Empirical Observations on Requirements Engineering Practices in Palestine

Samer ZEIN [a,1], Norsaremah SALLEH [b] and John GRUNDY [c]

[a] *Department of Computer Science, Birzeit University, Birzeit, Palestine,*
szain@birzeit.edu
[b] *Department of Computer Science, International Islamic University, Kuala Lumpur,*
Malaysia, norsaremah@iium.edu.my
[c] *Faculty of IT, Monash University, Melbourne, Australia, john.grundy@monash.edu*
ORCiD ID: Samer Zein https://orcid.org/0000-0003-3720-4384, Norsaremah Salleh
https://orcid.org/0000-0001-5625-7014, John Grundy
https://orcid.org/0000-0003-4928-7076

Abstract.

Requirements Engineering (RE) is critical to the success of software development projects. Industrial software projects that apply poor RE practices usually suffer from severe quality challenges and even project failures. Even though RE has been drawing more attention in the literature, there is a lack of empirical evidence of RE practices and challenges at industrial contexts. To address this we carried out a study to evaluate the perspectives of software engineers on their RE practices to understand more about how software engineers approach RE process and what are the challenges they face. We conducted a multi-case study by interviewing 8 participants from 5 software development companies in Palestine. Our results show that for all the RE process seems to be fairly systematic with whole team involvement. Further, the agile RE model is the dominant model, and over half reported that key challenges are caused by issues that originated from the client side. Finally, we highlight interesting future RE research from the perspective of industrial practitioners.

Keywords. Requirements engineering, software development, case study.

1. Introduction

Requirements Engineering (RE), remains an essential and pivotal part of all software development projects. All software practices require the gathering and refinement of stakeholder requirements in order to define what software should do [1]. RE refers to the set of methods or practices that are associated with requirements elicitation, requirements specification (documentation), requirements validation, and requirements change management [2,3]. A requirement is an essential artifact in the software project and repre-

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[1]Corresponding Author: Author Samer Zein, szain@birzeit.edu.

sents the actual need of every stakeholder and how the system will satisfy these needs. Requirements are usually written in natural language and are considered as the main input for the software design phase.

Correct implementation of RE practices serves as the key base for all other software development activities, and is considered to be vital to the success of software projects. According to [4], a large portion of software project failures are due to poorly elicited, documented, validated, and managed requirements. Further, the quality of applied RE methods can highly affect the company's revenue, reputation, goodwill, customer satisfaction, and ability to sustain high-quality products in today's competitive environment. Accordingly, RE is still receiving much attention from both researchers and practitioners to enhance the overall RE process and to identify more efficient practices.

Despite recent advances in the field of RE in terms of tools, methods, and promising contributions, relatively little is known about the state of practice of RE methods and their related challenges faced by software engineers in industrial contexts [1]. In fact, the overall empirical evidence about RE practices is rather weak and steered by conventional wisdom [5,6]. Thus, it is important to identify and analyze how industrial teams perceive and apply RE methods, and whether or not they are in tune with the state-of-the-art proposed in the literature. This can help researchers to provide new contributions that could allow software engineers to produce high-quality software products and meet expected quality targets [7].

In the context of Palestine, the IT and software development sector is very promising and constantly expanding. A large number of new software development companies of various sizes and business domains predominantly provide high-quality out-sourced projects to clients in Europe and North America [8]. It is true that there exist some studies that investigate various industrial software development practices in Palestine [9,10,11,12], however, to our best knowledge, there are no studies that investigate the area RE. Investigating the state-of-practice of RE methods in this sector can help expand our knowledge of how practitioners apply these methods and what are the challenges they face. Our main objective of this research is to explore and understand how practitioners apply RE methods and which problems do they experience. Such understanding can provide better insights on where future research should focus more in order to better steer the research community, and to produce solutions that are aligned with the actual needs of practitioners in the industry.

