Using Scrum for Managing Master Theses - A Case Study

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Abstract

The success rates of the master's theses in Instituto Superior Técnico's Master in Information Systems and Computer Engineering are very unsatisfactory and in the last five years, less than half of the students have completed this work in their first enrollment, but the success rates of a group of students that were supervised based on the Scrum framework are very promising.

Using the Case Study Research Methodology, we aim to study the current situation and explore if the use of Scrum to manage master's theses increases the probability of successfully complete a work of this nature and the benefits it brings to students. To obtain new insights, we used interviews to collect opinions and experiences of students that were oriented based on this framework.

To understand how Scrum can address existing problems in the development and guidance of master's theses, and which practices and benefits were present according to students, we performed a qualitative analysis and discuss the obtained results. We also discuss the practices and benefits of previous studies focused on the accomplishment of projects to understand which practices have a relation to the success in the development of a master's thesis.

Keywords: Scrum; Master's theses; Management of theses; Success rate

1. Introduction

Almost every master's program ends with a master's thesis. A master's thesis is an autonomous piece of academic work, and for the majority of students undertaking this assignment will be the first-time doing a work of this nature and complexity.

Within the Master program in Information Systems and Computer Engineering of Instituto Superior Técnico, the values for the success rate (or completion rate) of finishing a master's thesis work, that is, the percentage of students approved on the first enrollment has been increasing. For example, in the 2012/2013 academic year, the percentage of students' approval at the first enrollment in the master's thesis in a specific faculty's campuses was just 30%, but in the 2016/2017 academic year, the percentage on the same campus was 49%, which is still an unsatisfactory value.

Since the 2012/2013 academic year, studies and inquiries have been developed by the Statistics and Prospective Unit (NEP) to determinate the reasons that contribute to the existence of very unsatisfactory completion rates and the longer (than stipulated) average time of theses completion. In these studies, several students were surveyed to measure their satisfaction with the development process of the master's thesis. In the Master in Information Systems and Computer Engineering, among students who evaluated their orientation as unsatisfactory, the main reasons that led to dissatisfaction with the development process of the master's theses were: lack of commitment and limited time of the supervision team to monitor the work, insufficient knowledge transmission capacity, and lack of support for experimental work development.

Another issue regarding student's projects exposed by Hans, and Kudikyala and Dulhare is that *"the quality of the final products of the students' projects has by and large been declining over the past few years. Furthermore, the student's poorly completed projects are either late or are not delivered at all on the due dates"* [1][2][3]. The use of Scrum can be a strategy in order for projects to be carried out in an iterative manner, that would prevent students to wait for the final moments to work on them [1][2]. This strategy follows the general approach used in the application of the Scrum framework for software development.

According to Sutherland and Schwaber, Scrum is a *"framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possi-*

ble values" [4]. Scrum was initially thought to handle software development projects in enterprises, but since the results of applying this to software development are very positive, Scrum has been used in other settings [5].

Scrum focus on project management and can be a mechanism to handle complex projects with unpredictable settings, where the scope of a project may not be well defined and to minimize the risks associated with a project, therefore Scrum can help us to address uncertainty and to respond to changes and provide a set of rules and guidelines to be more productive [4].

Regarding the success rates of a group of students who were oriented and managed based on the Scrum methodology and the agile practices, these are very high compared to the rates presented in the studies done by NEP[1]. In Table 1, it is presented the number of students enrolled in the master's thesis work on both college campuses, the completion rates of the students who finished their master's thesis at the first enrollment in each campus and the completion rate of students that were guided based on Scrum during the development of their master's thesis.

Since the differences between rates in the several years are very large and based on what was exposed previously our research question is: does Scrum increase the probability of successfully complete a master thesis?

2. Related Work
In the literature, there is a considerable number of articles about the application of Scrum in both industrial and academic contexts, where the benefits and the use of Scrum and agile practices are presented, and their relation to the success of a project assessed.

