Requirements Engineering in Agile Projects: A Systematic Mapping based in Evidences of Industry

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Abstract. Interest in the adoption of Agile methodologies has grown in recent years as a strategy to minimize problems in software development. However recent studies indicate high rates of failure also in projects that use agile processes. In this context, this research conducted an exploratory study to investigate how Requirements Engineering is used in projects that adopt agile methodologies. For this, a Systematic Mapping was performed and it identified the engineering requirements techniques that are running in the industry, the problems and limitations in projects that adopt agile methodologies. The low involvement of users and the constant changes of requirements were identified as the main challenges to be overcome.

Keywords: Requirements, Agile Methodologies, Systematic Mapping

1 Introduction

Requirements are a specification of what should be implemented in a software. They are descriptions of how the application should behave and about the constraints to operationalization of the system [3]. The requirements are the starting point for the developing a system, so they are critical for the success of developing of a software.

Despite the importance of Requirements Engineering (RE) in the success of the development of the software and minimization of project risks, this activity is seen in agile methods as bureaucratic, which makes the process less agile.

Some studies point out limitations in adopting agile methodologies regarding the activities of requirements engineering [10] [12, 13]. In this context, this study aimed to obtain evidence of industry about how the requirements engineering has been conducted in projects that adopt agile methodologies.

2 Theoretical Background

2.1 Agile Methodologies

The agile development software definitions evolved in the 90s as part of a reaction against traditional approaches that were considered heavy, bureaucratic and not adequately supported the activities of developers.

In 2001, the publication of the Agile Manifesto [9] was a milestone for Agile Software Development. A group of 17 experts proposed practices to improve software development by defining values and principles that guide agile methodologies.

2.2 Requirements Engineering (RE)

Requirements Engineering (RE) provides the appropriate mechanism to understand what the customer wants, analyzing the needs, verifying the feasibility, negotiating solutions, specifying the unambiguous and managing their changes [2]. According to Kotonoya et al. most problems related to the RE are derived from the incompleteness or inconsistency of requirements and the divergences between stakeholders [3].

Agile methodologies treat very differently from traditional models of RE. Agile models begin the software development with only a general overview of the problem without further details. The understanding of the requirements is done throughout the project, in an iterative and incremental way from the customer feedback.

2.3 Related Works

Jaqueira et al. [5] presents a systematic review of RE in agile methods but has a different purpose from our systematic mapping, furthermore has different research questions. The review has some limitations as the lack of quality assessment and the absence of details of the data extraction method. The search string are not presented. The study selected 9 articles. Unlike Jaqueira, this mapping was based on studies that have been empirically validated in the industry. Kamei [10] conducted a systematic review of agile development methodologies. Despite not having the purpose of investigating on requirements, have been reported some limitations related to RE in agile projects.

3 Method

This study followed the guidelines suggested by Kitchenham [6] e Travassos [7]. A summary of the protocol of the systematic mapping is presented in the next sections.

3.1 Research Questions

The following Principal Research Question (PRQ) was defined:

- PRQ: How the requirements engineering has been conducted in projects that adopt agile methodologies?

The following Specific Research Questions (SRQ) were defined to guide the extraction, analysis and synthesis of results:

- SRQ1: In order to elicit requirements, which requirements engineering techniques are being used in projects that adopt agile methodologies?
- SRQ2: In order to specify requirements, which requirements engineering techniques are being used in projects that adopt agile methodologies?
- SRQ3: What are the challenges and limitations of Requirements Engineering techniques used in agile projects?
- SRQ4: What are the implications for the software industry and academia, reported in the current studies involving the Requirements Engineering in Agile projects?

3.2 Search Strategy

Requirements, Agile Methodologies and Software were the keywords extracted from the main research question. The terms used in the construction of the string was as inclusive as possible in order to return a greater number of papers, for this reason the PICO method is not used. The following String Search was defined:

- (("requirements" OR "use case" OR "use cases" OR "user stories") AND ("agile" OR "agility") AND ("scrum" OR "extreme programming" OR "xp" OR "dynamic system development" OR "dsdm" OR "crystal methodologies" OR "crystal clear" OR "crystal orange" OR "crystal red" OR "crystal blue" OR "feature driven development" OR "fdd" OR "lean software development" OR "adaptive software development" OR "test driven development" OR "tdd") AND ("software" OR "information system development" OR "information system engineering"))

3.3 Data Sources

For the selection of studies, sources were used automated and manual search. The sources used were IEEExplore Library, ACM Library, ScienceDirect, SpringerLink and Scopus. The manual search was conducted in the proceedings of International Requirements Engineering Conference and Agile Development Conference.