To do this, we conducted an exploratory multiple-case study of five software development companies in Palestine. Results showed that practitioners apply well defined requirements validation methods; the requirements change management is very systematic with high involvement of technical team; and practitioners apply different templates for requirements documentation based on team experience. Regarding the RE challenges, even though some of the challenges are the same as the one in the literature [5], new challenges are emerging such as the need to deal with the high expectations of the clients in terms of applications of AI (Artificial Intelligence) and smart features. Further, we suggest new research directions that are based on solid empirical foundation.
Our study provides the following main contributions:

- First study to investigate industrial RE practices in Palestine.
- In-depth insights on how requirements elicitation, specification, validation, and management are performed.
- Highlight new RE challenges that are faced by industrial teams.

- Highlight future research focus to better enhance the RE overall process.

2. Our Study

2.1. Research Methodology

Our main objective in this research is to explore and understand the state-of-practice of RE methods, and the challenges faced by practitioners in the context of IT sector in Palestine. It helps identify where future research should be focusing in order to enhance the overall RE process at industrial contexts. Case studies are qualitative research methods that focuses on the natural setting of phenomenon under investigation, and can provide in-depth information and deeper understanding [13,14]. Further, case studies are based on systematic methodology of data collection, data analysis, and are based on input from several data sources. We chose to carry out our study on Palestinian software company RE practices, in part inspired by lack of empirical industry studies on RE reported to date from the Middle East and Africa [6].

2.1.1. Case Study Design

According to [13], multiple-case study design is more robust and provides more evidence and deeper understanding than single case study design. In this research, we investigated empirical evidence from five different industrial companies (known as "cases") of different sizes and business domains. Such variety for selected cases will produce richer insights and resulting into more convincing conclusions. Each selected case under investigation represents a software development company in Palestine.

Yin [13] recommends that case study design is based on a theoretical framework. However, theoretical frameworks in software engineering are still underdeveloped [14], but still can be based on the literature review . Accordingly, based on our literature review, we developed the following theoretical bases that guided us in our data collection and data analysis process:

- *Overall RE process:* The overall RE process, including applied techniques and methods.
- *RE faced challenges:* The challenges faced by software engineers during the RE process compared with the literature.
- *RE future research:* Future research areas for RE as suggested by software engineers.

2.1.2. Research Questions

Based on our research aim, we developed the following key research questions:

- **RQ1:** What is the state-of-practice of RE methods in industrial contexts?
- **RQ2:** To what extent are applied practices aligned with the state-of-the-art?
- **RQ3:** What contemporary problems practitioners experience in RE?
- **RQ4:** Where future research should focus in order to better enhance the RE process?

2.1.3. Case Selection

According to [14], cases in software engineering can range from individuals, teams, processes, tools, companies, and so forth. In this research, each of our cases is a software development company, and the unit of analysis are the business or software analysts working in those companies. The selection of the companies was based on the availability, as well as, personal relationships with the main author. However, we also based our selection of practitioners on purposive sampling, which choosing interviewees based on the specific aims of answering our research questions [15]. Accordingly, business analysts and software analyst were considered as our primary target interviewees since they are mainly responsible for the entire RE process. Our interviewees' inclusion criteria can be seen at Table 1.

Table 1. Inclusion criteria for Interviewees

Criterion	Value
Education	Bachelor, Master, or Ph.D
Position	Business analyst, software analyst, product owner, project manager, or system analyst
Experience	At least three years of related experience
Projects	Participated in at least two software development projects
RE work	Significant involvement in RE practices

2.1.4. Data Collection

Our data collection methods were based on interviews and focus groups. Both methods were utilized using open-ended and semi-structured questions, allowing questions to be modified and added during the data collection process [16]. We conducted two focus group interviews and 3 single interviews. There were eight (8) participants in total. Interview protocol was designed early during study design and before the start of interviews. At the beginning of each interview and focus group, participants were informed about the main purpose of the study, confidentially, and estimated time (about 60-90 minutes). Interview questions were designed based on the research questions, and the first part of the interview collected demographic data about interviewees and their companies. The second part of the interview collected data about RE applied practices, challenges, future research, and so forth. Interviews were recorded using main author recording machine after getting the consent of the interviewees. It is worth noting that all interviewees agreed to record their interview sessions. After each interview, the main author transcribed the whole interview following guidelines from [14].

Following the chain of evidence guidelines by [13], all data collected from interviews and focus groups was given special identification numbers so as to be traced back to its original interview.

