of Workstations, (v) Simulation and (vi) Integrated Project in Industrial Engineering and Management II. Note that the last curricular unit mentioned is the result of the interaction between all the others and the company (

Figure 4).

Typically the objectives of the project of each team of students is to analyse, propose and implement improvements in specific areas of the assigned company. Throughout the semester students must develop the learning skills listed on the six curricular units directly involved in the project as well as other professional skills more linked to the real context project work.

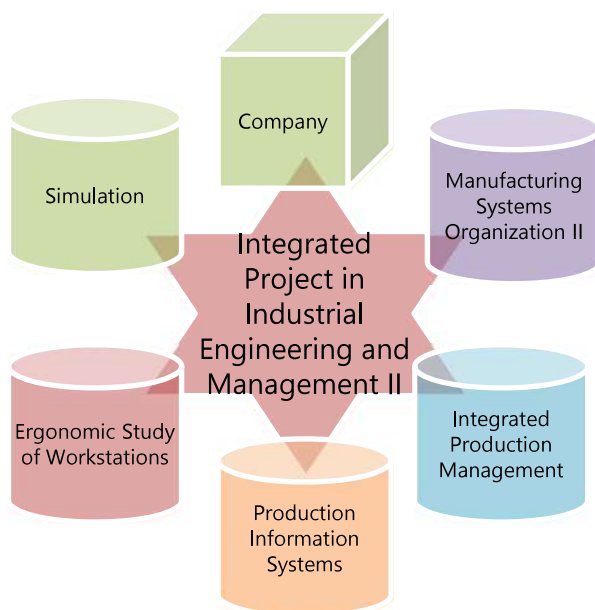


Figure 4 - Illustration of the interdisciplinary relationship between curricular units and the company.

During the project, students should characterize and diagnose the existing production system and evaluate its performance, identify waste, identify and model planning processes and production control, partially analyse how the implemented systems meet the functional requirements and the production system information and, create simulation models of the production system. Furthermore, students should also characterize workstations in the ergonomic point of view and their physical environment, and identify possible alternative actions and expected results.

The project is divided in three stages (Figure 5): (i) company exploration/recognition, (ii) analysis and diagnosis of the production system and (iii) improvement proposals; each stage's end was characterized by a milestone.

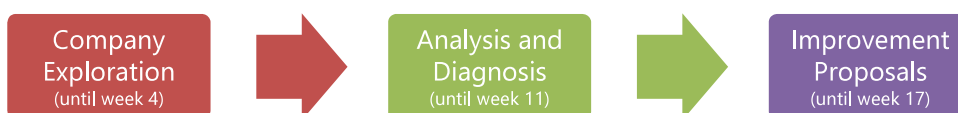


Figure 5 – The three stages of the project.

The PBL organizers encourage the student teams and company representatives to strive to implement the improvement proposals but it is not compulsory for the project approval. Ideally the improvements should be implemented within the semester but in many cases the improvements are implemented afterwards and in some cases the improvement proposals are never implemented.

3.1 PBL project with Scrum

This paper reports a study conducted in the last edition (2017) of the PBL project, briefly described above, where two teams of students applied Scrum as a tool to help them manage the project and the team. In this particular edition the number of students taking the course reached the highest number ever, forcing the teams to accommodate 10 and 11 elements. Teams with so many elements are a problem in many ways. It is a problem for companies in managing so many external people walking around their shop floor, it is a problem for the university to find physical space where teams can work and all the problems related to team and project management. The need for effective project and team management techniques and methodologies is becoming more and more remarkable as the student team size is increasing.

The Scrum methodology makes a lot of sense in PBL environments since many dimensions of the projects are unpredictable. In most cases no one knows how the project will evolve. Neither students nor most companies have any experience with this type of projects and therefore little knowledge exists about what will happen. The projects are evolving as they happen, depending on feedback from companies, feedback from teachers or from unexpected restrictions.

A bounded space in a room with tables, chairs, lockers and boards is assigned to each student team to work on the project and maintain their boards with information and other project related material. A board was assigned to keep scrum information in both teams that adopted scrum methodology.

