

Software Engineering Methodologies for the Evaluation and Monitoring of Projects of Higher Education Students

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Abstract. The change of strategies in teaching in Higher Education motivated the present work. With the application of cooperative and collaborative learning in the classroom, better results were obtained in the subject Research Workshop II, which is taught in Higher Education in Engineering. The work applying cooperative and collaborative learning impacted on the way to evaluate the participants, generating the need to find a way that allowed to have the elements to know who was contributing, which team progressed slower according to the program, as well as their peers in the development of the research project. In recent years in a significant number of companies dedicated to Information Technology and Communications have incorporated agile methodologies to manage different projects in very diverse branches, but especially in Software Engineering. In particular, the methodology used is Scrum. Therefore, Scrum was incorporated to develop students' projects, but also to evaluate the progress that students are making in the development of projects. With the incorporation of Scrum, better results have been obtained in the projects that the students develop, they and the evaluator are aware of the progress and delays they have in achieving them, in order to take actions that allow the products requested to be completed in a timely manner the curricular program of the subject.

Keywords: Cooperative and collaborative learning · Agile methodologies · Scrum

1 Introduction

The complexity of the last subject of research of the three that are taught in engineering careers at the University, has caused that traditional teaching-learning strategies are redirected by alternatives that allow the teacher to cover all the subjects of the study program. The subject, which includes the elaboration of prototypes, theses, articles presented in congresses and research forums, posters, slide presentations among others. These practices are applied in a 16-week course, where sixth, seventh, eighth and ninth semester students participate and sometimes apprentices from different areas come together, but mainly from the Computer Systems Engineering degree.

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The work begins in 2014, at which time the master teaching strategy is changed by cooperative and collaborative learning strategies, to organize the young people in the work they will develop during the semester. In addition, communication was incorporated beyond the classroom through social networks to follow up on the deliverables of the groups formed and to establish and maintain communication with them outside the classroom. This decision was made with the idea that the instructor could cover all the points indicated by the curriculum of the subject and the students had a better understanding of them. Thanks to the fact that better results were obtained in the scope of the subjects of the program of the subject, in advances of prototypes, elaboration of documentation, participation in specialized forums, it was decided to continue along this path.

The incorporation of different strategies in the classroom presents a problem for the management of the projects, the monitoring of the team work, the deliverables and the evaluation. Therefore, it was decided to incorporate Software Engineering methodologies so that students and professors had clarity in the scope of the work developed, to know in which part of the project the students were participating, to review advances in research documentation and prototype development, and thus having more elements for the evaluation of the participating students.

Agile methodologies have a high degree of flexibility and tolerance to frequent changes, increasing the probability of success in development processes. Mundra, Misra and Dhawale, consider that one of the factors that influences that agile methodologies lead to a good development, is the work in small groups, from four to ten collaborators, which allows a support collaboration between those that make up the team, plus it has been proven that small teams work better than large development teams [1].

In the following sections, we present the review of the literature that was made in relation to collaborative and cooperative work, learning strategies, surveys, projects and research that have been conducted on agile methodologies, ending with the results that have been achieved to date, by including SCRUM in the projects of the students and in the evaluation of the developments made.

2 Methodology

2.1 Cooperative and Collaborative Learning

Cooperative and Collaborative Learning (CL) has been defined as an instructional model that can teach diverse content at different grade levels. Students work in small, structured and heterogeneous groups to master the content of a subject [1]. From time immemorial, the Jews expressed in their holy book about teaching that a person will learn better if they have a partner that facilitates learning and in turn facilitate learning [2, 3]. On the other hand, the human history survival has been possible thanks to the cooperation of its members. It was not the individual advantage that made it possible, but the group. Regarding education Kagan and Kagan (2009) consider that cooperative learning contributed to solving the educational crisis that for several years had education in the United States [4].

As characteristics of the CL, the small trained groups work and cooperate to achieve shared objectives maximizing personal achievement, unlike competitive and

individualistic learning, in which one works to achieve a goal and a qualification without taking other colleagues into account [5].

