Using Agile Methods in Distributed Software Development Environments

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Abstract. Management is one of the factors with direct influence on the successful implementation of a project carried out in Distributed Software Development Environment (DSD), whereas mismanagement can result in schedule delays, loss of productivity and high costs. This article presents the benefits of using some of the key agile practices as well as the challenges encountered in DSD project management. The results were collected in quantitative research with the application of a survey among thirty-five professionals. These results indicate a positive contribution of the use of these practices.

Keywords: Distributed software development · Agile methods · Software engineering

1 Introduction

In search for competitive advantages, software development companies have undergone through a major evolution in their business, in which the development of software as a product has been accomplished by the distribution of their processes across cities, states and even in different countries, aiming to minimize costs, increase productivity and use geographically distributed resources; in this context, developing software in the same physical space, has become increasingly costly and less competitive [2].

Distributed Software Development (DSD) has provided several benefits to organizations that aim to develop projects with specific characteristics such as: productivity gains, low-cost skilled labor and the possibility of making use of some advantages over legislation [2]. However, as there are benefits in DSD, this type of work also presents several difficulties such as: physical distance, temporal separation, regional and

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organizational cultures, languages, infrastructure and others [4]. Therefore, it is not interesting to handle this type of project as a traditional development project, and as stated by Oliveira and Lima [12], the adoption of agile methods/frameworks for the software development process can provide a better project management in DSD environments.

This article presents a set of agile practices to be used in DSD environments, aiming to minimize management problems in this context. Existing challenges and the critical success factors for the adoption of these practices in such environments are presented as well. This research intends to answer the following question: what are the main difficulties and benefits provided by the adoption of agile practices used in DSD projects? The article is organized as follows: Sect. 2 presents the usage of agile methods/framework in DSD environments; Sect. 3 discusses related work; Sect. 4 presents the research methodology; Sect. 5 discusses the results of the research; Sect. 6 presents a selection of agile practices most used in DSD environments; Sect. 7 presents the final remarks; and Sect. 8 presents the research limitations and future work.

2 Agile Methods or Frameworks in DSD Environments

The agile methods have some striking differences compared to traditional methods, and the agile methods or frameworks that stand out the most is the XP (eXtreme Programming), which states the use of some practices focused on development [1], and the Scrum framework, focused on project management [16]. Methods/frameworks have their principles supported in the Agile Manifesto, which is a set of values elaborated in 2001 by a group of relevant software professionals, among them Martin Fowler, Beck [3].

Agile methods or frameworks are people-oriented, defining that a process works well for those who use it, and stating that no process can have the ability of a team, therefore, the role of the process is to support the development team in their work [8]. In agile software development, the communication becomes faster and easier, in which team members share face-to-face ideas [11]. But even in distributed teams, the usage of agile methods/frameworks proved to be ten times more productive than traditional models, as stated by other authors [14].

DSD inherits all existing features from traditional software development, adding new challenges that are provided due to the specific context in which it operates, nevertheless, there are several motivations for adopting DSD, e.g., access to low-cost, yet specialized labor available in developing countries [4]. Some of these motivations have attracted more companies to use DSD. It becomes increasingly significant the number of companies that are carrying out their development process in DSD environments [10].

The use of agile methods/framework can be a positive approach when combined with DSD, that is, the use of agile principles in DSD environments can minimize the various challenges arising from this work model [7]. According to Paasivaara et al. [13], the use of agile principles helps to improve trust among the stakeholders of different cultures that are part of the process; in addition, the same authors reported that the usage of Scrum in a distributed development project enabled the increase of motivation of

those involved, improved the communication, the software quality and increased the collaboration frequency.

3 Related Work

There are several researches that address the use of agile methods in DSD environments, and this paper will use as reference the studies described by: Audy and Prikladnicki [2]; Evaristo and Scudder [5]; Ryan and Sharp [15]; Shrivastava and Date [17].

