A Scrum-Based Method for Autonomous Learning Management

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***Abstract*—This paper proposes an agile learning management method based on Scrum to support autonomous learning for students. In conjunction with the proposed method, a case study was carried out involving students from several undergraduate courses participating in a software development training program based on Challenge Based Learning. In this study, the Scrum framework was adapted to support students' learning with their Challenge team and mentor's support. Events, artifacts, and team profiles were added, adapted, and excluded to improve the student's autonomous learning management. The case study covered data collected through questionnaires, interviews, observations, and archival records as a source for analysis. The use of the method showed significant results in learning, the management of Learning Objectives (LOs), and the participants' use experience. Besides, the study brings opportunities for improvements to the method and hypotheses for future work.**

***Index Terms*—learning management systems, challenge based learning, scrum, agile**

I. Introduction

The competition in the job market is becoming increasingly fierce for newly graduated students, and this situation becomes more and more evident when companies and organizations are under pressure to become more innovative [1]. Being innovative is a consequence of different abilities such as the willingness to experiment and being highly collaborative [2]. In general, such abilities fit under the soft skills umbrella of the so-called 21st-century skills, which involve creativity, critical thinking and problem solving, collaborative skills, information technology skills [3]. In this context, the development of such 21st-century skills involves individual and team work, as solving complex problems often requires a combination of skills that only groups can achieve.

Thus, it is necessary to prepare undergraduate students for a sophisticated job market whose preparation requires an effort beyond the current frontiers of education, where traditional teaching methods are not the most appropriate approach. Thus, students must learn based on problems and relevant projects [4]. In this direction, a current challenge in education is to offer an innovative vision and learning environment, adapting the best pedagogical methods to meet the needs of students.

Several active learning methodologies have emerged over the past few decades and have been used in different areas of education. The usage of active learning approaches such as Challenge Based Learning (CBL) [4], Case Based Learning [5], Problem Based Learning (PBL) [6], and Project Based Learning (PjBL) [7] has gained prominence in undergraduate courses involving technology, mainly in the area of computing. Furthermore, in an active learning environment, it is essential that students are constantly challenged and engaged in the learning process [8], and the student's autonomy in this context is an essential skill so that they can manage their learning independently [9].

In active learning interventions students may lack maturity and autonomy that are necessary in their independent learning path [10], which is a strong characteristic of such approaches where learners need to be more independent. In active learning initiatives, we don't see mechanisms supporting students in managing their own learning process. Previous researches have indicated that auxiliary approaches such as metacognition (i.e., "thinking about thinking") [11] can enhance the learning outcomes of students in active learning [12]. However, instead of such reflective thinking about their learning evolution, we were motivated to guide them in their pursuit of learning objectives that appear and frequently change as the central solution or project in their learning context evolves. In the context of this study, a variation of the CBL approach [13]–[15] was used in a software developer training program currently being carried out at the Federal University of Pernambuco (Recife, Brazil). In this scenario, the student is the manager of his/her learning journey and can plan the learning taking into account what the project demands and what he/she wants to learn, execute it, check the learning result, and carry out improvement actions autonomously. It is possible to observe subjectively that monitoring your own learning progress is a difficulty faced by undergraduate students participating in the program. In this work, we propose a Scrum-based method to support students' learning activities and identify how they deal with learning management. This method allows students to: (i) define the Learning Objectives (LOs); (ii) align and communicate LOss with colleagues; (iii) Plan the execution of the LOs; (iv) Execute the LOs; (v) verify the completion of these LOs with the team; and (vi) reflect on the learning acquired from the execution of each LO.

The paper is structured as follows. Section II describes the background on the fundamental concepts and the related work and used in this paper. Section III presents and details the proposed method used in the study. Section IV details the context in which we applied the method and the results. Finally, section V concludes the paper.

II. Background

A. Challenge-Based Learning

Challenge-Based Learning (CBL) is a relatively recent, multi-disciplinary, cooperative, and applied active learning approach. It is an approach that emerged so that students could develop 21st-century skills [16] [17] such as critical thinking, communication, collaboration, creativity in identifying solutions that solve real-world challenges in the context of a school, university, family, or local community [18].

