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Software Quality Issues in SCRUM: A Systematic Mapping

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Abstract: Scrum is a process framework used to develop complex software. As Scrum is one of the prominent approaches in agile development projects, it is significant to define the issues of quality in the Scrum method. In this paper, a systematic mapping approach is adopted to answer specific research questions through an objective procedure to identify the nature of quality issues in Scrum studies. For this purpose, a number of research studies are reviewed in electronic databases to find out about various quality issues related with Scrum. Here, the focus is on how these studies are affective in terms of defining such issues. A total of 53 research papers are examined in detail to answer nine research questions related to quality issues in Scrum. Finally, the responses to all research questions are provided along with suggestions to ensure quality in the Scrum. The results reveal that there is very limited research on people-related quality issues such as employee skills, satisfaction etc. However, process quality such as process effectiveness, conformity, visibility, acceptance etc. have received a lot of attention among researchers, whereas the product quality and project-related quality issues such as team performance, collaboration, etc. are also of interest among researchers.

Keywords: Quality, SCRUM, Agile Methods, Systematic Mapping, Quality Attributes, Metrics
Categories: D.2, D.2.8, D.2.9, D.2.m

1 Introduction

Recently, there have been many success stories in software development industry using agile methods, which is why it is being adopted widely by various software development organizations. Agile methods have passed early innovation adoption phase and become mainstream [Version one 2016]. Therefore, adoption and transformation is no more a central concern for practitioners [Mishra et al. 2017]. Agile methods have proven to be beneficial due to their focus on individuals and interactions over process and tools, working software over comprehensive documentation, collaboration with customers over contract negotiation, and responding to change over rigid planning. Agile methods promote teamwork, rich and precise communication, and the iterated delivery of running tested systems comprising the highest priority customer features [Mishra and Mishra 2011]. Active

participation of the user during development is one of the important principles of Agile methods [Mishra and Mishra 2010]. The Agile methodology has the ability to accept and efficiently manage change. It copes with unstable requirements by utilizing various techniques, out of which the most significant ones are: easy planning, short iteration, early release, and customer feedback. These attributes empower agile methods to release software within less time when compared to the waterfall approach [Ullah and Zaidi 2009]. Briefly, Agile approaches have many benefits, such as increasing productivity, expanding test coverage, improving quality, reducing time and costs, and higher customer satisfaction as some researchers suggest. Such benefits make the Agile approaches the first choice for developing any type of project [Serrador and Pinto 2015, Jeldi and Chavali 2013]. According to the 2012 CHAOS report from the Standish Group, Agile projects are three times more often successful than non-Agile projects [Chan 2013].

There are different agile methodologies, such as eXtreme Programming (XP), feature-driven development (FDD), dynamic systems development method (DSDM), Scrum and others. XP was the most popular method at first, but Scrum took over because it focuses on project management via Scrum master [Aamir and Khan 2017], and also due to its short development cycle as well as fast response time to change requests, it is now extensively used in the software development organizations [Aamir and Khan 2017]. Scrum framework is formed by a basic arrangement of practices and rules based on the Agile Manifesto, which envelops transparency, adaptation, and inspection. The pulse of Scrum is the Sprint; a time-boxed period, which in general differs from 2 to 4 weeks, where the Scrum team has to build and deliver part of working software [Wan et al. 2013, Luz et al. 2009]. It is a process which permits the developers to concentrate on delivering the highest business value in a short time. To attain a common goal, the development team has to work as a unit as opposed to the traditional methods [Jeldi and Chavali 2013]. There are three basic roles in Scrum which are: 'product owner', 'Scrum Masters' and 'development team' [Lee 2012]. It is important to know the advantages of using Scrum while working on any project. For instance, customer satisfaction in the Scrum is ensured by optimizing a turnaround time and responsiveness to demands. In terms of the project schedule, the Scrum enables more controlled, speed, and adaptability to changes [Mahalakshmi and Sundararajan 2013]. In addition, it is one of the methods of choice used to handle complex software development projects by applying iterative and incremental practices [Aamir and Khan 2017].

The quality of software is the main focus of an organization in a project. The choice of development process has a profound effect on the software quality. Therefore, to build a high quality software, it is expected to develop it in the best ways [Ullah and Zaidi 2009]. It is also important to know that, as a software evolves due to functional and non-functional changes, it requires Quality Assurance (QA) of both the product and the process. Moreover, a basic supposition of quality management is that the nature of the improvement and the testing processes specifically influence the quality of the product [Fuggetta 2000, Cugola and Ghezzi 1998, Kitchenham and Pfleeger 1996]. Zhao et al. [2014] implemented the exit criteria methodology using Scrum to control the quality of the system during the entire duration of a sprint and stated that the product quality ought to be controlled through the entire process, from the plan to the examination, and it should evaluate

the product itself as well as the product improvement process [Zhao et al. 2014]. As such, in the agile environment QA activities have to be incorporated into teams' daily activities so that it can move consistently to yield the expected benefits for product quality improvement [Bhasin 2012]. Early involvement and flexibility to adjust to continuous changes are the key to successful QA [Hewlett-Packard 2011].

Scrum is one of the agile approaches, which can be used as a solution for quality issues [Vijayasarathy and Turk 2008] since it has long been acknowledged as the most prevalent agile method [Dikert et al. 2016], and the interest in Scrum is increasing over time [Dingsøyr and Lassenius 2016]. Scrum works well with complex projects [Schwaber et al. 2007, Schwaber 2004]. To deal with complexity using the Scrum, the quality is considered as the main concern while developing a project [Luz et al. 2009]. Jeon et al. [2011] further mentioned that despite the known advantages of Scrum, it has three disadvantages: First, the backlogs of Scrum focus only on functional features, making it difficult to effectively reflect the quality attributes; second, these backlogs focus on implementing functional backlogs without a traceability analysis of the relationships among them; third, current agile methods are focused on individual teams or project needs, making it difficult to use the method in organizations with multiple cooperating teams [Lindvall 2004]. Therefore, it is important to address the quality issues in Scrum. The main backbones of the Scrum are its iterative process and continuous feedback [Harvie and Agah 2016]. Li et al. [2010] observed that continuous daily feedback received during sprint retrospective meetings proceed with more focus on software quality. The quality assurance practices of different agile methodologies have been studied by few authors [Mnkandla and Dwolatzky 2006, Timperi 2004]. Abbas et al. [2010] further supported that quality in agile projects as a key contributor to project success. The research and study on the quality of software development process is scarce because it is very difficult to collect data and verify the results [Zhao et al. 2014]. Furthermore, there is no systematic review, specifically a systematic mapping study, which shows the current state of the quality-related issues in Scrum. Systematic mapping is a methodology that is used to categorize the primary research papers in a research area [Catal and Mishra 2013]. Systematic mapping studies and systematic literature reviews are widely used in medicine, but are also common in other disciplines such as sociology, psychology, and, recently, software engineering [Kitchenham and Charters 2007]. These types of studies are the main methods of synthesis for Evidence-Based Software Engineering (EBSE), which applies an evidence-based approach to software engineering [Catal and Mishra 2013].

The objective of this systematic mapping study is to examine which quality aspects of the Scrum have been studied in the most detail, determine which quality attributes and metrics have been used as a basis for the quality assessment and improvement in Scrum research, and evaluate the current trends of this research area. Hence, a systematic mapping study has been performed to identify, select, synthesize, summarize, and assess all relevant studies related to this research topic. The availability of a systematic mapping study on the quality issues in Scrum can change the research perspective in this area, and also identify little researched areas [Kitchenham 2009]. Therefore, the results of the present study can be useful for both academics and practitioners.

This paper systematically reviews 53 journal and conference papers on the quality

issues in Scrum in assess the current status of the research so far and to direct future research in this area. There are two main contributions of this systematic mapping study. First, to the best of our knowledge, this is the first systematic mapping study on the quality issues in Scrum. Second, research papers are classified with respect to the quality area explored, quality attributes used for undertaking quality improvement initiatives, study context, and quality metrics used for evaluation. Accordingly, a classification based on several factors such as these can offer a better perspective for a systematic mapping study.

This paper is organized as follows: Section 2 reports the related work in this area. Section 3 presents the methodology used for this systematic mapping study whereas Section 4 provides results. While Section 5 illustrates the discussion and suggests issues for further research in this area, section 6 provides conclusions. Subsequent section shows the research papers used in the present study and finally a list of 53 papers included in this systematic mapping study is provided in the appendix. The reference style [Sd#] is used while referring to a paper listed in the appendix.

