On the use of Scrum for the management of research-oriented projects

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ABSTRACT

Working in a research group, integrating all the researchers can be the main factor for success in producing quality scientific research. In this sense, this paper presents a case study of the application of Scrum, an agile methodology for software development management, in the context of research-oriented projects. A group of undergraduate of the Computer Science course, master and doctoral students of the Informatics Post-graduation Program from the Federal University of Amazonas participated of the study. The Scrum controlled the whole research process, from initial literature review, through the software development phase, to the writing and presentation of the final project or thesis. During the study, the methodology was adapted to the context of research, seeking to resolve issues affecting the progress of the scientific production. At the end of every Sprint, the team held a meeting to validate the Scrum artifacts, exchange experiences and hold a debate on what the team produced during the Sprint. Observation and opinion survey show that the results were satisfactory, showing development in the production and quality of scientific work. This paper presents suggestions for improvements in the use of the Scrum methodology in research groups.

Categories and Subject Descriptors

• Social and professional topics~Project management techniques • Software and its engineering~Agile software development

General Terms

Management, Measurement, Documentation, Performance, Experimentation, Human Factors, Verification.

Keywords

Scrum, research projects, education.

1. INTRODUCTION

The Amazon Forest, one of the most important natural resources of the world, surrounds the capital city of the state of Amazonas, Manaus. In order to develop the city to be able to manage the resources, the government created a free trading zone in the city. After more than 40 years, a huge amount of industries has grown in Manaus leading to a great demand for qualifying personnel and researchers. The universities alone were not able to fulfill the necessity of professionals. For this purpose, the Federal University of Amazonas (UFAM) build partnerships with companies to create courses and programs targeting a high-quality education and research specialization focusing technologies used in the industries.

The UFAM's Informatics Post-graduation Program (PPGI) was created by the Computer Institute (IComp) aiming to establish researchers to work on the development of the companies. The program is one of the best informatics post-graduation programs of Brazil. Over 40 student, masters or doctorates, join the program every year, being submitted by a selection process. By the end of two years, the student must present the result of his/her research and it will be evaluated. The program requires the researcher to work with people in a very limited amount of time. For this reason, the training and adaptation of agile development methodology are crucial.

This paper proposes an adaptation of the Scrum methodology in a research group of undergraduates and students of the PPGI. All students were members of the Large Scale Qualification PROgram on MOBILE Technologies (PROMOBILE), created by the IComp and partners to train students on mobile technology focused research. The students were divided into groups, each responsible for a different research, but having to respond to the same teacher.

After the students were trained on the Scrum, the team architecture was adapted to the methodology and the more experienced student was pointed to be the Scrum Master, while the teacher advisor acted as the Product Owner. The Daily Meetings seek in a manner to affect the least on the academic life of the students, but not neglecting its role on the methodology. Once a month, an End of Sprint meeting was taken place inside the university to update all the teams about what was developed during the month, also the issues found and planning for the next month. Another purpose of those meeting is for more the experienced students to aid those with less research background, with tips and advice to improve their research and overcome problems that they might have already encounter. This research obtained excellent results as compliance with deadlines and proactivity of students to perform the activities of Sprints.

The remaining of this paper is organized in five separate sections. In Section 2, it is explained the context where the study is applied. Section 3 explains the principles of the Scrum methodology and its use on research projects. Section 4 describe the research team, which the study was applied, and the methodology. Section 5 express the results and discussion. Finally, Section 6 concludes the study.

2. CONTEXT

Manaus is located in the north of Brazil's territory and the Amazon Forest covers most of its area. The forest is known for its extensive resources including drinkable water. In order to defend the borders of the Brazilian territory, the government has established development programs for the region. The free trading zone of Manaus was created in 1967 in order to attract companies to the city. The first companies were dedicated to the production of VCRs and record players, but later huge companies from all around the world like Sony, Sanyo, Phillips and CCE joined the trading zone. Today Manaus is one of the largest industrial centers of Brazil with more than 700 companies.