The report made by Cohen, Brody and Sapon-Shevin, is related to the growing need to innovate teaching in classrooms, taking the proposal to include cooperative learning as a pedagogical option for learning. Therefore, many educational programs have increased the number of opportunities for teachers and students to experience cooperative and collaborative teaching and learning. That's why according to Cohen, Brody and Sapon-Shevin in education who works as a team has greater chances of success [6].

The vision of Ferreiro on cooperative learning is given from three perspectives, one in which the CL penetrates education and teaching. The other is to consider it as an educational model, to be used in all the components of the educational institution. Finally, it can be seen as a strategy that can be used in the classroom [7].

In cooperative learning the teacher performs functions as a mediator, enabling the student to learn to move from a state of not knowing, can do, to being another qualitatively superior one of knowing, of knowing how to do and being. In this other point of view, the teacher as mediator moves the apprentice in his area of potential development, stimulating the development of his learning potentialities while correcting the non-assimilated cognitive functions. This is how in the environment parents, friends and teachers are mediators, facilitating the transition from a real initial state to a potentially awaited state. In sum, in CL the mediator (a) favors learning, (b) stimulates the development of potentialities, (c) modifies deficient cognitive functions, (d) fosters the movement of an initial state of not knowing, doing, and being in a way that transcends the here and now [2].

Starting from the vision of cooperative learning as a learning strategy, the teacher should assume a role of mediator and be supplied with new skills that allow students to achieve joint achievements. A similar case represents the CL for the students, since for them it represents a change and they must learn to work cooperatively.

2.2 Learning Strategies

Páez, proposes several definitions of learning strategies, beginning with that of Poggioli (cited in Páez), which considers them as cognitive plans to achieve a successful performance. On the other hand, Schunk (cited in Páez), with a global vision, includes them as part of learning activities, considering them as techniques to maintain a better learning environment. Said author also considers that the strategies are the forms that are followed to reach the learning objectives. On the other hand, Dallimore, Herstentein and Platt (cited in Páez) see them as a means by which the quality of participation and effectiveness of the discussion in the classroom is increased by an active facilitation that allows the Students to present their experiences and add ideas. The authors also consider the value that teachers bring to the learning environment by asking effective questions. All this will produce constructivist contributions in the teaching process [8].

2.3 Agile Methodologies

In the development of software projects, the cost overruns for software projects, the late delivery of products, excessive documentation, the non-inclusion of changes arising in

the development process in the requirements of the systems are mentioned. Due to this, in order to try to amend this problem in the year 2001, 17 people from different companies such as Extreme Programming, SCRUM, DSDM, Adaptive Software Development, Crystal, among others, meet in Utha, looking for a solution to the programming directed by the documentation and driven by "heavyweight" software development processes. The Manifesto for Agile Software Development, agreed by all participants, arises from that meeting [9]. In the Agile Software Development Manifesto, individuals and their interactions are valued more, the work of software development that works, the collaboration with the client, as well as the response to the changes present in the life of software development.

Thanks to the success in the development of software products, the simplicity of its methods and its flexibility, agile methodologies in particular SCRUM have been adopted by large companies including Fuji-Xerox, Honda, Canon and Toyota. The case of Toyota shows an increase of four times its productivity and twelve times in the quality of the competitors, this was shown by Sutherland, Anton, Jack and Niklai on the 2007 [10].

In 2016, Uskov, Kondamudi, Krishnaiah and Singh rely on the 7th Annual State of Agile Development Survey, to justify collaborative work, and propose changes to the academic curricular program in engineering education, which includes topics, tools, curricular content, laboratory practices with a focus on the design and development of software and information systems for computers [11]. Among the questions included in the survey conducted by VersionOne in the 7th Annual State of Agile Development Survey, more than 4000 users about any agile methodology are; the agile methodology used, the agile technique used, causes of failure to follow an agile methodology, in what type of projects Kanban uses, who practices the agile management portfolio, among many concepts that were present in the survey [12]. The source used by Uskov et al. of the report, is related to the benefits experienced by users when using agile methodologies, reporting that 90% of respondents felt much better in the ability to manage the change in priorities, 85% reported that their productivity increased, 84% obtained better visibility in the improvement of the project, 84% reported an increase in morale in the work team, 81% reported that the quality of the software increased, 80% considered that the risks were reduced, the 79% thought that the product came faster to the market, 79% had a better experience in the alignment of IT and business objectives, 76% felt a simpler development process, in 74% it improved and increased the engineering discipline, and software maintenance and extensibility were also increased, finally 67% managed the agile methodology in distributed teams [11, 12].