The use of the CBL approach has been expanded to several areas of activity such as health, technology, and entrepreneurship [19]–[22]. CBL has also been drawing attention through published studies involving education in the areas of STEM (Science, Technology, Engineering, and Mathematics). These studies include applications and adaptations for robotics [23], [24], physics, mathematics, computational tools [19], and mainly for learning mobile application development [14], [25], [26]. According to [18], the CBL approach allows flexibility for adaptation and customization for different learning environments, providing several entry points according to personal or institutional learning goals.

B. Bloom's Taxonomy

Bloom's taxonomy is a structure that categorizes educational objectives with their original application or with variations and adaptations made over the years. Despite the taxonomy being composed of 3 domains (cognitive, affective, and psychomotor), the highlight of the cognitive domain is notorious in published studies that base Bloom's work on the classification of educational objectives within learning through levels of complexity and human knowledge [27]. The cognitive domain is decomposed into six different levels of complexity: (i) Knowing, (ii) Understanding, (iii) Applying, (iv) Analyzing, (v) Evaluating, and (iv) Creating. Through its cognitive domain, Bloom's taxonomy has been applied to monitor students' learning performance [28].

C. Scrum

Scrum is an agile methodology framework that offers flexibility to support frequent changes and fast delivery. This framework is used to manage complex projects with uncertainty about their requirements and technology. The intersection of these two types of complexity defines the total level of complexity of the project in which it is impossible to predict how everything will happen [29]. Scrum reduces risks, controls the cost, and helps develop a quality product supporting the timely completion of the project [30]. Scrum's essence is based on "Inspection and Adaptation", which consists of making regular stops to check whether what is being done in a project is going in the right direction and if the result is in line with what the people involved want [31].

Scrum has been used widely in education, mainly in undergraduate courses mostly related to software development [32] [33] [34], where its application depends on the context and not always with the possibility of fully replicating real-world scenarios [35]. The benefits associated with Scrum corroborate the use of Scrum as a basis for the learning management method proposed in this study.

D. Related Works

Some studies have shown satisfactory results in using the CBL approach in conjunction with Scrum. Such results can be seen in the combination of the Challenge-Based Learning and software development processes in an educational context for startups [36], and in the combination of Challenge-Based Learning together with lean startup [37]. [38] present factors that influence the teaching process in active learning environments, specifically in software development, using Scrum as a development method. In a study involving undergraduate students where there is integration between the CBL approach and Scrum for the development of mobile applications, it was observed that the use of Scrum efficiently helps the execution of the activities related to the challenges of the CBL cycles [15].

In contrast to the related works, the focus of this work is not the management of software development but learning management. This is necessary since the traditional Scrum method focus on product delivery and not on learning.

III. Proposed Method

The proposed method is an adaptation of Scrum to assist the learning self-management in the tracks programming, design, innovation, professional skills, and development process. The adaptation consists mainly of the inclusion, exclusion, and adaptation of the traditional Scrum method's events, artifacts, and roles. To show how this was done, the proposed method is represented in Fig. 1, with the adaptations highlighted in yellow and inclusions highlighted in red.

A. Steps, Artifacts and Actors

The proposed method comprises the steps: Definition of LOs, Prioritization of LOs, Sprint Planning, Sprint Review, and Retrospective (Fig. 1). These steps are performed several times during a CBL learning cycle. Students carry out the planning, execution, and follow-up phases with reflection on the LOs and reflection on opportunities for improvement in the process, tools, and relationships.

The first step is the definition of a list of LOs based on learning goals and project demands. In this step, students and teachers define learning goals at the beginning of a Challenge. The goals defined by the student are general descriptions of their learning desires, being a solid component for the development of autonomy and confidence.

The second type of input artifact for the method is the project's demands to be carried out. Students typically identify needs as learning opportunities during the project execution process and consequently define one or more LOs for each