As stated by Audy and Prikladnicki [2], distributed projects can follow a reference model. The authors consolidated the reference model (MuNDDos) to be applied in DSD environments, and their conclusions were based on their research, in which through some comparisons, it was possible to present the lessons learned that provided the identification of a category of factors (design, dispersion, stakeholder, organization and process of development) for the development of projects in DSD environments.

The studies from Evaristo and Scudder [5] focus at solving the challenges of DSD, however, the authors propose some factors that are important for the accomplishment of this work, such as: perceived distance, levels of dispersion, types of actors, development process and the existence of procedures and standards that can be used with the aid of agile practices in DSD environments.

As stated by Ryan and Sharp [15], agile distributed projects must follow some of the agile practices for success. The authors present in a research the relation on agility, team structure and virtual distribution to select the best agile practices. Their study was aimed to the generation of a set of best practices for the configuration of agile teams distributed globally. In this context, the authors' contribution was to select eight agile practices to be adopted in agile teams distributed globally.

Table 1. Comparison of related work

Approaches	Agile practices	Human factor	DSD support tool	Organizational factor
Audy and Prikladnicki (2008)	N	M	M	M
Evaristo and Scudder (2000)	N	PM	M	M
Ryan and Sharp (2011)	M	PM	N	M
Shrivastava and Date (2010)	M	PM	N	PM
This paper	M	PM	M	PM

M = Meets, **PM** = Partially Meets, **N** = No Answer.

The work from Shrivastava and Date [17] explores the intersection of two significant trends for software development, namely DSD and agility. The authors address the challenges faced by agile geographically distributed teams and proven practices for this

type of development. The authors' research demonstrates some dimensions based on the literature, which are necessary for organizations to operate with agile practices in DSD environments. Table 1 presents a summary of the related works. The comparison criteria were chosen based on the main challenges of DSD.

The analyzed approaches bring significant results to the selection of agile practices in DSD projects. However, there are still gaps to be addressed, such as the criteria cited in Table 1. Thus, this work explores the use of agile practices in DSD environments and their importance in distributed projects by listing practices that improve the project management process in DSD.

In comparison to the other identified works, this paper focuses on the use of agile practices in distributed software projects and their benefits to the organization. This paper presents tools to support the DSD and a set of agile practices that can be used in distributed software projects to maximize results and improve performance during the execution of projects in DSD environment.

4 Methodology

This research used a quantitative approach, with the objective of collecting information from participants who work in the software engineering and participate in projects that use agile methods/framework in DSD environments.

The analysis and interpretation of the data identified the current performance of the use of agile methods/framework in distributed projects, the success factors for their adoption, the main agile practices in usage and the main encountered difficulties.

The plan for the execution of this research was composed by the proposed phases as follows: Phase 1 (study of the theoretical basis): during this phase, works from the main authors in the areas of software engineering, agile methods and DSD were researched and studied; Phase 2 *(survey):* in this phase, a questionnaire was developed and applied to professionals in software engineering; Phase 3 (analysis of collected data): in this phase, it was performed an analysis on the collected data. Challenges, difficulties, benefits and advantages related to the use of agile practices in DSD environments were identified at this stage; Phase 4 (agile practices in DSD): a set of agile practices used in DSD was identified.

The individuals that participated in the survey consisted of thirty-five software engineering professionals from Brazil and Canada, who work in companies that perform projects in DSD environments.

It was applied a *survey* of twenty-three questions for data retrieval. The structure of the questionnaire was based on the related works that served as basis for the accomplishment of this research. From the analysis of each work, some gaps were identified regarding the use of agile practices in DSD. Thus, the questions that formed the questionnaire emerged from the identification of these gaps in a way that could identify the dimensions that the agile practices could reach in DSD environments. After analyzing the collected data, a conversion was performed to a database, in which these data were studied using the IBM® SPSS® Statistics Base software tool, that enabled a descriptive analysis of the data and the generation of the tables and graphs in this article.

