Signs of Agile Trends in Global Software Engineering Research: A Tertiary Study

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Abstract—**In this paper we present preliminary findings from a tertiary study on global software engineering. In particular, we observe current trends in the software engineering research and perform an investigation of the role of agile topics in the GSE research literature. Our findings indicate that agility is one of the topics attracting attention in the research agenda for global software companies. In contrast to recent beliefs that agile and distributed are two incompatibilities Global Agile development becomes more and more accepted, a trend which we also see from the growing amount of research on GSE and agile. Finally we conclude that there are indications that both globalization and "agilization" of software companies are stable trends for the future but that there is a strong need for further studies on the particular challenges that distribution of work imposes on the principles of agile development.**

Keywords-agile; global software engineering; tertiary study

I. INTRODUCTION

Global Software Engineering (GSE) and Agile Software Development are two rapidly growing sub-fields within the software engineering domain with an explicit interest both from industry and academia. While GSE is a wide concept, covering software development across both organizational and geographical borders, agile is usually associated with close collaboration and co-location. Despite the seemingly incompatible nature of global and agile software teams, previous research indicates that there is a trend of implementing agile development in global projects [1]. Empirical evidence from case studies [2, 3] shows successful implementation of agile values and principles in different globally distributed projects. This motivates assessing the viability of agile practices for distributed software development teams. The interest in becoming agile and distributed is also illustrated by the increasing number of research publications and seminars devoted to the topic.

From the managerial perspective, agile in GSE is motivated by the need to respond to customer needs and changing market conditions, while minimizing development costs and leveraging human resources around the world. From the engineering perspective, agile in GSE is motivated by the fact that agile development has recently attracted huge interest from software industry [4]. It is being recognized for its potential to improve communication and, as a result, reduce coordination and control overhead in software projects.

There is an increasing interest in becoming agile and distributed, and there is a growing number of studies on the topic, but there exists no common understanding of the concept of agile in GSE. This has motivated the following research questions:

RQ1: Are there any signs of interest in implementing agile methods in global software engineering?

RQ2: What is known about the application of agile practices in GSE?

The rest of the paper is organized as follows. In Section II we give an overview of the research and explain our methodology. We report our preliminary findings from investigating agile trends in GSE research based on a relatively large set of recent secondary studies on GSE in Section III, followed by a discussion of results in Section IV. Finally Section V concludes the paper with the major conclusions and future work.

II. REVIEW METHOD

We chose to perform a tertiary study as there already exists a large number of systematic literature reviews covering GSE where several of these cover agile practices in GSE. To develop a unified understanding of the concept of agile in GSE we identified all relevant secondary studies on GSE, selected the ones with a minimum level of quality, distinguished those studies covering implementation of agile practices in global projects, and finally systematized and presented a unified view of this knowledge.

A. Research Process

To guide this work, we have adapted guidelines for tertiary reviews developed by Kitchenham et al. [5] (Appendix 3). Several comprehensive databases offering complex searching facilities exist, but for reasons of convenience in this work we have decided to use ISI Web of Science and Google Scholar, which cover most other search engines. Future and more detailed investigations will be based on a more comprehensive search. To identify secondary studies addressing global software engineering (or similar concepts), we have used the following search phrases:

global software engineering OR global software development OR distributed software development OR distributed software engineering OR offshore software development OR offshore software engineering
AND
systematic review OR systematic literature review OR systematic map OR systematic mapping OR mapping study

Each database has different use of parentheses, logical operators and search principles, thus we have modified the search phrases for the particular use. In particular, the search in Google Scholar had to be split into five combined searches as the search interface has a limit on the length of the search string (<= 32 words). This search using Google Scholar returned 477 hits in sum. The search in ISI Web of Science returned two unique results. We collected journal and conference publications, as well as one workshop paper.

B. Exclusion/Inclusion analysis

The results of the search were further evaluated for a match with the scope of the tertiary study. This was done by reading abstract of each paper identified through the search and using pre-defined exclusion/inclusion criteria.