3.4 Study Selection Criteria

The studies were selected according to the inclusion and exclusion criteria, as described in Table 1. A study to be included had to meet all inclusion criteria. An article was excluded if at least one of the exclusion criteria was complied.

Inclusion Criteria	IC1. Studies addressing requirements on software projects using agile methodologies IC2. Studies validated in the industry IC3. Qualitative or quantitative research IC4. Primary or secondary studies

Exclusion Criteria	EC1. Studies written in a language other than English EC2. Duplicated study report, with no extra information EC3. Studies that do not address on elicitation, specification or modeling software requirements EC4. Incomplete studies, prefaces, slides or summaries EC5. Tertiary studies EC6. Studies that address only the teaching of agile or requirements EC7. Studies that do not address at least an agile methodology EC8. Papers that are not available for download in institutional environments UFPE or IFPB. EC9. Studies that no present empirical data

Table 1. Inclusion and Exclusion Criteria

3.5 Quality Assessment

The assessment of quality of primary studies was performed after application of the criteria (inclusion and exclusion). The evaluation was done using a questionnaire adapted from Dyba [11]. The applied questions are presented in Table 2. A three-point scale of Likert was used to evaluate the articles: 0 (Nothing in the paper that meets the criteria evaluated); 0.5 (The paper does not make clear whether or not meet the criteria) and 1 (Paper meets the criteria evaluated).

1. It is a research paper?
2. Is there a clear statement of the aims of the research?
3. Is there a description of the context in which the research was carried out?
4. Was the research design appropriate to address the aims of the research?
5. Was the recruitment strategy appropriate to the aims of the research?
6. Was the data collected in a way that addressed the research questions?
7. Was the data analysis sufficiently rigorous?
8. Has the relationship between researcher and participants been considered?
9. Is there a clear statement of findings?
10. Is the study of value for research of practice?

Table 2. Questions for Quality Assessment

Once calculate the sum of the scores of all the questions, the paper was classified into four quality groups: low, medium, high or very high. Studies with low quality were excluded, i.e. those that had sum less than three.

3.6 Study Selection Procedures

This research was conducted in four phases. The automated search was performed from the Reviewer[1] tool that performed the string simultaneously in all sources. The result was exported to an Excel spreadsheet, from which the next phases were performed. Then the manual search was conducted. Some relevant studies were added, forming the initial database of this study.

In the second phase, the criteria for inclusion and exclusion were applied from reading the titles and abstracts. In case of doubt about the relevance of the study, the paper was included for analysis in the following steps.

In the third phase, the criteria were applied from reading the introduction and conclusion of the resulting studies of the second phase. When necessary, the complete reading of the study was performed.

In order to reduce the bias of the research, the studies analyzed in the second and third phase were divided between two pairs of researchers. Once identified a conflict within a double, it was discussed with members of the other double trying to resolve the impasse.

The fourth phase assessed the quality of the papers from the previous stage. At this stage all sections of the papers were read. Two researchers evaluated the papers. The answers to the questionnaires were tabulated so that it was possible that members could comparing and discussing and to find a consensus. The papers with quality Very High (score> = 8.5), High (8 <= score> = 6) or Medium (5.5 <= score> = 3.0) were made available for extraction. The papers with low quality (score < = 2) were discarded.

3.7 Data Extraction

This process followed the recommendations of Cruzes [1]. Information of publication, context and results were extracted through a standard form. This form and the relation of the papers selected are available online for download[2].

Two researchers performed the extraction. Each researcher analyzed data extracted by the other. This revision was necessary to enhance the quality of data collected.