As stated by Wainer [19], the validity of an experiment is directly related to the level of trust that can be accomplished in the whole research process, that is, to obtain reliable elements from the theoretical basis adopted until the identified results, including the way that these are presented. Therefore, as a *survey* research in which participants respond to the questionnaire within their own environment, this research is subject to be influenced by behaviors that could not be controlled.

5 Results

This section presents the results from the analysis of the collected data on the usage of agile methods/framework in DSD environments. The consistency of the answers obtained through the utilization of the questionnaire revealed that this measuring instrument showed high reliability in the space where it was applied. The Cronbach's alpha value for this questionnaire was 0.843, considering the preference established by Streiner [18], which suggests that the coefficient values above 0.80 represents a high confidence level. Thus, by verifying the results statistics, it is possible to give a greater relevance and reliability to this research.

5.1 Identification of Participants

In order to identify the level of professional experience in distributed projects, each participant informed their years of experience with DSD and agile methods/framework in DSD projects. All the participants of the research have experience with DSD, as shown in Table 2.

Table 2. Professionals with experience in DSD

Experience with DSD	Number of professionals	
	Frequency	Percentage
Up to 1 year	6	17.1%
From 1 to 3 years	10	**28.6%**
From 3 to 5 years	10	**28.6%**
From 4 to 7 years	4	11.4%
From 7 to 9 years	1	2.9%
More than 10 years	4	11.4%
Total	35	100,0%

Among the participants (Table 3), 88.6% already used agile practices in their distributed projects, 11.4% reported not using agile methods in DSD projects. Concerning the professionals who already use agile practices in DSD, 2.9% said that they have 7 to 9 years of experience, 11.4% have 4 to 7 years, 17.1% have 3 to 5 years, 31.4% said that they had 1 to 3 years and 25.7% said that they had up to 1 year of experience. No participant had agile experience for over 10 years, thus, 4 (11.4%) participants who reported having experience in DSD alone and had no experience with the use of agile practices in distributed projects were excluded from the results regarding the use of agile

practices. The results related to agile practices are only valid to participants who have experience in agile projects in DSD environments.

Table 3. Professional's experience with agile practices in DSD

Experience with agile practices in DSD	Number of professionals	
	Frequency	Percentage
Up to 1 year	Referring to Fig.	25.7%
From 1 to 3 years	11	**31.4%**
From 3 to 5 years	6	17.1%
From 4 to 7 years	4	11.4%
From 7 to 9 years	1	2.9%
Not using agile methods in DSD	4	11.4%
Total	**35**	**100.0%**

5.2 Main Challenges in DSD Environments

To identify the main challenges in performing DSD projects, each participant contributed with information about the difficulties encountered in their projects, Fig. 1 shows that the *Communication* is the greatest challenge identified by participants, corresponding to 60.0%. And as stated by [6], communication stands out, as one of the activities of great importance among team members, also, Evaristo and Scudder [5] suggest the creation of communication patterns to minimize difficulties. And representing the lowest value are the *Processes and Tools*, with 11.4%.

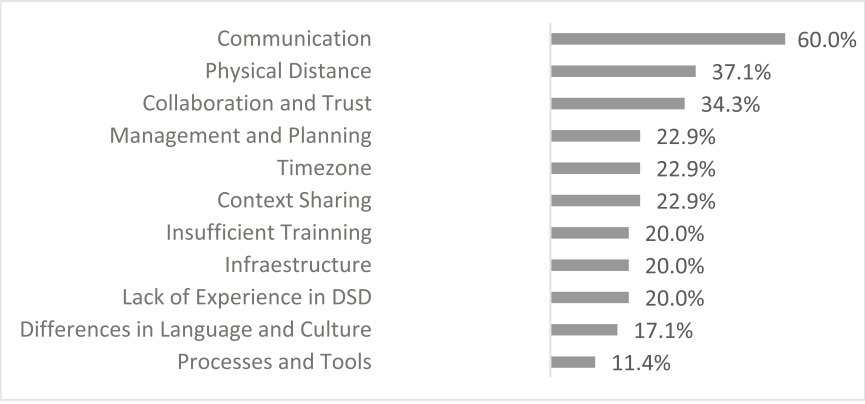

Fig. 1. Main challenges in DSD

5.3 Critical Factors for the Success of Adopting Agile Practices in DSD

To succeed in adopting agile practices in DSD environments, it is necessary to work on some critical factors in the team. The survey participants reported that *Motivated Teams* (with 71.4% of answers) and *Self-Managed Teams* (with 60.0%) are the main