2.1.5. Data Analysis

According to [13,14], qualitative data analysis is done in iterative process using thematic coding method. First transcribed interviews was read several times by main author to get familiar with the data and derive initial set of codes. The initial set of codes

were shared with second and third authors for validation, quality, and making sure the codes were grounded in data. Secondly, we used specialized thematic coding tool named Taguette [2] for highlighting text excerpts. Each code represent certain theme or construct. One code can be assigned to many excerpts and the same excerpt can be assigned to more than one code. In third step, coded excerpts are analyzed and codes can be merged, deleted, or combined to form hierarchies. In the final step, excerpts were grouped based on their codes, and themes were generated guided by our research questions and theoretical framework. All case study data collection and analysis can be found online [3].

3. Results and Discussion

In this section we present our multi-case study results. We first present demographic information for cases and interviewees, then we proceed into answering and discussing the research questions.

3.1. Demographic Information

To preserve participant confidentiality, we refer to our cases (companies) as C1, C2, C3, C4, and C5. The first case, C1 is a large and well established software development company with around 300 employees. They are specialized in providing health care and data science services for clients in the Gulf. The company has teams distributed in Palestine, Egypt, Saudi Arabia, UAE, and India. The second case, C2, is a small software development company with 6 employees, providing SaaS (Software as a Service) solutions for clients in Europe and North America. The third case, C3, is a medium software development company with about 100 employees. They provide software solutions for clients in Palestine and the Gulf. The fourth case, C4, is a large software development company with more than 300 employees, distributed in Palestine, UK, India and the US. They provide software products for running all aspects of management information systems (MIS), such as ERP, talent management, human resource management, payroll, and so forth. Finally, the fifth case, C5, is a small software development company with a team of providing international software solutions for the construction sectors and fleet management. Additional information about included cases can be found at Table 2.

Table 2. Demographics of Included Cases

ID	Business Domain	Dev. Model	size	No. Employees
C1	health care data science	Agile &Waterfall	large	300
C2	SaaS	Agile	small	6
C3	MIS solutions	Agile &Waterfall	medium	100
C4	HR, ERP, Payroll	Agile	large	300
C5	Construction &fleet management	Agile	small	13

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[2] www.Taguette.org

[3] https://github.com/szainbzu/RE$_{Case_study}$.git

We conducted two focus group interviews, and three single interviews. Total participants were eight (8). We will refer to our participants as D1 to D8 to preserve confidentiality. A summary of participants demographics can be seen in Table 3.

Table 3. Demographics of Participants

ID	Role	Years Experience	Gender
D1	Project Manager	13	Male
D2	Business Analyst	14	Female
D3	Business Analyst	4	Male
D4	Product Manager	12	Male
D5	Project Manager	23	Male
D6	Business Analyst	20	Male
D7	Product Manager	15	Male
D8	Product Manager	7	Male

3.2. RQ1:What is the state-of-practice of requirement engineering methods in industrial contexts?

Regarding the overall requirements engineering process, there are two main points to be highlighted. First, in all included cases, the RE process seemed to be fairly strict and systematic. All included cases despite their company size, business model, or software development process, have a well-defined RE process with detailed specification about each phase and when to move from one phase to another. The team member that is responsible for RE process, such as business analyst and software analysts, is considered to be the main bridge between the technical team and the client. Business analysts are the ones who have considerable experience and also domain experts. Further, business analyst should also have other important skills such as communication skills and be able to maintain personal trust with the client: *"BAs should be expert in the application domain. This is a critical point here since that generic BA experience may be not enough on its own."* – Business Analyst, C1.

Secondly, team work is very obvious during the requirements engineering process in all organisations. The technical team is involved from the early phases of RE process. During the initial phases of RE process, business analysts keep consulting the technical team to keep them involved regarding technical issues, requirements realization, feasibility, priority, and so forth. The overall process of RE is clearly iterative, in which, the business analysts start with eliciting high-level requirement, then move into detailed specification later on in a drill-down an iterative manner: *"During the requirements specification, we work in iterative manner, in which, we get new details from client. Then we consult our technical team for requirements feasibility and realization from a technical perspective."* – Product Manager, C1.