In [6] Hicks and Foster present SCORE, which is an adaptation of Scrum used to advise and work with PhD students. They decided to implement this adaptation of Scrum because their commitments and number of students increased, and therefore the number of meetings became more frequent which affected the quality of the work. The problem originated by this situation was the slow reaction to difficulties in the course of students' research. The two key elements of SCORE described by Hicks and Foster are three-times-per-week status meetings and on-demand one-on-one meetings. In status meetings, everyone exposes what they have done since the last meeting, what results were obtained, if they found any problems and what will they do next. To discuss more complex ideas or problems that emerged during status meetings or

when someone needs more time to discuss specific topics, they hold on-demand meetings.

The research developed by Mariz et al. [7] aimed at investigating the relationship between the success of projects that use Scrum and the use of agile practices. This research was made in an industrial context since the focus was on the development of software projects and twenty-five agile practices were evaluated to understand which practices are more related to the success of projects.

In the work developed by Solinski and Petersen [8] it is recognized the significant benefits that originate in the adoption of agile and which practices are commonly used by practitioners of agile methodologies.

Mahnic and Rozanc [9] present the results of a survey made in an academic context and in an industrial context to compare the Scrum practices that students perceive as more important for the success of software projects based on Scrum with the opinions of professional developers in order to understand similarities and differences between the point of view of both parties.

The work of Rover et al. [10] was performed in an academic context, more specifically in a capstone design project where it was used agile project management, similar to Scrum with Sprints and meetings held between the students, a faculty mentor, and a client.

Begel and Nagappan [11] conducted a research on agile development in an industrial context. In their work, they ask the participants which agile practices they used in their work and what are the top three benefits of agile were in order to form a ranking of common benefits.

3. Research Methodology
The approach chosen to guide this work was the Case Study Research Methodology (CSRM). This methodology is defined by Yin as an *"empirical inquiry that investigates a contemporary phenomenon within its real-life context"* [12]. This approach was chosen to make the best of the experience held by the participants and profit from their understanding of the adoption of Scrum in the development of a master's thesis, since it is key to draw conclusions about the use of this methodology in this specific context.

Another motive regarding the use of this methodology was due to the fact that there is insufficient information in the literature regarding the adoption of Scrum in this more specific academic context, that is, the development and guidance of master's theses. The CSRM is appropriate to follow up the work in these cases, whenever there is little evidence regarding a topic in the literature, since this

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[1]Studies regarding the success rates of master theses can be found at http://quc.tecnico.ulisboa.pt/en/dissertacoes/

Table 1: Information about the number of students enrolled in the master's thesis and the success rates in five academic years

	Academic Year				
	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017
Number of Students enrolled in Master Thesis (Campus Alameda)	116	110	148	151	146
Success Rate Campus Alameda	30%	48%	43%	55%	49%
Number of Students enrolled in Master Thesis (Campus Taguspark)	79	80	94	90	98
Success Rate Campus Taguspark	32%	48%	41%	54%	29%
Success Rate of Students Managed with Scrum	100%	80%	100%	100%	90%

methodology is suitable to *"find out what is happening, seeking new insights"* [13], therefore our Case Study followed an exploratory purpose within a qualitative approach.

3.1. Data Gathering Techniques

In order to obtain an insight about the utilization of Scrum in the context of a master theses, the main research object of analysis are students doing their master's theses using the Scrum framework and former master degree students, who made their theses also using Scrum. Fifty-five students were interviewed from different academic years, as can be seen in Table 2. Since the unit of analysis of this study is composed of several people, this case study is a multiple case study. In the following points it is presented the data gathering and analyses techniques used.

Table 2: Number of students interviewed by academic year

Academic Year	Number of Students
2009/2010	4
2010/2011	5
2011/2012	5
2012/2013	5
2013/2014	6
2014/2015	6
2015/2016	2
2016/2017	10
2017/2018	12

3.1.1 Interviews

Interviews are a qualitative method to collect data which is widely used in Case Study Research to *"provide in-depth information pertaining to participants' experiences and viewpoints of a particular topic"* [14] because *"Case Studies tend mostly to be based on qualitative data, as these provide a richer and deeper description"* [13].

Interviews are based on the communication between two (single interviews) or more (group interviews) people, therefore in an interview there could be a lot of interactions. *"Individual interviews yield significant amounts of information from an individual's perspective, but may be quite time-consuming. Group interviews capitalize on the sharing and creation of new ideas that sometimes would not occur if the participants were interviewed individually; however, group interviews run the risk of not fully capturing all participants' viewpoints"* [15].