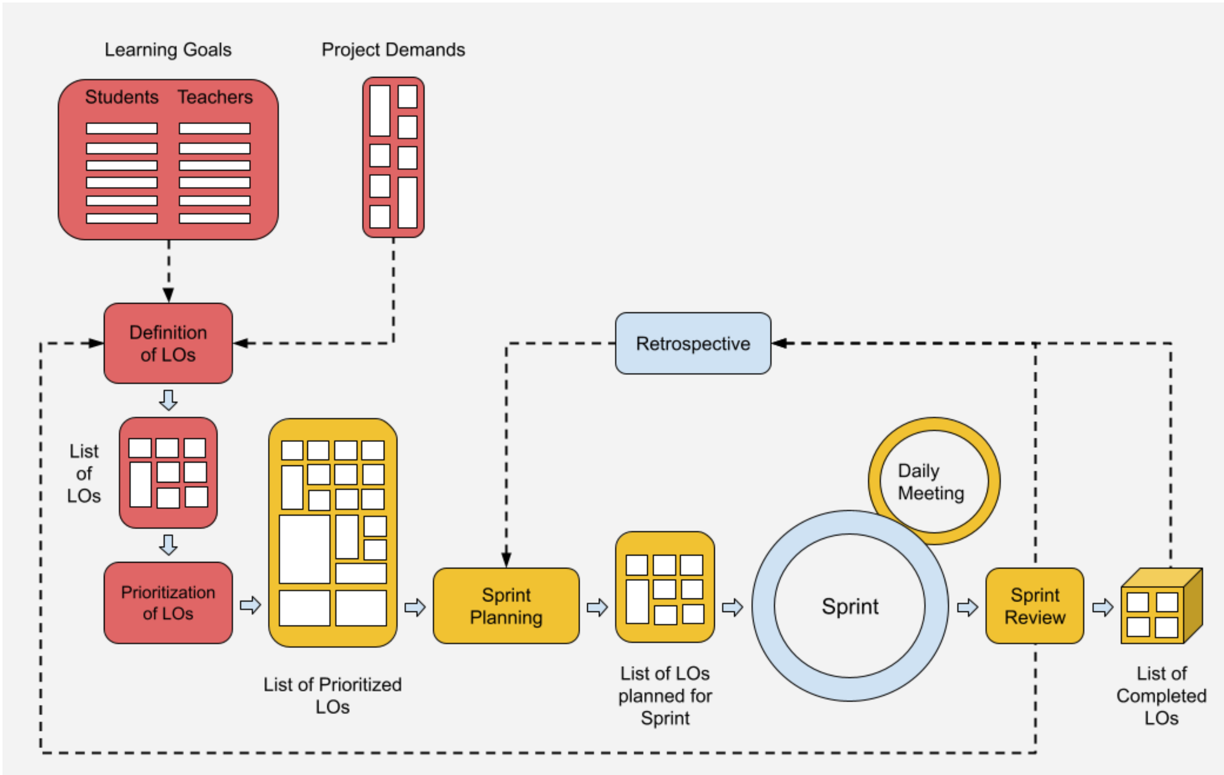

Fig. 1. Proposed Method.

opportunity. The following subsections describe the steps of the method where the artifacts and related actors are involved.

B. Defining Learning Objectives

Unlike learning goals, LOs are more specific and require evidence of learning. This evidence is according to the Cognitive Complexity Levels (CCLs) of Bloom's taxonomy [39] classified as to know, understand or apply. Although the definition of LOs can be made with the entire team present, LOs are individual, and each student must define their specific objectives and take responsibility for their planning and eventual execution.

The definition of an LOs is characterized by an initial survey of the student's learning demand. As the student is the main interested party in learning and must develop his/her autonomy, defining the LOs stimulates reflection on the learning possibilities that motivate him/her. This way, it allows the student to explore his/her interests alongside the project's demands, considering what is relevant in terms of learning, without being intimidated by the quantity and complexity of LOs. The definition of LOs does not imply a student's commitment to the completion of all listed LOs. However, if it is something that the student has already learned, it should not be considered an LO.

The result of the definition step is a list of LOs associated with a learning goal, track, and the responsible. The list serves as an entry for the prioritization of LOs step. It is important to note that the definition of LOs can be revised and updated at any time if the team deems it necessary.

C. Prioritizing Learning Objectives

After defining the LOs, they are analyzed and prioritized according to the proposed priority levels: Very High, High, Medium, and Low. For the prioritization of LOs, students consider the learning desire to be achieved in the Challenge for each LO. The prioritization of each LO is an individual responsibility, with team members having an opinion on the level of prioritization defined by the person responsible for the LO. In this way, similar LOs but with different managers may have different levels of prioritization.

As a pedagogical team member, the mentor participates in the prioritization step to clarify possible doubts about the suggested LOs in the menu and/or identify inconsistencies between the student's prioritization and the desire to learn. The mentor's participation should take place in the first executions of the prioritization step until the team members feel confident in their execution. The team may request the presence of the mentor in other executions of the prioritization stage.