Requirements Elicitation: It is the first phase in the RE process, and it is concerned with the methods of requirements collection. Our results show that interviews and focus groups are the main methods of requirements elicitation. These two elicitation methods are done using online and face-to-face means: *"...we mixed online and face to face methods to interview the customer. we interview everyone who will use the system."* – Product

owner, C5 ; *"Interviews are considered to be the main requirement elicitation technique. Interviews are done using both face to face and online methods."* – Business analyst, C1.

It is important to note that prototyping is widely utilized during the requirements elicitation phase and usually done by a specialized technical team: *"The UI/UX design team help us in building the prototypes of parts of the system to make sure that the client is on same line. Later on when the requirements are better understood, we make team reviews with architects, and quality assurance team members to validate the requirements more."* – Business analyst, C2.

Further, some cases stressed the importance of client on-site visits by business analysts to gain more insights about real need of the requirements and the problem they intend to solve: *"We also meet with the client at their work site. Emails are used but, only for the operational level only, not for requirement gathering."* – Business analyst, C1.

Below we provide results and discussion for methods applied for each of the main phases of RE process. The provided definition of each RE phase is taken from [2].

Requirements Specification: This phase is concerned with requirements documentation, in terms of how requirements are documented exactly, the templates and the software products used. We noticed that every case have its own template for requirements documentation. These templates have evolved overtime based on the experience and conventional wisdom of the business analysts and technical team: *"...we do not have specific format, we use special software called LeanTime . when we write new ticket, we focus on what is it, why we will do it? and how we will do it? this model is based on our experience, it is not the best model"* – Product owner, C5.

We also noticed that during requirements elicitation phase, the business analyst team tends to write down additional requirements specification such as the business value, goal, priority, as well as design models and UI prototypes: *"For each user story we specify it business value, goal, who will benefit from it, and its priority. Requirements narratives are supported with models, such as activity diagrams, and GUI prototypes provided by our UI design team"* – Project manager, C1.

Requirements validation: The primary goal of this phase is to make sure that the gathered requirements are correct, complete, feasible, and so forth. Based on our interviews, UI prototyping, team reviews, and test case generation by quality assurance (QA) team are the three main requirements validation methods that are applied across all included cases: *"...we make reviews with the customers, we use prototypes to demo the solution for clients. We have special UI/UX team for prototyping. we do team reviews in multiple levels. they are involved from initial stages, and keep consulting them, they need to be aligned, their feedback is much appreciated."* – Product owner, C4. The technical team, as we stated before, is involved during all the phases of RE process. Further, UI prototyping is usually done by specialized UI/UX (User Experience) technical team.

Requirements change management: After the software system has been installed and regularly used by clients, new requirements inevitably emerge. The main goal of this phase is to understand and control requested changes of requirements. All included cases use a well defined process for requirements change that have evolved overtime based on their experience. This phase is very critical for software development companies since they need to clarify the impact of the change request, estimated time and effort, whether it is out of scope or not, and how much it will cost the client: *Requirement changes are documented, numbered and analysed by our business analysis and designers teams to evaluate their impact, and if they are out of scope or not.* – Business analyst, C3.

3.3. RQ2: To what extent are applied RE practices aligned with state-of-the-art?

Before answering this question it is important to note that we do not expect that applied RE practices in the industry to be fully aligned with state-of-the-art. The agile development model is the dominant model for all included cases in this study as seen in Table 2. Accordingly, we compared the reported RE practices with Agile RE practices reported in the literature.

Inayat et al. [6] conducted a systematic literature review to report Agile RE practices. The study identified 17 Agile RE practices that are reported in the literature. Based on our interviews, we found that our investigated cases apply most of the reported 17 Agile RE practices such as face-to face communication, customer involvement, user stories, iterative requirements, requirements prioritization, prototyping, and so forth. The only practices that we did not find them applied were pairing for requirements analysis, and shared conceptualization. Further, the interviewees did not mention the adoption of any of the state-of-the-art methodologies for Agile RE reported by [17], such as User-Centered Design, Design Thinking, Contextual Inquiry, and Participatory Design. Overall we can conclude that the investigated industrial teams fairly apply basic Agile RE practices during their RE process. However, it is apparent that the industrial teams are not aware of state-of-the-art Agile RE methodologies reported in the literature.