2 Related work

Scrum is a light-weight process framework under agile software framework, and the most widely-used one [Dikert et al. 2016]. A "process framework" is a particular set of practices that must be followed in order for a process to be consistent with the framework [cPrime 2013]. For example, the Scrum process framework prescribes time-boxing and software is developed via a series of iterations called 'Sprints', the XP framework requires pair-programming. "Lightweight" means that the overhead of the process is kept as small as possible to maximize the amount of productive time available for getting useful work done [cPrime 2013].

A Scrum process is different due to its specific concepts and practices, which are divided into three categories: Roles, Artifacts, and Time Boxes. However, Scrum is most often used to deal with complex software and product development by using iterative and incremental practices [cPrime 2013]. It also enables organizations to adapt smoothly to fast-changing requirements of operations, and the production of a product that meets the evolving business objectives [cPrime 2013]. In this way, Scrum projects are assisted to achieve the highest customer satisfaction rates. Using Scrum can also be helpful to avoid some problems that can be faced during the development of any project. There are many studies that have used the Scrum method to avoid some obstacles.

Harvie and Agah [2016] modified the traditional Scrum based on three inspirations from mission command: end State, line of effort, and targeting. As a result, they have found that targeted Scrum did well in terms of helping the software development teams in the planning and identifying of the priorities of requirements, thereby improving the external and internal communication between the software development teams. Hong et al. [2010] customized the Scrum method for outsourced e-commerce software projects by tailoring the method in three ways: First, they made a table that illustrates the roles and responsibilities of the members of the project team for each stage. Second, sprint planning was divided into two phases. Finally, the project progress was monitored based on the number of completed web pages. Consequently, it was found that the modified Scrum method improved the quality of

the product and reduced the time needed to finish the project [Harvie and Agah 2016, Hong et al. 2010].

According to Sutherland et al. [2007], combining agile methods (Scrum) with CMMI in projects assists in providing the best quality software that meets the needs of customers at a faster pace. They observed that the first pilot projects in terms of productivity showed Scrum teams almost twice as successful as those of traditional teams as it can decrease the defects found during the final test by 40%. Weitzel et al. [2014] reports of a long-running Scrum project carried out in cooperation between industry and research in a so-called "joint research and development laboratory". They were able to decrease dramatically the refactoring effort and increase the speed of development without exceeding expenses by introducing the idea of "epic-architectures", which is the designed architecture for a coherent set of user stories [Sutherland et al. 2007, Weitzel et al. 2014]. Quality attributes, such as scalability and performance might be fulfilled using several architectural strategies to rate the importance of quality attributes in the system and the impact of architectural strategies on these quality attributes [Lopes and Junior 2017].

In terms of the adoption of the Scrum method in the context of the development of academic projects, Luciano Pinto et al. [Pinto et al. 2009] used Scrum in the development of academic projects in each of the undergraduate and graduates courses, to find a solution to the problems of poor self-management and insufficient division of activities. Ashraf et al. [2012] also adopted an Agile-Scrum model for the development phase of the final year project) to find a solution to the problem of the lack of coordination between the students and the limited interaction between the student and the supervisor. As a result, the proposed model increased student participation, coordination, and interaction between the student and the supervisor in a five-year project [Pinto et al. 2009, Ashraf et al. 2012]. In addition, Lin et al. [2014] suggested a light-weight Goal-Net based method, which can assist to model goal requirements in the process of agile software development, and the proposed method was assessed in the Agile software engineering projects at the university level. The method reached more than 50% improvement in terms of the proportion of high-quality user stories generated by the students [Lin et al. 2014].

According to Permana and Bali [2015], some of the benefits of using Scrum are as follows:

- Task Details Estimation: using the Scrum method allows the details of each task to be seen clearly at the end of each sprint;
- Quality: Scrum guarantees quality since Sprint offers strength for teams to begin the process of developing software that has been decided ahead of time;
- Quality Control: quality of the application is noticeable at the end of the sprint because quality control can be assessed at the end of the sprint;
- Application View: Since each team shows the job that has been done at the end of the sprint, as a result the display of the product being created is noticeable at the end of the sprint;
- Business Change: Once the product is illustrated, if there are any business transforms, they will be directly examined in the final sprint;
- Customer Feedback: The customer sees the product demo, and if the customer provides any feedback, it will be directly examined in the final

sprint; and

- Project Monitoring: With the Monitoring Board and online monitoring board, it offers straightforwardness and the chance to monitor the project whenever possible.

According to Koka [2015], software quality assurance measures should be applied to ensure quality in a project using Scrum. To guarantee quality assurance is included in the Scrum, and there are certain issues to be taken into account; for example, Scrum teams (especially Scrum leaders) should compel the others to adhere to standards in spite of time pressures and tight due dates [Harvie and Agah 2016]. It seems that the practice of close customer collaboration throughout the project due to their involvement in sprint review and retrospective meetings is working as a quality assurance mechanism [Harvie and Agah 2016]. Also, the final product is tested with customers. This practice is promoted and should be maintained. Code reviews must be upheld [Harvie and Agah 2016], and companies should invest resources into assets as well as steadily preparing developers, project software owners, project managers, team leaders and business analysts to routinely meet with the client to check necessities preceding the execution stage [Koka 2015]. Dynamic stakeholder contribution can limit advancement expenses and time [Koka 2015]. QA Analysts typically make test case scenarios based on user requirements. They also identify and capture complex and negative scenarios. They have to work closely with the technical writers and testers, while learning new skills, and expanding their expertise in new areas [Hasija 2012].

There are several metrics, which can be used to measure the performance of a Scrum team. Some of the metrics that can help the Scrum team to improve quality are: Scrum Metrics for Satisfaction, Scrum Metrics for Maturity, Scrum Metrics for Alignment, Scrum Metrics for Quantity and Scrum Metrics for Quality. Scrum metrics for quality can be used to assess if the delivered product is of high quality. Theses metrics include: defect count and the fault severity [Prowareness 2009]. Defect count is just a gathering of every single known defect in the product. Clearly, a low number of bugs means the software is high quality. In terms of the Fault Severity metric, it can be utilized to measure the severity of known defects [Prowareness 2009]. The use of quality metrics is important to measure and control the quality of a software.

3 Research Method

In this paper, a systematic mapping study, as shown in figure 1, is used to determine the nature and the extent of the available research papers to respond to specific research questions.

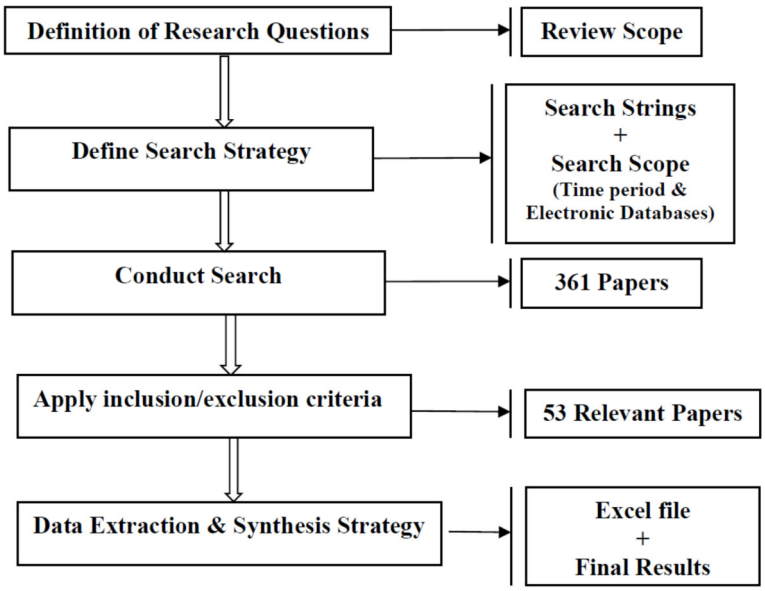

Figure 1: The Systematic Mapping Process

3.1 Definition of Research Questions

Research questions (RQs) were set up to determine the initial studies that explore quality issues in the Scrum as given in table 1.

3.2 Define Search strategy

The following key words and their synonyms were identified to search for relevant documents in electronic databases: “quality”, “SCRUM”, “Quality issues in Scrum”. A logical operator AND was used to create a combination of the basic terms. The final search was done in the following formats: [(“quality” AND “SCRUM”)]. The time period was set between 2008 and 2017 when this SM was conducted. Five electronic databases were selected, as shown in table 2.