D. Sprint Planning and Execution

A Sprint is a time interval defined in the initial plan of each Challenge by the pedagogical team. Thus, in the agile learning management method proposed, the minimum duration is one week. During the Sprint, students must develop the Challenge's project and simultaneously carry out the learning based on LOs. A set of LOs is planned in the Sprint Planning (SP) stage to be executed in the Spring. Actually it is at this point in the process that students make a commitment to accomplish the learning based on the the LOs.

During the SP stage, the Sprint Planning Meeting (SPM) takes place. SPM is an event where students review the list of LOs and individually define which set of LOs each team member plans to work on at Sprint, and team members who have similar LOs can plan for them on the same Sprint. Starting from the second SPM, the team begins the meeting by evaluating and implementing the list of actions generated in the Retrospective as described in subsection G, and repeats this procedure until the last SP.

In the SP stage, the student effectively commits himself to carry out the effective learning of LOs according to the desired CCL. Based on the Sprint duration, students define the schedule of the SPM considering a duration that does not exceed the maximum time of two hours for each week that makes up the Sprint. During SPMs, students select LOs with the highest level of priority considering the program's activities: classes, workshops, mentoring, among others. In addition to the program activities, students also consider restrictions on the learning cycle that impact the Sprint, such as duration, classes schedules, resource availability, and programmed interruptions.

The result of the SP is the list of LOs planned for the Sprint that contains the LOs' tracks (programming, design, innovation, professional skills, or development process), responsible, prioritization level, and related Sprint. Students may request the presence of the mentor to present or validate how they intend to execute the LOs to complete the Sprint plan and deliver the list of completed LOs at the end of it.

The execution of the Sprint starts after the SP when students start executing the LOs listed for the Sprint. Each student responsible for a LO updates its status and indicates whether the LO was completed, working on, or its execution has not started.

E. Daily Meeting

During the execution of the Sprint, daily meetings are held that take place at the first time of the team's activities on the day, lasting a maximum of fifteen minutes each. Team meetings can be based on discussions or questions involving:

- What the member did yesterday that helped him achieve the planned learning;
- What the member will do today to achieve the planned learning; and
- What the member sees as an impediment to him or the team that impacts Sprint's completion.

The team should use the daily meeting as an instrument to respond to changes and collaborate in learning. It is expected that the collective discussion of each member's progress will contribute to a better learning performance and strengthen a culture where each student takes care of the learning of all team members. After each daily meeting, the team can meet for more detailed discussions to remove impediments, adapt or redesign Sprint's work, and generate changes to the LOs when necessary.

As in the previous stages of the method, the mentor participates in the first daily meetings, encouraging communication and collaboration between members, and ensuring that they are carried out correctly. However, the team may request the mentor's participation for assistance and suggestions at subsequent meetings.

F. Sprint Review

At the end of the execution of each Sprint, the team and the mentor carry out the Sprint Review (SR) through the Sprint Review Meeting (SRM) to evaluate the completed and not completed LOs by each member. The SRM is an informal meeting where everyone collaborates with feedback on the LOs, reviewing their status, completed or not completed, and the CCL achieved for each completed LOs. During SRM, the mentor assesses and collaborates in LOs reviews based on the evidence presented by each responsible member. The CCLs achieved by completing LOs are evaluated through the evidence of learning presented by the student.

At the end of the status and CCL review of completed LOs carried out by the team and mentor, they will compose the list of completed LOs. Uncompleted LOs are reviewed by their parents, who decide whether they will continue to compose the list of LOs, whether they will be modified or re-prioritized. The list if LOs can be revised at the end of the SRM to adapt to the changes raised by the team members.

G. Retrospective

After the SRM, the team performs the Retrospective, another meeting to discuss the relevant facts during the Spring regarding people, relationships, processes, and tools. A maximum time of 45 minutes is recommended for each week that makes up a Sprint. The Retrospective is when the team reflects on the execution of the Sprint and identifies what worked well and what are the opportunities for improvement that can be implemented in the next Sprint. Through opportunities for improvement, students must propose actions to be carried out in the next Sprint. After the suggested actions, the students order the main ones and define a strategy for their implementation for the next Sprint. The reflection of the process and the search for improvement actions can become a challenge for students with little experience. However, it is a step that promotes the maturity of students and encourages them to take ownership of the learning method and feel comfortable in its use. The team can implement improvements at any time. However, the Retrospective is a formal opportunity to implement them.