In this thesis, we have chosen to conduct individual semi-structured interviews, which is the type of interviews most often used in qualitative research. In this type of interview it is allowed the exploration of topics and other questions that arise during the interview [16].

In semi-structured interviews, the sequence of questions may vary according to the answers provided by the interviewee and on the flow and the development of the conversation between interviewer and interviewee. This also depends on the experience of the interviewer, to *"establish an appropriate atmosphere through which his/her interviewees would feel more at ease and thus talk freely"* [17] and provide their insight about a topic. Although the order of questions may vary from the several interviews, the use of an interview guide ensures that the interviewer address all the questions in the interview guide in every single interview.

3.1.2 Cognitive Mapping

Cognitive Mapping is a qualitative technique that allows researchers to represent the knowledge, opinions, and understanding of an individual regarding a specific topic or issue as a graphical representation [18]. Cognitive Mapping can be used as a method to take notes during an interview and can be used to transcript interviews in order to analyze and understand the data retrieved from an interview [19].

Cognitive Mapping helps researchers to structure, organize and analyze data of a person's understanding of specific issues and we choose to use this technique because it offers a graphical representation that manages qualitative information and can be an alternative to take notes during an interview. The representation also provides the results of what was discussed in an interview.

This technique allows to structure thought through symbolic and graphical representation rather than *"linear layout, managing a large amount of qualitative information, and can improve interview capability"* [18]. Other positive aspect of using this technique is that the information obtained

is clearly communicable [18], through the graphical representation of a person's understanding of specific topics.

4. Results

In a qualitative data analysis, the main objective is to derive conclusions from the data and keeping a clear chain of evidence [13], therefore the exposure of the data and opinions of the interviewees is key in this aspect. Since the information in the transcripts was textual and the amount of interviews was significant we decided to use a tool to help us in the coding process, that is assign sections of text or testimonials in categories, that are derived by the emerging themes of the interviews [20]. The emergent themes are also known as codes [13] and one code is usually assigned to many pieces of text, and one piece of text can be assigned more than one code. Codes can also form a hierarchy of codes and sub-codes. This process allows the grouping of quotes and discovery of patterns in order to expose a chain of evidence. The tool used in this process was NVivo 12 qualitative data analysis software.

4.1. Analysis of Interviews

The interview guidelines used were based on previous works related to the experience and practice of Scrum in several contexts [6][21]. We asked several questions regarding the previous knowledge of Scrum before the development of the master's thesis, what were the elements of Scrum present during the development of the master's thesis, how these elements were applied together, if Scrum was really applied, and in their opinion what were the benefits and drawbacks of Scrum in the context of their thesis development. Also we questioned if there were any noticeable improvements and if the use of Scrum was recognized as a factor contributing to the successful conclusion of the thesis.

In the following points we will discuss some of the codes retrieved from the data analysis and some testimonies given by the interviewees.

4.1.1 Previous Knowledge

We started by asking the interviewees if they already knew Scrum before they started their master's thesis and if they had already used or adopted it in some context.

Of all the interviewees, only seven did not know, nor had used Scrum, until they began to be managed with it, during the development of their master's thesis. Of the remaining forty-eight interviewees, only three said that they did not know, nor did they used scrum in an academic context, instead they obtained knowledge about Scrum and used it in professional contexts. The other students throughout their academic career learned about Scrum and developed a project in the context of a software development course.

4.1.2 Expectations

We asked students (interviewed while developing this work) that begin their master's theses in the 2017/2018 academic year if they had some expectations regarding the adoption of Scrum in the context of their master's thesis. Only one student had no expectations regarding the use of Scrum in the development of the master's thesis. The rest of the students saw Scrum as a mechanism to help them to be more organized in their work and expected it to be a tool that would allow a closer monitoring by the supervisor.

Testimony: *"My expectation was that it was something useful and that would improve my performance at work and would not let me accumulate work."*

4.1.3 Elements of Scrum present in the context of the thesis

In terms of Scrum roles, meetings, and artifacts we asked the interviewees which elements commonly applied in Scrum are being and were used in the context of their thesis.