There is another study, that of Caeiro et al., Related to the adoption of lean and agile methodologies in the universities of four countries: Greece, Portugal, Spain and Estonia. They conducted this study because they consider it important that students prepare in these methodologies, given their current application in the business world. They found that in addition to traditional teaching, it is now common to use active learning methods such as problem-based learning (PBL) and the use of simulations and serious games such as "Dice of Debt" or "Scrum Game". These games and simulations were designed to be played in teams, face to face, finding them appropriate for ICT subjects or e-learning situations [13].

2.4 SCRUM

The survey financed by VersionOne, in the question of what agile methodology is used in the company; Scrum and its variants appear with 72%, far above any other methodology present [12]. In an article presented by Srivastava, Bhardwaj and Saraswat in 2017, it is mentioned that agile methodologies have been better for a faster and more effective software development and they find that the adoption of these methodologies has helped companies achieve better levels of CMM in the organization. They describe the SCRUM methodology as a personalized way of working to conduct different projects in which the requirements are selected in a flexible way, without a predetermined path to follow [14].

Schwaber quoted in [16], presents the basic principles of the methodology:

- "The incremental development of the project requirements in short and fixed time blocks.
- Prioritization of the requirements by value for the client and development cost of each iteration.
- Empirical control of the project. At the end of each iteration, the client is shown the real result obtained, so that he can make the necessary decisions based on what he observes and the context of the project at that moment. The team synchronizes daily and makes the necessary adaptations.
- The empowerment of the team that is committed to deliver some requirements and for which the necessary authority is granted to organize their work.
- The systematization of collaboration and communication.
- The timeboxing of project activities to help in decision-making and obtain results" [15].

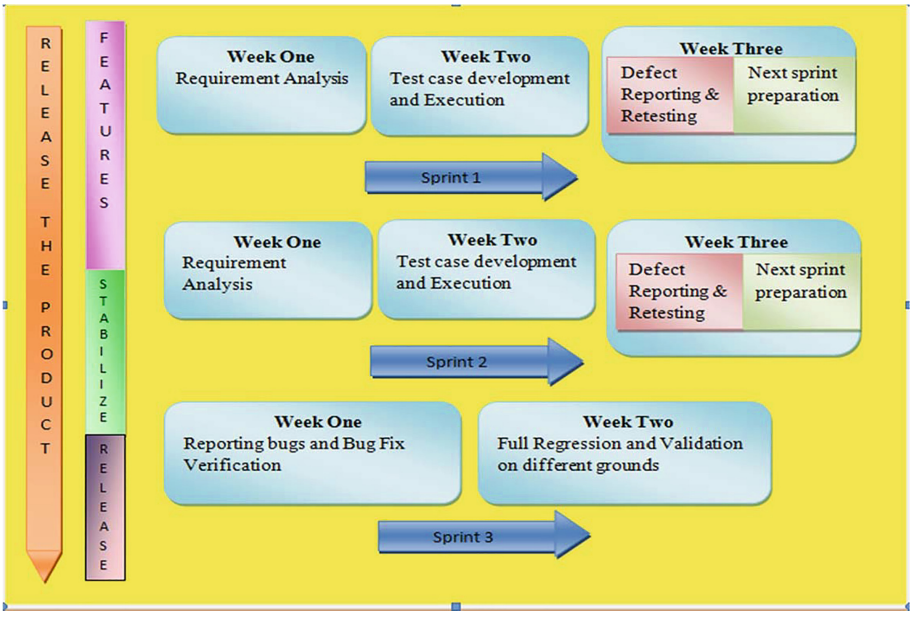


Fig. 1. Explanation of sprint cycle in SCRUM (source of [14])