Research questions	Main motivation
RQ1: Which journals and conferences are more focused on quality in SCRUM?	Identify the important journals and conferences in this area. Additionally, support researchers with a list of journals and conferences with potentially relevant papers.
RQ2: What is the yearly distribution of articles?	Assess the vulnerability of research related with quality issues in Scrum. Reduced research in recent years may increase vulnerability.
RQ3: What is the country-wise distribution?	Identify the countries contributing the most to research. If research is taking place in multiple countries, it potentially shows that this topic may be relevant for researchers in many places.
RQ4: How many researchers have a long-term interest in quality in Scrum?	Assess the vulnerability of research related with quality issues in Scrum. Having few researchers may increase vulnerability.
RQ5: What is the distribution of student/simple projects versus professional projects in the literature review?	Provide recommendations, if necessary, for the change of use of the projects' data.
RQ6: What are the different sub-areas explored within quality?	Identify the quality areas most widely explored. Moreover, determine those quality areas not studied extensively and, hence, still having potential for further research.
RQ7: Which quality attributes are used as the reason for undertaking quality assessment/improvement studies?	Identify which quality attributes are widely used for quality assessment and improving initiatives in the Scrum.
RQ8: How many papers have used quality metrics for quality assessment or improvement?	Identify the number of studies using quality metrics for quality assessment and improvement in Scrum. It may identify the strength (or shortcomings) of the current state of art in this area.
RQ9: Which quality metrics are used?	Identify the frequently- used quality metrics for the evaluation of quality assessment and improvement in Scrum.

Table 1: Research questions and main motivation

Source	Location
IEEE Explore	http://ieeexplore.ieee.org
ACM Digital Library	http://portal.acm.org
Science Direct	http://www.sciencedirect.com
Springer	http://www.springer.com
Scopus	https://www.scopus.com
Web of Science	http://apps.webofknowledge.com

Table 2: Selected databases

3.3 Execution

In this phase, various electronic databases were searched using the search string. Initially, around 361 preliminary studies on quality issues were found related with the Scrum.

3.4 Apply Inclusion/Exclusion Criteria

In general, the title, abstract, and conclusion were reviewed to identify articles that focus on Scrum and quality of the product, process, project and people. There were some papers that were excluded based on the following criteria:

- Studies not offered in English.
- Studies not available in full-text.
- Studies not related with Scrum quality
- Literature review studies

Table 3 shows the number of papers that have been initially obtained and later included in this study after applying the exclusion criteria.

Database	Obtained	Included
IEEE explore	138	15
ACM digital	80	5
Springer link	78	6
Scopus	40	15
Web of Science	25	12
Total	**361**	**53**

Table 3: Articles related with quality in Scrum

3.5 Data Extraction and Synthesis Strategy

A spreadsheet was created for the data extraction properties for each category as shown in table 4. The data extraction properties were discussed and agreed upon between the authors and also mapped to research questions.

Category	Properties	RQ Mapping
General information	year of publication, type of publication, authors	RQ1, RQ2, RQ3, RQ4
Context	subject type (students/professionals)	RQ5
Quality sub-areas	process quality, product quality, quality of project related aspects, people quality	RQ6
Quality attributes	various quality attributes such as correctness, productivity, reliability, complexity, etc.	RQ7
Quality metrics	quality metrics such as development efforts, No. of bugs detected, etc.	RQ8, RQ9

Table 4: Extracted data categories along with data extraction properties and mapping to research questions

4 Results

RQ1. Three-fourth of all the articles have been published in conferences as shown in figure 2.

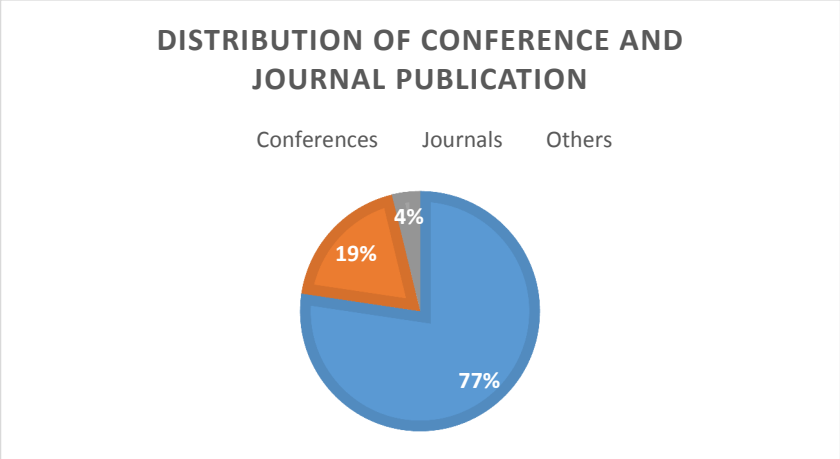

Figure 2: Distribution of Journal & Conference Papers

There are eight different conferences that have published more than one paper related to quality issues in the Scrum as shown in table 5, and the rest of were published in different conferences.

Conference Name	Number of Papers	Articles
Agile Conference (AGILE)	5	[Sd3, Sd4, Sd24, Sd26, Sd43]
Hawaii International Conference on System Sciences (HICSS)	3	[Sd9, Sd11, Sd18]
Agile Software Development Conference (XP)	2	[Sd36, Sd52]
Empirical Software Engineering and Measurement (ESEM)	2	[Sd17, Sd48]
Global Software Engineering (GSE)	2	[Sd7, Sd29]
Adaptive Science and Technology (ICAST)	2	[Sd14, Sd30]
Computational Science and its Applications (ICCSA)	2	[Sd22, Sd34]
SoutheastCon	2	[Sd12, Sd13]

Table 5: Conference with high focus on quality in SCRUM

In terms of journal papers, it is difficult to distinguish which journal has more than one paper related to the quality topic in the Scrum, because there are ten journal articles and all of them appeared in ten different journals, as shown in table 6.

Journal Name	Number of papers	Articles
IEEE Transactions on Software Engineering	1	[Sd6]
IEEE Software	1	[Sd16]
International Journal of Advanced Computer Science and Applications (IJACSA)	1	[Sd21]
International Journal of Appl. Math. Computer. Sci.	1	[Sd23]
Innovations in Systems and Software Engineering	1	[Sd28]
International Journal of Applied Engineering Research	1	[Sd33]
Robotics and Computer-Integrated Manufacturing	1	[Sd35]
Journal of Software: Evolution and Process	1	[Sd39]
Australasian Journal of Information Systems	1	[Sd42]
Technical Gazette	1	[Sd44]

Table 6: Journal with higher focus on quality in SCRUM

RQ2. This study includes papers published between 2008 and 2017. The number of articles published in 2016 is higher compared to other years by 12% as shown in figure 3. Meanwhile, the lowest number in this regard was in 2009 and 2017.

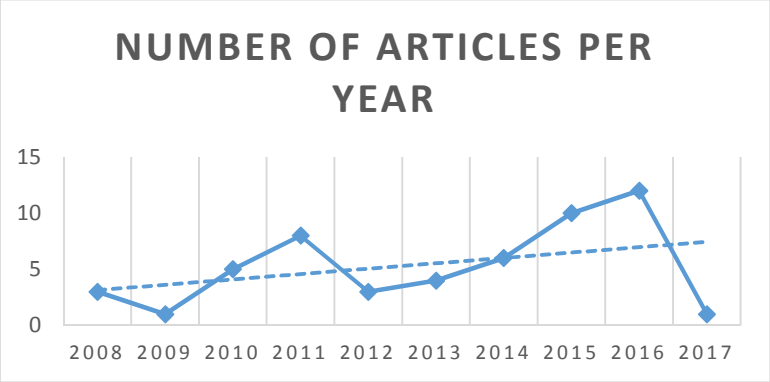

Figure 3: Number of papers per year

RQ3. Main authors of the publications, included in the present study, are from twenty different countries as shown in table 7. Most of the lead authors are from the U.S.A followed by Brazil and India as the countries having the highest number of authors in this area of research.

RQ4. 53 research papers are published in this area involving 146 authors. Most authors have written a single paper or participated in one paper. However, seven authors have written two papers each. Three of them have published only in conferences while the rest have written one paper each for a conference and a journal, as shown in table 8.

RQ5. Comparing student/simple projects with professional projects provided a clear idea whether the articles' results are based on real professional projects or not. It can be seen from figure 4 that the ratio of professional projects (49 articles) is much more than student or simple projects (4 articles).