In order to *not* be excluded, each study had to fulfill the following five criteria:

1. Be a systematic literature review on GSE or similar

2. Have defined research aim or question(s)

3. Provide a description of the search process

4. Provide a description of the data extraction and/or data analysis process

5. Be peer reviewed

Comparative analysis of the level of agreement between the two reviewers (author one and two) identified one disagreement concerning a review, which was resolved after a discussion. The paper was rejected as it was found not to match the first criteria – the review was devoted to GSE teaching and not GSE per se. We also discovered two pairs of reviews that used the same collection of primary studies and had the same focus of investigation. We decided to reject the two earliest publications, which are conference publications and keep the two most recent ones, which are journal publications.

Accordingly, out of the total 21 studies identified from the search, we excluded 9 publications and included 12.

C. Data Extraction and Synthesis

To fulfill the research goals of this workshop paper, we browsed the included systematic reviews and extracted the following data:

- The source (i.e. the conference or journal),

- The year, when the paper was published,

- Main software engineering topic area,

- The author(s) and affiliation,

- Research question/issue,

- Summary of the conclusions,

- The list of primary studies used:

  o The source (i.e. the conference or journal),

  o Title of the paper,

  o Year, when the paper was published,

  o The author(s).

The analysis goals were twofold. First of all, the main author performed a qualitative analysis of each review and extracted the data concerning the focus and conclusions of each review included in the analysis. This data was further used in a comparative analysis to identify the role of agility in GSE research and any interesting trends or limitations concerning the application of agility in global projects. At the same time the second author extracted the list of primary studies and performed detailed analysis of these studies, their overlap and the proportion of agile-related studies versus the rest of the literature included in the reviews. This was done to evaluate the emphasis of agile-related topics in the GSE research. The findings were afterwards combined to achieve a comprehensive view of the research trends.

III. RESULTS

In this section we describe our results from performing a tertiary study: we offer general findings about the GSE literature, and then point out the signs of agile trends in the GSE research. An overview of our findings can be found in Figure 1.

A. Systematic Reviews in GSE

Twelve systematic literature reviews (SLRs) devoted to GSE were included in the final analysis. These reviews represent original work published in different venues. Most of the reviews are conducted by different authors except for three cases where the same or nearly the same groups of authors have published two publications out of their SLRs ([SLR1] and [SLR4], [SLR3] and [SLR6], and [SLR8] and [SLR12]). When it comes to the focus of SLRs, it is noticeable that several systematic reviews focus on challenges and solutions ([SLR3], [SLR6], [SLR7], [SLR10] and [SLR12]), while two reviews were conducted specifically on the agile theme ([SLR5], [SLR9]). All reviews were published from 2008 to 2011 (see Table 1).

TABLE I.   PUBLISHING PERIOD

Years	Reference and Venue	Authors
2008	[SLR6] – Conference – SEAFOOD[1]	Jiminéz & Piattini
2009	[SLR3] – Journal – ASE[2] [SLR5] – Conference – ICGSE[3]	Jiminéz & Piattini Hossain et al.
2010	[SLR1] – Journal – IST[4] [SLR2] – Journal – EMSE[5] [SLR4] – Conference – EASE[6] [SLR7] – Journal – ACM Inroads [SLR9] – Conference – ICGSE [SLR10] – Conference – ICGSE [SLR11] – Workshop – CRIWG[7]	Prikladnicki & Audy Smite et al. Prikladnicki et al. Noll et al. Jalali & Wohlin da Silva et al. Steinmacher & Chaves
2011	[SLR8] – Journal – JSS[8] [SLR12] – Journal – IST	Khan et al. Khan et al.

Detailed analysis of the list of primary studies helped to identify 434 unique primary studies included in the twelve SLRs. Most of the primary studies included in the reviews were published during 2000-2007.

B. Agile studies in GSE

An overview of the results can be found in Figure 1. Each bubble represents a secondary study and is labeled as a conference, journal or workshop paper. The bars above represent the number of primary studies included in the reviews, while grey coloring indicates those primary studies that are focusing specifically on agile theme.

The bars are further connected with arrows to the bar that indicates the total number of primary studies on Agile GSE on the left side of the figure. Time coverage in terms of the years when the primary studies were published is illustrated with the vertical bars below.

To summarize our findings, we have identified 89 unique primary studies devoted to agile in GSE in total among the SLRs, which represents 20% of all primary studies. The vast majority of these studies come from the two thematic reviews. Interestingly, seven other reviews on GSE have included up to nine primary studies on agile, while three reviews did not contain any primary study devoted to agile.

