Agile methodologies at an educational context: a systematic review

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***Abstract*—This is a work in progress and the category is research. This paper presents a systematic review on the usage of agile methodologies in educational environments. During history, multiple strategies were created in order to solve the necessity of helping students on building their knowledge. The arrival of new technologies opens new possibilities due to the easy access to information, and this fact transforms student's profiles worldwide. In this context, it is important to find new ways to assist learners through the journey of learning while improving their motivation. Recently, the application of agile project management methodologies, such as Scrum and Extreme Programming, has emerged as an option to be adopted inside the classroom aiming to improve learning. Due to their capabilities of flexibilization of student's self-regulation, these methodologies have become an interesting option in an educational environment hence their high adaptability to requirements changes that may occur during the time. In other words, new requirements can be perceived by the teacher, for instance, learning a new tool that was not planned on before, and, therefore, the class plan can be modified to accommodate this new necessity. Through the mapping of the literature it was possible to obtain a knowledge base on the subject and to understand the current state of the research on the topic.**

***Index Terms*—Agile methodologies, learning, teaching, class room**

I. Introduction

The learning process can be a unique task for each student, since each individual has a way to learn and build his or her own knowledge. Helping students to build their own knowledge has never been an easy task. In an environment like the classroom, several variables that can affect the way teaching can be carried out, such as the peculiarity of each student, availability of resources and the teaching style adopted by the teacher. Agile methodologies, such as Scrum and Extreme Programming (XP), allow flexible management of software development. Due to their ability to enhance cooperation and self-organization of its members, it becomes interesting to apply them in an educational context. The capacity on adapting to new requirements of agile methodologies during the course of a project is an attractive feature to the educational environment, as it allows the class to be shaped by the students' needs, thus increasing their engagement and motivation. This work performs a systematic review on the use of agile methodologies at the educational context.

II. Pedagogical aspect

Historically, education is a process in which the teacher was, or sometimes still is, the holder of knowledge and the student is the one who absorbs this knowledge to learn [1]. According to [4] when the subject, student, is seen by the teacher as a blank sheet to be filled with the knowledge, it is an empiricist approach. The student only learns if a teacher teaches [5]. The empiricism denies the action of the subject, in this case student, in the process of knowing. The learning process should offer the tools that the learner need to create their own knowledge. The teacher's role is to create an environment that sparks the need for answers of the subject, which will subject him to build his own knowledge [6].

A. Constructivist Theory

The constructivist theory is the result of research by several thinkers like the Soviet psychologist Lev Vygotsky and the Swiss psychologist Jean Piaget. While Piaget focused his research on the relationship of the individual in the construction of his own knowledge, in a more individualistic way, Vygotsky is interactionist and takes into account social interaction in the construction of knowledge. These two different approaches have given rise to a theory called social constructivism [5-6].

In the constructivist theory, the individual's mental processes and evolution are in continuous change and, therefore, each new information added takes him to a new mental state. Piaget demonstrates that the human subject is, like the object, are in constant change [5]. The deduction that the subject and the object exist is correct, however they constitute and collaborate with each other in the interaction. According

to Piaget, cognitive growth occurs through assimilation and accommodation. When the individual assimilates a new reality, he can change internally. Assimilation is characterized as the appropriation of new knowledge [5]. When the mind changes, accommodation occurs, which in turn leads the individual to new assimilation processes. In accommodation, the previous assimilation schemes are reorganized so that, in this way, the possibility exists for new assimilations. A question generates a response that generates other questions and thus the person builds his own knowledge. Piaget states that there is learning only when the assimilation is accommodated. According to [14], Piaget, through the assimilation and accommodation mechanisms, explains the individual's adaptation to the environment in a sense analogous to that of biology.

B. Problem-based Learning

Problem-based learning (PBL), is recognized worldwide as an approach capable of promoting knowledge acquisition and developing professional attitudes on its participants. Unlike conventional teaching methods, which introduce problems to be solved only after demonstrating the theory that explains them, PBL uses problems to initiate and motivate learning [17]. Through the introduction of a problem, PBL seeks to instigate in the student the search for new assimilations that can answer the questions that may arise through this new irresolution.

Problem-based learning can vary depending on many factors like subjects, curricula and institutions where it is being implemented [1]. The process of using this method should normally be characterized by the flow described below. First, a problem is presented to students who, in teams, will try to solve it using the knowledge they have; Then, through discussion, students will list the aspects they do not understand; Afterwards, students must prioritize problems and decide how, by whom and when they will be investigated so that they can then be shared with the other team members; After this stage, when the team is reunited, they must explore the problems they previously faced and integrate their knowledge into the context of the problem; Finally, after finishing working on the problem, students should reflect on the problem solving process as a team.

In addition to making the class more pleasant, not only for students but also for teachers, the use of PBL empowers students by promoting self-directed learning [1]. PBL can make the class more attractive and facilitate the learning process which would affect the motivation of students in positive way [21].