Forty-three interviewees said that a planning component was part of the management process of their master's theses. The interviewees said that this component corresponds to the Sprint Planning meeting of Scrum. Interviewees also showed that this component is connected with their backlog, that is defined by them as a list of tasks that they committed to do during a Sprint. During the planning, interviewees informed about the next steps and tasks that were to be addressed in the context of their thesis, and explained that the definition of tasks was a negotiation between the supervisor and the student, in which both gave suggestions of what should be done next in order to establish the next Sprint. Interviewees also said that planning was based on what was accomplished on the previous Sprint, on the review of that Sprint and on tasks that were in the backlog and had not been assigned to a Sprint.

Regarding the review component, thirty-seven interviewees said that review was present in the method used in the management of the master's theses. The interviewees said that the review is made based on the tasks in the backlog. The interviewees also said that they indicated the tasks that were completed, those that were still performing and those that were still to be done and explain what was accomplished during the Sprint. Then the supervisor asked students questions in order

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to see if the goals of the tasks defined previously had been met and if students, in fact, did the tasks they committed to do during a Sprint, or if the task needed to be addressed again in the next Sprint, in case the objectives had not been achieved.

Testimony: *"The review was based on the tasks, the ones that were in the state done, doing and to-do in that Sprint Backlog and basically giving feedback on what was done, so the supervisor was not limited to just seeing what was done, he would ask what your definition of done was and I would explain and then he would ask me questions, and it is interesting that in addition to believing in you, he asks you a few questions in order for you to question yourself and for him to see if you can answer his questions to realize if we had indeed fulfilled and perceived what was necessary to achieve tasks. We sometimes decided that it was better to perform the tasks again in order to really understand some issues and topics related to the thesis. So, the review was not just to see the tasks and say okay, in every task he effectively asks if we had realized everything and if everything was clear."*

Regarding the retrospective, only seventeen interviewees said that this component was present and used in the management of their master's thesis. Interviewees noted that during group meetings, they exposed the difficulties that emerged during the development of their work and explain how they overcame these problems, or if they have not overcome them, try to solve it with the help of the supervisor and with the suggestions of the other colleagues. Interviewees also exposed that this was very positive, since this allowed to share knowledge regarding the problems and issues that happen during the development of the thesis, and how they could overcome or avoid that problems, since there was a learning experience from the issues, mistakes and solutions of the other colleagues. Interviewees also noted that other perspective of the retrospective was understanding the reasons why a task was not performed during the sprint it was allocated to be performed.

Testimony: *"What I felt was that at the next meeting we talked about the work we had done and what was already happening in that exact moment, and there was always a lot of feedback from the supervisor and from my colleagues in trying to help, in order to improve my work, or redirect it in the right direction and I, in my case had many moments, even in the part of results that I found... I have the vision that there are theses that in a certain way are limited by the things that you can do and since I was in doubt as to what I can do to enrich my thesis more and this part I can map it with the retrospective because I often ended up talking about what had been my week and my difficulties*

and what I had done and many times I managed with the help of the supervisor, to redirect my work to improve it and get the results I wanted, so I think that the three ceremonies were quite present. Now this depends a little bit of the people and how you expose your theme and topics."

Fifty interviewees stated that Sprints were present, while they were working on their master's thesis. Interviewees noted that Sprints were the period of time, in which the tasks discussed and agreed with the supervisor should be performed. At the end of each Sprint, these tasks were reviewed, new ones were planned and the Sprint Backlog was established in order to begin a new Sprint, as has been said previously in this subsection. Interviewees said that these Sprints normally had a duration of fifteen days, that is, two weeks. Interviewees exposed that having Sprints is a mechanism that promotes contact between students and supervisor, which allows students to have several chances to communicate with the supervisor and present their difficulties and the work status in short periods of time.

Testimony: *"Every two weeks, we had a meeting with the supervisor, in which each student looked at his backlog and at the tasks he had agreed that would work and finish in those 2 weeks, that is, the Sprint and it was done a presentation of what was done, feedback was collected and it was decided what was to be done in the next two weeks and we every two weeks basically defined what would be our backlog for that Sprint."*

4.1.4 Meetings

After asking what elements of Scrum were present in the interviewees' opinion, we asked if they could explain how these elements were applied together. Forty-four interviewees reported having group meetings, which marked the end and beginning of a Sprint. It was in these meetings that the planning and review that was addressed in the previous point took place. In these meetings, the supervisor brought together all students in the same space.