RQ6. The areas explored within quality in this study are: process quality, product quality, quality of project related aspects and people quality. For this reason, in this question we intend to find out which sub-area received more attention from researchers.

Country	Number of Journals and Conference Publications	Articles
USA	14	[Sd4, Sd6, Sd11, Sd12, Sd13, Sd16, Sd17, Sd24, Sd26, Sd28, Sd31, Sd35, Sd37]
Brazil	7	[Sd3, Sd5, Sd9, Sd39, Sd41, Sd43, Sd46]
India	6	[Sd29, Sd33, Sd34, Sd47, Sd49, Sd53]
Pakistan	3	[Sd2, Sd15, Sd21]
Finland	3	[Sd7, Sd27, Osd40]
China	2	[Sd1, Sd19]
South Africa	2	[Sd14, Sd30]
Spain	2	[Sd23, Sd38]
Australia	2	[Sd42, Sd51]
Norway	2	[Sd36, Sd48]
Germany	1	[Sd8]
South Korea	1	[Sd10]
Bangladesh	1	[Sd20]
Portugal	1	[Sd22]
Malaysia	1	[Sd32]
Montenegro	1	[Sd44]
Morocco	1	[Sd45]
Canada	1	[Sd50]
Italy	1	[Sd52]
Austria	1	[Sd25]

Table 7: Country wise distribution

Author name	# Journal	# Conference	Total	Articles
Karlheinz Kautz	1	1	2	[Sd42, Sd51]
Thomas Heide Johansen	1	1	2	[Sd42, Sd51]
Andreas Uldahl	1	1	2	[Sd42, Sd51]
Imrul Kayes	1	1	2	[Sd20, Sd28]
Frank J. Mitropoulos	-	2	2	[Sd12, Sd13]
Carsten Ruseng Jakobsen	-	2	2	[Sd4, Sd26]
Jeff Sutherland	-	2	2	[Sd4, Sd11]

Table 8: Distribution of papers per author having more than one paper

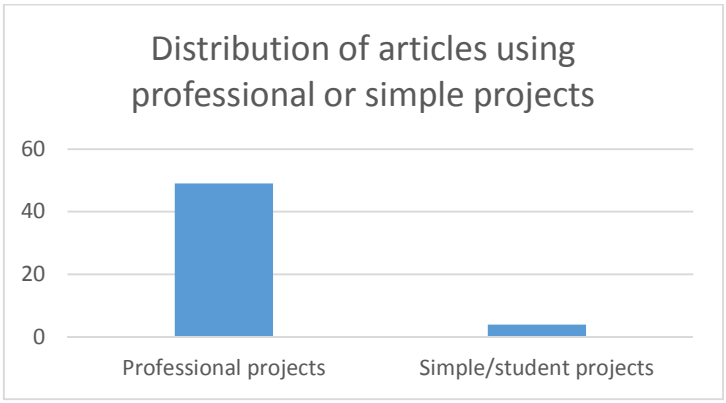

Figure 4: Distribution of articles using professional/simple projects

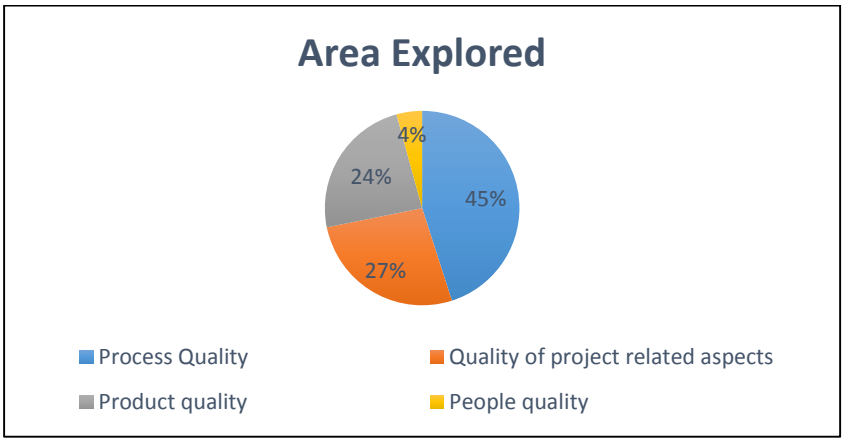

Figure 5: Articles distribution according to their focus on different quality areas

Many articles explored more than one sub-area, but the most examined sub-areas of quality is the process quality (assessment and improvement), whereas, the number of articles related with project related quality aspects is almost similar to product quality as shown in figure 5.

RQ7. Although the studies focus on different areas such as process quality, project-related quality, product quality, people quality, the objective of these studies is to achieve some improvement in the underlying quality attributes related with process/project/product/people. Studies focusing on process assessment and improvement not only improve process visibility/conformity/effectiveness but also product quality (correctness/maintainability/completeness) as well as project-related quality aspects (productivity). Table 9 shows the distribution of articles focusing on different sub-areas and, thus, tries to achieve an improvement in different underlying

quality factors.

Process Quality	Process visibility and acceptance, process conformity, process effectiveness, process transparency, knowledge sharing, test process quality, quality assurance process, requirement prioritization, requirement quality, traceability, correctness, complexity, completeness, maintainability, code performance, productivity, cost reduction
Quality of project related aspects	Project effectiveness, sprint effectiveness, team communication, communication between team and customer, team performance, employee performance, team work quality, availability, traceability, productivity, performance, transparency, flexibility
Product quality	Correctness, completeness, complexity, modularity, reliability, safety, recoverability, performance, security, stability, flexibility, availability, maintainability, requirement traceability, customer satisfaction
People quality	Employee satisfaction, Individual satisfaction, Individual performance and motivation

Table 9: Distribution of articles with main focus and underlying quality attributes

RQ8. According to figure 6, around 65 percent of the articles employed various metrics to measure the improvement in quality, whereas 35 percent either did not employ or specify the metrics in their work.

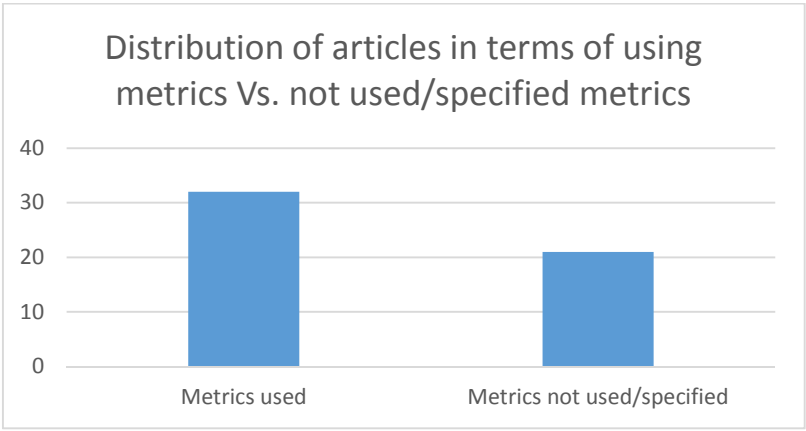

Figure 6: Articles distribution according to the use of metrics for quality assessment/improvement efforts

RQ9. Table 10 presents the different metrics used in the measurement related with different quality attributes.