factors for success in distributed projects. Through the data analysis it was identified that the individuals with 1 to 3 years of experience with agile methods in DSD believe that the approach of a self managed team is the main critical factor for success. Professionals with less than 1 year of experience have the preference of keeping motivated teams as their main success factor. Among the professionals with experience from 5 to 7 years, the highest preference for the factor of success of a distributed project is to have an experienced coach and to keep the team motivated. And with 20.0% of the answers, *Specialized Teams* were considered as a factor without much criticality, as shown in Fig. 2.

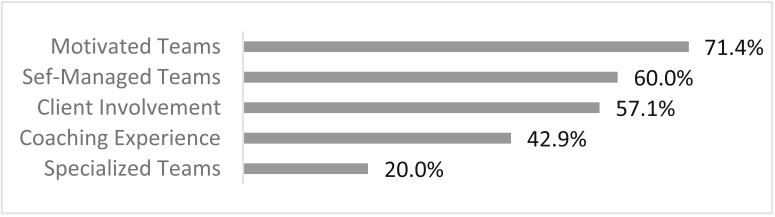

Fig. 2. Critical factors for successful use of agile practices in DSD

5.4 Most Commonly Used Tools in DSD Environments

For a distributed project to succeed, it is necessary to manage all its parameters as well. Therefore, the use of tools has provided a better follow-up of the processes that are part of the distributed project and these tools have become critical to success in DSD. Respondents stated that the *Apache Subversion* (40.0%) is the most used software version control tool and the *Microsoft Excel* has 31.4% of participants' preference as a necessary tool for control and monitoring of distributed projects. Other tools such as *Redmine* and *Microsoft Project* had 20.0% preference among the participants as the main tool to manage their Projects. Other tools (CA-ChangePoint, Bitbucket, PivotalTracker, Smartsheet, GoogleDocs, Dropbox, Gmail and Skype) were cited and preferred by 40% of the participants, as shown in Fig. 3.

5.5 Agile Methods/Frameworks Used in DSD Environments

The "Total" column in Table 4 shows the overall value of participants who stated that they use agile methods/frameworks in DSD projects. Most of the respondents, (77.1%) stated they used the *Scrum framework* to manage their projects. Through the analysis of the collected data it was possible to realize that Scrum is the most used approach by professionals with 1 to 3 years of experience in the development of distributed projects.