Testimony: *"We have an annual thesis group of master's students from the advisor and every 15 days, these students were all gathered in a room and we did the Sprint meeting in which we started with a student and followed the others in which we explained what I said, what was done in those 15 days, what were the obtained results, what were the conclusions drawn, what had to pass to backlog or to the next Sprint and this was done sequentially throughout the meeting by each student."*

4.1.5 What were the perceived benefits?

Next we proceeded to ask the interviewees what were the benefits that the adoption of Scrum in the management process of their thesis had brought to them. Twenty-seven interviewees noted that with Scrum and developing the work in Sprints was something that helped to explore the work in the initial moments of the master's thesis in order to address issues that are not well defined. Interviewees noted that at the beginning of the thesis they did not know what the final goal and objectives of their work may be, how they will address it and what has been studied previously in the context of their work. While researching about the work in Sprints, interviewees noted that this allowed to present frequently what was researched in order to perceive the related work and to define the final objective and to refine it in the following sprints together with the supervisor.

Regarding the group meeting, in which the supervisor joined all students together, thirty-nine interviewees said that this meeting was beneficial since it was an opportunity to present and expose to the supervisor the current situation of the work. With this update, thirty-eight interviewees noted that students could obtain feedback in relation to work done in the Sprint and understand if something needed to be improved or needed to be reviewed during the next Sprint, then discuss the next steps and plan the tasks for the next Sprint together with the supervisor. Interviewees also mentioned that Sprints led to having frequent checkpoints, deadlines and deliveries (pointed out by forty-six interviewees) and having frequent definition of tasks and objectives (pointed out by forty-four interviewees). These frequent updates also allowed a constant monitoring by the supervisor, an important aspect pointed out by forty students.

A benefit which derives from the feedback, monitoring and the constant updates stated by twenty-nine interviewees is understanding if the work path they are following is correct, that is, with the feedback received and the discussion regarding the next steps and tasks, students have a notion, if the way they are approaching the work is leading to the expected and desired results in their opinion and in the supervisor's opinion, in order to understand if something needs to change regarding the way they perform their tasks.

Twenty-two interviewees noted that the review component and Sprints allowed for a earlier identification of issues. With the frequent exposure of the tasks accomplished and discussion between student and supervisor, this led to the students to expose their difficulties and problems that have emerged during the Sprint in order to receive help from the supervisor to unblock these situations.

With the group meetings, there was a sharing of knowledge regarding the problems that emerged in the theses of several students and how they overcame these issues alone or with the help of the supervisor. By sharing this knowledge with other colleagues, if a problem previously discussed and exposed by a student occurs in a thesis, the student already has an idea of how to solve that problem. Learn from the work of other colleagues was pointed out as a benefit by thirty-eight interviewees.

Another benefit exposed by forty-three interviewees was the incremental and iterative nature of the work. The interviewees said that with the bi-weekly frequency of meetings, these were treated as checkpoints or deadlines. Other benefit related with the incremental and iterative nature of work is the a commitment to do the tasks discussed in the planning phase of the group meetings, this made the students more motivated in order to achieve the goals set at the beginning of the Sprint, and helped them develop their sense of responsibility. Thirty-four interviewees stated that this aspect as a benefit of Scrum. Other aspects pointed out by interviewees that derive from these benefits were the accomplishment of tasks and deadlines, the definition of next steps, the division of a large work into smaller parts (pointed out as a benefit by twenty-eight interviewees), establish a work pace (pointed out as a benefit by thirteen interviewees), and learn not to leave work behind in order to meet the final deadline.

In addition, interviewees said that structure (pointed out by fifteen interviews) and organization (pointed out by thirty-one interviews) are extra benefits, which came from the methodology used during the development of the master's thesis. Interviewees stated that Scrum imposed a structure, based on Sprints which made them better prepared to organize and plan in various Sprints that they needed in the context of their thesis development.

4.2. Analysis of Cognitive Maps

In order to have a graphical representation of the principal ideas discussed and exposed by the interviewees, that could aid in the analysis of patterns, we choose to use the Cognitive Mapping technique. From each interview, we have drawn a cognitive map, to make a final cognitive map composed of the most common ideas and concepts presented by interviewees in their interviews.

