Towards an Approach for Integrating Risk Management Practices into Agile Contexts

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Abstract: Risk management has been perceived as important to assist in the delivery of software products that meet the expected scope, schedule, and costs. In traditional plan-driven software development, risk management includes identifying, analyzing, planning responses, monitoring, and controlling risks. In agile methods, however, risks are typically managed implicitly, through practices and values that tend to keep risks under control. However, in many contexts, such as software development for highly regulated domains, such as health and finance, this implicit risk management may not be enough. This paper presents an action research on the introduction of explicit risk management practices in a healthcare software development organization that uses agile methods. Based on identified risk management practices used in agile contexts, the research intervention is planned, applied in two teams during three iterations and the collected data are evaluated and interpreted. The results of the study raise evidence that the agile risk management practices adopted were effective in identifying and mitigating risks and improving project results, without negatively impacting the team's productivity or the agile values adopted by the organization. Also as a result of the application of the study, a possible approach to introduce risk management practices in agile contexts emerges.

1 INTRODUCTION

Risk management in software development projects has historically been perceived as important, as software projects are subject to various risks related to scope, stakeholder expectations, estimates, technology evolution and deadlines (Islam et al., 2014), (Abdelrafe et al., 2016).

Risk management is a well-established process in the traditional plan-oriented software development methods. These methods have adopted risk management practices, such as risk identification, qualitative and quantitative analysis, response planning and risk monitoring and controlling (PMI, 2021), (International Organization for Standardization, 2009), (International Organization for Standardization, 2010).

In agile methods, however, risk management is usually treated implicitly since typical agile methods' practices, such as small increments, work visibility and expectations management, tend to optimize predictability and, thus, mitigating risks (Concha et al., 2007), (Nyfjord and Kajko-Mattsson, 2007).

However, the absence of explicit risk management practices has often led agile projects to fail (Dhir et al., 2019), (Tam et al., 2020), (Tanner et al., 2014), especially in certain software development scenarios where the typical implicit risk management strategy of the agile methods has not been enough to keep risks under control (Hauck and Vieira, 2021) (Shrivastava and Rathod, 2015), (Nelson et al., 2008).

This need to improve agile risk management, leaving traditional and cumbersome processes aside and without losing agile principles, has attracted recent attention of researchers and practitioners, leading to different approaches to adopting risk management practices in agile methods (Afshari and Gandomani, 2022), (Ylimannela, 2012), (Godse and Rajiv, 2021).

This same need for risk management has been observed in a software development organization that uses agile methods and develops products for the healthcare and educational domains. The organization has more than 180 employees, serving 2.500 municipalities with more than 75.000 direct users in Brazil. Due to the domains of application, that are subject to possible risks with very high human impact, two of the authors of this study, who work at the organization, have perceived the need to integrate explicit risk management practices into the agile meth-

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ods used in the organization.

Thus, our research question is ”How to integrate explicit risk management practices in a software development organization that uses agile methods?”. In an initial investigation through a Systematic Mapping Study (SLM) (Garcia et al., 2022), we did not find any specific guide that establishes an approach for integrating risk management practices into agile methods.

Based on the results of the previous SLM, we carried out an *action research* following the approaches proposed by (Petersen et al., 2014) and (Avison et al., 1999). Initially, a diagnosis of the organization is carried out, then the action planning is performed followed by the design of a possible solution. The intervention is then applied in the organization, data are collected and analyzed and the lessons learned are documented.

The main contributions of this study are twofold. For researchers, we present an action research, reporting and discussing the main results and finally generalizing the steps in an initial proposal of an approach, contributing to the recent research on the adoption of risk management with agile methods. For practitioners, we present a practical application that can serve as inspiration for how to apply explicit risk management practices in those scenarios where the implicit risk management of the agile methods may not have been enough.

The rest of this paper is organized as follows: the next section presents related works (2), followed by a section on methods (3), the action research planning (4), action taking (5), evaluation (6) and specifying learning (7). Finally, the conclusion section (8) summarizes the key findings.

2 RELATED WORK

Given the importance of risk management, the integration of these practices into agile methods has attracted the attention of researchers and practitioners (Garcia et al., 2022). In this section we present works that propose different strategies for this integration of risk practices.

Brandão (Chiste Brandão, 2013), based on empirical research, reported that a significant number of software companies do not regard risk management as an established practice. Additionally, certain software methods do not officially incorporate risk assessment, and instead rely on informal practices to mitigate risks (Chiste Brandão, 2013). While in (Elkhatib et al., 2022), agile or hybrid projects have been found to carry less risk compared to waterfall projects. Also, the research suggests several recommendations to reduce project risk, such as incorporating customer vision, selecting the appropriate project approach, having an experienced project manager and team, involving customers in the project, obtaining organizational policy support for an agile approach, promoting a supportive culture, and utilizing analytical tools.