3.8 Synthesis of Data

The results of the data extraction and quality assessment were analyzed with MS Excel® software support, which was also used to generate the graphs and tables. The Thematic synthesis technique was used following the guidelines suggested by crosses and Dyba [1]. However, it were also raised figures on the frequency of occurrence of the mapped codes.

This activity was conducted by a researcher, and then reviewed by another researcher. The coding procedure was done from the reading of the forms containing the

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[1] Reviewer (https://github.com/bfsc/reviewer)

[2] Forms with the extracted data are available in https://drive.google.com/folderview?id=0B-Nlp0nCynhJdFBjUkc4QkQ2TWM&usp

extracted data. For SRQ3 synthesis, each problem was identified with a code. Then, the codes was grouped into themes. A review of the codes was performed trying to identify similarities, duplicate and undue codes. The next step was the grouping of subjects into categories (or high-level themes). The codes, themes and categories were successively revised until you get the results presented in the next section.

4 Results

4.1 Results of the search and selection procedure

The automated search returned 2501 papers and the manual search 351 papers, totaling 2852 papers. The IEEExplore Library returned the greatest amount of papers (8). ScienceDirect returned the smallest number of papers, only two. The Figure 1 shows the resulting number of studies per phase. 2540 papers were excluded while reading the title and summary of the studies, that reduced to 312 potentially relevant studies. The inclusion and exclusion criteria were applied from reading the introduction and conclusion. After consensus among researchers, 231 studies were excluded, leaving 81. The quality evaluation was conducted on articles 81 resulting from the previous phase. At this stage, 7 papers were excluded due to low quality and 50 papers were excluded after reading and finding that should have been excluded in the previous phases. Accordingly, the Systematic Mapping was based on 24 studies from which data extraction was performed. Of the 24 selected papers, 20 studies were obtained from the automated search, three papers were obtained from the use of the snowball technique and a paper obtained from the manual search realized in RE Conference. Of the nine papers studied by Jaqueira [5], five (AS2, AS4, AS21, AS23 e AS24) are among the 24 papers selected by this study, the other four papers were not included because they did not meet the criteria this study.

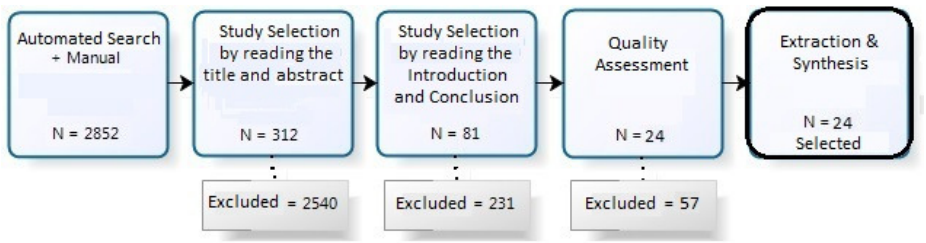


Fig. 1. Primary studies selected by phase

Overview of the included studies

From the data collected in the 24 selected studies, it is observed that more than 50% of the studies were published in the last 3 years, as shown in Figure 2, thus enhancing the relevance of this subject today. Regarding the agile methodology, 89% of the studies used Scrum or XP.