Since we interviewed students from different academic years, we decide to make a final cognitive map for each academic year (except for the 2015/2016 academic year, because only two people from this year were interviewed, a small number of interviewees compared to the other years).

In this document, we only present the cognitive map of the 2012/2013 academic year (Figure 1) to illustrate as an example of the maps obtained, but the remaining cognitive maps are present in the dissertation final document.

From the maps drawn for each set of interviewees, that is, taking into account the academic year in which they began the master's theses, we can compare and analyze which factors and components students felt were present during the guidance they received based on Scrum. The concepts that are part of each map are those that were mentioned and addressed by at least half of the students of an academic year.

Among the several cognitive maps, the concept "retrospective" is only present in two of these maps as a concept, something that is in accordance with what was presented in the subsection 4.1.3, since the retrospective was the Scrum ceremony that the interviewees least mentioned as being applied in the thesis management process. The interviewees that referred that the retrospective was present noted that this was a mechanism to realize what went wrong and failed in a Sprint and to understand what can be done better in the next Sprints.

Regarding the final cognitive map of the 2010/2011 academic year, none of the Scrum ceremonies, nor the Sprint or the backlog are represented as nodes. Despite this, many of the concepts present in this cognitive map reflect attributes that are very common in the practice of agile methodologies, such as Scrum. The common agile attributes referred by the interviewees of the 2010/2011 academic year as concepts were: "regular deadlines and checkpoints", "definition of tasks", "earlier identification of issues", "incremental and iterative work", "provide a point of view of the state of the work", and "receiving constant feedback".

In the other cognitive maps, Sprints and the backlog were represented as a concept, thus making these components of Scrum a pattern of the application of Scrum (except for the case of the 2010/2011 academic year, discussed in the previous paragraph).

Regarding the other two Scrum ceremonies, the planning and the review are not present as nodes in one cognitive map respectively, beyond the map of the 2010/2011 academic year. In the cognitive map of the 2009/2010 academic year there is not a node that corresponds to the planning and the review is not represented as a node in the map of the 2016/2017 academic year.

In the cognitive maps, where the planning is represented as a concept, interviewees noted that this lead to deciding the work to be performed, discuss the objectives to be achieved, establish the back-log for that Sprint and having a focus on what to do during a Sprint.

Concerning the review, in the cognitive maps where this was represented as a concept, interviewees noted that this lead to exposing the work done in a Sprint, checking with the supervisor if all the combined work between student and supervisor was done and collecting feedback.

One very important concept to refer, present in all cognitive maps is the concept "group meeting", that in the case of the map of the 2009/2010 academic year was referred as "regular meetings" by the majority of interviewees of that academic year. This concept is very important because taking into account the information gathered it was in these meetings that planning and review occurred, the backlog was updated, and the meetings themselves marked the beginning and end of the Sprints. These group meetings also lead to the exchange of knowledge, experiences and issues between students, present the status of the work, and positive pressure. These meetings were a key point in the application of Scrum to the interviewees, because as has already been said, it was in these meetings that the concepts of Scrum were applied and adopted.

5. Discussion of Results

The qualitative analysis of the interviewees' opinions and experiences concerning the adoption of Scrum in the management process used during the development of their master's thesis, allowed us to understand which agile practices and benefits of Scrum are present in the method applied to manage students in their work in order to perceive patterns within the data gathered.

In this Section, we are going to map the results obtained with the results of other studies presented in Section 2, to show advantages, benefits, practices and the relationship between the use of agile and the success of projects.

Among the obtained results in [7], the practices that presented a higher correlation to the success of a project were the regular delivery of software and correct integration testing. Practices such as following agile-oriented project management, delivering most important features first, members with high competence and good relationship with the customer also presented a positive level of correlation.