The mentor's participation takes place in the first Retrospective meeting to ensure the correct execution of the process and ensure that they are positive and productive, and also respects its duration.

IV. Applying the Proposed Method

A. Context

The case study unit of analysis was defined as part of the students participating in the program in question. A comprehensive and diversified number of students was sought to compose the unit of analysis of the case study, resulting in 19 participants distributed among 5 teams. 2 of these teams consisted of three members; 1 team included four members, and 1 team included 5 members. Besides that, 2 teams were made up of students from computing courses, and 3 teams were made up of students from other courses than computing.

As the Implementation stage of the CBL learning cycle is the most similar to the traditional software development process, the application of the proposed method was carried out in the Implementation phase of the CBL learning cycle selected for the case study.

The application of the proposed method encompassed the last four weeks of the learning cycle object of the case study, thus totaling four Sprints. From this structure, we sought to adhere to the sequence of the Scrum framework [40] with the distribution of events throughout the week.

B. Qualitative Data: Categories raised by interviewing

The analysis of the transcripts of the interviews carried out through descriptive coding [41] allowed the identification of the following categories: Learning, Management, Teamwork, and Personal Perception. All 19 participants made citations related to the category “Learning”, 16 participants made citations related to the category “Management”, 14 made mentions related to the category “Teamwork” and 14 participants made citations related to the category “Personal Perception”.

Learning: The “Learning” category refers to how the use of the self-management learning method impacted the students’ learning and which aspects most influenced the learning. This category was cited by all participants in the case study. It was observed that the participants reflected on what they learned, especially in the Sprint review stage. This aspect was also noted in the interviews, as can be seen in the following quote:

> *”When you create personal LOs, you don’t depend on the content given from the teacher. You have more responsibility and much more clarity about what you want to learn. So creating LOs at the beginning, reading the list of LOs and recognizing what you want to learn at the moment helps in your identification with learning ...”.*

Management: This category refers to how students managed their learning. Many management activities were reported and observed in the various stages of using the proposed method. The response to the change was one of the highlighted factors observed during the execution of the Sprints, and it occurred autonomously, without interference from agents outside the team.

> *“In previous Challenges, even though I knew what I wanted to learn, I didn’t think about the goals during the process. When you define a list of LOs and follow them, you can better coordinate your learning and are always remembering what your LO is about.”.*

Self-perception: The category ”Self-Perception” refers to the participants’ feelings and sensations due to using the proposed method. The participants’ autonomy in the management of learning had a strong influence on motivation, which was widely reported by the participants, having as associated aspects confidence and satisfaction.

> *“... the list of LOs was made up of things I would really like to learn. I think that we get more motivated when we are learning what you want. If there were only suggested goals on the menu, we probably wouldn’t be too much motivated.”.*

Teamwork: Regarding the ”Teamwork” category, the use of the method provided a feeling of good communication for students compared to previous Challenges, verified during observations and reports of the participants, mainly in the daily meetings, retrospective, and during the execution of the Sprints. Teamwork was an additional positive result of applying the method since the learning was individual. This category points to collaboration as one of the main factors that contributed to team learning. The students collaborated in the execution of the LOs and the continuous improvement of the teams’ work process. It reflected the existence of a sense of mutual care with the learning among the members of the teams.

> *“The Daily Meetings made me want to learn about what I said I was going to do and also to reflect on the learning of the previous day. They caused me the feeling of commitment between members in the search for knowledge related to the LO and that stimulated the learning.”.*

C. Quantitative Data: Learning Objectives Management

The analysis of the archival records extracted from a cloud database tool provided a complementary source of information (Table I) related to the management of LOs carried out by the participants in the case study.

TABLE I
TOTAL NUMBER OF LOS AND AVERAGE PER PARTICIPANT

LOs	Avg	Total
Defined	21.16 (100%)	402
Prioritized	21.16 (100%)	402
Planned	12.63 (59.69%)	240
Completed	11 (87.09%)	209
Not Completed	1.63 (12.92%)	31

As a result, it was identified that 402 LOs were defined and prioritized, resulting in an average of 21.16 LOs per participant. Participants planned 240 LOs, with 209 completed and 31 not completed, resulting in an average of 12.63, 11.00, and 1.63 LOs per participant.