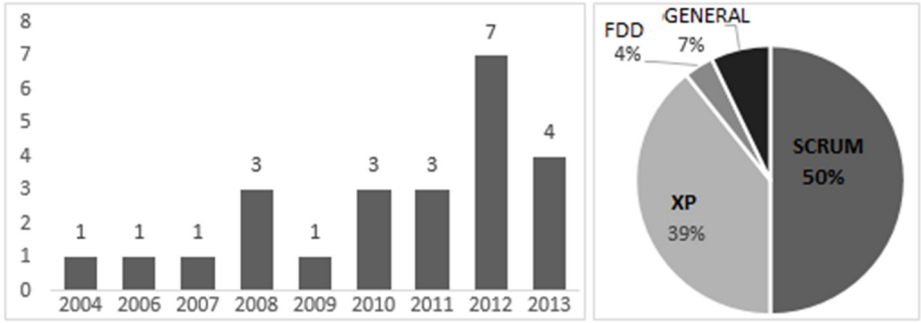


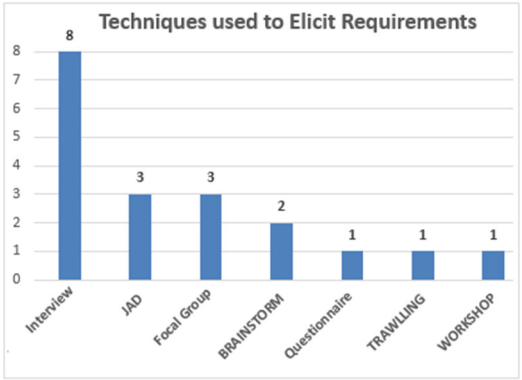
Fig. 2. Number of primary studies by year and % Agile Methodology

Case Study is the most widely used research method. It was used in 11 studies, and two of them were also used another method. The papers also reported the use of Ethnography, Experiment, Grounded Theory and Action Research.

4.2 Mapping of Evidences

In the next sections, the results are presented by research question.

QPE1: In order to raise requirements, which requirements engineering techniques are being used in projects that adopt agile methodologies?
According to the studies analyzed, seven different strategies are being used to elicit requirements, as shown in Figure 3. Of the 24 papers analyzed, only nine papers reported the technique used to elicit requirements. The interview technique is the most used. The following techniques was reported by paper AS05: interviews, questionnaires, Trawiling[3] e Workshops.



	Interview	JAD	Focal Group	Brainstorm	Questionnaire	TRAWLLING	Workshop	Total
AS04	x	-	-	-	-	-	-	1
AS05	x	-	-	-	x	x	x	4
AS08	x	-	-	-	-	-	-	1
AS12	x	-	-	x	-	-	-	2
AS13	x	-	-	-	-	-	-	1
AS16	-	-	-	x	-	-	-	1
AS20	x	x	x	-	-	-	-	3
AS23	x	x	x	-	-	-	-	3
AS24	x	x	x	-	-	-	-	3
Freq.	8	3	3	2	1	1	1	

Fig. 3. Techniques used to elicit requirements in Agile Projects

[3] http://www.systemsguild.com/requirementstrawling.htm

SRQ2: In order to specify requirements, which requirements engineering techniques are being used in projects that adopt agile methodologies?
The Table 3 presents the techniques used to specify requirements. Twenty and one different techniques have been reported. The most widely used techniques are User Stories and wireframes. Nine studies reported the use of only one technique: XXM, Activity Diagram, AUC, ALC, ACC, Mind Map, INVEST, and GPM and Cucumber[4].

	1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
	Use Case	User Storie	XXM	Feature	Story Card	WALL	XSBD	Diag. Ativ	Doc Req.	Task	Wireframe	Scenarios	Personas	AUC	ALC	ACC	Mind Map	INVEST	GPM	Cucumber	Total
AS01	x	x		x																	3
AS02		x		x																	2
AS03	x		x					x													3
AS04		x		x	x				x		x										6
AS05		x			x						x							x			4
AS06		x		x																	2
AS07																				x	1
AS08		x			x	x															3
AS09		x																			1
AS10		x		x			x				x	x									6
AS11		x		x							x										4
AS12		x								x	x										4
AS13		x																			1
AS14																	x				1
AS15		x			x									x	x	x					5
AS16	x						x				x	x									5
AS17		x								x	x	x									5
AS18		x								x	x										4
AS19		x			x	x															3
AS20		x		x							x		x								5
AS21		x											x								2
AS22		x		x	x						x										5
AS23					x				x										x		3
AS24		x		x																	2
freq.	3	19	1	9	7	2	2	1	2	3	10	3	2	1	1	1	1	1	1	1	

Table 3. Frequence of Specification Techniques by selected studies

SRQ3: What are the challenges and limitations of Requirements Engineering techniques used in agile projects?

[4] https://cukes.info/

Initially 115 codes, 15 themes and 7 categories were identified. After successive refinements review, eliminating duplication and grouping similarities, there was a reduction to 49 codes, 10 themes and 5 categories. The Figure 4 shows a thematic map containing the challenges encountered in the 24 selected articles. Due to space limitations, the codes are represented by their identifiers, for example, C30. The number in parentheses represents the number of papers in which the issue was reported. A textual description of the codes is presented in Table 4.