The increasing number of industries also influenced the universities in the region. In the interest of satisfying the demand and advance on the research for new technologies, the Federal University of Amazonas invested on high-quality courses and programs, forming partnerships and improving the education of the city. The Computer Institute leads the research on nine computing subareas, distributed in six research lines, each one with a specific laboratory inside the university.

In 2013, the Informatics Post-graduation Program was evaluated with the highest grade according to the Higher Education Personnel Improvement Coordination (CAPES), being the only computing post-graduation program with this grade in the north region of Brazil. It was created in 2001 and ten years later more than 200 masters and 10 Ph.D. students had graduated in the program and now work developing research for universities and companies. Every year, an average of 35 masters and 15 Ph.D. students join the program, after a selective process and teacher evaluation. For the fields of computing, it covers database and data recovery, artificial intelligence, algorithm optimization, computer networks, embedded systems and computer vision. Each one with a specific laboratory. By the end of the program, the students have to present their research to a thesis defense committee, leading or not to publishing it. In an effort to build professionals more adequate for the companies' profile, professors of the ICOMP created the Large Scale Qualification PROgram on MOBILE Technologies. The project aims to develop high quality professional in several fields of computing, where undergraduate and graduate students work on projects with the support of higher experienced members under an agile software development method: Scrum.

3. THE USE OF SCRUM IN RESEARCH PROJECTS

Over decades, the industry has always sought to optimize the production of goods, for minimal cost and maximum profit, so, many methodologies for the design of such products were created. In software development, the traditional methodologies focus on tools and processes [1]. At the beginning of the software industry, there were no personal computers, then the development was focused on large companies, in this context, the main concern was with contractual details and what would be delivered in the software features. Once decided the planning and collected information on customer needs, the contract between the parties was used as a reference for the software development. It is observed in this process, that the customer waited for a product that would meet his demand, but performed little or no interaction with the developers and received the software only at the end of the process. There were many critics of this strategy because it does not allow changes or adaptations of the requirements, which, adding to the long period of development, could result in a software not suited for the client current needs. As an alternative to the traditional software development strategies, the agile methodologies emerged as flexible, adaptable and allowing regular customer interaction in the development process. Agile methods propose short development cycles valuing individuals and communication, focusing on software and changes [2]. In this work, we use the Scrum, one of the agile methods widespread in the industry.

3.1 Scrum

Scrum is an agile methodology for software development management with flexible and adaptable features. It is recommended for management of the product development process, in which results must be delivered regularly and in a short time. Scrum allows the organization in teams such that they should focus on delivering products with a high value associated and at regular periods. The Scrum framework consists of roles, events, artifacts, and rules [1]. The roles are assigned to individuals who participate in Scrum, so forming the Scrum Team. Events refer to actions that must be performed by the Scrum Team at a given time. The artifacts are the records of the activities performed in Scrum.

The roles in Scrum are Product Owner, Scrum Team, and Scrum Master. Scrum events are Sprint Planning Meeting, Sprint, Daily Meeting, Sprint Review Meeting and Retrospective Meeting. Artifacts are Product Backlog, Sprint Backlog, and Burndown chart.

The Product Owner is the individual who thoroughly understands the demands of what must be produced. It is the client and establishes the priorities of the activities to be performed [1]. The Product Owner is responsible for approving or disapproving the products delivered by the development team.

Scrum Team is responsible for product development and should deliver, periodically, the results according to the demands

prioritized by the Product Owner. Scrum states that development teams should not need supervision, being self-organizing and with people from different areas working together so that their skills are complementary.

Scrum Master is responsible for keeping the team focused on activities established by the Product Owner and eliminate any impediment, so the team reaches the goals. The Scrum Master also mediates communication between Scrum Team with the Product Owner and coordinates the Scrum events.

Sprint Planning Meeting is the event where Product Owner, Scrum Master, and Scrum team selects the activities to perform during the Sprint. This activities subset, called Sprint Backlog, is selected from the Product Backlog, which is the set of all product activities, recorded in Scrum as User Stories. Sprint is a time interval, usually two to four weeks, where the Scrum Team develops User Stories at Sprint Backlog. At the end of the Sprint, in the Sprint Review Meeting, the development team must deliver a usable product part to be presented to the Product Owner who must approve or reject the results.