In (Afshari and Gandomani, 2022), authors have proposed a risk management model in a hybrid approach, combining Scrum and XP. The model validated in a case study showed positive results by reducing the number of duplications, change requests, identified risks, and occurred risks. It also increased team efficiency and eliminated risks.

In (Ylimannela, 2012), authors propose modifications to the risks identifying approach by incorporating a risk matrix onto a risk board, utilizing red sticky notes for potential risks and yellow ones for potential solutions. A checklist is used to identify high-risk areas, giving weight to the security of the case, and the checklist is added to the sprint backlog for monitoring. Once a response has been implemented, the note and risk are transferred to a new location on the board. Any accepted risks are saved in digital format for future re-evaluation. However, as helpful as it was, authors found difficult to decide on a high-risk feature and there were issues with unnecessary bureaucracy.

Tomanek (Tomanek and Juricek, 2015) suggested a risk management technique for the Scrum framework utilizing the PRINCE2 approach. The authors justified this combination by highlighting the process oriented nature of both methods. The research found that the most critical aspect of risk is its seriousness, and the best moment to address risks is during Sprint planning. The outcome of the study demonstrated that incorporating Scrum with PRINCE2 approach results in enhanced product delivery time. However, the study also highlighted that while incorporating risk management and holding risk identification meetings in Scrum can be beneficial, it may not be suitable for all project types.

In summary, related works propose different approaches to risk management and provide insights on the benefits and challenges of implementing risk management in agile software development projects. However, none of the related works presented a generic approach capable of effectively managing risks across different agile contexts, as they, separately, lacked support for various risk management processes and domains. Thus, different from related works, this paper presents an action research study covering different risks practices based on literature, systematically selecting, applying and evaluating the most suitable ones and, based on the results of the

study, pursuing a possible general approach for the incorporation of explicit risk management practices into software organizations that use agile methods.

3 RESEARCH METHOD

This study adopts action research as its methodological approach. Action research is an iterative process that involves researchers and practitioners collaborating on a particular set of activities, such as problem diagnosis, action intervention, and reflective learning (Avison et al., 1999).

Based on the organization's context we defined our main research question as "How to integrate explicit risk management practices in a software development organization that uses agile methods?".

Initially, in order to understand how primary studies have been reported the integration of explicit risk management practices into agile methods, we carried out a Systematic Mapping Study (SLM) (Garcia et al., 2022). Thus, based on the needs identified in the organization and the experiences gained from the SLM, we carried out this action research study following the steps proposed by (Petersen et al., 2014) and (Avison et al., 1999). Figure 1 presents the steps followed in this study.

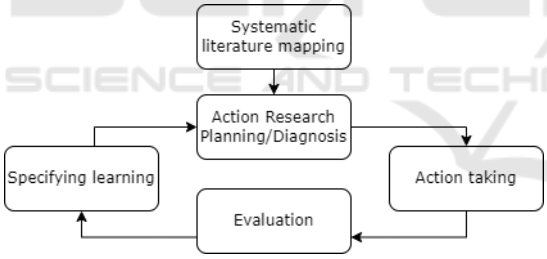

Figure 1: Study methodological approach.

As shown in Figure 1, after performing the SLM, we started the first step with a diagnosis to understand and describe the problem to be solved. In the next steps, we carried out the planning, diagnosis and design of the action, where we studied alternatives for solving the problem and choose the most appropriated ones. The next step was to carry out the intervention action itself, where the plan is executed. Next, we carried out the evaluation of the effects of the action through the application of structured interviews with the participants. Finally, the learning gained through the evaluation of the intervention was documented as an organization's draft approach to integrate risks management practices. These methodological steps are presented in detail in the next sections.

This study was approved by the Human Research Ethics Committee of the Federal University of Santa Catarina number 55851622.8.0000.0121.

4 ACTION RESEARCH PLANNING

Following the adopted methodological approach, the first step is to plan the action research. The planning of this study consists of defining the objective of the action, defining a schedule and allocating the organizational resources needed to carry out the study.

The main objective of the study is derived from the research question (Section 3): "To introduce explicit risk management practices in the context of the target organization that uses agile methods".

This study was planned to be carried during three months involving two of the organization's development teams. The selection criteria for these teams were: (i) the relevance of the software products developed by the teams, which are the most important for the organization; (ii) the proximity to one of the authors of this study who works in one of the teams; (iii) the participants' availability.

The teams involved in this study and their characteristics are presented in Table 1. The two chosen teams are treated from now on as Team A and Team B. A more detailed analysis of this context is presented in the next section.

Table 1: Teams' characteristics.

	Team A	**Team B**
Agile method	Scrum	Scrum
Team size	6	10
Application domain	Healthcare	Education
Product type	Web	Mobile

4.1 Diagnosis

This step consists of understanding and explaining the problem. Thus, we conducted an initial diagnosis of the organization's context and, based in this context, we formalized the problem definition.