3.2 Scrum Teams

From the existing 6 teams in the PBL project semester, two teams were randomly selected to adopt scrum methodology as the main project and team management methodology. The selected teams were briefly trained on the main features of Scrum and a teacher was assigned to both groups to play the scrum master role. A teacher playing the traditional tutor role is always assigned to each PBL team but in this case a teacher with motivation and some degree of Scrum knowledge was assigned to play the Scrum Master role. The Product Owner role was performed by the responsible for the "Integrated Project in Industrial Engineering and Management II" course. Regarding the sprint length, both groups decided upon using sprints of one week period. Both groups also decided to have the review meeting on Friday afternoons, followed by their sprint planning meeting. The initial plan was for them to have the sprint planning meeting on Mondays but because they couldn't manage to meet on Mondays, due to lectures that they must attend that day, they decided to have the sprint planning meeting at the end of the Fridays, after the review meeting.

3.2.1 Student Team 1

Student team 1 was composed of eleven elements (9 male and 2 female) and the project assigned to the team takes place in an aluminium foundry company. The main objectives of the project were to analyse the production reality (production flows, layout, performance indicators, training, human factors, production information systems), identify problems and improvement opportunities and draw improvement actions and implement them. The company assigned the continuous improvement coordinator as the liaison person to supervise, guide and help the student team in the company.

3.2.2 Student Team 2

Student team 2 was composed of ten elements (8 female and 2 male) and the project assigned to the team takes place in a company that produces wiring systems for tractors. The company in reality proposed two projects. The objective of one project was to analyse and implement improvements in a particular assembly cell and the other project was to map an existing process and introduce improvements. The existing process was the set of the existing steps necessary to result in a new prototype solution that could fulfil in the best possible price the specifications of a customer. The team decided to assign some team members to one project and other team members to be focused on the other project. The company assigned the production manager as the liaison person to supervise, guide and help the student team in the company.

4 Methodology

The research methodology focused on a qualitative approach. An online survey, applied at the initial phase of the project, was used to collect data from the two teams using the Scrum method in the project. Besides this, direct observation of team meetings and teamwork developed in the project rooms, informal conversations with students and the team tutor and a document analysis of the scrum events and artefacts were included in the analysis.

Students' expectations were collected through an online survey, which included five open ended questions and one closed question. The questions included the following:

1. What did you like most about Scrum?
2. What did you like least?
3. How do you expect Scrum to help you with the project management?
4. What are the difficulties that you expect to find with the use of Scrum?
5. If you had to explain what is Scrum to a friend, what would you say?
6. In general, how useful do you find Scrum? From 1 (little useful) to 10 (very useful)

In total, 14 students answered the survey, during the first two weeks of October 2017. This corresponds to the initial phase of the presentation of the Scrum method by the tutor (scrum master) to the two PBL teams involved in this study. After this phase, the teams started to implement the Scrum method and regular visits, by the researcher, the team tutor and the PBL staff members were made to observe the teams working in the project rooms. Data reported in this study refer to the first half of the semester of the PBL approach.

5 Preliminary Results

The following sections present the preliminary results based on students' initial perceptions about Scrum and a brief analysis of some of the scrum events and artefacts.

5.1 Students' initial perceptions about Scrum

As a result of an online survey applied to the two PBL teams using the Scrum methodology to manage the project and the team, the following categories were organized.

5.1.1 What is Scrum

When asked to describe what Scrum is, students identified several characteristics about the method such as: planning, organization, defining tasks, setting goals, time management, team management, weekly sprints, individual responsibility, etc. Students' answers illustrate their views in regard to what are the main components of Scrum, such as presented in the following quotes.

"Method for group work, which aims to plan tasks to be developed, especially in short term. Tasks are defined based on the individual competencies of each team member. The task planning results from a process of brainstorming. Scrum is always followed by sprints – weekly meetings, in this case – where an evaluation of the week is made, reflecting on what went well, what went wrong and what could be improved, etc."

"Set long term goals and tasks, to be attained in short term. The information is organized on a board that is continuously updated."

"Task and time management tool."

"There are weekly Scrum meetings with the aim to define the tasks to be developed. As new tasks arise, each team member defines, confidently, a specific time necessary to complete this task. Through this method, it is possible to verify if each team member understood the task. The sprint is defined (tasks to be developed during the week), according to the available hours in the week. In the following week, a reflection on the sprint is done and a new sprint will be planned."