A percentage index of 87.09% of completed LOs and 12.92% of unfinished ones were obtained. As these indexes are not benchmarked in previous CBL learning cycles, this result will serve as benchmarks for future experiments in the program’s learning cycles. In addition, considering that the case study took place in a learning environment with a

TABLE II
STUDENTS' PERCEPTION OF THE PROPOSED METHOD USAGE

LOs	CCL	Sprint 0	Sprint 1	Sprint 2	Sprint 3
Not Completed	—	0.89 (56.67%)	0.47 (11.84%)	1.42 (36%)	0.79 (15.63%)
Completed	—	0.89 (43.33%)	3.53 (88.16%)	2.53 (64%)	2.26 (84.38%)
	Applying	0.53 (76.92%)	1.68 (47.76%)	1.68 (66.67%)	2.89 (67.90%)
	Understanding	0.05 (7.69%)	0.84 (23.88%)	0.63 (25.00%)	0.74 (17.28%)
	Knowing	0.11 (15.38%)	1 (28.36%)	0.21 (8.33%)	0.63 (14.81%)

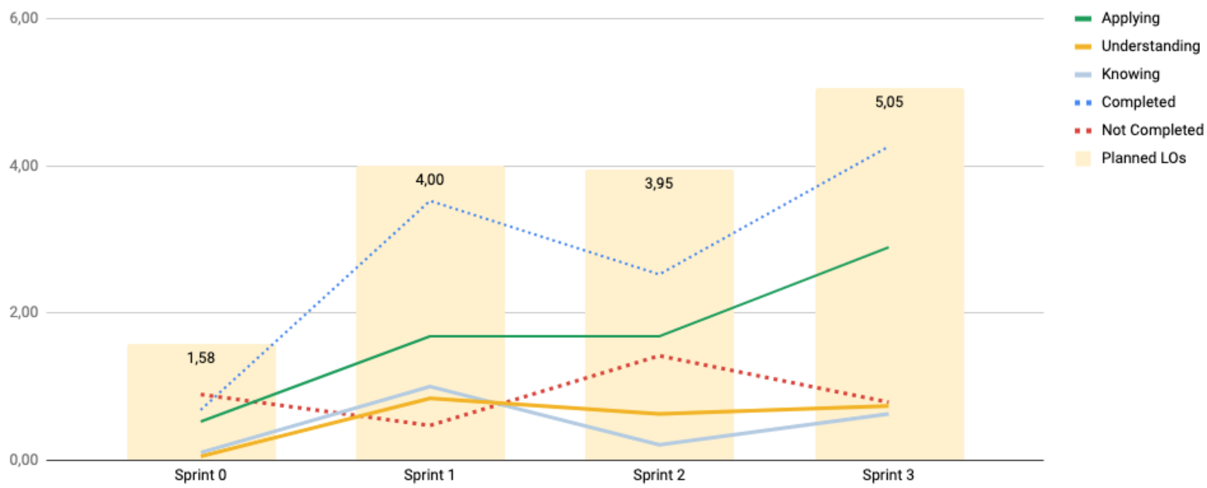

Fig. 2. Evolution of the planned Learning Objectives over the sprints.

high degree of autonomy for the participating students, the percentage rate of 12.92% is considered reasonable for LOs not completed. These results are in line with the data from the interviews where it was identified that the participants had a good perception of learning in the CBL learning cycle of the case study.

Concerning the weekly evolution of the LOs management, it was observed that the participants improved their management capacity throughout the Sprints, especially planning and execution. Evidence of this fact appears in the significant growth in the amount of LOs completed over the Sprints.

As shown in Table II and Fig. 2, the evolution of the planned LOs index during Sprints was constant except for Sprint 2, which remained relatively stable compared to the previous week. However, there was a significant drop in the evolution of the index of completed LOs also in Sprint 2. This same drop also occurs in Sprint 2 with the evolution of the index of completed LOs with cognitive complexity level “Knowing” and “Understanding”. It is important to note a world conference during Sprint 2 where the participants attended at least one of their several sessions. Another relevant factor is the evolution of the index of LOs completed for all levels of cognitive complexity in Sprint 3, emphasizing those of cognitive complexity level ”Apply” indicating that the participants increasingly applied the learning in the project.

