

A Systematic Literature Review of Challenges and Critical Success Factors in Agile Requirement Engineering

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ABSTRACT

Nowadays, the complexity of software requirement has been increased due to the rapidly changing requirements. Therefore, Agile software development has been widely adopted as it promises some benefits such as continuous changes and customer satisfaction to handle the increase of complexity. However, agile requirement engineering is still facing some challenges and limitations, hence the process has been widely explored by the academicians and researchers. Hence, this paper aims to investigate and understand the concepts of agile requirement engineering by using Systematic Literature Review (SLR). Initially, 2530 articles were obtained through search without restrictions. Then, the total number of articles was reduced to 145 articles which published from 2002 until March 2018. After analysing the articles, the paper presents ten (10) challenges, seven (7) critical success factors and four (4) issues of agile requirements engineering that need more attention by the researchers in the future studies.

Keywords: Agile software development, agile requirements engineering, systematic literature review.

I INTRODUCTION

Nowadays, Agile Software Development (ASD) has been widely used to handle the increase of complexity in software development industry (Schön, Thomaschewski & Escalona, 2016). ASD provides 12 principles which promise benefits such as on time delivery and customer satisfaction (Dingsøyr & Dyba, 2008). Besides, agile Manifesto promotes a project environment of adoption, teamwork, self-organization, rapid delivery, client based development and clear prioritization which should be addressed for each task in agile methodology process (Elghariani & Kama, 2016). However, Clancy (2014) in the Standish Group report conveyed that fifty eight of the top projects were eliminated due to the elements relevant to requirements which are defective requirements, low client participation, unrealistic expectations, change in requirements and redundant requirements. Moreover, all procedures and stages illustrated on

conventional RE become vague when an agile method is used.

Requirements are the core elements of software products, hence requirement engineering (RE) plays an important role in software development. Traditionally, RE involves with several activities which are elicitation, documentation, validation, negotiation and management. Likewise, exploration, interviews, team collaboration, user involvement, requirement prioritization, requirement modeling and requirement documentation are suggested to be adopted in ASD (Elghariani & Kama, 2016). However, these activities are not clearly separated in agile RE. According to De Lucia and Qusef (2010), agile RE procedures are repetitive and non-sequential whereas Port, Olkov and Menzies (2008) stated that the RE procedures are informal and largely depends on the experience of the practitioners. Agile RE is hard to be explained and distinguished by both the software developers and academicians as it is still vague. Yet, according to Elghariani and Kama (2016) the flexible and dynamic way of agile RE make it able to solve some issues in traditional RE. Moreover, Inayat, Salim, Marczak, Daneva and Shamshirband (2015) have determined that although agile RE provides some promising features such as lesser documentation, quick feedback and prototyping yet there is a need for further research on agile RE and its real-world impact and applications.

Hence, this research has been conducted to investigate the agile RE by using SLR approach. The study aims to determine challenges and limitations of the agile practices, as well as identifying critical success factors of agile RE. The paper is organised as follows: Section II provides the related work on agile RE. Section III describes the research method. Section IV presents the discussion of findings from the SLR. Finally, Section V concludes the paper with a summary of the main findings and future work.

II RELATED WORK ON AGILE RE

In the software engineering field, a number of systematic literature review on agile RE. The articles that mainly focused on systematic literature review on agile RE are Inayat et al. (2015) and Schön et al. (2016). Inayat et al. (2015) conducted a systematic literature review to determine the adopted practices and challenges of agile RE and

traditional RE. They presented seventeen (17) practices which ensure the effectiveness of agile ways of dealing with requirement; five challenges of traditional RE which relate to communication gaps, overscoping, requirement validation, requirement documentation and rare customer involvement; and for the practical challenges of agile RE, the study found eight challenges which are minimal documentation, customer availability, budget and schedule estimation, inappropriate architecture, neglecting non-functional requirements, customer inability and agreement, contractual limitations and requirements and requirements change and change evaluation.