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[1] Software Engineering for Offshore and Outsourced Development

[2] Journal of Advances in Software Engineering

[3] International Conference on Global Software Engineering

[4] Journal of Information Systems and Technology

[5] Journal of Empirical Software Engineering

[6] Conference on Evaluation and Assessment in Software Engineering

[7] Collaboration Researchers' International Workshops on Groupware

[8] Journal of Systems and Software

C. Application of Agile Practices in GSE

Based on an initial review of the conclusions and claims from the 12 selected secondary studies we find several aspects relevant to agile practices in the context of GSE.

First of all, several of the studies simply establish the fact that there *is* a trend of adopting agile principles in GSE ([SLR2], [SLR5]), meaning that parts of the industry sees the potential in at least some of the agile principles. Based on [SLR2] we find that out of 40 identified empirical cases agile, incremental and iterative methods were by far the most used type of methodology. Related to this, Jiminéz and Piattini conclude that the use of agile methods is an important factor for succeeding in GSE [SLR3]. These are indications that there is an interest in adopting agile practices in global projects (RQ1). Another observation supporting this claim is the relatively high number of primary studies on agile GSE (89 out of 434), and also the two studies that directly address agile and GSE (two out of twelve). Although, this is not a sign that agile is dominating in the GSE research, we believe that it deserves to be regarded as a trend. Hossain et al. in [SLR5] identified 20 publications explicitly about the Scrum method being applied in GSE contexts. Jalali and Wohlin in [SLR9] identified 77 publications related to 'agile practices' in GSE. For a relatively new and restricted field of research we find this number high and interpret it as a clear sign on both industrial and academic interest. Further analysis of these primary studies on a timeline suggests that the number of studies is growing (see Figure 2 diagram on the left). Interestingly, we have found that this trend as demonstrated by the shape of the curve that indicates the number of primary studies on agile in GSE over time is very similar to the one found in a recent literature study on agile software development [6]. Note that the number of publications on agile software development for 2009, and publication on agile in GSE for 2008 do not include all publications for that year, therefore the curve seemingly indicates a decrease. From this analysis we interpret that the popularity of agile software development in software engineering is one reason for why agile is becoming popular in GSE. We also expect that there will be a lot of new publications on the topic of agile and GSE during the next years.

Leaning on the two identified secondary studies, which explicitly look into agile methodologies and principles in GSE ([SLR5], [SLR9]), we see that:

1) The use of Scrum practices may be limited by various GSE project's contextual factors. Important challenges are related to lack of effective collaboration tools for distributed teams, management of large teams and lack of dedicated meeting rooms with necessary infrastructure.
2) Project distribution influence communication, coordination and collaboration processes. Cultural and linguistic diversity may hamper communication, leading

to ineffective retrospective meetings. Poor communication bandwidth and transmission quality can also be problematic.

3) Scrum practices which intentionally are simplistic need to be extended or modified in order to support globally distributed software development teams. A few examples are synchronized work hours, strict communication policy, and asynchronous retrospectives.

4) Most studies on agile GSE are successful empirical experiences in which globally distributed teams collaborate over a long time on small to medium sized projects.

5) The most common practices used are continuous integration, daily standup scrum meetings, pair programming, retrospectives, scrum of scrums meetings, and test-driven development (TDD).

These findings are also supported by several of the other secondary studies on GSE that didn't emphasize agile methods in particular ([SLR7], [SLR8], [SLR10]). For example, we see that some of the studies discuss challenges related to establishing effective communication, coordination and control in globally distributed projects. This is relevant as agile methods in many respects are mainly concerned with these aspects of managing software teams.

