Information and Software Technology 96 (2018) 161–180

Contents lists available at ScienceDirect

Information and Software Technology

journal homepage: www.elsevier.com/locate/infsof

Systematic literature review on agile practices in global software development

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ARTICLE INFO

Keywords:
Global software development
Global software engineering
Distributed software development
Agile software development
Agile practices
Scrum
Extreme programming
XP
Systematic literature review

ABSTRACT

Context: Developing software in distributed development environments exhibits coordination, control and communication challenges. Agile practices, which demand frequent communication and self-organization between remote sites, are increasingly found in global software development (GSD) to mitigate said challenges.
Objective: We aim to provide detailed insight into what is reported on the successful application of agile practices in GSD from 1999 to 2016 and also identify the most frequently applied agile practices and reported distribution scenarios. We further strive to uncover research opportunities and gaps in the field of agile GSD.
Method: We build our systematic literature review on top of a previous review, which investigated studies published between 1999 and 2009, and extend the review by years 2010–2016, for which we conduct both a quantitative and a qualitative analysis.
Results: Our results show that the majority of the cases studied is global and involves complex distribution scenarios with Scrum or combined Scrum/Extreme Programming being the most used agile methods. Key results include that in contrast to 1999–2009, where four Extreme Programming practices were among the ten most frequently used agile practices, in 2010–2016 Scrum is in the center of agile GSD implementations with eight Scrum-based practices in the top ten agile practices used in GSD.
Conclusion: Agile GSD is a maturing research field with higher quality contributions and a greater variety of publication types and methods from 2010 to 2016 than before from 1999 to 2009. However, researchers need to report full empirical contextual details of their studied cases in order to improve the generalizability of results and allow the future creation of stronger frameworks to drive the implementation of agile practices in GSD.

1. Introduction

Global software development (GSD) promises cost savings, access to large multi-skilled workforces, a reduced time to market [16] and the possibility to follow critical-path tasks around the clock [11]. These deciding factors, among others, have made GSD a daily reality in today's IT organizations although development environments are more complex and exhibit several challenges such as: physical distances and time zones, loss of “teamness”, culture differences [5], strategic issues, process differences, knowledge management and technical challenges [22].

Agile methods are built around empowered and self-organizing teams with a strong focus on collaboration and communication supported by various agile practices including pairing, customer collaboration, stand-ups, reviews, retrospectives and the planning game [24]. Agile practices are regarded as being able to mitigate the challenges faced in GSD by several authors such as e.g. Ramesh et al. [19], Paasivaara et al. [17] and Hossain et al. [12]. However, neither the leading agile method Scrum [21] nor Extreme Programming (XP) [6] was designed for teams working in distributed environments. Hence adaptations to the original process are necessary [4]. The goal of these adaptations is to transfer agile values, which produced excellent results in the last decade for collocated teams [8], to GSD environments. Combining agile practices with GSD has not only been an active research stream (S112) but is also extensively practiced in industry as the usage of distributed agile teams has more than doubled from 35% in 2012 [28] to 86% in 2016 [29].

The objective of this study is to provide a systematic literature review (SLR) on the successful usage of agile practices in GSD. We define *agile* according to ([7], p. 340) as a “method to rapidly or inherently

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https://doi.org/10.1016/j.infsof.2017.12.004
Received 4 April 2017; Received in revised form 1 December 2017; Accepted 5 December 2017
Available online 06 December 2017
0950-5849/

create change, proactively or reactively embrace change, and learn from change while, contributing to perceived customer value". A practice within the scope of this study is understood as "the customary, habitual, or expected procedure or way of doing of something",[1] and we regard an *agile practice* as a central component (such as e.g. the daily standup or pair programming) which originates from an agile method (such as e.g. Scrum, Extreme Programming, FDD or Kanban), either used in its original or an adapted form. Furthermore, in accordance with (S62), we understand global software development as the "development of a software artifact across more than one location" ([25], p. 122), which includes all scenarios of geographical distribution, not only global ones.

Our main contribution is to provide a comprehensive understanding and analysis of the successful usage of agile practices in GSD. To that end, we continue the analysis carried out by Jalali and Wohlin (S62; S63) covering years 1999–2009 with an extension for the years of 2010–2016. We strive to both expand on their results for an updated state of the art as well as offer a comparison between the two periods of investigation (1999–2009 by Jalali and Wohlin, 2010–2016 added in this study). We provide an overview of successful empirical cases, identify which agile practices are used and which cases are typically reported (concerning their empirical context such as e.g. project duration, project size or application domain but also their distribution scenarios such as shoring and sourcing strategies). Further important contributions of our study are that practitioners can use our findings to identify which agile practices are commonly used to successfully drive their own implementation of agile GSD while researchers can gain an aggregation of past results to build upon and focus future research on the research gaps identified and avoid repetitions.