Daily, during the Sprint, in order to keep a focused and productive team, occurs the Daily Meeting, where each person of the team presents what did since the previous meeting, what will do until the next meeting and the impediment that is making work difficult, if any. In Retrospective Meeting, the Scrum Team team discuss the lessons learned and difficulties encountered. The Scrum Master together with Scrum Team seeks to evaluate what was good and should be continued as working practice and what should be discontinued. Although agile methods are a response to the needs of industry, there are studies in the literature that show the use of Scrum in the academic context. These works generally perform adjustments to match the role and agile principles to activities in which they are applied. The following are some works that use agile methodologies in the academic context. Figure 1 shows the Scrum framework.

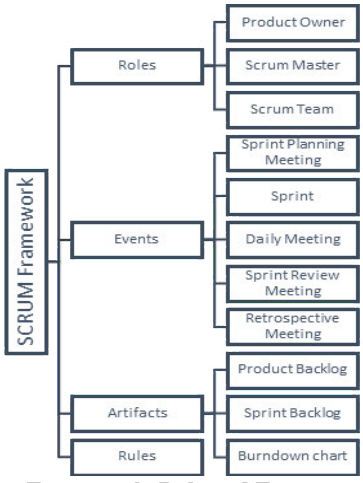

Fig. 1. Scrum Framework. Role and Events are the core of Scrum methodology.

3.2 Scrum in the academic environment

The paper in [1] presents a case study of the application of an agile method based on Scrum adapted to the academic reality of the Computer Institute of the Federal University of Amazonas. The authors point out the adjustments made, the improvements perceived and suggest some improvements based on what was observed. The paper presented the roles, events, and Scrum artifacts and linked with the components of the research group. For example, the role of Scrum Master was assigned to a group of students, while the Product Owner (PO) was associated with the teacher guiding the group's projects and development teams were organized by projects. The study aimed to inspire the improvement of basic skills such as speaking, writing, leadership, decision-making and knowledge of Scrum principles without being major interference in the routine of the participants.

The paper in [3] proposes the use Scrum to deal with the communication and tracking of the performance of Web-based education students. The goal is to show how Backlog can be used in web-based education and how to use it to track student performance. Through an equivalence between Scrum elements and the educational context, the work creates the following relationship:

- Product Backlog consists of the learning objectives set by the teacher.
- Product Owner is the very subject teacher. He creates and maintains the Product Backlog, provides the learning content, determines what needs to be learned, monitor and evaluate the results obtained by the students.
- Scrum Master is selected among the students: takes care of the team learning, he constantly communicates the team evolution and resolves difficulties.
- Scrum Team is called in the work as Student Team: they should meet, together, the acceptance criteria, fulfilling all the stories of Sprint.

With the inclusion of regular meetings, students have continuous feedback, the Scrum Master keeps constantly informing the teacher about the group status. The methodology proposed in the article creates a collaborative environment, promoting self-motivation and self-learning teams.

Reference [4] presents a case study using interdisciplinary and Scrum applied to Problem Based Learning (PBL). The PBL is to solve a real market problem within the academic environment [4]. The application of Scrum was given in conjunction with the MVC (Model-View-Control) design. Several subjects participated in the process, students from each discipline involved were responsible for a part of the solution. The Software Test students performed the tests and played the role of Product Owner. The Systems Project Database class were responsible for activities related to Layer Model, while the group of Information Technology was in charge of the Vision and Control layers.