Schön et al. (2016) conducted SLR to derive deep insights on the aspects of agile RE stakeholders and user involvement, data gathering, user perspective, integrated methodologies, shared understanding, artifacts, documentations and non-functional requirements (NFR) from 27 relevant studies. Based on the qualitative analysis of the related studies, they found that there were many problems concerning the direct involvement of users and stakeholders. The study also identified key artifacts for documentation of requirement which are user stories, prototypes, use cases, scenarios and story cards. They stated the need for more empirical evidences that work on agile RE especially on requirement management using various kinds of project settings such as different agile methodologies, scaling and distance of project member to provide appropriate guidelines in practice.

Elghariani and Kama (2016) conducted a systematic review to study on agile RE practices and challenges from 22 research papers. They provide almost similar findings to Inayat et al. (2015) where they found sixteen (16) practices and six (6) challenges of agile RE. The challenges are lack of documentation, client availability, project constraints (budget and time estimation), inappropriate software architecture, ignoring non functional requirements such as security, maintainability, testability and usability; and change of requirement and also re-evaluation.

Fernández, Wagner and Kalinowski Wagner (2017) highlighted on the lack of empirical knowledge on the state of practices and contemporary problems in agile RE. Hence, they conducted an international survey in North America, South America, Central Europe and Northern Europe on agile RE practices and problems. They present some challenges and problems in agile RE practices which include free text documentation, continuous change of requirements, code and requirement are explicitly linked, unmeasurable non functional requirements, communication (with the team and between

developers and customers), incomplete and inconsistent requirements and moving target (in term of changing goals, business processes and requirements).

Moreover, Heikkila, Lassenius, Damian, and Paasivaara (2015) performed a mapping study on agile RE by examining 28 articles and they found that the comprehension towards agile RE is weak. Other than revealing some advantages and troublesome parts of agile RE, they also suggested several resolutions to the challenges.

Furthermore, Soares, Alves, Mendes, Mendonça and Spínola (2015) integrated a literature review with an investigative research where they examined the difficulties while working with requirements in an agile situation and factors that may contribute to documentation debt such as insufficient requirements. Likewise, Alam, Nazir, Asim, and Amr (2017) performed an SLR after analyzing more than 60 articles within 2002-2016, with the goal to highlight the weaknesses in the demonstration of RE stages in agile practices. In addition to that, they also discovered some issues and problems faced by agile practitioners in conducting agile practices.

Indeed, most of the studies focused on the practices in agile RE. However, there are limited articles focused on critical success factors (CSFs) and the gaps in agile RE. Besides, the CSFs can help developers by avoiding serious pitfalls and increasing the chance of successful projects. Moreover, finding the gaps can open the doors to further research in the future studies. Therefore, the study derived the research questions from the weakness of the derived SLR.

III RESEARCH METHOD

The research framework adapted the principles and guidelines advocated by Kitchenham and Charters (2007). Thus, the major procedures of the systematic review which comprised of planning, performing and reporting the review outcomes followed the structure advocated by these authors.

A. Research Question

The study aimed to answer the research questions as below:

RQ1: What are the challenges in agile RE?

RQ2: What are the critical success factors in agile RE?

RQ3: What are the issues regarding agile RE?

B. Search Strategy

The search procedure in this research mainly relied on secondary data from the electronic databases and printed proceedings like ACM, IEEE, Springer Link, Science Direct, ISI Web of Knowledge, Wiley

Inter Science and Taylor & Francis ISI web of knowledge. This included the identification of the search space such as digital libraries and electronic databases. The articles were first obtained from the digital libraries, followed by a thorough analysis to discover other significant articles through the references of the articles. The technique employed was known as snowball sampling. Plus, Digital Bibliographic Library Browser (DBLP) database was utilized in searching the publications of the authors.

The search string used for this study consists of two parts; S1 and S2, S1 is keywords such as “agile requirements”, “agile requirements engineering”. S2 is a string made up of keywords related to agile requirements engineering such as “agile requirements challenges”, “issues in agile requirements”, “success factors for agile requirements”, “agile nonfunctional requirements”.