Quality attribute	Metrics Used
Productivity	Story points implemented, No. of story points, Total LOC/Total efforts in hours, LOC/hour, FP per developer per month, Development efforts (PM), Development time, Implementation months, progress rate, lines of code delivered, Lines of code produced, Development productivity, Test productivity, % of SVN check-in (Subversion), Reduction in refactoring efforts, Defect opening rate vs. closing rate, WPM & HRM metrics, Amount of LOC for each developer, Development cycle time, Test cycle time, Event B specification metrics, Bug fixing time, points per person, Total points, Effective lines of code, No. of interruptions, No. of uninterrupted development hours, Bug fixing time
Cost reduction	Cost per story point
Completeness	% of functionality completed
Process quality & effectiveness	Lean six sigma metrics, Defects deferred, Defects detected (operation, development, test), Development defect density, Test defect density, Operation defect density, Running tested feature (RTF)
Sprint effectiveness	% user stories done in a sprint, story point completed
Requirements quality and prioritization	Proportion of high quality user stories reflecting stakeholders' goals, ISO/IEC external metrics
Test process quality and test quality	PRAT metrics, Product Backlog Rating (PBR), test coverage, % of automated tests
Correctness	No. of bugs detected, No. of defects, % of failed tests, Defect rate, Defects detected, Open defects in an iteration, Defect density (defects/KLOC), Total defects, User requirement satisfaction, Maintenance efforts, Test coverage, No. of minor errors
Complexity	Cyclomatic complexity, MLOC, NBD, NORM, MCC, WMC, EC, NDM, LCOM, CBO, No. of static paths, parameters, executable lines, Maximum nesting of control statements, functional call count, Event B specification metrics
Traceability	Requirements-Task-Code Traceability
Maintainability	Documentation coverage, Event B specification metrics, Defect fixing, code modularisation
Customer satisfaction	No. of open defects, Net promoter score
Employee & team performance	User story cycle time, No. of uninterrupted development hours, Principal & current amount of interest

Table 10: Metrics used

5 Discussion

The present study searched five electronic databases - IEEE Explore, ACM Digital Library, Scopus, Web of Science, Springer - to find research papers related with quality issues in Scrum. As a result, approximately 361 research papers on Scrum were found, but only 53 of them were related to the research subject. Scrum works well with complex projects and it is formalized to deal with the complexity of the software development [Schwaber et al. 2007, Schwaber 2004], On the other hand, quality is considered as the main concern while developing the project using Scrum [Wan et al. 2013]. The Scrum focuses on quick and frequent delivery of working software by the use of development cycles called sprints. Most of the quality assurance and quality control activities are skipped in Scrum because of its short sprint duration and due to the absence of a committed quality assurance team [Aamir and Khan 2017]. They further argued that more attention is given by the development team to the delivery of products according to the customer satisfaction, and mainly user acceptance testing and story success criteria. However, only acceptance and integration testing are not sufficient to achieve a quality product [Aamir and Khan 2017]. They also observed that, quality is mostly not taken into account in the Scrum framework due to the quick delivery of product. For this reason, some questions are framed in this study to identify the quality issues in Scrum.

A spreadsheet was created for the data extraction properties for each category as shown in table 4. There were approximately 53 conferences, journals papers, and others such as newsletters. It is easy to notice from figure 2 that most of the papers (77%) are in conferences. There are eight conferences that have published more than one paper related to quality issues in the Scrum as shown in table 5, and the rest were published in other conferences. There were five and three papers published in the Agile conference (AGILE) and Hawaii International Conference on System Sciences (HICSS). Therefore, they seem to be the most useful sources for software quality issues in Scrum.There is no specific journal with higher publications in this area. In general, conferences publish results earlier than journals and are also more in numbers.

This study includes papers published between 2008 and 2017. It can be seen easily (figure 3) that the quality in Scrum has received more attention during the last two years more than ever. Therefore, the number of journal and conference papers that have been published in 2015 and 2016 are higher compared to other years. It shows quality issues in Scrum is an active area of research as the worldwide adoption of the Scrum method has motivated researchers [Kayes et al. 2016]. Since the searches pertaining to this paper were performed at the beginning of 2017, the number of papers published in 2017 has been limited. It is interesting to observe an increasing trend, which shows that there are still many unresolved issues in this area and, therefore, quality issues in Scrum are gaining prominence again among researchers.

In terms of country-wise distribution (table 7), The USA represents the highest number of authors (14 authors) who participated in research concerning quality issues in Scrum, while Brazil and India have the second highest number of authors (7 and 6 authors respectively). The rest of countries have fewer authors each as shown in table 7. During our search, 53 research papers are found to be related to this subject involving 146 authors. Most of them have written one paper or participated in one

paper. However, seven authors have written two papers each as shown in table 8. Still, there is one researcher with a long-term focus in this area. Although new researchers bring novel perspective to a research area; however, long term researchers have more opportunity to take the work forward in much detail and refine their results considering different constraints and limitations. Therefore, it is critical for high-quality research in any area that number of researchers with a long-term focus should be more compared to researchers with a short-term focus.

Most of the research papers results are based on professional projects (92.5%), whereas there are few articles involving student/simple projects (7.5%). It shows that most of the studies' results can be considered credible because the results based on professional projects are more likely to be valid as they provide more realistic constraints than student/simple projects. Studies based on simple/student projects are required to be validated in real professional projects to find out their constraints and limitations.

In terms of the quality areas explored, the most examined field are the process quality (45%), followed by project-related quality issues (27%) and product quality (24%) as shown in figure 5. After an extensive literature survey, we found that quality issues related with the Scrum process (such as process effectiveness, conformity, visibility, acceptance, testing effectiveness etc.) have received a lot of attention among researchers, whereas the quality of the product being developed using Scrum and project-related quality issues (such as team performance, collaboration, etc.) are also of interest among researchers. However, studies focusing on people-related quality issues (such as employee skills, satisfaction etc.) are scarce. This is interesting considering that agile methods rely more on people than process and, therefore, it is important to explore people-related issues. Ahmed et al. [2010] also found various attributes, such as active stakeholder participation, self-organizing teams, team size, etc. to have an impact both on productivity and quality of the finished product.

A wide range of quality attributes are explored in various studies to explore these areas such as process, people, project, and product as shown in table 9. The use of quality metrics is important to measure and control the quality of a software. Around 65% of the studies used metrics to measure different quality attributes, whereas the rest did not employ or specify the metrics used. Variety of software metrics have been used in the published articles as shown in table 10.

Aamir et al. [2017] observed that in most organizations, quality is not taken into account in the Scrum framework due to the quick delivery of sprints. They state that in Scrum, the quality control process starts when a sprint begins and the test cases are designed based on user stories included in that sprint. Thereafter, quality assessment is done on the basis of the frequency of leftover bugs. The best way to ensure quality in a project that has been developed using the Scrum method is to ensure that adequate software quality assurance measures should be applied. Additionally, following recommendations should be taken into consideration while devising the quality control procedures [Harvie and Agah 2016]:

- Scrum teams (especially team leaders) should compel acquiescence to standards, in spite of time pressures and strict due dates.
- It appears that the exercise of working with the customer to test the final products as a quality assurance mechanism benefits all. This practice is promoted and should be maintained.

- Code reviews must be upheld, and companies should invest resources into assets as well as steadily involve the developers.
- Project software owners, project managers, team leaders and business analysts ought to routinely meet with the client to check the necessities preceding the execution stage. Dynamic stakeholder contributions can also limit advancement expenses and time [Koka 2015].

6 Conclusion

Scrum is an agile project management framework lightweight with a wide application to manage and control iterative and incremental software projects. As Scrum is currently the most popular agile paradigm used in complex software development, it is important to seek for quality issues in it. Articles were searched in major electronic databases, and the search string returned 403 studies, but after more examination by looking for the title, abstract and conclusion, 53 papers were found related to quality issues in Scrum. However, nine research questions were identified and investigated further in detailed manner using 53 research papers.

In terms of the number of researchers who have a long-term interest in quality in Scrum, there were 146 authors, most of whom have written one paper, while seven authors have written two papers. There are around eight conferences that have published more than one paper in this area and, therefore, seem to be the most useful sources for software quality issues in Scrum.There is no specific journal with higher publications in this area. In our opinion, quality issues in Scrum in the coming years will be an active topic of research because Scrum is widely used among agile methods. In addition, the process quality followed by project-related quality issues and product quality present the higher percentage of sub-areas explored concerning quality and approximately 65% of the studies mentioned the use of one or metrics to measure different quality attributes. Process quality issues such as process effectiveness, conformity, visibility, acceptance, testing effectiveness etc. have received a lot of attention among researchers whereas product quality and project-related quality issues such as team performance, collaboration, etc. are also of interest among researchers. However, studies focusing on people-related quality issues such as employee skills, satisfaction etc. are scarce. As Agile methods focus more on people and their interaction for the success of the project, therefore it is important to explore this area further.

During the search process five electronic databases were used, which are: IEEE Explore, ACM Digital Library, Scopus, Web of Science and Springer Link, however, there are many other electronic databases which may also include some papers in this field. There are some limitations in the systematic mapping and experimental studies that can restrict the results of this study. For this reason, both internal and external validity threats are discussed. The internal validity matters are fundamentally in the papers' chosen procedure. Especially, the issue related to the possibility of missing relevant papers. To ensure a thorough repository for our research, we searched the well-known academic databases, including IEEE Explore, ACM Digital Library, etc. We also tried to use different combinations of the topic of interest and their synonyms related to Scrum, or quality issues in Scrum. External validity is related to what

degree the results of the SM study can be applicable. The research papers selection process only included those papers written in English language, while those written in different languages, were rejected. One potential problem may be that the papers incorporated into this systematic mapping will not be able to illustrate all the important works related to Scrum quality issues, whereas other risk may originate from the keywords that were used, the databases that were chosen and the inclusion/rejection criteria. We pursued a comprehensive search procedure to ensure that all relevant research papers are included in the present study.