The work in [5] presents a Scrum adjustment applied to Final Year Projects (FYP), mandatory item in the curriculum of distance students from the Virtual University of Pakistan Software Engineering course. A team of project mentors, who act as Product Owner and Scrum Master, supervises the FYPs. The hybrid approach is based on Scrum in the Waterfall model. There were more students than supervisors, leaving about 80 groups (maximum of two students per group) for each supervisor. The projects are divided into two semesters: in the first half, the waterfall model was used, it was spent preparing the documentation (analysis and requirements gathering, design). In the second semester, students who have completed the first half were divided into two groups. One group used Scrum to carry out the development of the project and the other group continued using the

Cascade Model for the same activity. The supervisor acted as Scrum Master and Product Owner defining the Sprints planning and user stories. Students should report the tasks of each story every day, they were also motivated to work with a repository where they could store the produced code. The repository maintained the record of every update made by the student and was verified a greater participation of students who used Scrum in relation to the group using the cascade model. The functionality delivery, interaction with supervisor, frequency of developed code updates in the observed range, was higher among students who used Scrum.

Reference [6] describes the use of the agile method in undergraduate research projects. The study was applied in a project that lasted a year, divided into two semesters. The projects were of two types: based on customer, based on research. Some interesting observations were drawn from the survey:

- Both types of projects should have frequent progress monitoring.
- Small teams are better for research projects.
- The peculiarity of the academic environment does not allow daily meetings. It was also observed that for research projects, meetings every day are not necessary.
- For research projects, regardless of team size, communication is important. The article also suggests larger Sprints, between 6 to 8 weeks; smaller teams, 3 to 5 members; weekly meetings instead of daily.

The paper in [7] proposes the creation of an educational model based on Scrum principles. The model was applied to the Computer Management class at the Economics and Business course, University of Zagreb (Croatia). The model proposes the use of Scrum throughout the teaching process, unlike most works, which, in general, apply Scrum only in student projects. The model was divided into three Scrum units related to theoretical knowledge presentation, practical skill training through projects, and assessments and examinations. The teacher takes the role of Scrum Master, but the study does not have the role of Product Owner. The Sprints have activities that depend on the Scrum unit that the cycle belongs. The article points out some limitations due the short duration of the course (20h) and a small number of participants. The great difference of this work is that it is applied to the entire teaching process and not only in the project development phase.

The article in [8] presents the implementation of Scrum in projects of Electronic Systems Laboratory at the University of Madrid, for undergraduate and graduate students. The method was used to provide students with an experience similar to what happens in companies. Students held the roles of Project Owner and Scrum Master. The Scrum Master guarantee the correct implementation of the methodology, the Project Owner was responsible for communicating with the client (teacher). In total, five sprints with a two weeks duration were conducted. Students pointed out the degree of satisfaction with the Scrum method compared to traditional laboratory method.

Based on the works mentioned above, we conclude that it is necessary to adapt Scrum to the academic context. Now we present how Scrum was implemented in this study.

4. SCRUM USE IN MOBILE LEARNING GROUP

The survey was conducted on the premises of UFAM in the research group dedicated to the Mobile Learning field. Initially, the group consisted of six students, composed of undergraduate, masters and doctorate in computing, as well as a doctorate teacher and group supervisor, who played the role of Product Owner, and a Scrum Master, who had advanced knowledge in the use of Agile Scrum methodology. To manage and monitor the activities, was used the VersionOne [9], an adapted web software for working with Scrum.

Each group consisted of one to three students; groups of two or three were formed by at least one student of master's or doctorate and the remaining by undergraduate students. The Daily meetings were conducted within the research lab inside the campus, where the Scrum artifacts were produced. This strategy allows a deeper analysis of the group progress and, if necessary, discuss any problem, give feedbacks and remove difficulties found between meetings. Table 1 shows the timeline of the agile methodology evolution in the research group, with activities and their periods:

Table 1. Timeline

Name	Period	Activities
Period 1	May/2014 – June/2014	Meetings and initial trainings, Scrum tool course, beginning of Scrum with Sprint Planning /Review/Retrospective and Daily Meeting.
Period 2	June/2014 – March/2015	Daily Meeting, Sprint Planning/ Review/ Retrospective and lectures among the group.
Period 3	March/2015 -	Daily Meeting, Sprint Planning/Review/Retrospective, lectures among the group and organization improvements.

According to Table 1, at the beginning, there were a training with those involved in the process, which was presented the role that each participant should represent inside the Scrum methodology. However, as it was focused on software development, several meetings were necessary to define its application within the research group, as it dealt with many activities as research, software development, scientific and technological projects and articles writing. In addition, a training regarding the VersionOne tool was done, so each group could use it to manage their activities.