4.1.1 Context

As already mentioned, the target organization of this study is a software development organization that develops web and mobile systems for the healthcare and education domains, reaching thousands of users in Brazil. With currently 180 employees, the organization has 15 development teams working on 3 different software products.

All software development teams in the organization are using the agile Scrum method as the main reference for their software process. However, each team is free to adapt the method according to their needs. Below, for a better understanding of the context, the software process of the teams involved in this study is briefly presented.

Teams work in a hybrid work regime, with some members working asynchronously most of the time. They use the Slack tool [1] to facilitate asynchronous communication and the Google Meet tool [2] for synchronous interactions. Teams use GitHub [3] for source code management. In addition, they use Google Drive, Docs and Sheets [4] to record goals, activities and other types of shared materials.

The teams use iterations of two weeks-long Sprints that are initiated with a Sprint planning ceremony, which takes place on the first day of the Sprint. Both teams maintain a history of the past Sprints so that the total effort on selected tasks does not exceed the team's development capacity. The roles of Product Owner (PO) and Scrum Master (SM) are maintained in both teams (Schwaber and Sutherland, 2020).

After the planning ceremony, the Sprint execution begins, carrying out the selected tasks. During the Sprint execution, Daily Meetings are performed, aiming to follow the task's progress as well as to remove impediments.

During the Sprints execution, the integration among the organization's teams is carried out through weekly Scrum of Scrums (Sutherland, 2021) ceremonies, meetings where only the SMs of each team participate to follow the progress of the Sprints.

At the end of each Sprint, the Sprint Retrospective and the Sprint Review ceremonies are held, following Scrum practices (Schwaber and Sutherland, 2020).

The organization also uses the Agile Wheel technique (Soares, 2017) as a continuous improvement approach, periodically holding meetings to assess the progress of the teams.

4.1.2 Problem Definition

As it can be seen in the previous section, currently no explicit risk management practices are carried out by the participant teams. Thus, given the software products domains (education and especially healthcare) which leads to possible serious impacts of the materialization of risks, the need to make risk management explicit was perceived by the two authors of this study who work at the organization.

The main problem, however, emerges from the need to introduce risk management practices without losing the values of the agile methods adopted by the organization, such as adaptation to change, short delivery cycles, open and frequent communication, which are very important for the organization's culture.

4.2 Selection of Solution Alternatives

The analysis of problem solution alternatives begins with the identification of risk management practices that have been adopted by organizations that use agile methods. The most used risk management practices were identified from the initial Systematic Mapping Study (Garcia et al., 2022). The complete list of identified agile risk management practices is available at: http://bit.ly/3pecgSF. As many risk management practices have been identified in previous research, and that we do not wanted to create new practices, in order to choose alternatives for the problem solution, we previously selected four practices using as criteria:

- Practices applied in similar contexts (organization size, agile method or product domain);
- Practices with reported successful results of application;
- Practices with a minimal description sufficient to be applied;
- Practices that can cover risk identification, register, analysis or monitoring, when possible;
- Practices that are aligned with the values of the agile manifesto.

Based on these criteria, the pre-selected practices are defined below, accompanied by a brief description as present in the primary study that proposed it.

- Risk Brainstorming: This practice is used to awaken ideas and creative thoughts. For the reality of risk management, this practice helps mainly in identifying risks, and can be performed in a structured way, in the form of an interview, in a coordinated session or in a free form, allowing everyone to discuss the risks of the project (Hammad and Inayat, 2018).
- Risk checklist: This practice allows a starting point to identify risks, using checklists developed from the experiences of other projects, listing the main risk categories and aspects (Ghobadi and Mathiassen, 2017). The list of possible risks to populate this checklist was extracted from those

[1] https://slack.com/
[2] https://meet.google.com/
[3] https://github.com/
[4] https://docs.google.com/

risks identified in the SLM (Garcia et al., 2022) as most common in agile methods. The complete list of identified risks is available at: bit.ly/3pecgSF.

- Risk matrix: This is a practice to aid in risk analysis considering the criticality of a risk, in which the x-axis is cost/impact and the y-axis is the probability of occurrence. We can evaluate each risk with the matrix, where a classification is defined for each threat and axis, the greater the severity. In terms of colors, red, yellow and green indicate high, medium and low priority risks, respectively. With the union of the numerical value and the color of a risk, criticality is determined (Cuong et al., 2019).
- Risk Register: When a project is already contractually agreed between the interested parties, a risk register is developed, which contains, in addition to the threats and opportunities identified, analyzes and response strategies, recorded in a table (Alharbi and Qureshi, 2014).