Regarding the results of [7], we can map that the practice of regular deliveries has a positive correlation to the success of a project and therefore of the thesis development process. With frequent meetings and the commitment to do the tasks discussed in the planning phase of the group meeting, there are frequent deliveries and deadlines, as exposed
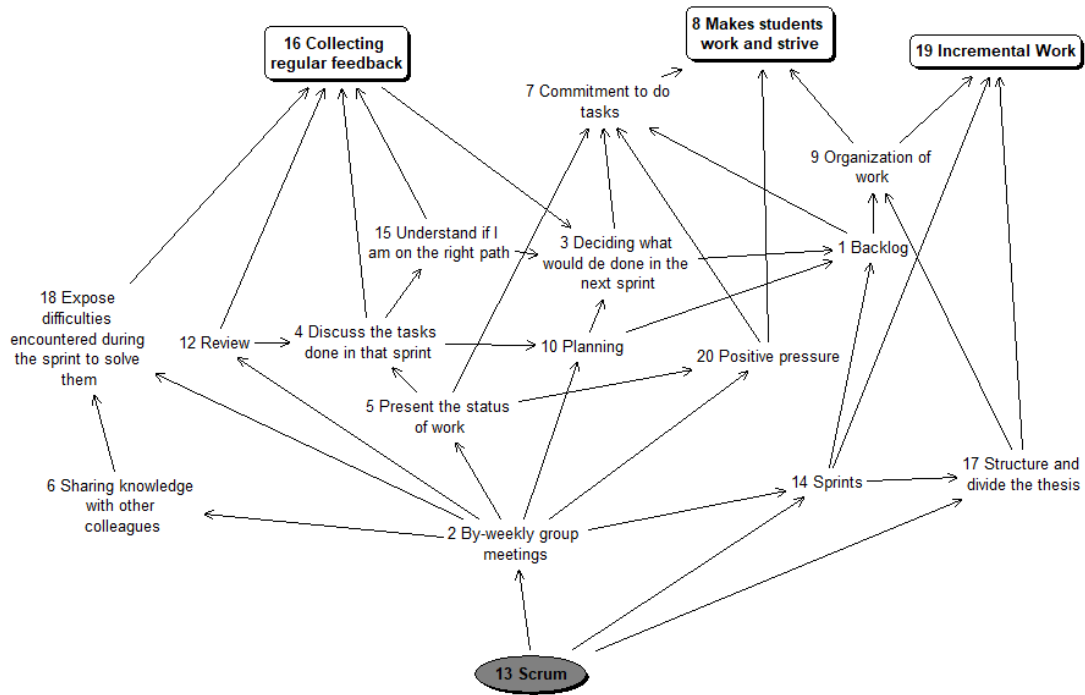
Figure 1: Final Cognitive Map drawn from interviews with interviewees of the 2012/2013 academic year

by interviewees, that lead them to perform their tasks incrementally, stay focused on work, not wait for the final moment before the deadline to work on the thesis, and according to an agile paradigm this is a relevant factor for a successful development of projects.

According to Solinski and Petersen [8], the most significant benefits of adopting agile are knowledge, learning, feedback, and confidence. Regarding our results, we can map these benefits to the feedback that a student obtains during the review phase and the opportunity, in the group meetings to exchange experiences, attend the planning and review process of other colleagues, and understand how other colleagues solve their issues.

Regarding the practices, it is accepted that *"agile with few rigid development practices and balanced processes allow to achieve a higher number of benefits"* [8]. The practices presented in both approaches are: iteration planning meeting, iteration review and retrospective, face-to-face communication, small self-organizing cross-functional teams, frequent planning/reporting, and prioritized list of requirements.

Concerning the practice of small self-organizing teams, the context of a thesis is individual and as stated by the interviewees the key elements are the students and the supervisor, but the responsibility of performing the work belongs to the student and therefore we cannot map this practice with our results since this is an individual work.

Regarding the prioritized list of requirements, we

also do not map this practice to our results, since interviewees only exposed that all they have is the backlog of tasks that they are supposed to do in a Sprint, or that have not yet been allocated to a Sprint. Interviewees stated that tasks were planned to do in a Sprint and there was a compromise to perform those tasks, but did not refer if priorities were discussed during planning.

Practices such as iteration planning meeting, iteration review, frequent planning/reporting and face-to-face communication are present in the theses management process according to the interviewees. The Scrum ceremonies, in this case, planning and review, take place in the same meeting. In the review phase, it is presented the work done and what was accomplished in that Sprint, and then the supervisor asks students questions about the work in order to both parties understand if the goals set for the Sprint were achieved. Moreover, the review focus on the tasks already present in the backlog and discusses the next steps a student will do in the next Sprint. Since this process happens every two weeks, there is a frequent planning/reporting between both parties.