In general, the students seem to have an idea about what the scrum method is in terms of sprint planning, showing great concern with the issues related to the definition of tasks and the deadlines for their accomplishment. This concern is quite natural, as mentioned previously in the literature review section, where the need to create a detailed and closed set of requirements at an early stage of the project is presented as one of the drawbacks of project management.

5.1.2 Most / least positive about Scrum and difficulties expected

Most of the students were aware of the advantages of Scrum, as they identified positive aspects which they liked about the Scrum method. The most positive aspect mentioned by students was task management. Linked to this topic, is the definition of deadlines and the weekly planning, which are interrelated (see table 1). It is clear that students understand the objectives and procedures of the Scrum method, as they also mention that these were simultaneously some of the issues that they liked less about Scrum, probably due to the difficulties found in the implementation process and the lack of experience in using this method. Some students referred that the Scrum method was a “waste of time”. Some explanations to understand this point of view were explored in the informal conversations with students, during the visits to the project rooms. The arguments were mainly related to the difficulty in defining the duration of each task, one of the requisites for defining a weekly sprint. While still not being aware of the advantages and potential of the time spent on the planning phase in order to successfully achieve the objectives of the sprint, the students found this aspect as one of the most critical issues of the Scrum method.

Table 1: Students’ perceptions of the most positive and least positive aspects about Scrum

Most positive about Scrum	Least positive about Scrum	Difficulties expected
Organization of tasks (7)	Waste of time (4)	Definition of the duration of tasks (6)
Defining deadlines (4)	Planning of the Sprint (3)	Sprints (2)
Weekly planning (3)	Definition of the duration of tasks (3)	Meetings (2)
Team management (3)	Meetings (2)	Accomplishment of tasks
Visual management (2)	Applying the burndown chart	Lack of time
Sprints (2)	Not useful	Managing other “extra” tasks
Burndown chart		Scrum board
Reflection		Rapidness
Team motivation		

5.1.3 Scrum to support project management

In the PBL approaches carried out at the IEM program, students must develop a project, in teams made up of 9 to 11 students, during a semester. The projects are developed in interaction with industry and students must keep up with a set of *milestones* defined by the PBL staff coordination team. Considering the demands of this active learning approach, the volume of tasks necessary to attain the project’s objectives and the limited time available to conclude the project (one semester), the use of Scrum is a valuable tool to support project management.

According to students’ answers, Scrum will support the team in the project management process by providing a better organization of the team, a better planning and management of tasks and also the fulfilment of deadlines in the stated dates. Individual responsibility is also enhanced through this process. The following quotes from students confirm this.

“It helps the organization of work. There is no doubt about that. The fact that we analyse problems and transform them into tasks and, at the same time, we make each member responsible for the achievement of each task, in the timeframe of a week, encourages the team to work effectively. Setting goals to keep up with this method is, in my opinion, an encouragement for the group”.

“It encourages personal organization and fulfilment of deadlines, resulting in a better management of the project”.

“Since there are many members in the team, the use of Scrum helps to keep the team focused”.

“I hope it helps the team not to procrastinate and to be more organized and work as a team”.

Other topics were also mentioned, referring to the role of Scrum in the project management process, such as visual management tool, team motivation, weekly planning, group cohesion, project monitoring, avoiding procrastination, etc.

To complete this analysis, results from the single quantitative question included in the online survey can be crossed with this question. The majority of students classified the usefulness of Scrum, on a scale from 1 to 10, with classifications above 7 (13 out of 14 answers). The average was 7.76. Only one student considered Scrum of little usefulness, attributing the classification of 3 for this question. However, this result does not seem very worrying, considering the overall classifications.

5.2 Analysis of Scrum Events and Artefacts

The scrum event that was more important in both groups was the sprint planning (see 3rd column from the left on Figure 3). Although in the beginning most students did not see its value, as they were gaining experience in defining the tasks, they became more and more aware of its effectiveness. The scrum master played an important role in maintaining the students focus in defining the tasks in the most clear and possible way. The students realised that the time spent in defining the tasks in detail, its workload and responsibility gave them the advantage in achieving very good performance every week. In the beginning, one group had the temptation of defining small number of big tasks instead of large number of small tasks as if it would save some time in planning. Later they learned that the execution of such big tasks was difficult to predict and the results were bad.