D. Survey: Proposed Method Usage

All 19 case study participants answered the questionnaire to assess the perception of using the method. The data collected through the questionnaire had the primary purpose of identifying positive and negative aspects and opportunities for improvement of the proposed method. This questionnaire evaluated the use of the method in the components “Motivation” [42] and “Learning” [43]. The collected data were structured and analyzed at component and dimension level through frequency distribution and central tendency, as shown in Fig. 3 and Fig. 4.

a) Motivation: The method brought a positive perception to the participants and presented itself as a mechanism that contributes to the motivation for learning (Fig. 3). We can highlight that the method was positively evaluated in the dimensions: ”Attention”, ”Relevance”, and ”Satisfaction”; and moderately positive in the ”Confidence” dimension.

In general, the proposed method captured the attention of the participants who evaluated the ”Attention” dimension positively concerning the format of the proposed method and its variation (content and activities), and moderately positive the indication of something interesting at the beginning of its execution (Fig. 3). It can be considered that the method was relevant for the participants according to the evaluation of the

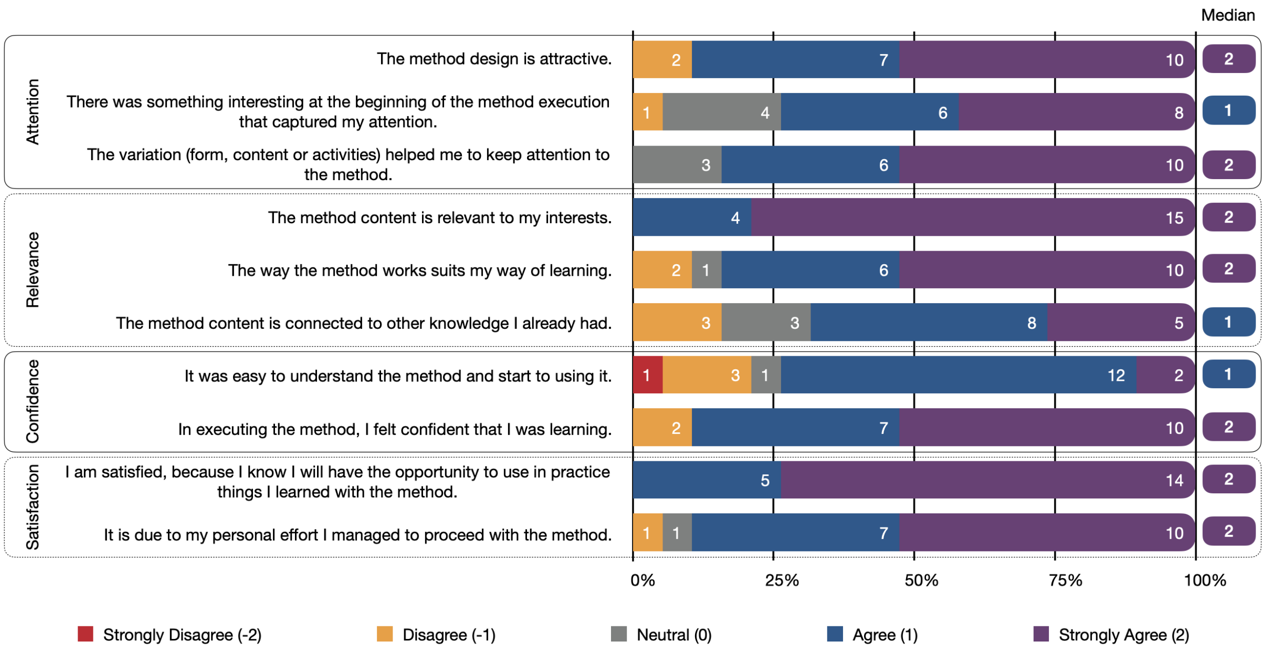

Fig. 3. Students' perceived motivation under four dimensions: Attention, Relevance, Satisfaction; and Confidence