4.3 Data Collection Planning

The Goal Question Metric (GQM) (Koziolek, 2008) approach was used to plan the data collection for this action research. The GQM approach defines measurement objectives and derives questions and metrics that should be collected to reach those objectives. The measurement objectives (MO) of this study are derived from the research question and the main objective, as presented. Thus, planning the study data collection, measurement objectives and related questions are presented bellow.

MO1: Analyze the team's effort during the application of risk management practices, from the point of view of the software development teams in the context of the target organization.

- Q1.1: What is the total effort spent by the team members to apply risk management practices?

MO2: Analyze the applicability of risk management practices in agile teams at the organization, from the point of view of the software development teams in the context of the target organization.

- Q2.1: Are risk management practices easy to understand and apply?
- Q2.2: Was the experience of applying the practices beneficial to the participant teams?
- Q2.3: What were the main difficulties in applying risk management practices?
- Q2.4: Was there an impact on the team's velocity when applying risk management practices?

MO3: Analyze the acceptance of risk management practices, from the point of view of the software development teams in the context of the target organization.

- Q3.1: Does the team intend to continue using the presented practices? If yes, why?
- Q3.2: What were the main results in the application of risk management practices?

For each question, following the GQM approach, metrics were also defined. For the objective OM1, the effort is collected through a spreadsheet already used by teams to register their activities and using an online stopwatch tool during the meetings. For data collection of OM2 and OM3 metrics, we developed a questionnaire containing all the derived questions to be applied at the end of the intervention. The questionnaire form is available at https://bit.ly/4aj9PjV.

5 ACTION TAKING

This section describes the execution of this action research as defined in the planning section.

Initially we started by motivating team members to participate in the study, clearly stating how the study would be conducted and what problem it was intended to solve. This motivation was carried out through a meeting with each of the teams.

Then, based on the four practices pre-selected from the literature, both Team A and Team B were involved in selecting the practices that seemed most appropriate for the reality of the teams. This step is presented in Section 5.1.

After that, tools were developed to facilitate the recording and monitoring of identified risks. This step is presented in Section 5.2.

Finally, the selected practices were applied by both Team A and Team B during the planned period, covering six and four Sprints performed by each team, respectively. Details of this application are presented in section 5.3.

During the execution of this study, the intervention was monitored by the authors in order to verify the impact and collect data regarding the metrics described in Section 4.3.

5.1 Selection of Risk Management Practices

The initial step is to choose the risk management practices that best meet the needs of the organization and that are better aligned with the organizational context.

As already presented, a list of the most used risk management practices in agile contexts was extracted from a SLM carried out prior to this study.

In order to involve the teams in the selection of the risk management practices to be used, a meeting was held with two members in leadership positions from each team. In Team A the PO and Tech Leader participated, in Team B the members involved were PO and SM. In the first moment of the meeting, we presented the selected risk management practices with a brief explanation of each one. Afterwards, an open discussion took place among the team members to clarify any doubts and make informed decisions about which practices would best suit their specific context. This decision-making process was based on the team members' experiences and considerations of the current ceremonies that accompany the development cycle, ensuring that the chosen practices could be seamlessly integrated into their existing workflow. In addition, the team members took into consideration the project constraints while choosing the practices. They evaluated how the selected practices aligned with the project's specific limitations, such as time, resources, and budget. This consideration ensured that the chosen practices were not only suitable for their context but also feasible and practical within the given project constraints.

From that meeting, the two teams selected the **Risk Checklist** and **Risk Matrix** practices. Brainstorming was discarded as it required an additional synchronous ceremony for the risk identification, which would cause significant time loss. Also, the Risk Register was not selected because it required the creation and implementation of detailed action plans, which was considered by the participants as possibly compromising the team's agile values, by requiring additional documentation and possibly impacting their productivity.

After the meeting, the selected practices were presented to the teams by the leaders in an informal meeting, so that they could be validated. Then, both teams agreed with the implementation of the chosen practices.

5.2 Development of Tools for Risk Management

After defining the adopted practices, we created a facilitating tool for the application of the practices. Both teams wanted at least part of the implementation of the practices to be asynchronously so that the team's productivity was not compromised.

Thus, we created a simple tool on Google Forms for each team, which is mapped to a table in Google Sheets. This form implements the **Risk Checklist** previously populated with the list of most common risks reported in the literature (Garcia et al., 2022) and provides an open field for members to fill in other identified risks. In this way, it was possible for the teams to identify risks asynchronously without the need to use or create a ceremony for this purpose. Figure 2 shows the defined form.

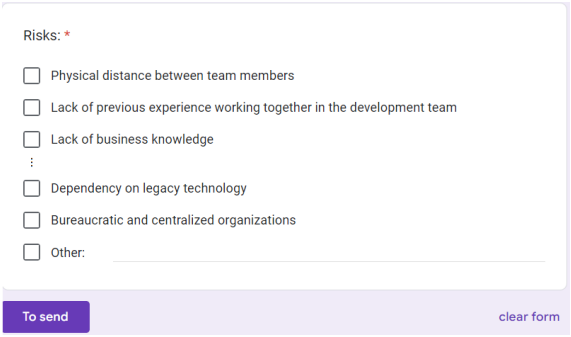

Figure 2: Risk Checklist form.