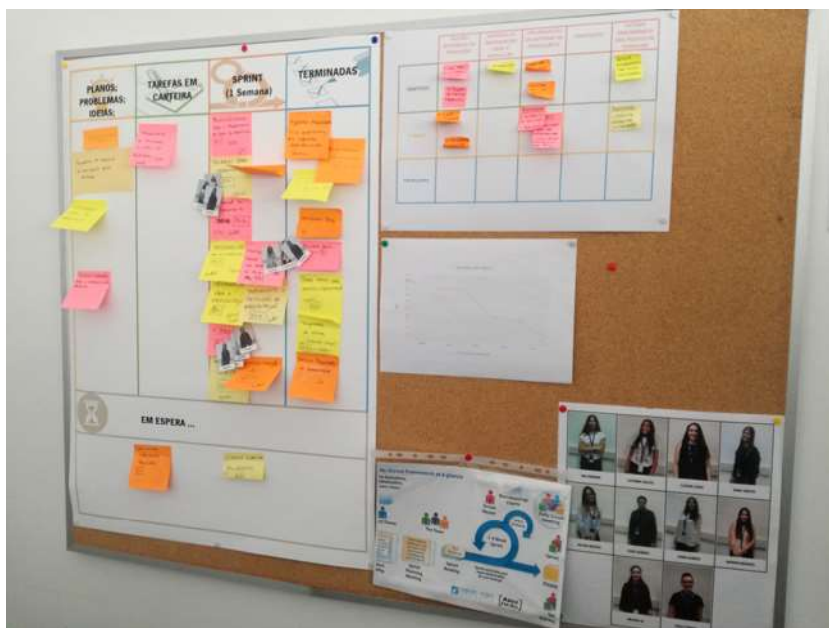


Figure 6 – The scrum board of one team.

The Backlog was something that neither group really grasped maybe because they knew little about the end results expected in the project. Since the company did not define very well the expected deliverables, the students don't see advantages in creating a backlog. This is one of the issues that must be developed in future PBL editions.

The burndown charts were created in every sprint planning meeting according to the man-hours available and the amount of hours required for the planned tasks to the next sprint and then updated as tasks are completed. The sprint reviews played an important role in the success of the scrum adoption since many problems were founded and avoided in the next sprints (see upper right side of the board in Figure 3). The burndown charts had a particular characteristic in this experience since the number of man-hours available each week varies from week to week and the team had to assign tasks that could fit the available capacity of the following week. This dynamic aspect of their reality gave them the need of making very detailed planning. An example of a

burndown chart is shown in Figure 4 where it is clear that on Wednesday they perform most of the work because is on Wednesdays that they do not have any classes and they spend the day doing project work.

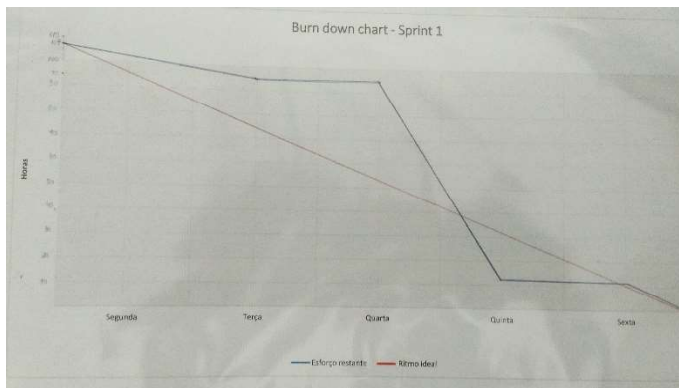


Figure 7 – One example of a burndown chart.

The sprint planning became so important for one of the groups that some students confessed that they could not manage their project without it. They also said that they take pictures of the board so that they can have a look at it when they are not in the room, and that shows how much they became dependent on it.