C. Inclusion Criteria and Exclusion Criteria

This research reviewed a total of 2530 articles related to agile RE. Prior to the application of the inclusion and exclusion criteria, the discussion topic were searched on the digital libraries and databases. In the first round, the irrelevant articles were excluded by filtering the content based on titles, abstracts, and conclusions. At the end of the first round the total articles are 157. In the second round, the articles which do not explain the methodology were filtered and excluded and eventually, from the 2530 articles only 145 were usable.

D. Data Analysis

Among the 145 selected articles, roughly 72 articles were disseminated at conferences, 40 in journals and the rest of 33 articles were disseminated in workshops, symposiums, and magazines. The outcomes also showed that articles conducted preferred some sources of information and this was verified by 72 publications (49.65%) out of 145 publications. Upon the announcement of agile manifesto in 2001, the number of articles conducted on this topic started to increase due to the increase in interest towards ASD. However, the general community including the practitioners still did not comprehend agile RE and did not know how to tackle it even though there were several articles conducted on RE in ASD (Curcio, Navarro, Malucelli, & Reinehr, 2018). Hence, researchers and academicians were inspired and tend to explore deeper in comprehending agile RE. Figure 1 shows the articles published by year. Only one article exist in year 2018 since this study was performed in the beginning of the year.

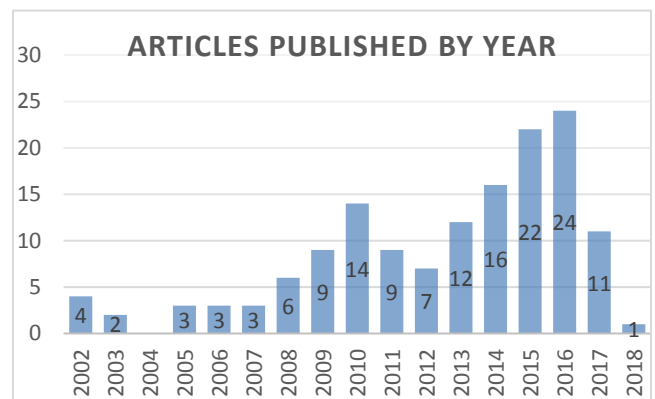


Figure 1. Distribution of the Published Articles

The following segment will explore about the results of SLR pertaining to the SLR questions of RE in ASD as a phenomenon that is still weak (Curcio et al., 2018). Motivated by this need, it is possible to see a tendency of more and more researchers getting deeper in understanding this approach.

IV RESULTS

Table 1 below provides the findings of search articles in the digital library database.

Table 1. Summary of Findings Per Database

Database	Mapping Date	Results
IEEE Xplore	2002 – March 2018	1617
ACM	2002 – March 2018	144
Science Direct	2002 – March 2018	359
Springer Link	2002 – March 2018	288
ISI Web of Knowledge	2002 – March 2018	72
Wiley Inter Science	2002 – March 2018	18
Taylor & Francis	2002 – March 2018	32
Total articles downloaded		2530

Next, the findings of stipulated research questions are presented.

RQ1: What are the challenges in agile RE?

To some extent, agile approaches that encouraged changes have influenced the RE activities in traditional software development. The association between agile approaches and RE as well as the implications brought by the agile approaches were emphasized by many academicians and researchers to have a better comprehension and illustration pertaining to agile RE. According to Cao and Ramesh (2008), the unique characteristics of agile RE that allowed changes and alterations pertaining to the consistent inquiry and feedback from the stakeholders triggered the introduction of requirements during the development process. Wolfgang (2011) discussed that agile approaches

did not support the stage-driven methods and the alterations were persistent. This feature made the agile RE different from the requirements of conventional software development. Agile approaches aimed to tackle many challenges of RE practices and this was the main reason why academicians and practitioners are still keen on conducting research on agile RE. Table 2 shows ten (10) challenges that identified.