3.4. RQ3: What contemporary problems do practitioners experience in RE?

In order to answer this question, we classified the challenges faced by business analyst during the RE process into two categories: (i) internal challenges; and (ii) client-side challenges. Internal challenges are the ones concerned with issues originated from the development team itself. In contrast, client-side challenges are challenges caused by issues that originated from the client context. Overall, we found that about 60% of reported challenges belong to the client-side category. Table 4 shows the list of challenges, their corresponding category, and the company (case).

Overall, we noticed that software development companies that provide customized software products for international clients suffer more with the problem of different agreements and signing regulations from one client to another. Further, they suffer from the problem of having business analysts that are not experts in the client domain. On the other hand, software development companies that provide SaaS (software as a Service) solutions did not report considerable challenges since that they already provide well-defined software product with almost fixed services. On the other hand, one of the interviewees made it clear that new advancements in AI and ML (Machine Learning) are making it hard to satisfy customer expectations. Apparently, customers are noticing the new advancements in AI and ML and are increasing their demands to reach new levels of expectations. *"Depending on this new attitude, we are facing more difficulties to do requirements engineering that satisfy a high level of expectations from the clients"* – Product owner, C2.

3.5. RQ4: Where should future research focus in order to better enhance the requirements engineering process?

Out of the five cases, three stressed the need for more research to **better manage requirements change requests** in terms of identification of change effect to minimize cost

Table 4. Reported Requirement Engineering Challenges

Challenge	Category	Case
Poorly written requirements	Internal	C1
Poor team internal communication	Internal	C1, C4
Business analysts not asking the right questions	Internal	C4
Business analyst is not familiar with client domain	Internal	C3
Business analyst not aligned with development team and client	Internal	C1
Business analyst lacking communication skills	Internal	C1
Low client experience in client domain	Client-side	C1, C3
Client not always available, unwilling to cooperate, or providing late feedback	Client-side	C1,C3, C4
TOR (Terms of Reference) is ambiguous or very abstract	Client-side	C3
Client point of contact lacking the empowerment to sign agreements	client-side	C1, C3, C5
Client has several points of contacts	Client-side	C1
Changing requirements that go out of scope	Client-side	C3
Agreement regulations that are different from on client to another	Client-side	C5
Recent advances in Artificial Intelligence services have made it harder to achieve customer expectations	Client-Side	C2

and time. Apparently, the industry have to deal with a large number of requirements change requests. This has also been shown in other recent empirical industry survey work [18] However, keeping pace with those requests can be challenging, and time and cost consuming. More research is needed in real industrial contexts to identify and evaluate better requirements change methods [19].

On the other hand, one interviewee stressed the need for **new RE methods that can simplify the client approval process**, especially when dealing with daily requirements change requests. Another interviewee highlighted the need for more research in the **area of requirements validation**. The interviewee stated that customers are now looking for more evidence that goes beyond the capabilities of UI prototypes. For instance, the interviewee stated that some customers during the RE initial phases are even asking to see how the detailed reports will exactly look like. Such new expectations can be very challenging to meet for industrial teams.

Finally, based on our interviews, we noticed the need for more research to i**dentify and evaluate the optimal RE methods** that can increase work productivity and lower cost and time in general. It seems that industrial teams are implementing various RE methods for elicitation, specification, and evaluation, without knowing which methods are the most effective. Again, more empirical research is needed **in real industrial contexts** to answer such emerging industrial needs. Such needs agree with the recommendations by others[5,6], which clearly statesthat empirical research for industrial RE is weak and is largely dominated by studies that focus on aspects that can not be readily generalized.

3.6. Threats to Validity

All empirical studies are subject to validity threats. We discuss threats to validity based on the classification proposed by [14,13].

Internal validity is the degree in which study design and conduct is likely to prevent systematic errors. According to [13], the internal validity was not considered since the nature of this study is exploratory.

External validity is the degree to which the results and observations of this study can be generalized outside the study. Our study is based on answers of eight participants from five different companies. Accordingly, the results cannot be widely generalized and are only valid in this context. However, this study is exploratory in nature and intend to suggest new research direction for future studies.