6 Final Remarks

In this paper, the Scrum methodology was explored in the context of PBL teams to analyse its effectiveness to improve team performance and project management. The specific characteristics of the PBL approach carried out in the fourth year of the IEM project, where the student projects are developed in articulation with a company, based on complex and open problems, show the importance of effective project and team management techniques and methodologies, as many dimensions of the projects are unpredictable.

The objective of this paper was to describe the implementation of the Scrum methodology as the core project management methodology in two PBL teams. Findings collected from the participants involved in the study (student teams, scrum master and project owner) provided a positive view of the overall impact of the use of the Scrum method. As most positive, students refer to the advantages of Scrum for weekly planning, task management and definition of deadlines. The difficulty in defining the duration of tasks was one of the main problems found, probably due to the lack of experience of students in using this method. However, after getting acquainted with the method and the sprint planning, one of the teams admitted that the Scrum method was truly effective for project management and that the team felt highly committed to its use.

In general, the results of this study contribute to understand the effectiveness of the application of Scrum to complex PBL learning environments. The results presented in the study provided important inputs to improve the way PBL student teams manage themselves as well as their projects.

7 Acknowledgements

This work has been partially supported by projects COMPETE-POCI-01-0145-FEDER-007043 and FCT-UID-CEC-00319-2013, from Portugal.

8 References

- Beck, K., Beedle, M., Bennekum, A. v., Cockburn, A., Cunningham, W., Fowler, M., . . . Thomas, D. (2001). Manifesto for Agile Software Development. Retrieved from <http://agilemanifesto.org/>
- Bruegge, B., Krusche, S., & Alperowitz, L. (2015). Software engineering project courses with industrial clients. *ACM Transactions on Computing Education*, 15(4). doi:10.1145/2732155

- Delhij, A., Solingen, R. v., & Wijnands, W. (2015). The eduScrum Guide. Retrieved from eduScrum website: [http://eduscrum.nl/en/file/CKFiles/The_eduScrum_Guide_EN_1.2\(1\).pdf](http://eduscrum.nl/en/file/CKFiles/The_eduScrum_Guide_EN_1.2(1).pdf)
- Dinis-Carvalho, J., Fernandes, S., & Filho, J. C. R. (2017). Combining lean teaching and learning with eduScrum. *International Journal of Six Sigma and Competitive Advantage*, 10(3-4), 221-235. doi:10.1504/IJSSCA.2017.086599
- Lima, R. M., Dinis-Carvalho, J., Sousa, R. M., Alves, A. C., Moreira, F., Fernandes, S., & Mesquita, D. (2017). Ten Years of Project-Based Learning (PBL) in Industrial Engineering and Management at the University of Minho In A. Guerra, R. Ulseth, & A. Kolmos (Eds.), *PBL in Engineering Education: International Perspectives on Curriculum Change* (pp. 33-52). Rotterdam, The Netherlands: Sense Publishers.
- Mahnič, V., & Časar, A. (2016). A computerized support tool for conducting a scrum-based software engineering capstone course. *International Journal of Engineering Education*, 32(1), 278-293.
- Rodriguez, G., Soria, A., & Campo, M. (2016). Measuring the Impact of Agile Coaching on Students' Performance. *IEEE Transactions on Education*, 59(3), 202-209. doi:10.1109/TE.2015.2506624
- Schwaber, K. (2004). *Agile Project Management with Scrum*. Microsoft Press. ISBN 978-0-7356-1993-7.
- Schwaber, K., & Sutherland, J. (2013). *The Scrum Guide*, 17. Retrieved from <http://www.scrumguides.org/docs/scrumguide/v1/Scrum-Guide-US.pdf>
- Stawiski, S., Germuth, A., Yarborough, P., Alford, V., & Parrish, L. (2017). Infusing Twenty-First-Century Skills into Engineering Education. *Journal of Business and Psychology*, 32(3), 335-346. doi:10.1007/s10869-016-9477-2
- Sutherland, J. (2012). Scrum: The Future for Education? Retrieved from <https://www.scruminc.com/scrum-future-for-education-2/>
- Sutherland, J. (2014). *Scrum - a arte de fazer o dobro de trabalho na metade do tempo*. São Paulo, Brasil: Leya.