In terms of future work, the use of a combination of the Scrum with other methods during software development is required. As a result, Scrum can be used with other agile methods such the XP or DSDM. In addition, it can be used with the traditional software development methods. It would be interesting and further research needs to be done to know how the quality can be ensured in such scenarios.

References

[Aamir and Khan 2017] Aamir, M., Khan, M.N.A.: Incorporating quality control activities in Scrum in relation to the concept of test backlog, *Sādhanā* (2017), 42(7), 1051–1061.

[Abbas et al. 2010] Abbas, N., Gravell, A.M., Wills, G.B.: The Impact of Organization, Project and Governance Variables on Software Quality and Project Success, 2010 Agile Conference, Orlando, FL (2010), 77-86.

[Ahmed et al. 2010] Ahmed, A., Ahmad, S., Ehsan, N., Mirza, E., Sarwar, S.Z.: Agile Software Development: Impact on Productivity and Quality, *2010 IEEE International Conference on Management of Innovation & Technology*, Singapore (2010), 287-291.

[Ashraf et al. 2012] Ashraf, M., Shamail, S., Rana, Z.: Agile Model Adaptation for E-Learning Students' Final-Year Project. *Proceedings of IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE) 2012*, Hong Kong (2012), T1C-18-T1C-21.

[Bhasin 2012] Bhasin, S.: Quality Assurance in Agile: A Study towards Achieving Excellence, *2012 Agile India*, Bengaluru (2012), 64-67.

[Catal and Mishra 2013] Catal, C., Mishra D.: Test case prioritization: a systematic mapping study, *Software Quality Journal* (2013), 21(3), 445-478.

[Chan 2013] Chan, K.: Agile adoption statistics 2012 (2013), Available at http://www.onedesk.com/2013/05/agile-adoption-statistics-2012/

[cPrime 2013] cPrime: SCRUM & AGILE Everything You Need To Know, (2013), available at https://www.cprime.com/wp-content/uploads/woocommerce_uploads/2013/05/Scrum-and-Agile-Everything-you-need-to-know.pdf (Accessed on 28.03.2016).

[Cugola and Ghezzi 1998] Cugola, G., Ghezzi, C.: Software processes: a retrospective and a path to the future, 5th International Conference on Software Process, Lisle, IL (1998), 14-17 June 1998, available at http://home.deib.polimi.it/cugola/Papers/SPIP-final.pdf

[Dikert et al. 2016] Dikert, K., Paasivaara, M., Lassenius, C.: Challenges and success factors for large-scale agile transformations. *Journal of Systems and Software* (2016), 119(C) (September 2016), 87-108.

[Dingsøyr and Lassenius 2016] Dingsøyr, T., Lassenius, C.: Emerging themes in agile software development: Introduction to the special section on continuous value delivery, *Information and Software Technology* (2016), 77 (September 2016), 56-60.

[Fuggetta 2000] Fuggetta, A.: Software process: a roadmap, In: Proceedings of the conference on the future of software engineering, ACM (2000), 25–34.

[Harvie and Agah 2016] Harvie, D.P., Agah, A.: Targeted Scrum: Applying Mission Command to Agile Software Development, in *IEEE Transactions on Software Engineering* (2016), 42(5), 476-489.

[Hasija 2012] Hasija P.: My Experience as a QA in Scrum, available at https://www.infoq.com/articles/experience-qa-Scrum (accessed on 20/02/2017).

[Hewlett-Packard 2011] Hewlett-Packard Development Company: "The Impact of Agile Development Processes on Quality Assurance", available at http://www.qcagileaccelerator.com/PDFs/Whitepapers/ImpactofAgileDev.pdf (accessed Oct 2, 2016)

[Hong et al. 2010] Hong, N., Yoo, J., Cha, S.: Customization of Scrum Methodology for Outsourced E-commerce Projects, *2010 Asia Pacific Software Engineering Conference*, Sydney, NSW (2010), 310-315.

[Jeldi and Chavali 2013] Jeldi, N., Chavali, V.: Software Development Using Agile Methodology Using Scrum Framework, *International Journal of Scientific and Research Publications* (2013), 3(4), 1-3.

[Jeon 2011] Jeon, S., Han, M., Lee, E., Lee, K.: Quality Attribute Driven Agile Development, *2011 Ninth International Conference on Software Engineering Research, Management and Applications*, Baltimore, MD (2011), 203-210.

[Kayes et al. 2016] Kayes, I., Sarker, M. & Chakareski, J.: Product backlog rating: a case study on measuring test quality in Scrum, *Innovations in Systems and Software Engineering* (2016), 12(4), 303-317.

[Kitchenham 2009] Kitchenham, B., Brereton, O. P., Budgen, D., Turner, M., Bailey, J., Linkman, S.: Systematic literature reviews in software engineering: A systematic literature review. *Information and Software Technology* (2009), 51(1), 7–15.

[Kitchenham and Charters 2007] Kitchenham, B. A., Charters, S.: Guidelines for performing systematic literature reviews in software engineering. Technical report EBSE-2007-01 (2007), available at http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=D87D1E54B5C2CDAF36A7365FCD31210C?doi=10.1.1.117.471&rep=rep1&type=pdf

[Kitchenham and Pfleeger 1996] Kitchenham, B., Pfleeger, S.L.: Software quality: the elusive target, *IEEE Software* (1996), 13(1), 12–21.

[Koka 2015] Koka, A.: Software Quality Assurance in Scrum Projects: a case study of development processes among Scrum teams in South Africa, available at http://digitalknowledge.cput.ac.za/jspui/bitstream/11189/3194/1/213304376_Koka_A_MTech_IT_FID_2015.pdf

[Lee 2012] Lee R.C.: The Success Factors of Running Scrum: A Qualitative Perspective, *Journal of Software Engineering and Applications* (2012), 5(6), 367-374.

[Li et al. 2010] Li, J., Moe, N.B., Dybå, T.: Transition from a plan-driven process to Scrum: A longitudinal case study on software quality, *Proc. ACM/IEEE Int. Symp. Empirical Softw. Eng. Meas.*, Bolzano/Bozen, Italy (2010), 13:1-13:10.

[Lin et al. 2014] Lin, J., Yu, H., Shen, Z., Miao, C.: Using Goal Net to Model User Stories in Agile Software Development, International Conference: Software Engineering, Artificial Intelligence, Networking, and Parallel/Distributed Computing (SNPD), June 30-July 2, Las Vegas, USA (2014).

[Lindvall 2004] Lindvall, M., Muthig, D., Dagnino, A., Wallin, C., Stupperich, M., Kiefer, V., May, V., Kahkonen, V.: Agile software development in large organizations, *Computer* (2004), 37(12), 26-34.

[Lopes and Junior 2017] Lopes S.V.F., Junior, P.T.A.: Architectural Design Group Decision-Making in Agile Projects, *2017 IEEE International Conference on Software Architecture Workshops (ICSAW)*, Gothenburg (2017), 210-215.

[Luz et al. 2009] Luz, M., Gazineu, D., Teófilo, M.: Challenges of Adopting Scrum for Distributed Teams in Home Office Environments, *World Academy of Science, Engineering and Technology* (2009), 59, 308-311.

[Mahalakshmi and Sundararajan 2013] Mahalakshmi, M., Sundararajan M.: Traditional SDLC Vs Scrum Methodology – A Comparative Study, *International Journal of Emerging Technology and Advanced Engineering* (2013), 3(6), 192-196.

[Mishra et al. 2017] Mishra, A., Garbajosa, J., Wang, X., Bosch, J., Abrahamsson P.: Future directions in Agile research: Alignment and divergence between research and practice, *Journal of Software: Evolution and Process* (2017), 29 (6), 1-4.

[Mishra and Mishra 2011] Mishra, A., Mishra D.: A curriculum for agile software development methodologies, *ACM SIGSOFT Software Engineering Notes* (2011), 36 (3), 1-2.

[Mishra and Mishra 2010] Mishra, D., Mishra A.: Managing requirements in market-driven software project: Agile methods view, *Tehnički vjesnik* (2010), 17 (2), 223-229.