Once identified in the form, the risks are automatically allocated in a line on the spreadsheet and can then be analyzed later according to the practice selected by the team. This spreadsheet supports the **Risk Matrix** practice, as in addition to the risk description, the worksheet also allows team members to rate the risk in Impact ("Insignificant", "Moderate" and "Catastrophic") and in Probability ("Low", "Medium" and "High"). Figure 3 shows the spreadsheet model used by the teams. The Risk Matrix below was also made available so that teams can define risk priority.

Probability/Impact	Insignificant	Moderate	Catastrophic
High	Medium	High	High
Medium	Low	Medium	High
Low	Low	Low	Medium

Figure 3: Qualitative matrix.

In order to facilitate the use of the tools, we recorded a video with a brief explanation on how to use the tools. In the video, we presented the selected risk management practices, the form to be completed by the team members, and the spreadsheet to which the risks were mapped, analyzed and monitored.

5.3 Application of the Risk Management Practices by the Teams

After the beginning of the applications of the practices in both teams, during the next three Sprints of

two weeks each, the participants were free to apply the chosen risk management practices in the way they considered most appropriate for the context of the team.

Both teams opted to perform risk analysis during the last Daily Scrum ceremony at the end of each Sprint. The identification of risks occurred recurrently during the Sprint duration. One of the authors of this study accompanied the teams during the ceremonies clearing everyone's doubts.

Next, some specificities of the application of practices in each of the teams are presented.

5.3.1 Application in Team A

In Team A, the explanatory video was made available on the Slack tool team channel. Together with the video, the tools for identifying and analyzing risks were also made available.

Team A form received 6 responses during the first Sprint of applying the Risk Checklist identification practice and, according to the participants, each member responded to the form only once.

The risks identified by the team were mostly those already present in the support list. With greater appearance of risks "Complex project" and "Dependency on legacy technologies".

After identifying the risks, in the following Sprint, the participants carried out the risk analysis and monitoring through the application of the Risk Matrix practice. This process was carried out synchronously during a specific synchronous online meeting after the Daily Scrum ceremony.

The discussion lasted for 53 minutes. During this process, the team evaluated each of the identified risks and attributed a value to Impact and another to Probability, in order to calculate the Priority based on the Risk Matrix. The prioritization result is compiled on bit.ly/3NG8uvD.

Team A scored 6 high priority, 7 medium, and 3 low priority risks. In addition, a risk that was filled in using the "Other" field on the form was not understood by the team and, therefore, was not assessed.

In addition, some identified risks were later taken to the Agile Wheel (Soares, 2017) ceremony to be discussed in greater depth. This culminated in the spontaneous creation of an action plan by the team to improve asynchronous communication between members, the plan was derived from the risk "Physical distance between team members".

5.3.2 Application in Team B

Team B also had the explanatory videos and tools released, as well as in Team A. However, at first, the team had difficulties in identifying risks. The first answers were obtained only during the second Sprint of the application and only one risk was identified: "Bureaucratic and centralized organizations". In all other responses, members reported not having identified risks.

However, during the third Sprint, new answers to the form were obtained, which included both risks present in the checklist and risks identified individually by the participants. The most prominent risk was "unpredictability on the part of the customer".

Some risks obtained needed to be adjusted for the spreadsheet, as they contained more than one risk described in the free text field. After this adjustment, the team prioritized risks using the Risk Matrix practice. Prioritization was also carried out asynchronously, in the case of this team the PO individually collected opinions about each of the risks through Slack and then filled in the table with the results. Introducing them later to the team. The result of the application is available on bit.ly/3NG8uvD.

6 EVALUATION

In this step, the effects of the action are captured and analyzed. First, we collected data during all Sprints in both teams. Then we analyze each of the Measurement Objectives based on the collected data.

6.1 Data Collection

Data collection was carried out throughout the duration of this study, which lasted three months. For the collection of quantitative data, the tools already used by the teams were used, including follow-up worksheets to collect the effort applied during the Sprints. Finally, as the practices were applied during team ceremonies, it was possible to record the time spent during the study using a digital stopwatch to measure the precise effort spent.

A questionnaire with discursive questions was also designed to collect qualitative data during implementation, as mentioned in section 4.3. Furthermore, the artifacts generated by the two teams during the application were also collected and analyzed.

The questionnaire was sent at the end of the study to all team members. A total of 11 responses were received, 6 from Team A members and 5 from Team B members. Some participants also made verbal comments that were registered.

6.2 Data Analysis

At the end of data collection, we analyzed it to verify whether the defined objectives were met. The analysis is presented individually for each Measurement Objective, grouping the answers to the questions according to the collected data.