Besides the activities described, in the migration from the first period to the second, meetings and accompaniments were held with the Scrum Master and the successor who would take over its function. Thus, it was observed that the Period 1 was the most demanding to frame the agile methodology in the research group, due the lack of research group experience and short time.

In the Period 2, another Scrum Master assumed the role, but the rest of the team remained the same. At the end of this Period, it was held a series of lectures among the research group. Those lectures were related to the member’s research, as they shared the same

computer field, their individual themes could help one another. In the Period 3, the Scrum Master who assumed was a member of a group, so he had knowledge of how the groups worked and the use of the methodology. All the activities from the previous Periods persisted and the working organization improved, as well as the time the group takes to complete an activity.

4.1 The IComp's informatic post-graduation program

At the university under consideration in this study, the Computer Institute created the program to educate graduate students in the process of research development. The main objective is to provide deep knowledge in the computer field and supply the resources and environment to develop scientific research. Masters and Doctorates can join the program with different requirements, but both must develop and present a research at the end. The program requires the master student to attend specific courses in a total for 180 hours, for doctorates, the time extends for more 120 hours. The required courses cover computer related topics such as Analysis and Design of Algorithms, Theoretical Foundation of Computing and Directed Study in Computer, but there are several elective courses for those willing to improve their research and paper development. The quality of their research is evaluated at the end of at least two years when they need to make a presentation for their adviser and other teachers. The program counts with over 20 doctorate professionals being part of the advising team, working in several different fields of computing, it also has six laboratories, each one focused on a different field.

4.1.1 The research group

The PPGI counts with several subtopics of the artificial intelligence field, such as adaptive interfaces, assistive technologies, and learning-teaching process mediation. The study was applied to a group of researchers of the PROMOBILE projects dedicated to the artificial intelligence field. This group featured undergraduate and graduate students and several projects. Each subgroup was responsible for one project and monitored by the same Scrum Master. The study extends from the initial literature review to the presentation of the subgroups, describing the adaptations made on the Scrum method to suit better in the context of the project.

4.1.2 The proposed and applied method

The members dedicated to Mobile Learning, and which each participant played a role conducted the Scrum adoption processes in the research group. Figure 1 shows the operation process within the research group.

Generally, Sprints last about one month for the closure. As shown in Figure 2, the Daily Meeting was held between the Scrum Master and student groups, which initially occurred 3 times a week at the Intelligent Systems Laboratory, located on the premises of UFAM. At this stage, the Scrum Master and Scrum Teams gathered to check the progress of their productions, if there was any impediment that caused, the Scrum Master should help to fix it if the impediment was related to equipment and infrastructure and not the individual intellectual capacity. Sometimes occurred a Scrum Team does not appear in one of the designated days when it happened, it is up to each member to use email as a tool to perform the Daily Meeting.

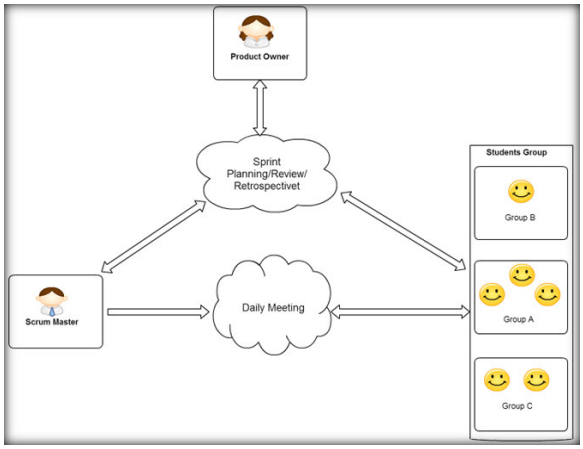

Fig. 2. The working architecture. The Sprint Planning, Sprint Review and Sprint Retrospective occurs in the same time. Nowadays, Daily Meeting occurs twice a week.