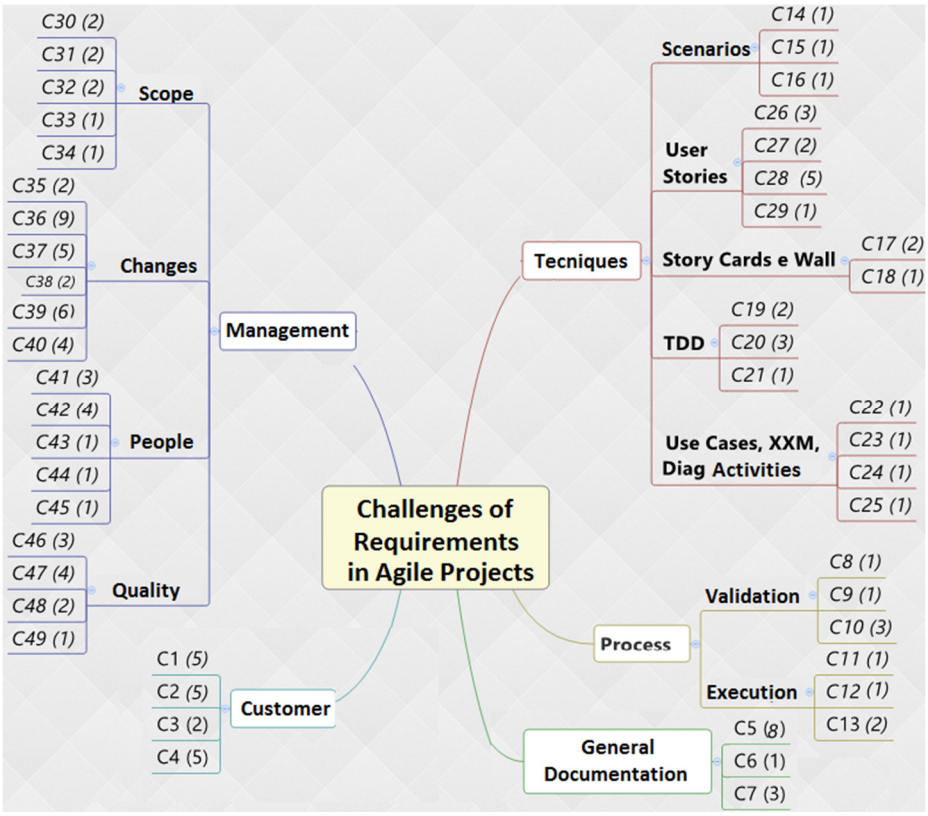


Fig. 4. Thematic Map of ER Challenges in Agile Projects

Analyzing the data collected found that the themes Change (28) and Client (18) have the highest occurrences of problems (challenges). This signals that the agile value "Teams adapt quickly to changes" is not the reality of the companies investigated in the studies. Nor is it reality "Continuous interaction with the customer". Looking at the Categories also noticed a large amount (27) of occurrences of problems in current techniques used for requirements specification. In total, the studies selected reported occurrences of 124 issues reports, as shown in Table 5.