The rest of the paper is organized as follows. Section 2 discusses the research significance, motivation and objectives of this study in light of related work. The detailed study design and procedure is explained in Section 3. Section 4 presents the results of the systematic review, both in continuation of, covering 1999–2016, and in comparison to, covering 1999–2009 vs. 2010–2016, previous research by Jalali and Wohlin (S62; S63). Section 5 presents the discussion including future research opportunities and limitations of this review study. Section 6 concludes the report. Some studies referenced in the first few sections of this report, such as e.g. (S62; S63), are part of our review's set of included studies, which is why they are referenced by their included study ID (S62; S63) rather than as a general reference, for consistency and to avoid the listing of duplicate references.

2. Research motivation and objectives

Global software development is an active research field as several systematic reviews account for [15,20,27] and all seem to agree that there is a need for more primary studies in GSD research. Most relevant to our line of research are systematic mapping (SM) and systematic literature review (SLR) studies focusing on the application of agile practices in GSD.

Jiménez et al. [13] conducted an SLR on challenges and improvements in distributed software development. Although Jiménez et al. [13] identified agile methodologies as one success factor in GSD, their study's focus was different to ours and no concrete agile practices were addressed. Hossain et al. [12] conducted an SLR on Scrum and GSD, which is the first SLR addressing agile practices in GSD, but in contrast to our SLR their focus is limited solely to Scrum. Jalali and Wohlin were the first to deliver an extensive overview of agile GSD by conducting a systematic mapping study (S62) and a systematic review (S63) on top. Both studies (S62; S63) covered years 1999–2009. There is also a related tertiary study by Hanssen et al. [10] summarizing twelve SLRs in GSD by looking through an agile lens, where the authors conclude that agile is a frequent topic in GSD, but many publications lack proper research design and rather have the character of industrial reports. Furthermore Hanssen et al. [10] call for a new SLR for agile in GSD to cover publications of 2008 and newer.

The most comprehensive and recent review relevant to our approach is by Rizvi et al. (S112), who investigated distributed agile software engineering for years 2007–2012. Our scope is different as we focus on the state of the art of agile practices and methods, whereas Rizvi et al. (S112) look closer at underlying reasons for adopting agile methods to GSD as well as risks. The distinguishing factor is that Rizvi et al. (S112) aim to understand the prospects of the agile adoption in GSD while Jalali and Wohlin (S62; S63) and our systematic review study, in continuation of work by Jalali and Wohlin, focus on the evolvement of the field and the practices that have been used in different scenarios. Another recent SLR is by Alzoubi et al. [3], who investigate the communication challenges in distributed teams that adopt agile methods up to the year 2014. Alzoubi et al. [3] categorize found challenges in six categories, but their focus is different to ours because agile practices are not taken into account. The newest SLR in the field is by Alsahli et al. [2], who studied the years of 2006–2016 in their SLR and tried to aggregate how agile practices mitigate GSD challenges. Apart from their shorter period of analysis, the distinguishing factor to this SLR is that Alsahli et al. [2] only include studies which particularly state the GSD challenges that a practice mitigates, which is why their result set is much more limited.

The successful application of agile practices in GSD is also a very important topic to the practitioner, as the 11th annual state of agile survey report [29] shows that the usage of distributed agile teams has more than doubled from 2012 to 2016: while in 2012 35% of the respondents reported to work in distributed agile teams [28], in 2016 the number increased to 86% [29].

In conclusion, although there have been reviews covering different aspects of agile GSD in the past, we have identified the research gap that there is no recent study focusing on aggregating and synthesizing the state of the art on the successful application of agile practices in GSD, which as our discussion of related work shows, is a very recent and relevant challenge to both researcher and practitioner and deserves further research attention.

In order to answer the identified research gap, we build our research on top of (S62; S63) in order to both continue their analysis on 1999–2009 for the years 2010–2016, and also to compare our newer studied period (2010–2016) to theirs (1999–2009). This study is furthermore unique in the way that it effectively covers the usage of agile practices in GSD from agile origins (1999) to recent time (2016). Although it can be regarded a limitation to build on the methodology and results of others (see Section 5.2), we see particular value in our study by continuing the work of Jalali and Wohlin (S62; S63) to perform a complete and updated analysis in contrast to covering the whole time frame on our own, which would not only be duplicate work but also infeasible given the amount of studies over the years. We also strive to identify future research potential based on our analysis.

3. Research design

Jalali and Wohlin conducted a systematic mapping (S62) and a systematic review (S63) for the years 1999–2009. We expand on their work in order to continue their analysis and provide up-to-date maps and results. Since the systematic review of (S63) also contains the mappings of (S62), we decided to focus on the revised study (S63), with the exception of our Table 3, which has only been published in (S62), but is also part of our analysis.

In order to be able to continue the work of Jalali and Wohlin (S62; S63) and compare results, we chose an almost identical study design. A few minor changes are explained in the remainder of this section. On top of that we also consulted guidelines for systematic review study design by Kitchenham and Charters [14] and Petersen et al. [18].

[1] Oxford Dictionary: https://en.oxforddictionaries.com/definition/practice.