Finally, we would also like to add a comment on the missing focus on teamwork in agile GSE. We were surprised by the lack of this emphasis. We perceive teamwork as an important topic in GSE as software development depends significantly on team performance, and teamwork is even more challenging in a distributed project
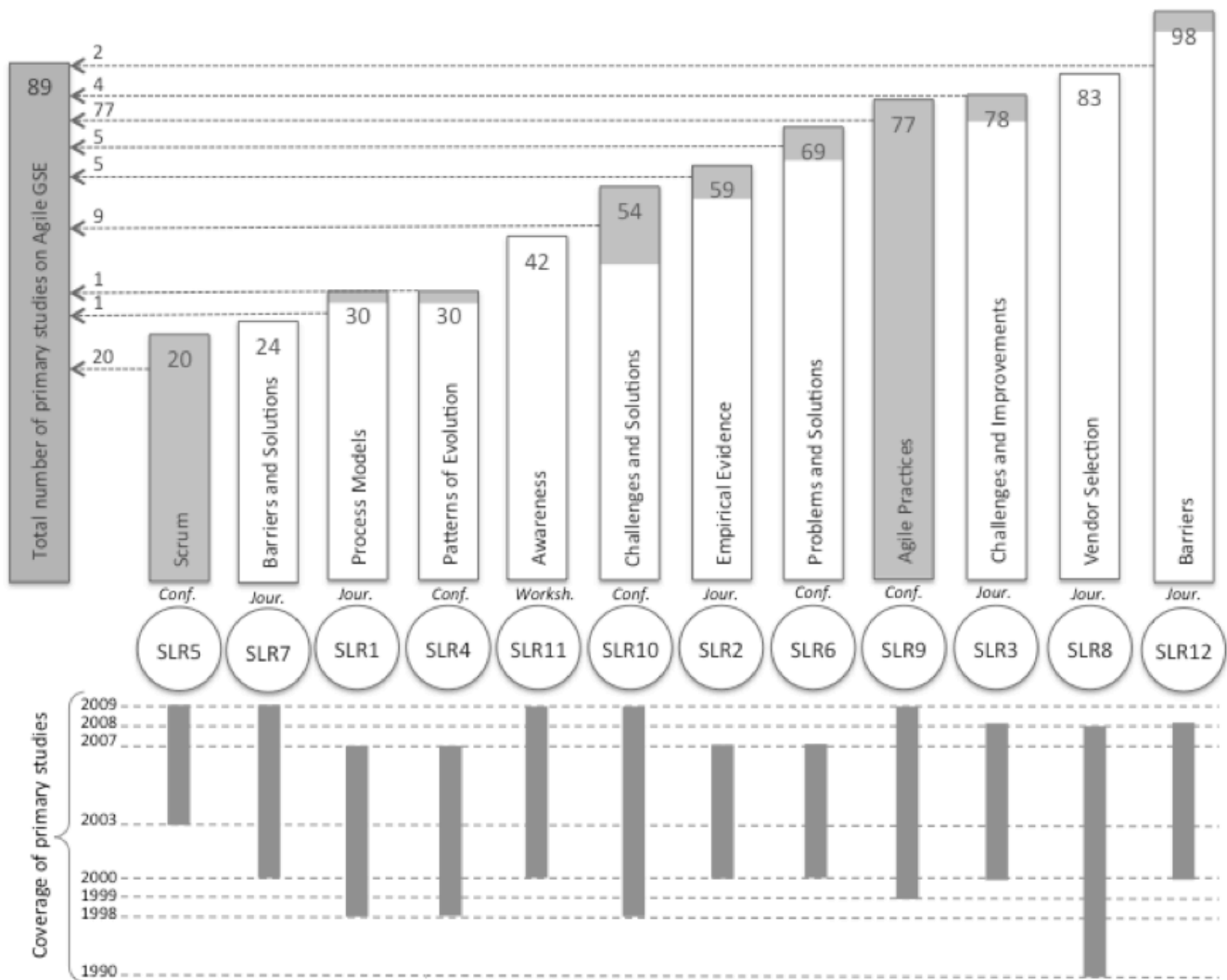