III. Agile Methodologies

According to [1], software development occurs in two stages: First, there is the requirements analysis stage. Then there is the development stage, where the process of coding the requirements that were raised in the analysis stage is carried out. This is a very simplistic view of the software development process that, despite being dated, still exists in the industry. In a more realistic view, given the real complexity of the software development process in large companies, more steps are required in order to develop a project [1]. This form of software development is known as a waterfall model. The waterfall development model is one of the oldest paradigms in software engineering. Among its biggest deficiencies, it stands out its inflexibility, since a project follows a sequential flow according to the planned and, in case of the occurrence of requirements change, this can cause problems in terms of its delivery time [16]. In addition, customers, those who demand the list of requirements, hardly know all of their demands at the beginning of the project, which possibly can lead to changes during the development of the project.

A. Extreme Programming

In the agile methodology Extreme Programming (XP) the software development process occurs in small incremental iterations. Instead of analyzing and designing a long-term solution to a problem, XP explores the cost reduction of gradual changes in software requirements [2]. Through its practices and philosophies, the XP methodology allows its users to prioritize what will be delivered in the next interaction, or release, assessing the priority of this requirement, here called history, based on their costs. The customer chooses which story will take priority and the team works to deliver it in the next iteration. Some of XP's most important practices are:

- Planning game: : The customer decides which story has the highest priority for the next release;
- Small releases: The software is built incrementally through small deliveries of functionalities;
- Testing: The software must be tested constantly at each iteration;
- Pair programming: All code must be written in pairs, that is, two people sharing only one computer;
- On-site customer: The customer must be present full time.

In short, the customer first lists their requirements, then stories are created from these requirements. After this phase, the iteration begins, the stories are divided into smaller tasks and the developers, in pairs, create the software and run the necessary tests. The customer must accept the tests and provide feedback on the software produced. Finally, the realease is delivered and another cycle can be started.

B. Scrum

The Scrum agile methodology is a framework, a concept that supports a system, in which people can manage complex adaptive problems productively and creatively delivering products with the highest possible value. The term Scrum was created in 1986 and refers to the formation of American football teams. It is one of the most popular agile methodologies today, used in several companies around the world. Scrum is based on an iterative and incremental process. The process of reaching a conclusion is the result of the repetition of several rounds of analysis and execution of operations. The goal is to bring incremental improvements, small pieces of functionality, to each iteration.

The Scrum framework uses small pre-defined time frames called sprints that can vary from one week to a month in length. Each sprint starts with a plan and ends with a retrospective of the work done in it. During each Sprint the Scrum team works together to complete one or more of the project's increments.

Scrum implements some events to reinforce its practices. These are:

- Daily scrum: A daily meeting at which all participants on the development team must be present. This is a stand up meeting, that is, the participants must not sit because the meeting should not last for longs. The objective is to contextualize all of the work status of other colleagues;
- Sprint review: In this meeting, everyone involved in the project will hold a retrospective of the sprint that was carried out. The objective is to provide feedback on the functionalities delivered;
- Sprint retrospective: A meeting to discuss the development process itself and modify it if necessary. Sprint Review is focused on the product and Sprint Retrospective on the process.

Still, the Scrum framework has some artifacts that assist in the execution of the proposed tasks:

- Product backlog: It consists of an ordered list of everything needed to compose the project. It is constantly evolving and is never complete;
- Sprint backlog: It is a list of everything the team is committed to doing in the current sprint.

Finally, the Scrum framework has different roles for the participants of the team. These are:

- The product owner: Is directly responsible for listing the most important requirements for the project through the backlog;
- Developers: Members of the development team who perform the primary task of developing the project. They can organize and manage their own work collaboratively with others. The development team must have 3 to 9 members;
- Scrum master: It is responsible for ensuring that the team works within the Scrum values and that it is using the framework correctly.

IV. Agile methodologies at an educational perspective

The popularity growth of agile methods in the industry has generated interest from several researchers to apply such methods at the educational environment. Some studies have demonstrated how the use of agile methodologies can be beneficial in the teaching-learning process [10] . A constructivist learning environment is the subject of discussion in the field of education in computer science. The adoption of problem-based learning is common in computer science education [12]. The combination of the adoption of agile methods in the classroom and the Problem-based learning method can create an educational environment designed to encourage students' initiative to build their own knowledge. By instigating them through problems in order to encourage them to seek their own solutions and, consequently, create new assimilations. The teacher, who in the case of agile methodology plays the role of manager, serves as an advisor or mediator. His role is not that of an instructor, holder of knowledge, but of a facilitator that aims to assist students in the construction of new knowledge through agile practices.