According to Figure 2, the steps of Sprint Planning, Review and Retrospective were performed at the end of the Sprint by the Product Owner, Scrum Master and Scrum Teams composed by Students Group, the reason for performing all of these steps on the same day was due the incompatibility of schedules among members. In the Sprint Review, each team must present every product backlog item, explaining what it is about to help the understanding of the participants, the main purpose of this step is to verify that each group reached the primary goal of the Sprint, and adjusting Product Backlog items that were not completed for the next Sprint. In Sprint Retrospective, each group must submit to the other members what worked well and what can be improved for the next Sprint.

After those two steps, the Sprint Planning is performed to define the items in the Product Backlog with their scores and priorities within each group. In this step, the communication and synchronization between the Scrum Teams and the Product Owner are very important, since each undergraduate or graduate student must submit a final project for the completion of the course, it must involve activities of research and completion of their course. At the end of all stages, the group of students must give a lecture to the other participants to generate knowledge to those involved in research, thus members learn about issues related to the research area.

5. RESULTS AND DISCUSSION

At the beginning of the deployment, it was observed that Scrum needed to be adjusted used in research group context because the actions taken by the group are focused on different activities not only development. Over time, it was noticed that the production level of students increased considerably and that Scrum has brought many benefits to the research group. Students who participated in the Scrum Team were more engaged in the activities and consequently in reaching the results, since in the end of the Sprint was necessary to present research productions.

In period 2, through the experience of agile methodology in the research group, it was observed a way to better encourage and enhance knowledge among the groups. It was proposed that, at the end of each Sprint, each group should give a lecture about an issue to the other members, thus it was found that participants

knowledge level increased and were used during the following Sprints, demonstrating that the lectures are a very important tool to be used in Scrum.

In period 3, there were difficulties of using VersionOne during the Sprint Meetings, because sometimes the Internet did not work. In order to circumvent this problem, Scrum Master previously captured information about the Sprint, but some members update their Users Stories after the screenshot, so as a solution students started to copy VersionOne data to their presentations, only to show their results. With this, the presentations did not depend on the Internet anymore and this optimized the meeting time. The schedule available for meetings changed, so it was necessary to reschedule the meeting at a time when everyone could be present. With this limitation, it was no longer possible to maintain the lectures.

5.1 Improvement suggestions

Through observation and opinion survey among the participants, it was found satisfactory results, showing that there was an improvement in the production and quality of scientific work. For improvements of the method, it is necessary to have a Scrum Master with comprehensive research knowledge, Scrum implementation knowledge, and communicative skills and be proactive, due the busy schedule of the research group members, it is necessary to be more flexible and patient. It is very common to members work overnight to complete their activities and thus completes the research. It is for the Scrum Master with advanced knowledge to adjust the methodology aiming the best performance of the members, such as:

- Reducing Daily Meetings during the week in order to enable the best performance among the Scrum Teams. Meetings can be, for example, on Tuesdays and Wednesdays.
- Using cloud services to store deliveries Sprint. Every Sprint, the products are stored in folders for each member of Scrum Teams. Articles, programs, technical reports, surveys and so on.
- Using a presentation template for the Sprint Planning / Review / Sprint Retrospective Meeting. This makes it faster and understandable presentation.
- Create groups in messaging applications. This facilitates team communication that is not in the same place. This is because each student has a different agenda.
- Choosing the Scrum Master among students. This facilitates the communication process and approximates Scrum Master and Scrum Team.

6. CONCLUSION

We presented in this paper a case study of the application of Scrum, in the context of research-oriented projects. The Mobile Learning Group used Scrum to manage their research projects.

The Scrum Teams were composed of 1-3 participants. The Scrum Master was chosen from students, which facilitated communication between students. The Daily Meeting was adapted to the context and now occurs twice a week. In the Sprint Review, meetings take place the planning, review, and retrospective. The artifacts of Sprints are stored in the cloud where every student has a folder to store their results. The differential of this study is that Scrum was applied to the entire research project not only with the development phase. Excellent results were obtained as compliance with deadlines and proactivity of students to perform the activities of the Sprints.

7. ACKNOWLEDGMENT

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