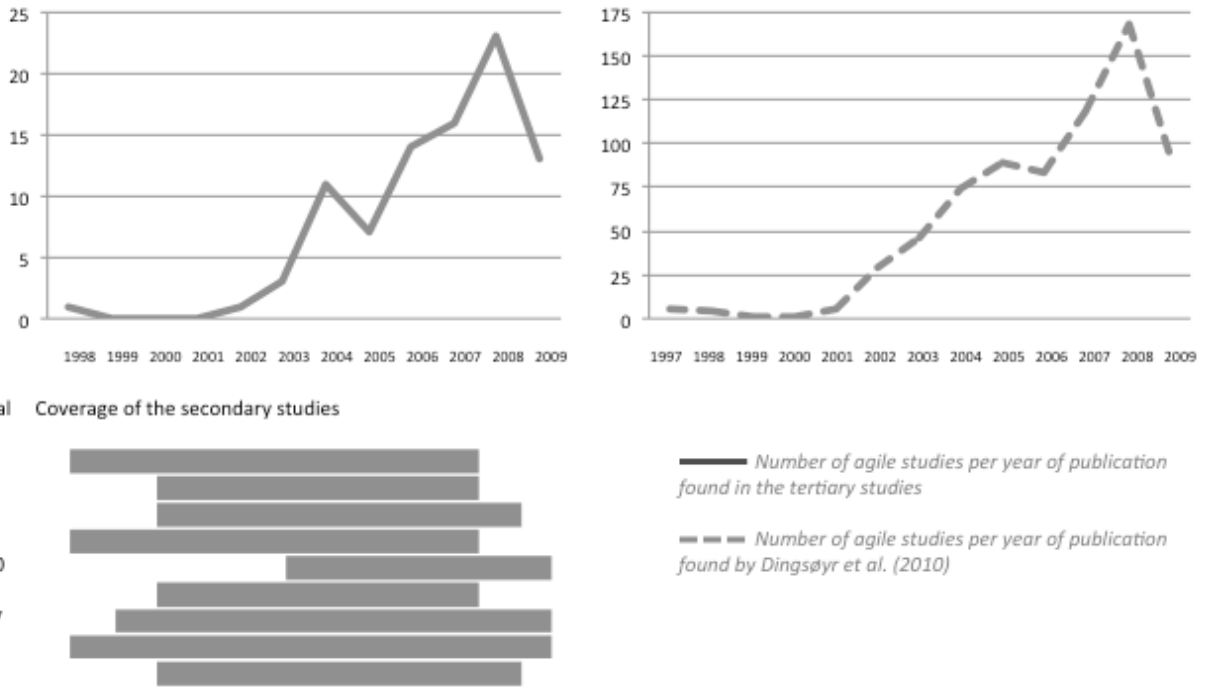Figure 1. Characteristics of the primary studies

Reviews	Total	Coverage of the secondary studies
[SLR1]	1
[SLR2]	5
[SLR3]	4
[SLR4]	1
[SLR5]	20
[SLR6]	5
[SLR9]	77
[SLR10]	9
[SLR12]	2

Number of agile studies per year of publication found in the tertiary studies

Number of agile studies per year of publication found by Dingsøyr et al. (2010)

Figure 2.   Trends in research on agile GSE

IV. DISCUSSION

Returning to the motivation for this tertiary study one may be interested to further explore whether agile and GSE are a good match. The well cited agile manifesto[9] turns 10 years in 2011 but still represents a simple yet precise overview of the core idea of agile methods. We believe that the four fundamental values are worth a revisit:

Individuals and interactions over processes and tools
Working software over comprehensive documentation
Customer collaboration over contract negotiation
Responding to change over following a plan

These are all approaches that naturally become hard to practice in a distributed setting. This conclusion develops across several of the secondary studies that emphasize the natural or inherent problems and challenges that emerge from distributing software work [SLR5], [SLR7] to people who are geographically distributed, meaning that they may have to work asynchronously and within different cultural contexts. Some reported challenges seem particularly relevant to agile practices; such as enabling *effective communication*, *trust*, *knowledge transfer*, and *tracking and control,* as discussed in [SLR10]. Other aspects of relevance

to agile practices are *communication gaps*, *poor relationship management*, and *lack of project management* [SLR12].

On the other hand, this type of challenges, which inherently follow distribution of work, seem like challenges which agile methods and principles are designed or indented to resolve, so to speak. For example, efficient *knowledge transfer* is, according to agile principles [7], ensured through proximity between people, low formalism and a high frequency of communication. Another example is *tracking and control*, which in agile methods ideally are done as simple as possible using "low-tech" solutions and remedies such as whiteboards, paper notes, burn-down charts etc. [8]. This naturally becomes harder in a distributed setting.