In SCRUM there are several roles, to carry out a very close collaboration in the development of the project, they are: (1) Product Owner, (2). Master Scrum and (3). Team Scrum. Each role has a specific task; thus, the task of the Master Scrum (MS), is to eliminate the obstacles that arise in the development of the project. The Team Scrum (TM), is formed by developers, testers and other experts from other fields, which lead to develop a product that satisfies the client. Tasks are divided into small blocks, called sprints. A sprint is assigned a small group of people, who will carry out the task. The task to be performed is documented in a sprint backlog and is determined by the Product Owner, calling them user stories. They are associated with the sprint planning which includes methods to finish the sprint [16] cited by [14, 18]. At the end of the day, a meeting is held to review whether the assigned task was achieved or advanced. The goal of each sprint is to release a potential product. The meeting with the Product Owner is done at the end of the sprint, presenting the finished product, for review [14]. The objectives of the sprint cannot be changed, however, in the following sprints new features can be added to the project [17] cited in [14]. A normal SCRUM cycle is presented in Fig. 1.

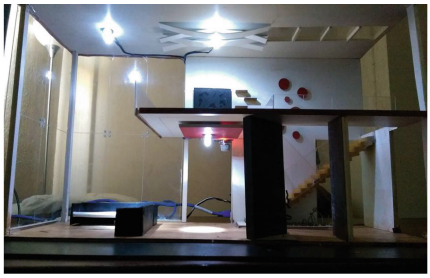
3 Results

The beginning of the investigation dates to 2014, initially SCRUM was not incorporated, in the projects developed by the students, nor as a way to evaluate the projects carried out by the trained work teams. However, since the first semester in which cooperative and collaborative learning was used quantitatively and qualitatively, they began to have better results in the projects carried out by the students. By incorporating SCRUM, young people have greater clarity in what is being done, progress is made faster in the objectives defined in the projects, better documentation of these is achieved, participating in local and national forums and congresses (Table 1).

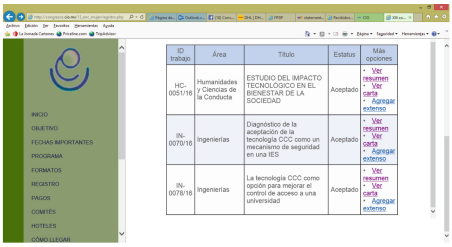
Table 1. Project management results.

Semester	Total projects	Finished projects
Jan–Jun 2014	8	1
Aug–Dec 2015	5	5
Jan–Jun 2016	6	5
Aug–Dec 2016	5	3
Jan–Jun 2017	4	3
Aug–Dec 2017	4	3
Jan–Jun 2018	3	3
Aug–Dec 2018	4	4

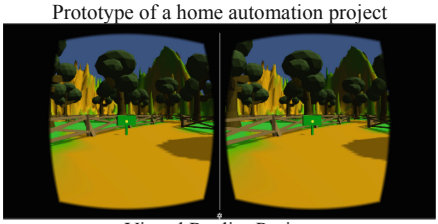
The projects developed by the students have been diverse, so they have built projects of home automation, e-Commerce, Machine Learning, Machine Vision, Virtual Reality, help to motor recovery of people, layout of buildings, among others, in Fig. 2, some of them are shown.



Prototype of a home automation project



Acceptance of articles in national forum



Virtual Reality Project



Student interacting with his project

Fig. 2. Examples of products generated by students

In Table 2, an extract of the methodology that was used in a layout project that was prepared in the semester Aug-Dec 2018 by a team of students of the subject is presented.

Table 2. Overview of the general sprint of a layout project.