ID	Code Description	CATEGORY (High-Order Tema)	THEME
1	Customer expectations are not met	CUSTOMER (18)	Customer (18)
2	Inadequate user-developer interaction		
3	Users don't know what they want		
4	Low availability of customer		
5	Insufficient documentation for Implementation, Maintenance and Training	DOCUMENTATION (12)	Documentation (12)
6	Inefficient sharing of documentation		
7	Difficult to transfer project knowledge to a large team		
8	Validation of Requirements without the customer's perspective	PROCESSO (9)	Validation (5)
9	Requirements not agreed with the team development		
10	Inefficiency in the requirements analysis and inspection		
11	Low availability of specific tools for ER agile		Execution (4)
12	No possibility to reuse requirements and specifications		
13	Overscoping		
14	Needs Intense communication with the customer	TECNIQUES (27)	SCENARIOS (3)
15	Difficult to include technical limitations in the scenarios		
16	Effort necessary to learn to write good scenarios		
17	Story cards and the Wall are an incomplete notational system		SC, WALL (3)
18	Necessary the customer presence to understand Wall and Story Cards		
19	TDD requires a thorough understanding of the requirements		TDD (6)
20	TDD requires extensive collaboration between the developer and the customer		
21	TDD involves refining low-level specifications iteratively		
22	Use cases has too much information presented		UC, XXM, AT (4)
23	Diagrams (XXM, UC, Diag Ativ) are more use to the design team than the customer		
24	None of the diagrams were identified by the customer to be useful in finding faults		
25	The diagrams (XXM, UC, Diag Ativ) were hard to interpret		
26	Stories are short, vague and ambiguous		US (11)
27	Technical skills required to write usable user stories		
28	US - detail level is not appropriate, considerable effort is required		
29	US - not adequate to describe technical aspects		
30	Tedious scoping sessions with customers	Managment (58)	Scope (8)
31	Difficulty in the managing large backlogs		
32	Keeping SRS Updated		
33	Extra effort to integrate the requirements		
34	Detailed requirements specification is produced upfront		
35	Team unmotivated because of constants changes		Changes (28)
36	The control in changing requirements is inefficient		
37	Architectures are not scalable because of constant changes		
38	Time spent with changing requirements		
39	It is difficult to create estimates accurate of cost, schedule, performance		
40	Frequent reprioritization of requirements		
41	Requirements from various sources generate many confiltos		People (10)
42	Communication gaps		
43	Difficulties with Distributed Teams		
44	Difficulty in promoting the sustainability of teams		
45	There are a number of misunderstandings due to the absence of key people		
46	Nontransparent relations between the problem and solution spaces		Quality (12)
47	Requirements unreliable, unstable, shallow, ambiguous		
48	Weak in defining NFRs		
49	Essential Requirements are not properly treated		

Table 4. Codes of the challengs (problems) identified

The Table 5 presents the issues that were reported by each paper, totaling 124 occurrences. The table also shows which paper address a particular problem.

	Studies Selected																								
ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Freq
1		x				x										x		x						x	5
2				x			x													x			x	x	5
3											x									x					2
4			x	x			x										x			x				x	6
5		x	x			x	x					x							x	x				x	8
6										x															1
7																		x	x	x					3
8	x																								1
9						x																			1
10	x						x									x								x	3
11																						x			1
12	x																								1
13		x				x																			2
14																	x								1
15																	x								1
16																	x								1
17								x											x						2
18																			x						1
19				x			x																		2
20				x			x							x											3
21				x																					1
22			x																						1
23			x																						1
24			x																						1
25			x																						1
26								x										x			x				3
27												x								x					2
28												x	x					x		x	x				5
29																					x				1
30	x											x								x					2
31												x						x							2
32		x								x															2
33				x																					1
34						x																			1
35		x				x																			2
36		x				x	x		x		x	x					x			x		x			9
37	x			x		x											x				x				5
38		x				x																			2
39		x		x		x						x						x							6
40		x				x														x				x	4
41	x					x	x																		3
42		x		x		x				x															4
43										x															1
44																				x					1
45					x																				1
46	x	x				x																	x	x	5
47		x				x					x										x				4
48							x								x										2
49							x																		1
	7	12	6	9	1	15	10	2	1	4	3	6	1	1	1	2	6	6	4	11	5	2	2	7	124

Table 5. Relationship between papers selected and challengers identified

SRQ4: What are the implications for the software industry and academia, reported in the current studies involving the RE in Agile projects?
An interesting fact is that the vast majority (20) of the papers are academic studies, but with empirical validations in real projects in the industry. The analysis of the problems identified points some research opportunities for the academic community. For example, what adjustments need to be made in the current techniques used to specify requirements in agile projects? Is the productivity of teams compromised by the adoption of RE in agile projects? Is smaller the quality of software specifications in agile projects than in traditional projects?

Another question that deserves attention of the academic community is the low quality of the papers. Initially, 31 items would be used for data extraction. However, during quality analysis stage, 23% of papers (7) were excluded due to low quality. Of 24 papers selected, only 6 papers has a very high quality. Only a paper appropriately considered the relationship between the researcher and the other people involved in the research. This point to the need for better attention of researchers in the conduction of yours researches for the results may be effectively used.