[Mnkandla and Dwolatzky 2006] Mnkandla, E., Dwolatzky, B.: Defining Agile Software Quality Assurance. Proceedings of the International Conference on Software Engineering Advances (ICSEA'06), IEEE Computer Society (2006).

[Permana et al. 2015] Permana, P., Bali, S.S., Bali, D.: Scrum Method Implementation in a Software Development Project Management, *International Journal of Advanced Computer Science and Applications*, 6(9).

[Pinto et al. 2009] Pinto, L., Rosa, R., Pacheco, C., Xavier, C., Barreto, R., Lucena, V., Caxias, M., Maurçcio, C.: On the Use of Scrum for the Management of Practical Projects in Graduate Courses, *39th IEEE Frontiers in Education Conference*, San Antonio, TX (2009), 1-6.

[Prowareness 2009] Prowareness: Agile Metrics, Let the Numbers tell the Tale, Concordia University (2009), available at www.Scrum.nl/media/Agile_Metrics/$FILE/whitepaper_agile_metrics.pdf.

[Schwaber et al. 2007] Schwaber, C., Leganza, G., D'Silva, D.: The truth about agile processes (2007). available at http://www.rallydev.com/sites/default/files/The_Truth_About_Agile_ Processes_Forrester_white_paper.pdf

[Schwaber 2004] Schwaber, K.: Agile project management with Scrum". O'Reilly Media, Inc, Sebastopol, (2004).

[Serrador and Pinto 2015] Serrador, P., Pinto, J.: Does Agile work? — A quantitative analysis of agile project success, *International Journal of Project Management* (2015), 33, 1040–1051.

[Sutherland et al. 2007] Sutherland, J. , Jakobsen, C., Johnson K.: Scrum and CMMI Level 5: The Magic Potion for CodeWarriors, *Agile 2007 (AGILE 2007)*, Washington, DC (2007), 272-278.

[Timperi 2004] Timperi, O.P.: An Overview of Quality Assurance Practices in Agile Methodologies, T-76.650 SEMINAR IN SOFTWARE ENGINEERING (SPRING 2004) available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.601.7862&rep=rep1&type=pdf

[Ullah and Zaidi 2009] Ullah, M., Zaidi, W.: Assurance Activities in Agile - Philosophy to Practice. Master's thesis, School of Computing, *Blekinge Institute of Technology* (2009).

[Version one 2016] Version one: The 10th Annual State of Agile Report (2016), available at https://versionone.com/pdf/VersionOne-10th-Annual-State-of-Agile-Report.pdf

[Vijayasarathy and Turk 2008] Vijayasarathy, L.R., Turk, D.: Agile software development: A survey of early adopters, *Journal of Information Technology Management* (2008), 19(2), 1-8.

[Wan et al. 2013] Wan, J., Zhu, Y., Zeng, M.: Case Study on Critical Success Factors of Running Scrum, *Journal of Software Engineering and Applications* (2013), 6(2), 59-64.

[Weitzel et al. 2014] Weitzel, B., Rost, D., Scheffe, M.: Sustaining Agility through Architecture. *2014 IEEE/IFIP Conference on Software Architecture*, Sydney, NSW (2014), 53-56.

[Zhao et al. 2014] Zhao, X., Xuan, X., Wang, A., Liu, D., Zheng, L.: Software Quality Control via Exit Criteria Methodology: An Industrial Experience Report. Software Engineering Conference (APSEC), 21st Asia-Pacific, Jeju, South Korea (2014), 23-26.

Appendix

[Sd1] Guang-Yong, H.: "Study and Practice of Import Scrum Agile Software Development," in Proceedings of the 3rd International IEEE Conference on Communication Software and Networks (ICCSN), Xi'an China (2011), 217-220.

[Sd2] Ashraf, M.A., Shamail, S., Rana, Z.: "Agile model adaptation for e-learning students' final-year project," in IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE), Hong Kong (2012), T1C-18-T1C-21.

[Sd3] Braz, A., Rubira, C.M.F., Vieira, M.: "Development of Complex Software with Agile Method." In Agile Conference (AGILE), Washington, DC (2015), 97-101.

[Sd4] Sutherland, J., Jakobsen, C., Johnson, K.: Scrum and CMMI level 5: The magic potion for code warriors. In Agile Conference (AGILE), Washington, DC (2007), 272–278.

[Sd5] Mattei, A.L.P. et al..., 2015. Nanosatellite event simulator development using Scrum agile method and safety-critical application development environment. In: 2015 12th International Conference on Information Technology-New Generations (ITNG), Las Vegas, NV (2015), 101-106.

[Sd6] Harvie, D.P., Agah, A.: Targeted Scrum: Applying mission command to agile software development. IEEE Transactions on Software Engineering (2016), 42(5), 476-489.

[Sd7] Piri, A., Niinimäki, T.: Does distribution make any difference? Quantitative comparison of collocated and globally distributed projects. Sixth IEEE International Conference on Global Software Engineering Workshops, Helsinki, Finland (2011), 24-30.

[Sd8] Weitzel, B., Rost, D., Scheffe, M.: Sustaining Agility through Architecture: Experiences from a Joint Research and Development Laboratory. *2014 IEEE/IFIP Conference on Software Architecture*, Sydney, NSW (2014), 53-56.

[Sd9] Machado, J.B., Isotani, S., Barbosa, A., Bandeire, J., Alcantara, W., Bittencourt, I.: "OntoSoft Process: Towards an Agile Process for Ontology-Based Software," *2016 49th Hawaii International Conference on System Sciences (HICSS)*, Koloa, HI, USA (2016), 5813-5822.

[Sd10] Nayoung, H.: Customization of Scrum methodology for outsourced Ecommerce projects, in: Y. Junbeom, C. Sungdeok (Eds.), Asia Pacific Software Engineering Conference, IEEE, Sydney, Australia (2010), 310–315.

[Sd11] Sutherland, J., Schoonheim, G., Rijk, M.: Fully distributed Scrum: replicating local productivity and quality with offshore teams. In: Proceedings of the 42nd Hawaii International Conference on System Sciences (HICSS '09). IEEE, Big Island, HIUSA (2009), 1–8.

[Sd12] Farid, W.M., Mitropoulos, F.J.: NORPLAN: Non-functional Requirements Planning for agile processes. In *2013 Proceedings of IEEE Southeastcon*, Jacksonville, FL (2013), 1-8.

[Sd13] Domah, D., Mitropoulos, F.J.: The NERV methodology: A lightweight process for addressing non-functional requirements in agile software development. In *SoutheastCon 2015* IEEE, Fort Lauderdale, FL (2015), 1-7.

[Sd14] Khalane, T., Tanner, M.: Software quality assurance in Scrum: The need for concrete guidance on SQA strategies in meeting user expectations. In *2013 International Conference on Adaptive Science and Technology (ICAST)*, Pretoria (2013), 1-6.

[Sd15] Sultana, S., Motla, Y. H., Asghar, S., Jamal, M., Azad, R.: A hybrid model by integrating agile practices for Pakistani software industry. In *2014 International Conference on Electronics, Communications and Computers (CONIELECOMP)*, Cholula (2014), 256-262.

[Sd16] Zhang, Y., Patel, S.: Agile model-driven development in practice. *IEEE software (2011)*, *28*(2), 84-91.

[Sd17] Williams, L., Brown, G., Meltzer, A., Nagappan, N.: Scrum+ engineering practices: Experiences of three Microsoft teams. In *2011 International Symposium on Empirical Software Engineering and Measurement (ESEM)*, Banff, AB (2011), 463-471.

[Sd18] Green, P.: Measuring the impact of Scrum on product development at adobe systems. In *System Sciences (HICSS), 2011 44th Hawaii International Conference on*. IEEE. Kauai, HI (2011), 1-10.

[Sd19] Lin, J., Yu, H., Shen, Z., Miao, C.: Using goal net to model user stories in agile software development. In *Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD), 15th IEEE/ACIS International Conference on,* Las Vegas, USA (2014). 1-6.

[Sd20] Kayes, I.: Agile testing: introducing PRAT as a metric of testing quality in Scrum. *ACM SIGSOFT Software Engineering Notes (2011)*, *36*(2), 1-5.

[Sd21] Asghar, A.R., Bhatti, S.N., Tabassum, A., Sultan, Z., Abbas, R.: Role of requirements elicitation & prioritization to optimize quality in Scrum agile development. International Journal of Advanced Computer Science and Applications (IJACSA), *7*(12), 300-306.