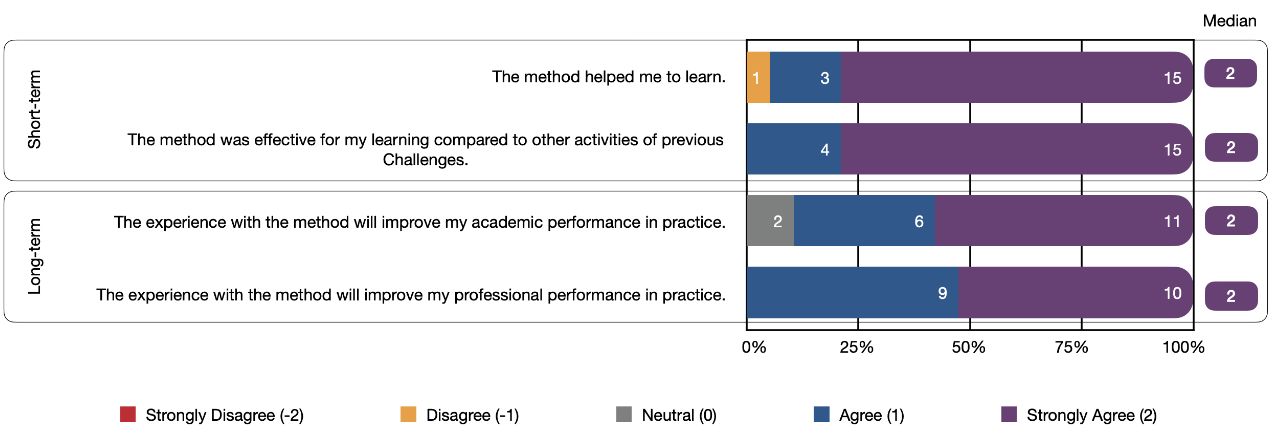

Fig. 4. Students' evaluation of the learning process using the method.

dimension "Relevance", where they positively evaluated the content of the method and how its operation adapts to how they learn. They assessed the connection between the content of the method with previous knowledge as moderately positive.

The students assessed the "Confidence" dimension in a moderately positive way. In this dimension, 3 participants disagreed and 1 participant strongly disagree with the ease of understanding the method to start using it in practice. In addition, 2 participants did not feel confident that they were learning when executing the method. Although moderately positive, the assessment of confidence with the method presents an opportunity to improve the application of the method in future CBL learning cycles. Finally, the evaluation of the "Satisfaction" dimension of the method was primarily positive, demonstrating that the participants recognize that they were able to proceed with the method due to personal effort and that they are satisfied to know that they will have the opportunity to use what they have learned with the method in practice.

b) Learning: The evaluation of the short and long-term learning using the method was considerably positive (Fig. 4). The majority of the participants demonstrated that they believe that the proposed method contributed positively to their learning, helping them learn effectively and bringing benefits to short and long-term learning [43]. These results provided by participants indicate that the method can represent a valuable contribution for students' learning management.

E. Limitations

Despite the results described previously, this study also presents the following limitations: (1) The first one was that the program's activities and this case study were conducted entirely remotely due to the COVID-19 pandemic. Therefore the results of the study may be different in a scenario where members of the team are developing activities in the same physical environment. (2) The small number of participants in the sample of the unit of analysis may have caused results with bias. (3) In addition, the fact that the study involves a single program that uses CBL in a specific social and cultural context can directly or indirectly interfere with the results, not reflecting the reality of other contexts. (4) In addition, the method was applied only in the Implementation phase of the CBL learning cycle. (5) The codification, analysis of the samples, and results were reported impartially and objectively. However, influences by value judgments or by the generation of limited results by the researchers.

V. Conclusions

The main objective of this work was to present a case study to investigate and understand how a learning management method based on Scrum influences the learning of students in the context of using CBL for the training of developers in a multidisciplinary course. Thus, through observations, interviews, and archival records, this study identified that using the method impacted learning positively learning, demonstrating the benefits of using the proposed method in the sample of the analyzed program. Aspects such as learning autonomy, reflection, response to change, the collaboration between team members, satisfaction with the use of the method were identified. These aspects were grouped into four categories: Learning, Management, Teamwork, and Personal Perception.

The analysis also presented results related to the participants 'learning performance and the management of the LOs, showing evidence of the benefit of the proposed method for the autonomy of the students' learning process.

Finally, the participant's perception of the use of the proposed method in the dimension of motivation was analyzed using the ARCS model [42] and in the dimension of learning by combining the levels of cognitive complexity of Bloom's taxonomy [39], and short to long-term learning [43]. The results served as a source of complementary evidence so that the method can be applied in future contexts with possible improvements and further analysis such as: comparison between STEM and Non-STEM profiles, comparison between teams as a unit of analysis, and other aspects related to participants (gender, age, time since graduation, etc.).

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