Table 2. Challenges in Agile RE

Challenges	Description	Reported Articles
Minimal documentation	User Cards such as user stories and task description and backlog are the only documents in agile RE	Schön et al.(2017), Elghariani and Kama (2016), Inayat et al.(2015), Daneva et al. (2013), Carlson and Matuzic (2010), Ramesh, Cao, and Baskerville (2010), Cao and Ramesh (2008), Goetz (2002)
Customer Availability	Clients availability to specify the requirement and feedback	Elghariani and Kama (2016), Inayat et al.(2015), Daneva et al. (2013), Ramesh et al. (2010)
Inappropriate Architecture	Inadequate infrastructure can cause problems during later project stages	Elghariani and Kama (2016), Inayat et al.(2015), Ramesh et al. (2010)
Accuracy of Estimates	Not possible to make upfront estimates due to unstable requirements	Alam et al.,(2017), Elghariani and Kama (2016), Inayat et al.(2015)
Requirements Prioritization	Prioritization of the requirements for all iterations should meet the customer satisfaction	Asghar et al. (2017), Asghar et al. (2016), Ramesh et al. (2010), Cao and Ramesh (2008)
Contractual Limitations	Fixed-price contracts do not allow changes	Ramesh et al. (2010) Daneva et al. (2013)
Neglecting NFRs	Ignoring the NFRs until a later stage	Behutiye et al (2017), Alam et al.,(2017), Elghariani and Kama (2016), Inayat et al.(2015), Maiti and Mitropoulos (2015), Cardinal (2014), Farid and Mitropoulos (2012), Ramesh et al. (2010), Cao and Ramesh (2008)
Customer Inability and Agreement	Incomplete domain knowledge and in consensus among customer groups	Heikkila et al. (2015) Ramesh et al. (2010) Cao and Ramesh (2008)
Requirements Change	Welcome requirement changes at any time	Alam et al.,(2017), Elghariani and Kama (2016), Inayat et al. (2015), Ernst, Borgida,

		Jureta, and Mylopoulos (2014), Sarkan, Ahmad and Bakar (2011)
Missing Requirements	Requirements are not identified in the beginning or discovered after detailed design	Mendes et al. (2016) Bjarnason et al. (2016) Soares et al. (2015) Larsson and Borg (2014)

RQ2: What are the critical success factors in agile RE?

Generally the determinant factors can be classified into four dimensions namely organization, people, project and process. In fact, different researchers who investigated the same factor in distinct studies might discuss the matter in a different way. This is obviously seen when the ‘top-level management support’ factor was classified under organizational factor by Robert, Cavana, and Daellenbach (2015) whereas Nasir and Shamsul (2011) believed that it should fall under people factor. On the other hand, there are studies that did not employ the classification approach to categorise the factors (Kouzari, Gerogiannis, Stamelos, & Kakarontzas 2015; Mohanarajah & Jabar, 2005). Robert et al. (2015) further subdivided the people factor into client and team factors and such phenomenon implies that there is a lack of uniformity for the classification of CSFs. Hence, based on qualitative review, the CSFs in agile RE can be are categorized as accuracy of estimates (precision of approximation), environment and culture of the organisation, training, client participation, development approach, communication, and the size of the project.

RQ3: What are the issues regarding agile RE?

Through the analysis related articles, the study managed to discover four main issues regarding the agile RE.

1. Insufficient Empirical Assessment Studies: Wohlin, Höst, and Henningsson (2003) assessed their study by employing controlled empirical study and they believed that the classification like a case study, questionnaire or a post-mortem examination could be regarded empirically analysed. On the other hand, the articles that employed other approaches such as simulations, comparative articles or focus group were regarded as non-empirically examined. Throughout the detailed examination, the study managed to find that among the identified articles, there were only 59 articles were empirically examined and 86 articles were not empirically evaluated. This revealed that around 59% of the articles were not validated empirically.