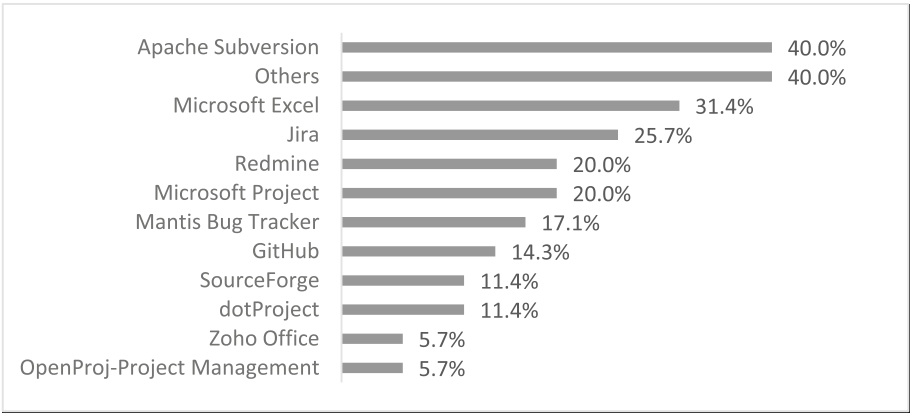

Fig. 3. Most commonly used tools in DSD environments

Table 4. Preference of frameworks in agile DSD

Framework and/or Agile method	Experience of the professionals in DSD projects, using agile practices					
	Up to 1 year	From 1 to 3 years	From 3 to 5 years	From 4 to 7 years	From 7 to 9 years	Total
Crystal	100.0%	0.0%	0.0%	0.0%	0.0%	**2.9%**
FDD	0.0%	0.0%	0.0%	100.0%	0.0%	**2.9%**
Kanban	12.5%	37.5%	25.0%	25.0%	0.0%	**22.9%**
Lean	25.0%	0.0%	25.0%	50.0%	0.0%	**11.4%**
Scrum	25.9%	37.0%	22.2%	14.8%	0.0%	**77.1%**
XP	16.7%	33.3%	16.7%	25.0%	8.3%	**34.3%**
Others	33.3%	0.0%	0.0%	33.3%	33.3%	**8.6%**

Even being the most used approach for project management among the respondents, Scrum is questioned by some authors about its efficiency in distributed teams, and according to Gregório et al. [9], has its main weaknesses in the lack of scalability for large and geographically dispersed teams. However, this view was empirically denied by Paasivaara et al. [13], who state that Scrum was used successfully in several large projects whose teams were distributed in several business plants. Other 34.3% of the respondents reported using XP, 22.9% using Kanbam, 11.4% using Lean, and the lowest values were found with *FDD* and *Crystal*, both with 2.9%. Finally, 8.6% reported using other methods. It is important to mention that 100.0% of participants who already use agile practices in DSD projects do not use only a single framework/methodology to follow their projects.

5.6 Benefits of Agile Practices in DSD

Concerning the advantages and benefits of the use of agile methods/framework in DSD projects, some questions were applied to retrieve the experience of the participants in this context. The results are shown in Table 5.

Table 5. Benefits of agile practices in DSD

Benefits from the adoption of agile practices	Experience of professionals in DSD projects using agile practices					
	Up to 1 year	From 1 to 3 years	From 3 to 5 years	From 4 to 7 years	From 7 to 9 years	Total
Accelerate the Time to Market	23.1%	38.5%	15.4%	23.1%	0.0%	**37,1%**
Productivity increase	33.3%	27.8%	22.2%	11.1%	5.6%	**51.4%**
Better change control	6.7%	53.3%	33.3%	6.7%	0.0%	**42.9%**
Improvement in self esteem	27.3%	45.5%	18.2%	9.1%	0.0%	**31.4%**
Improvement in the system quality	25.0%	33.3%	33.3%	8.3%	0.0%	**34.3%**
Reduction of costs	40.0%	20.0%	20.0%	20.0%	0.0%	**14.3%**
Processess simplification	7.1%	50.0%	21.4%	14.3%	7.1%	**40.0%**

Respondents indicated that the *Productivity Increase* was the greatest benefit obtained from agile practices in DSD environments, with 51.4% of answers. As a result of the data analysis, it was possible to perceive that this benefit had its highest index among the participants who use Scrum, XP and Lean. The *Better change control* appears with 42.9%, followed by 40.0% who reported the *Processess simplification*. 37.1% reported that they obtained benefits in *Time to market,* 34.3% reported that their systems have obtained a better quality, and 31.4% identified *Improvements in self-esteem* of the involved professionals. The Reduction of Costs was the lowest benefit stated, with 14.3%, as shown in Table 5. In this scenario, 94.3% of the participants stated that the use of agile methods/framework adds positive values to DSD. Among the professionals with experience with agile methods in DSD, only two of them, with 1 to 3 years of experience with distributed projects, reported that the usage of agile methods/framework would not aggregate any value in DSD projects, and these respondents did not justify their responses. However, participants who stated that agile practices contribute to the development of distributed projects justified their responses, as stated by respondent A: "I consider it essential to use agile methods in DSD since they aim to streamline and organize activities avoiding damages derived from the distance of the stakeholders" and reaffirmed by respondent B: "There will always be improvements in the adoption of agile methods in any type of environment or project."