We thus conclude that there is sort of *a tension* between agile benefits and difficulties of implementing agile — some challenges, fundamental to GSE, seem solvable using agile practices, but some of these practices cannot be practiced in a distributed setting.

In this tertiary study we have covered just a few examples of practical problems that follow from applying agile principles in globalized work. While on the surface one may believe that there is nothing to do about the distance, we suggest looking beyond the necessity of physical co-location. We argue that many of these are solvable. For example, we have seen that close customer interaction in distributed agile development is feasible by the use of video conferencing

solutions between people that have an already established relationship through previous physical meetings [9]. Other challenges could potentially be addressed by using social networks and related services to compensate for the lack of social connectedness between co-workers [10]. Even such practices as task planning and collective ownership are now mediated through the use of specific technical solutions [11]. Thus we argue that future work on agile GSE should focus on how to cleverly use information and communication technology to compensate for the inherent problems of distributed work and bridge the remote sites together. It is of high importance to facilitate practitioners with answer to the following questions: How can we ensure the benefits and agility of face-to-face like communication in a distributed setting? How can we establish distributed tracking and control showing the same simplicity as a plain whiteboard or similar? How should distributed projects connect and interact with the customer side?

V. CONCLUSIONS

A. Primary findings

To conclude, we seek to address our research questions.

RQ1: Are there any signs of interest in implementing agile methods in global software engineering?

The surprisingly large amount of secondary studies on GSE (we identified 12) shows that there are also an increasing number of studies on *agile* principles and practices in GSE (Figure 2). One explanation is the general popularity of agile software development, which covers most aspects of software engineering, including GSE. Another explanation is that agile practices seem to address some of the inherent challenges following from distribution of work, like complexities in communication, coordination and collaboration. This however creates a tension that potentially can be reduced through clever adaptation of agile principles and practices. Thus, the signs of interest in implementing agile in GSE are growing and this promises, similarly to other settings, the benefits of collaborating closely with customers and delivering quality software within time and budget – but at the same time utilizing development teams in a distributed setting.

RQ2: What is known about the application of agile practices in GSE?

Based on our preliminary overview of the secondary studies we conclude that adoption of agile principles in globalized work is feasible, it has a large potential but may be limited by inherent challenges in distributed work. Distributed work complicates fundamental activities in agile development, such as frequent communication, lightweight coordination and close collaboration. Accordingly, agile practices need

adjustments to function in a distributed context. Notably, most available studies to date are industrial experience reports with little description of study characteristics and context. This has an important implication, as it makes it difficult to judge the applicability of the lessons learned in the readers' contexts.

B. Implication for research

- The research community needs to work towards defining the state of the art and state of the practice in terms of characteristics of the various agile methods used in GSD and lessons learned from applying such methods in industry.

- We find our preliminary results relevant to the growing interest on software ecosystems [9], which address open innovation and collaboration across organizational borders.

- Most agile research is authored in Europe, followed by North America, Oceania and Asia [6]. There is a need to better understand if the same experiences would be applicable for Agile in GSE, where global context is geographically wider, and what the implications for this would be.

- There is a need for a new review on agile in GSD since existing reviews do not cover 2008 – 2011, and from the trend-curve it is expected that most publications on the topic are published in the period from 2008 until 2011.

VI. FURTHER WORK

We believe that the community should develop a common agenda for research on GSE in general and on agile GSE in particular. Quite many of the secondary studies call for more detailed studies ([SLR1], [SLR2], [SLR3], [SLR4], [SLR11]). Another challenge for further studies on these topics is to provide rich (enough) contextual descriptions, several secondary studies conclude that vague or missing background about the studied cases in the primary studies makes it hard to comprehend the results ([SLR1], [SLR2], [SLR3], [SLR4], [SLR9]). This naturally also makes it hard to provide detailed and concise secondary studies. Finally, we also believe that there is a need to develop and test new and innovative approaches to communicate, coordinate and collaborate in distributed contexts while keeping the benefits of agile principles and methodologies.

Finally we would like to comment that quite many of the secondary studies in GSE were published within a short period of time, around 2010 – meaning that several of the authors probably were not aware of the ongoing work of each other. We believe that the collective value of this work in the future would benefit from better collaboration between researchers addressing GSE and agile GSE.

REVIEWS INCLUDED IN THE TERTIARY STUDY

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