2. Limited Studies for Change Management: This matter is closely associated with requirements

management and one of the basic phases in agile RE. In the perspective of requirements management, only 6 articles were found to be relevant. Other than examining on how to respond to rapid change in requirements when working with ASD, Butt and Ahmad (2012), as well as Soundararajan and Arthur (2009), also tackled on the approaches to adapt them. Similarities and distinctions between the agile and conventional methods (V-model) in handling volatility in requirement gathering were also discussed by Anitha, Savio, and Mani (2013) and Sillitti, Ceschi, Russo, and Succi (2005). To tackle the expensive cost of accommodation towards the requirement changes, Ernst et al. (2014) introduced a structure known as RE-KOMBINE. This framework aimed to assess the factors that could support the featherweight agile requirements process that could be altered, interpreted and modeled comprehensively. Shim and Lee (2017) believed that although it would be flexible, it is still hard to learn and adopt in reality as it is a formal approach. However, the change management is considered as a challenge in agile RE and still need further research in future studies.

3. Neglecting Non-functional Requirements:

Although there is a wide coverage on the articles pertaining to non-functional requirements (NFRs), it is crucial to explore other subjects associated with the quality requirement. The researchers have agreed that ASD approaches are gaining popularity in their community. However, Farid and Mitropoulos (2012) discussed that the agile approaches had not sufficiently modeled NFRs and their prospective resolutions. Moreover, Curcio et al. (2018) also commented in their study that the agile development approaches did not have the clear practices for NFRs. Farid and Mitropoulos (2012) also introduced NORMAP in the effort to resolve the NFRs. Moreover, NORMATIC is a simulation instrument which is Java based and it also helps to model the NFRs for semi-automatic processes whereas NORMAP is a featherweight engineering of NFRs for agile processes. However, these methodologies have limitations and weaknesses (Maiti, 2016). Moreover, the NFRs are still not taken seriously and are often considered as an afterthought towards the end of the development phase in ASD (Maiti, 2016; Saadatmand, Cicchetti, & Sjodinm, 2012). Indeed, the neglecting NFRs in agile RE need for further research in future studies.

4. Limited Studies for Measuring Requirements:

Such topic is closely associated to the postulation of volume which is useful in examining the size of requirements change, in approximating the price of a task related to development or maintenance or even merely to be used as the denominator in different measurement. Among the 145 articles

selected after applying the exclusion and inclusion criteria, only four articles were related to this topic. Dragicovic, Celar and Turic (2017) introduced a Bayesian network model which was helpful and effective in effort estimation in agile approaches. The prime aim of the study was to discover an approach that could help to ease the evaluation of the required effort. A replication study was conducted by Ochodek (2016) which founded on an approach advocated by Hussain, Kosseim, and Ormandjieva (HKO). The approach introduced by HKO could be employed to spontaneously categorise textual requirements concerning their COSMIC functional size. By supplying extra information to the agile teams, the effort estimation was expected to be more precise. However, there was a major drawback where the categorization performance deteriorated with the increase of size classes' number (Ochodek, 2016). Grapenthin, Book, Richter and Gruhn (2016) presented the outcomes of a research that evaluated the result of employing risk and effort annotations on the degree of shared comprehension of project teams, the precision of estimation and approximation bias. The prime factor for the vast distinction between actual and estimation effort was the challenges pertaining to requirements. Usman, Börstler, and Petersen (2017) discussed the reasons like terribly defined user stories, neglecting the NFRs, missing requirements, and requirements change. Story points or planning poker was employed to evaluate the effort required to execute a user story by the agile teams. Moreover, the estimation techniques base on the knowledge of stakeholders, however the lack of prior experience might lead to various problems (Ochodek, 2016). On the other hand, the accuracy of effort estimation is one of the prime factors for the project's success. Indeed, future studies should focus on the reasons for the inaccuracy of effort estimation and how to address it.

V CONCLUSION

This paper presents an SLR on challenges, CSFs and issues pertaining to agile RE. The guideline of conducting the SLR is adopted from Kitchenham and Charters (2007). A total of 2530 articles related to agile RE were found in common electronic databases which were published from 2002 until March 2018. Out of these articles, only 145 articles were further analysed and examined for answering the stated research questions. Hence, the findings in this study provides future dimensions to industry and research experts for further work on agile RE.

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