6 Selection of Agile Practices Used in DSD

After analyzing the answers from the survey, the main agile practices used in distributed projects were identified, as shown in Table 6.

Table 6. Identification of agile practices and respondents

Main agile practices in DSD	Experience of professionals in DSD projects using agile practices					
	Up to 1 year	From 1 to 3 years	From 3 to 5 years	From 4 to 7 years	From 7 to 9 years	Total
Collective coding	37.5%	37.5%	25.0%	0.0%	0.0%	**22.9%**
Clean coding	28,6%	0.0%	42.9%	14.3%	14.3%	**20.0%**
Requirements prioritization	27.3%	27.3%	27.3%	13.6%	4.5%	**62.9%**
Pair programming	25.0%	12.5%	25.0%	25.0%	12.5%	**23.5%**
Refactoring	30.0%	30.0%	30.0%	0.0%	10.0%	**28,6%**
Retrospective meeting	18.8%	25.0%	37.5%	18.8%	0.0%	**45.7%**
Daily meeting	24.0%	36.0%	24.0%	16.0%	0.0%	**71.4%**
Code revision	25.0%	33.3%	33.3%	8.3%	0.0%	**34.3%**
Others	0.0%	0.0%	100.0%	0.0%	0.0%	**2.9%**

It is expected that these best practices will help and minimize the possibility of errors in the realization of projects in DSD environments. It was verified that the professionals included in the research sample, denoted a more frequent use of three practices, as follows: *Daily Meetings*, with 71.4%; *Requirements Prioritization*, with 62.9%; *Retrospective Meeting*, with 45, 7%, as shown in Table 6. At the end of this research, it was possible to verify that the use of some agile practices in distributed teams proved to bring considerable benefits to the final quality of the product. Therefore, the main result of this research was the conception of a proposal of the main agile practices used in DSD environments.

7 Final Remarks

In this research, we analyzed the use of agile methods/frameworks in DSD environments and we investigated the use of the main agile practices, tools, challenges and critical factors for success in the adoption of agile practices in this area. This was demonstrated throughout the study and reinforced with the results of the research, in which 94.3% of participants stated that the usage of agile practices aggregates value to DSD projects. Thus, with 60% of the answers, *Communication* was identified as the main difficulty. Between the critical factors for the success of agile practices in DSD, the *Motivated Teams* factor stood out with 71.4% of the answers, and the greatest benefit elected by the participants, was the *Increase of Productivity*, with 51.0% of the answers. It was possible to conclude that this work contributed to the exploration of the existing gaps identified in Sect. 3 through the related works. And even by this work not being a

definitive solution to the difficulties faced in DSD, it contributes to the management of distributed projects, providing a list of agile practices and tools most used for companies that are interested in adopting agile methodologies in DSD environments. The results showed that the use of the practices provides the optimization of project management activities. In this way, we conclude that the process of adoption of agile practices in DSD has contributed significantly to the development of distributed software projects.

8 Research Limitations and Future Work

One of the main limitations of the research is directly related to the number of people who answered the questionnaire, restricting the generalization of the results collected, however, it is important to note that the research results were sustained in the studied theoretical basis and the information extracted from the *survey* applied to the participants, in which each one of them collaborated with their professional experiences in the DSD area, which allows a good degree of security in the conclusions drawn.

As a suggestion for future work, a deepening in this area of study can be done applying experiments to validate the use of practices in distributed projects. Elaborate a research with more participants as well as the elaboration of a specific process model for the use of agile methodologies in DSD environments and their application in a real project to verify whether positive values are added during software development.

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