Q1.1 - What is the total effort spent by the team members to apply risk management practices?

As risk identification was performed asynchronously, most of the effort on managing risks was applied to risk analysis. As the risk registration form was left open to collect the team members' suggestions throughout the study period, being analyzed at the beginning of each Sprint, the team members were registering possible risks asynchronously. Therefore, this effort was not formally registered, as it was not considered relevant by the teams.

Team A performed the risk analysis synchronously right after a Daily Scrum meeting. The risk analysis meeting duration was recorded and lasted 53 minutes, involving 6 participants, resulting in a total effort of **5 hours and 18 minutes**.

Team B also performed risk analysis asynchronously. We observed that the average time to fill the analysis risk questionnaire was of 5 minutes. As the questionnaire was filled asynchronously by 6 Team B members, the effort on risk analysis was **30 minutes**.

With that, the total effort of the teams exclusively applied in risk management of **5 hours and 48** minutes was recorded.

Q2.1 - Are risk management practices easy to understand and apply?

To obtain these data, a question of the questionnaire was used. For 36.4%(4) of the participants who answered the questionnaire, the application was considered very easy. Already 54.5%(6) considered the application easy and, finally, 9.1%(1) considered the application neither easy nor difficult. (Figure 4).

Some respondents also commented the reason why they rated the ease of application in this way. 3 team members commented that "the application form was simplified due to the tool offered", which was "intuitive" and "quick to use". Another participant highlighted that the checklist already has common and easy-to-understand risks listed, made "risk identification quite simple".

Q2.2 - Was the experience of applying the practices beneficial to the participant teams?

For 63.6%(7) of the participants, the application of risk management practices was beneficial for the team. Already 27.3%(3) stated that the application was very beneficial. While 9.1%(1) considered the application neither beneficial nor harmful (Figure 5).

Figure 4: Q2.1 Ease of risk management practices.

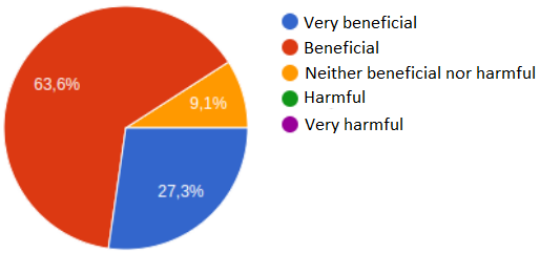

Figure 5: Q2.2 Benefit of practices.

Two of the participants responded that the application was "beneficial to the team" and that "the risk analysis process involved the team in discussions about important issues". One of the participants also highlighted that "the practices allowed for some reflections that brought greater clarity among team members regarding the team process". Other respondent also commented that "it is possible that continuing with the applications will make the process more refined and bring more benefits".

Already 2 participants raised the point that although discussions were encouraged, "there was no time during the study for the development and execution of action plans for risk mitigation", which "harmed the results of the application". That's why, one of the members responded that the study brought neither benefit nor harm to the team.

Q2.3 - What were the main difficulties in applying risk management practices?

This question was collected through an open question in the questionnaire. For this question, 4 participants from Team A highlighted that a difficulty was "the understanding of one of the risks raised in the "Others" field". According to the respondents, the description of the risk was vague and the person responsible for identifying such a risk chose not to comment in order to clarify the issue. Thus, these 4 participants stated that the fact that "risk identification through the tool is anonymous and can cause such conflicts".

One participant commented that a possible difficulty encountered was "the number of risks identified", which, according to him, "was higher than ex-

pected", resulting in "considerable time devoted to risk analysis". However, this participant stated that, despite this, "the analysis time was not long enough to be considered a problem". Three Team B members responded that an obstacle they encountered was "generating engagement among team members to participate in the application". The justification was that the "team is working on a relatively new project".

One Team B member also commented that "the lack of familiarity with project risks caused an initial awkwardness among team members and difficulty in identifying risks even with the help of the checklist". This strangeness was also identified in another answer, which mentioned that "it was difficult to assess the priority of risks". Finally, one response also mentioned that "no difficulties were encountered".

Q2.4 - Was there an impact on the team's velocity when applying risk management practices?

In order to answer this question, we compared the velocity of the Teams prior to this study and during this study.

During the four Sprints prior to applying the risk management practices, Team A had **an average velocity of 19.9** story points. During the three Sprints in which the study was applied, **the team's velocity dropped to an average of 17.41** story points. **Causing a difference of approximately -12.5%**.

Team B, started to use story points only from 2 Sprints prior to the application of the study. So, **the average velocity of these two sprints was 11 story points**. During the sprints in which the practices were applied, **the average velocity was 13.5 points**, **resulting in an increase of 22.7%**. Figure 6 shows the evolution of Teams A and B velocity by Sprints.