TABLE I
Translation of agile values to an educational context

Agile Value	Agile Value applied to Education
Individuals and interactions over processes and tools	Knowledge construction over assessments and evaluations
Working software over comprehensive documentation	Building Competencies over grades
Customer collaboration over contract negotiation	Collaboration among students and teachers over dictation
Responding to change over following a plan	Flexibility in learning and teaching over following a strict plan

The values of the agile manifesto guide agile methodologies in their practices, seeking their specific objectives in the development of projects. When it comes to the educational context, [11] suggests a translation of these values, which can be were adapted and are presented in Table 1, since the objectives of applying the methods differ from the industry. If, on the one hand, the objective in the industry is to obtain the best possible product while achieving maximum efficiency, on the other hand, in education the objective is to provide the best opportunity for the student to build knowledge. The table 1 shows a possible translation of the values of the agile manifesto.

V. Systematic Literature Review

In this chapter, the procedures adopted for the execution of the systematic review carried out will be described, whose objective is to obtain an overview of the research area.

A. Adopted Methodology

A systematic review of the literature consists of identifying, evaluating and interpreting the set of relevant studies in order to understand the current state of a field or phenomenon of interest [9]. It also states that individual studies that contribute to systematic review are called primary studies while, on the other hand, a systematic review is a form of secondary study.

The research was carried out following the stages proposed by [15]: Initially, research questions were established. Then there was the search for primary studies relevant to the topic. Afterwards, the screening stage of these studies was started according to the inclusion and exclusion criteria.

B. Research Questions

This study aims to synthesize the research carried out on the use of agile software development methodologies as a learning tool in the educational context. For this, research questions were formulated according to:

- Question 1: Are agile methodologies used as a teaching and learning tool in the educational context?
- Question 2: Does the adoption of agile methodologies in the classroom improves learning?
- Question 3: What agile methods are used in the educational context?
- Question 4: What are the difficulties of adopting agile methods in the educational context?

C. Selected Scientific Databases

The selection of Databases included events related to education, technologies, information technology in education and scientific research in general. The chosen bases were:

- New Technologies in Education Magazine (RENOTE): Publish works in the field of information technology in Education in Brazil;
- Revista Brasileira de Informática na Educação (RBIE): Collects works related to methods, tools and practices that assist in the use of technology in the teaching and learning process in Brazil;
- Scientific Electronic Library Online (Scielo): Brazilian electronic library that offers a large collection of scientific journals from more than 15 countries in different areas of study;
- ACM Digital Library: A digital library that brings together thousands of publications from different areas of knowledge;
- IEEE Xplore: A large digital library that aggregates content on technological innovation.

VI. Results

According to the sorting criteria adopted, it was then possible to select a total of 643 studies for the screening stage. At the screening stage, all abstracts were read and the exclusion criteria was applied. The majority of the retrieved works were not related to the educational environment and for this fact were excluded from the selection.

The table 2 presents the number of related works found at the selected databases and the selected works for this systematic review.

TABLE II
Retrieved works

Database	Retrieved Works	Selected works
RENOTE	4	2
RBIE	2	1
ACM Digital Library	107	2
Scielo	19	1
IEEE	511	7
Total	643	13

After reading the selected studies in full and analyzing the documents, some characteristics were identified. During the classification of studies that used agile methods in education, it was observed that the majority of applications of agile methods for teaching and learning occurred in higher education (71%) rather than high school (29%). This fact demonstrates that agile methodologies are used at the educational environment, despite of the fact that most applications are for studies at the educational field.

Another important categorization was the field of study where the agile methodology was applied. Most applications occurred in the area of information technology in software development projects. The only exception was a study that took place in a high school where students developed learning objects of their own in the discipline of mathematics through practices of the agile Scrum framework.

One of the most relevant facts about each study was the chosen agile methodology. The methodology would not necessarily need to be adopted in full, as there are quite significant differences between the business environment, a place of common adoption of agile project management methodologies, and the educational environment. Some studies used practices from more than one agile methodology.

It is still difficult to evaluate their effectiveness since providing objective evidence of the effectiveness of a learning strategy is not a trivial task. For that reason it is difficult to evaluate if such methods improves learning. Each group of students is unique and this makes the task of measuring their performance very complex. However, [7], highlight that a higher level of engagement was observed among students who were more motivated to attend the classroom since they had greater power of choice. For this reason, the authors highlight a greater attendance of students when compared to previous years. The biggest challenge on using agile methodologies in the class room occurs when students have as their main goal only to be approved in a discipline, concerned only with their grades, this tends to make it difficult to conduct the agile methodology once that it is based on student collaboration [19].

VII. Conclusions

Agile methodologies are adopted in the educational environment. However, considering the amount of relevant work obtained when conducting this research, it is clear that the adoption of this approach is still underused. In conclusion, the student's role in his learning is of paramount importance in the construction of his knowledge. It is necessary to direct pedagogical practices towards a self-regulating process so that this role can be achieved [20]. All people have a certain degree of self-regulation to manage their projects, progress and strategies in the face of tasks and obstacles [8]. It is important to offer opportunities for the subject to exercise his self-regulation favoring his autonomy progressively. The use of agile software development methodologies has the potential to provide an environment where students' self-regulation is part of the teaching and learning process.

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