[Sd22] Oliveira, J., Vinhas, M., da Costa, F., Nogueira, M., Ribeiro, P., Machado, R.J.: Is Scrum Useful to Mitigate Project's Risks in Real Business Contexts?. In *International Conference on Computational Science and Its Applications,* Springer, Cham., (2016), 422-437.

[Sd23] Colomo-Palacios, R., González-Carrasco, I., López-Cuadrado, J.L., García-Crespo, Á.: ReSySTER: A hybrid recommender system for Scrum team roles based on fuzzy and rough sets. *International Journal of Applied Mathematics and Computer Science* (2012), *22*(4), 801-816.

[Sd24] Samios, H.P.: Overcoming Traditional Project Release Reporting with an Agile Approach Focused on Change. In *Agile Conference (AGILE),* IEEE (2012), 131-135.

[Sd25] Eckhart, M., Feiner, J.: How Scrum Tools May Change Your Agile Software Development Approach. In *International Conference on Software Quality* Springer, Cham. (2016, January), 17-36.

[Sd26] Jakobsen, C. R., Johnson, K. A.: Mature Agile with a twist of CMMI. In *Agile, 2008. AGILE'08. Conference,* IEEE (2008, August), 212-217.

[Sd27] Välimäki, A., Kääriäinen, J.: Patterns for distributed Scrum—a case study. In *Enterprise interoperability III,* Springer, London (2008), 85-97.

[Sd28] Kayes, I., Sarker, M., Chakareski, J.: Product backlog rating: a case study on measuring test quality in Scrum. *Innovations in Systems and Software Engineering* (2016), *12*(4), 303-317.

[Sd29] Jha, M.M., Vilardell, R.M.F., Narayan, J.: Scaling Agile Scrum Software Development: Providing Agility and Quality to Platform Development by Reducing Time to Market. *2016 IEEE 11th International Conference on Global Software Engineering (ICGSE)*, Irvine, CA (2016), 84-88.

[Sd30] Khalane, T., Tanner, M.: Software quality assurance in Scrum: The need for concrete guidance on SQA strategies in meeting user expectations. *2013 International Conference on Adaptive Science and Technology*, Pretoria (2013), 1-6.

[Sd31] Ramirez-Noriega, A., Juarez-Ramirez, R., Navarro, R., Lopez-Martinez, J.: Using Bayesian Networks to Obtain the Task's Parameters for Schedule Planning in Scrum. *2016 4th International Conference in Software Engineering Research and Innovation (CONISOFT)*, Puebla (2016), 167-174.

[Sd32] Alsalemi, A.M., Yeoh, E.T.: A survey on product backlog change management and requirement traceability in agile (Scrum). *2015 9th Malaysian Software Engineering Conference (MySEC)*, Kuala Lumpur (2015), 189-194.

[Sd33] Thirunadana Sikamani, K., Dharmapal, S.R.: Using Key Six Sigma and Lean Metrics on Agile Scrum Methodology for Performance Improvement. *International Journal of Applied Engineering Research* (2016), *11*(6), 4576-4578.

[Sd34] Mundra, A., Misra, S., Dhawale, C.A.: Practical Scrum-Scrum team: Way to produce successful and quality software. *2013 13th International Conference on Computational Science and Its Applications*, Ho Chi Minh City (2013), 119-123.

[Sd35] Lei, H., Ganjeizadeh, F., Jayachandran, P. K., Ozcan, P.: A statistical analysis of the effects of Scrum and Kanban on software development projects. *Robotics and Computer-Integrated Manufacturing* (2017), *43*(February 2017), 59-67.

[Sd36] Hanssen, G.K., Haugset, B., Stålhane, T., Myklebust, T., Kulbrandstad, I.: Quality assurance in Scrum applied to safety critical software. In *International Conference on Agile Software Development* (XP 2016), Edinburgh, UK (2016), Springer, 92-103.

[Sd37] Scharff, C.: Guiding global software development projects using Scrum and Agile with quality assurance. *2011 24th IEEE-CS Conference on Software Engineering Education and Training (CSEE&T)*, Honolulu, HI (2011), 274-283.

[Sd38] Caballero, E., Calvo-Manzano, J.A., San Feliu, T.: Introducing Scrum in a very small enterprise: A productivity and quality analysis. In *European Conference on Software Process Improvement (EuroSPI),* Roskilde, Denmark (2011), Springer, Berlin, Heidelberg, 215-224.

[Sd39] Perkusich, M., Gorgônio, K. C., Almeida, H., Perkusich, A.: Assisting the continuous improvement of Scrum projects using metrics and bayesian networks. *Journal of Software: Evolution and Process* (2017), *29*(6).

[Sd40] Olszewska, M., Ostroumov, S., Waldén, M.: Using Scrum to Develop a Formal Model–An Experience Report. In *International Conference on Product-Focused Software Process Improvement* (PROFES), Trondheim, Norway (2016), Springer, 621-626.

[Sd41] Maria, R. E., Rodrigues Jr, L. A., Pinto, N. A.: ScrumS: a model for safe agile development. In *Proceedings of the 7th International Conference on Management of computational and collective intElligence in Digital EcoSystems,* ACM, Caraguatatuba, Brazil (2015), 43-47.

[Sd42] Kautz, K., Johanson, T. H., Uldahl, A.: The perceived impact of the agile development and project management method Scrum on information systems and software development productivity. *Australasian Journal of Information Systems* (2014), *18*(3), 303-315.

[Sd43] Oliveira, F., Goldman, A., Santos, V.: Managing technical debt in software projects using Scrum: An action research. In *Agile Conference (AGILE),* Washington, DC (2015), IEEE, 50-59.

[Sd44] Popović, T.: Getting ISO 9001 certified for software development using Scrum and open source tools: a case study. *Tehnički vjesnik* (2015), *22*(6), 1633-1640.

[Sd45] Bougroun, Z., Zeaaraoui, A., Bouchentouf, T.: The projection of the specific practices of the third level of CMMI model in agile methods: Scrum, XP and Kanban. *2014 Third IEEE International Colloquium in Information Science and Technology (CIST)*, Tetouan (2014), 174-179.

[Sd46] Maranzato, R. P., Neubert, M., Herculano, P.: Moving back to Scrum and scaling to Scrum of Scrums in less than one year. In *Proceedings of the ACM international conference companion on Object oriented programming systems languages and applications companion,* OOPSLA 2011, Portland, OR, USA (2011), 125-130.

[Sd47] Gupta, R.K., Manikreddy, P., Arya, K.C.: Pragmatic Scrum Transformation: Challenges, Practices & Impacts During the Journey A case study in a multi-location legacy software product development team. In *Proceedings of the 10th Innovations in Software Engineering Conference,* Jaipur, India (2017), 147-156.

[Sd48] Li, J., Moe, N. B., Dybå, T.: Transition from a plan-driven process to Scrum: a longitudinal case study on software quality. In *Proceedings of the 2010 ACM-IEEE international symposium on empirical software engineering and measurement,* Bolzano-Bozen, Italy (2010), Article 13, 10 pages.

[Sd49] Tuli, A., Hasteer, N., Sharma, M., Bansal, A.: Empirical investigation of agile software development: cloud perspective. *ACM SIGSOFT Software Engineering Notes* (2014), *39*(4), 1-6.

[Sd50] Ktata, O., Lévesque, G.: Designing and Implementing a Measurement Program for Scrum Teams: What do agile developers really need and want? In *Proceedings of the Third C* Conference on Computer Science and Software Engineering,* Montréal, Quebec, Canada (2010), 101-107.

[Sd51] Kautz, K., Johansen, T. H., Uldahl, A.: Creating business value through agile project management and information systems development: The perceived impact of Scrum. In *International Working Conference on Transfer and Diffusion of IT,* Aalborg, Denmark (2014), Springer, Berlin, Heidelberg, 150-165.

[Sd52] Lavazza, L., Morasca, S., Taibi, D., Tosi, D.: Applying SCRUM in an OSS development process: an empirical evaluation. In *International Conference on Agile Software Development,* Trondheim, Norway (2010), Springer, Berlin, Heidelberg, 147-159.

[Sd53] Reddaiah, B., Reddy, R. P. K., Nagaraju, C., Sree, V. H.: A novel approach to adopt Scrum by an enterprise. In *Artificial Intelligence and Evolutionary Computations in Engineering Systems,* Chennai, India (2016), Springer, New Delhi, 645-654.