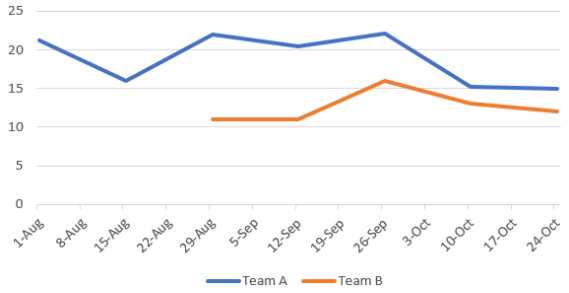

Figure 6: Q2.4 Teams' velocity.

The participants did not observe any unforeseen risks during the projects. Additionally, no low or medium risks were identified that could potentially waste the team's time. The project proceeded smoothly, and the team's velocity remained unaffected by any unexpected risks.

Q3.1 - Does the team intend to continue using the presented practices? If yes, why?

All the participants (100% - 11) answered that they would continue using the risk management practices applied. The main reason, highlighted by 3 members, was that the checklist contributed to the identification of risks that existed in the project but that had not been previously noticed.

In addition, 2 participants commented that the discussions that took place during the risk analysis process were taken to other ceremonies, such as the Agile Wheel meeting, resulting in action plans based on these analysis.

Finally, 1 member commented that "identifying risks adds to the team's future performance by allowing problems to be recorded as points of attention or dealt with before they cause greater damage".

Q3.2 - What were the main results in the application of risk management practices?

In general, the biggest positive result identified by the respondents was the beginning of the use of a systematic method for identifying and managing project risks. 4 members commented on the importance of such formality and 5 highlighted that risk management was not present in the context of the organization until then.

In addition, 3 members commented that the discussions and reflections that took place during the risk analysis process helped the team members to better understand each other's point of view, improving the team's internal communication. And, 6 praised the discussions that were raised from the risks identified.

Two of the participants responded that the practices made it clearer which risks the team should focus on initially and 1 of these mentioned that some of these risks were not visible before applying the risk identification practice.

Finally, 1 participant highlighted that "the presence of the checklist helped to identify risks for members who had more difficulty finding possible problems in the project". Another member stated that "applying the practices made the team feel more prepared to identify and contain new risks that could appear in the future".

6.3 Discussion

The results collected and the observation of the participating teams during and after the application of this study raise initial indications that it is possible to integrate explicit risk management practices in an organization that uses agile methods.

The total effort applied by 5,48 person/hours represents 0,21% of the total effort applied by the entire teams (2.560 person/hours) during the period of the study. This percentage was considered acceptable by

the participants and the team leaders involved. Regarding the negative and positive variation in velocity, it is not possible to state that they were due to the intervention carried out. For the Team A, for instance, the decrease in the team's velocity could be explained by the entry of a new development team member in lieu of an experienced team member during the application of the study. Thus, this variation, both positive and negative, was not considered relevant by the leaders of the participating teams due to other influencing factors.

Therefore, similarly to what was observed in related works (Afshari and Gandomani, 2022) (Tomanek and Juricek, 2015), this study reinforces the tendency that the application of explicit risk management practices does not significantly interfere with the productivity of the teams.

The risk management practices were considered easy to understand and apply, as they were selected based on the literature and applied with the support of simple tools and short explanatory videos.

In addition, no increase in bureaucracy or loss of agile values and practices already adopted by the organization were observed, that is, they complemented and seamlessly integrated with the existing agile processes. The risk management activities did not introduce excessive documentation, unnecessary formalities, or additional overhead that could impede the agility of the development process. These results contrast with some related studies that identified some difficulties such as the increase in bureaucracy when introducing risk management practices, such as in (Ylimannela, 2012).

Also, all team participants intend to continue carrying out the practices after the study. However, although the identification and analysis steps were successful, the participants felt that there was a lack of support for effectively implementing the risk responses.

By adopting these practices, the projects gained several potential benefits. Firstly, the teams would have improved visibility and awareness of the potential risks associated with their projects. This increased awareness allows for early detection and timely response to risks, minimizing the likelihood and impact of potential negative events.

Finally, it is possible to note that the application of the practices was useful to the teams, in particular by encouraging discussions and reflections on the project and processes developed. And that, in general, the teams benefited from both the Risk Checklist and the Risk Matrix. However, since the teams had never used traditional risk management processes, we cannot compare these practices to traditional methods.

We also see the results as positive as the risk management practices are still being applied on the teams months after the action research and are been adopted by the other teams as an organizational process.

6.4 Threats to Validity

There are several factors that may influence the results obtained by this study. Such factors may thus threaten the validity of these results.

In relation to internal validity, given the small sample size and the restrictions of a study carried out in a single organization, it is not possible to establish correlations nor causal relationships between the results obtained and the intervention (Wohlin et al., 2012). To minimize this limitation, we carried out a systematic evaluation of the study, defining data collection using the GQM approach. We also involved two different teams that develop different software products for two different domains.