Sprint:	General
Team scrum	Anuar Sánchez
	Liliana Gallegos
	David Villanueva
	Ricardo Rea
Master scrum	Ricardo Rea
Backlog	Acquire necessary knowledge of Unity
	Download software Unity
	Download software Sketchup
	Obtain plane of the Institute (general distributions)
	Establish standard measures of buildings
	Capture of the elements of each building
	Digitization of buildings
	Digitization of other structures (green areas, vegetation, fences).
	Export elements from Sketchup to Unity
	Unification of the components Configure point of view
	Road configuration

From the general sprint, this in turn was divided into several sprints, in which the Scrum Masters were rotated, until reaching several specific objectives. It is worth mentioning that the last sprints could not be made due to lack of adequate equipment. In Fig. 3, some buildings of the layout made are shown.

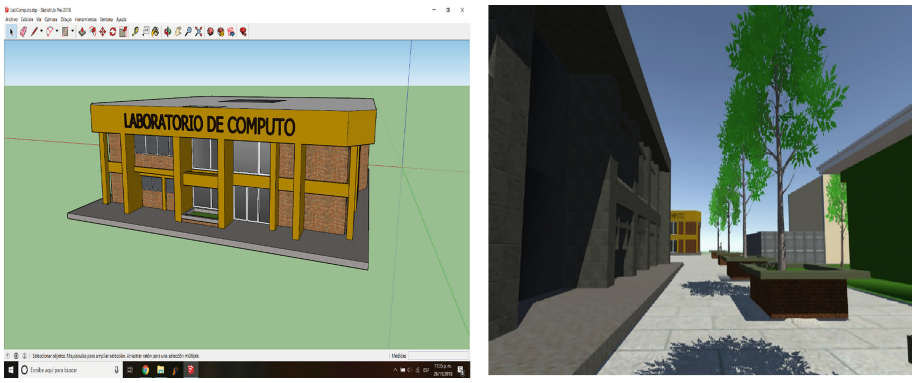


Fig. 3. Layout of some buildings

In Table 3, the pending's of the first sprint of another Project in which SCRUM was used for its elaboration are shown.

Table 3. Estimating the pending of the first sprint.

Pendings	Estimate in size (small, medium, large)
Design screen for CISCO phones	Large
List of places to be called test	Medium
Installing the Internet Explorer browser with version 7 on the machines in which the system is to be used	Medium
Configuring a server with Apache system, using PHP and MySQL	Medium
Phone 7945, 7965 or 7975 available for development integration	Small
Creation and configuration of the users in the call manager to be able to interact and to inject to the phones	Large
Running label injection on the remote phone	Large
Running label injection on the local phone	Large

The use of SCRUM, to evaluate the work of the students, has been very useful, since the evaluator in this way knows the work carried out by each participant and the quality that each sprint contributes to the final work. The progress meetings face to face

with the different work groups are held each week, achieving personalized attention, in which progress and jams of the work are detected and with the social networks a less formal monitoring of the work that the students are doing is maintained. For those groups with progress problems, more meetings face to face are held during the week, from two to three meetings, so that they can keep pace with classmates.

4 Conclusions

The change of paradigm in the teaching in the matter Research Workshop II, to the cooperative and collaborative learning, generated better results in the learning of the students. Even as indicated in Table 1, in the semester Jan–Jun 2014, only one project was completed, the rest achieved better results than the work done individually. In the following semesters, cooperative and collaborative learning continued, with an area of opportunity in the way teams were evaluated. Better products were obtained by the student teams, however, the elements to evaluate the students were not very clear. This led to a revision of the Agile Methodologies, used in a good number of companies dedicated to Information and Communication Technologies in different types of projects. The results that have been obtained since the beginning of using Scrum have allowed for a better control of the progress and results of the projects prepared by the students. Several projects have begun to be presented in research forums, articles have been prepared for congresses, prototypes are available, documentation of a thesis is reached in the majority at 80% and in very few cases at 100%; even when 90% of students start their project in the subject. Another thing that was detected is that the students stay very motivated during the course and some have continued with their work beyond the final semester. We also consider that it is very important that they are given the necessary tools, devices and equipment for the development of their work, which sometimes go beyond the budget for this.

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