Based on the results obtained, it is observed that the adoption of Agile Methodologies also present a large number of problems in software development, mainly related to the management requirements. In 124 mapped occurrences, 58 are related to requirements management problems: Scope, Changes, Quality and People. This signals the need for companies in to analyze their current development processes looking for these bottlenecks that compromise the productivity of teams, the quality of requirements specifications, the motivation of teams and customer satisfaction.

It is hoped that future research may to help companies to overcome the problems identified, suggesting practices to minimize the problems identified, and thus increase success rates in projects that adopt methodologies.

5 Discussions and Concluding Remarks

5.1 Results

Responding to PRQ (How the requirements engineering has been conducted in projects that adopt agile methodologies?), it is interesting to note that the 24 papers investigated 68 companies, involving 270 people. According to the data collected, the most used technique to elicit requirements is the interview. User Stories was reported by more than 80% of the papers, as the most used technique to specify requirements. The studies also indicate that most of the problems are due to Frequent Changes in Requirements (Theme Changes) and Low Customer Involvement (Theme Customer). Only one article assumes that the absence the specific tools for RE in Agile projects is a problem.

Most papers (13) reported the use of some practice to validate the requirements (TDD, Acceptance Tests and Test Cases). Maybe so, only few problems were reported about Validation of Requirements. Only three papers reported problems in this area, only 5 occurrences were identified, as shown in Table 5.

The Management category was the one with the greatest amount of problems (58), which can be justified by the low use of practices such as Burn Down Chart, Project

Plan and General description of the Goals and Objectives. The adoption this practices has only been reported in 2, 4 and 9 papers, respectively.

Thus, we consider that this study reached the objectives expected by researchers, requiring the definition and implementation of actions to academia and to industry in order to minimize the problems that currently compromise the RE in agile projects.

5.2 Comparison with Related Works

Comparing the results obtained in this study with related works (Jaqueira [5] e Kamei [10]) is observed that this mapping identified a greater number of problems, as shown in Table 4 and Table 6. However, three challenges identified in the related work were not reported in the papers of this mapping. Jaqueira reported challenges related to Traceability (J1) and Multifunctional Team (J2) and Kamei reported problems with the Absence of a formal contract with the customer (K1), as shown in Table 6. Inadequate user-developer interaction (1), Insufficient documentation (5) and Difficulty in the accurate estimation (39) are reported by three studies.

Code Challenge	Jaqueira [5]	Kamei [10]	This Study
C1		X	X
C2	X	X	X
C3	X		X
C4	X	X	X
C5			X
C6		X	X
C7		X	X
C8	X		X
C9	X	X	X
C10		X	X
C11	X		X
C12	X		X
J1	X		
J2	X		
K1		X	

Table 6. Convergence of some challenges

5.3 Limitations of this Systematic Mapping

This study did not consider papers published in 2014 because the research was under way. Approximately 6% of selected papers could not be analyzed with a view that was not available for download on the network of UFPE and there was no success in attempts to get the items directly to the authors. It is possible that some relevant paper has not been included for analysis. The available information on the techniques to elicit and specify requirements did not allow make a conceptual analysis. Therefore, it may be that there are techniques with common characteristics.

5.4 Lessons Learned

The use of Reviewer tool for automated search facilitated the initial analysis from the title and abstract. The tool generated a spreadsheet with this information, so that there

was no need to download the papers. Initial planning provided for the participation of four undergraduate students to work in the first phase of the mapping. However, this practice was not effective, the divergence rate was too high for the evaluation of the other member of the pair. Thus, their participation was canceled.

5.5 Further Research

During the extraction phase were also collected data about good practices on RE. In this way, we intend to make a thematic summary similar to what was done to the problems, challenges and limitations. We intend to propose actions that can be taken to minimize the problems identified in the articles analyzed in this study. The results of this systematic mapping will be used as source of information for the realization of a Survey to be conducted with software engineers who work in companies that adopt agile methodologies in three states of Brazil. The goal is to know the perception of engineers on the customer's participation in the activities of requirements, the implications that the RE have on quality and productivity. The results of the Survey will be faced with this mapping to verify the points of convergence and divergence.

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