Another factor that may influence internal validity is that two of the authors of this study are members of the target organization. Although they do not work directly in the participating teams, this proximity may have influenced the participants' responses. In an attempt to minimize this threat, we also collected quantitative data that does not depend on the participants' opinions, such as teams' effort and velocity, to answer research questions.

With regard to external validity, this study incorporates the typical limitations of this type of research, as the results of single-organization studies are usually difficult to generalize and interpret (Zelkowitz, 2009) (Wohlin et al., 2012). The attention to detail of this type of study can lead to non-observance of relevant aspects of a possible general framework of more cases. Thus, the effects of a typical situation can be observed appropriately, but in general it is not possible to establish a reliably generalization (Zelkowitz, 2009) (Wohlin et al., 2012).

7 SPECIFYING LEARNING

In this action research step, general learning is specified based on the practical experience and can be used in future improvements (Lings and Lundell, 2005).

During the study, we realized that the steps adopted in the intervention could perhaps be generalized to enable the adoption of explicit risk management practices in contexts in which this is perceived as necessary. Thus, by abstracting the steps taken during the intervention, a possible general approach emerged. We separate the actions we performed dur-

ing this study into two phases: setup, where we prepare for the introduction of explicit risk management practices, and execution, where risk management practices are carried out. Figure 7 presents the general approach in BPMN (OMG, 2010).

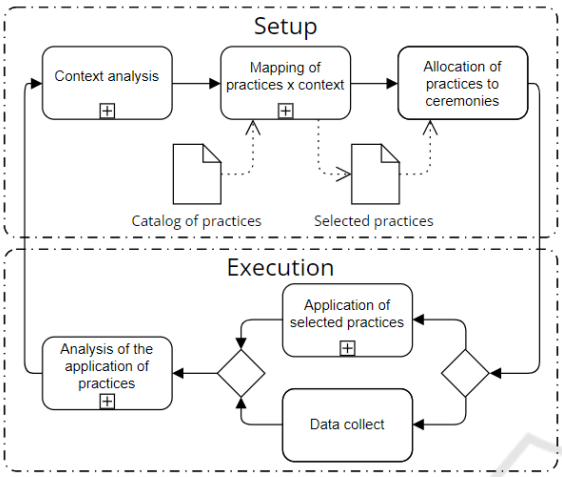

Figure 7: Proposed Agile Risk Management approach.

The **Setup** phase begins with the subprocess *Context analysis*, which consists of identifying the organizational context and the need for risk management. Some of the aspects that may be considered include the application domain, the team size, and the agile method used. These main context characteristics were identified in our previous SLM (Garcia et al., 2022). The results of this activity will guide the next steps.

Having the context characteristics in mind, the best-suited risk management practices are selected in the subprocess *Mapping of practices x context* based on the *Catalog of practices* collected from the literature (Garcia et al., 2022). Through this mapping, it is possible to verify which practices are most appropriate for a given context.

After choosing the practices, the activity *Allocation of practices to ceremonies* defines in which ceremonies the chosen risk management practices will be incorporated, avoiding unnecessary bureaucracy of additional meetings. To achieve this, the teams need to analyze each practice and identify which ceremonies are best suited for its implementation, considering the frequency of the ceremonies and the level of involvement of the team members.

The **Execution** phase begins with the *Application of selected practices* subprocess and the *Data collect* activity running in parallel. During the application, the selected risk management practices are implemented in the project. The practices should be implemented according to the plan defined in the *Allocation of practices to ceremonies* activity. In the *Data collect*, data about the implementation of the selected risk management practices are collected.

The *Analysis of the application of practices* activity is the final subprocess of the Execution phase. This activity aims to evaluate the effectiveness of the implemented practices. The data collected in the previous activity are analyzed to evaluate the application of the practices. The metrics previously defined are used to measure the effectiveness of the practices in mitigating risks, providing insights for future applications.

8 CONCLUSION

This paper presents an action research study on integrating explicit risk management practices into an organization that uses agile methods.

The study begins with the diagnosis of the problem, which involves the analysis of the organizational context. Based on this analysis, the intervention, which consists of selecting agile risk management practices, is planned and alternative solutions are investigated. The intervention is then executed, starting with the selection of risk management practices, development of the necessary tools and application of the practices in two different teams.

The observed results raise initial evidence that the risk management practices were effective and without harming the productivity of the teams. Implementing explicit risk management practices had positive impacts on project performance, increased team collaboration, and reduced project risks. As another result of the knowledge acquired with this study, a draft of a generic approach for the integration of explicit risk management practices in agile contexts emerges.

As future work, we are currently consolidating the detailed definition of the approach and planning to carry out case studies to evaluate its effectiveness in different agile contexts.

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