According to Rover et al. [10] Sprints and meetings between students, mentors, and clients foster communication. The benefits originating from these practices are teamwork, product quality, customer focus and iterative development. Benefits such as teamwork were not referred by students since the context of the work studied was from an individual perspective. Product quality was also not

referred by students as a benefit of the adoption of Scrum in the context of the development of the master's thesis. Regarding customer focus [10], it is said that each Sprint involves face-to-face communication, feedback, and collaboration with the customer. In this context, there is no communication with a customer, but instead, there is communication between the students and the supervisor at the end of each Sprint, involving face-to-face communication and feedback in order to plan and review the work.

Regarding iterative development, this aspect was already exposed in this section as regular deliveries are reported in [7]. According to Rover et al. [10], *"bi-weekly meetings kept students accountable and motivated them to spread work throughout the semester"*, which is also noted by the interviewees as a factor to deliver the master's thesis within the stipulated time.

Begel and Nagappan [11] highlights the top benefits of agile to form a ranking of common benefits. The top three benefits perceived by participants were improved communication, quick releases and quick response of changes (flexibility of design). Regarding these benefits, the only that we have not yet approached in this section is flexibility of design, and we did not present it as a benefit of adopting Scrum in the management of master's theses development because it was only exposed as a positive aspect by eight interviewees and therefore we cannot map this with the practices and benefits obtained with the interviews.

The results presented by Mahnic and Rozanc show similarities between students and developers regarding the practices that lead to the success of a project [9]. Both parties agree that the two most important success factors are teamwork and communication among team members, and good communication with the Product Owner. These factors were not mentioned by the interviewees, since more than half of them refer that Scrum roles do not make sense in master's thesis development because the context of this process is individual, but as also stated by them, there is a constant communication exchange with the supervisor.

Based on the interviews and comparing the information obtained from these with the information obtained in the literature on advantages, benefits, practices and the relationship between the use of agile and the success of projects, we can say that the adoption of Scrum and agile can help in the success of the development of a master's thesis.

Regarding the issues presented by students who were not satisfied with the guidance received, we can say that an adoption of Scrum is a way to foster communication and contact between students and supervisor, since face-to-face communication is key to the development and success of projects, since it is a way to provide feedback, understand if a student is complying with what is supposed and desired to do, and to monitor the work. By adopting Scrum and consequently adopt the realization of Sprints and frequently schedule meetings that encompass the planning and review of Sprints (two to four weeks according to Sutherland and Schwaber [4]) is a way to establish a compromise between students and supervisor and have always marked a by-weekly (for example) period of time when both parties reunite in order to present what was done and to provide feedback and monitor the work.

Regarding the insufficient knowledge transmission capacity problem, interviewees noted the effect of having a group meeting with all students guided by the same supervisor as an opportunity to follow the work from other people, learn with their work, their mistakes, and their solutions to the problems encountered during the development of the master's thesis. Interviewees noted that this was very positive because if a problem previously reported by a colleague occur in their work, they might already have an idea how to solve that problem and thus the time spent solving that problem could be minimized and used in performing the remaining tasks. Other knowledge transmission aspect reported was the feedback provided by the supervisor, in the sense, that the supervisor could suggest alternatives ways to perform given tasks, review the tasks performed, and give an opinion on what has been achieved and done. Interviewees noted that this feedback was very important in order to understand if they have to improve their tasks, redo their tasks and understand if what was desired by the supervisor was achieved. Scrum as an agile methodology *"makes people feel purposeful, improves knowledge transfer and learning between team members"* [8].

6. Conclusion

This research had the purpose of examining the experiences and use of Scrum by a group of students that were guided in the development of their master's thesis based on this framework. Within this case study, based on qualitative data gathered through interviews, we presented which practices of Scrum and agile were applied according to the interviewees, and which benefits were generated by them.

We wanted to contribute to the literature with a case study implemented in a specific academic context, the adoption of Scrum in the development and management of a master's thesis, something that has not yet been addressed. Furthermore, in order to understand factors that could lead to the success of this specific group of students, we dis-

cussed the work done by other researchers, assessing which practices, and benefits were related to the success of projects that applied Scrum and agile practices.

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