Construct validity is concerned on the extent of the accuracy of observations and how they describe the phenomena of interest. In the data analysis methods, the coding and thematic analysis can suffer a creation bias from the main author. To overcome this threat, the second and third authors reviewed the generated codes and themes on regular bases.

4. Related Work

Requirements engineering practices. The study by [20] presents a comparison and analysis of results obtained from three surveys collecting data about RE practices in the industry. The study aims to investigate the changing landscape of industrial RE practices over the years. The overall results show that RE practices are gaining higher satisfaction level. Further, some RE practices showed no significant change such as requirements inspection and prototyping. On the other hand, the longitudinal study by [5] attempts to address the problem of lack of empirical data regarding what RE challenges exist, as well as, state-of-practice. the study performed replication data gathering from 228 companies in 10 different countries with a cause-effect analysis. The results identified the contemporary problems faced by development teams during the RE phase and their root causes and effects, and their success factors that would mitigate such problems.

The study by [7] focused on the fact that RE practices can help teams in software development startups to deliver solutions that better serve user needs in the market. The authors performed a systematic mapping study to analyze state-of-the-art of RE evidence for startups. The authors argue that requirements elicitation, documentation and prioritization is losing focus. However, the number of research studies in RE for startups is on the rise.

In another study by [21], the authors realize the importance of correct implementation of RE practices at the industry and how this affects the software project overall quality. The study conducted a survey research to gather information from software development companies in Pakistan, to identify current challenges faced in the RE practices. The authors argue that a large portion of software development companies in Pakistan comply with the state-of-the-art of RE techniques. Further, the studied companies aware of the latest trends in RE and are capable of competing in the global markets.

Agile requirements engineering practices. Inayat et al. [6] performed a systematic literature review to identify RE practices and challenges in agile software develop-

ment teams. The study reveals 17 agile practices for RE. The study reveals common RE challenges and how they are resolved in agile teams, and challenges that are specific to agile RE practices. They found agile RE practices generally outperform more traditional approaches in most studies analysed. They also found a number of reported limitations with currently industrial practices and empirical, including change management, self-organising RE teams, and very limited geographic studies on RE practices in industry, including none in the Middle East, South America or Africa.

In a study by [22], the authors conducted a survey-based research to increase the empirical knowledge of RE practices and contemporary problems at industrial contexts. They have collected data from 92 different organizations. The results showed that agile teams mainly use free-text documentation of requirements and that a large variety of requirements elicitation techniques are applied. Further, the backlog is considered as a central means when dealing with requirements changes. On the other hand, three main challenges were identified: incomplete requirements, moving targets, and communication flows.

In a recent study by [23], the authors focused on investigating the practices used in industrial agile software development projects to gather and document non-functional requirements. Non-functional requirements have been reported as being problematic issue at agile software development projects. The authors started their investigation using a systematic literature review method to identify an interview guide and non-functional requirements elicitation and documentation techniques. In the second phase, the authors conducted semi-structured interviews with 10 professionals in the industry. The results also reveal discrepancies between agile software development practices in theory and practice. The practitioners aim to identify non-functional requirements early during the development process. Additionally, there is a lack of elicitation techniques that are directly associated with the elicitation of non-functional requirements.

In another recent study, Kasauli et al. [24] performed a multi-case study with seven large-scale software development companies to understand best practices and challenges of RE in industrial contexts. the study reveals common challenges cases such as establishing a shared view of value between different stakeholders, supporting requirements change and system evolution, and representation of requirements knowledge.

5. Conclusion

In this research, we conducted an exploratory multiple-case study involving five different software development companies of different sizes and business models. The aim of the study was to investigate and understand the RE practices applied at industrial teams, as well as, the challenges faced and the future of RE research from the perspective of the industry. Focusing on the IT Industrial sector in Palestine, we have interviewed 8 participants from 5 software companies. Our results indicated that: i) in all included cases, the RE process seemed to be fairly systematic and the technical team is involved from the early phases of RE, ii) many of the RE practices reported in the literature are applied in practice and agile development model is the most dominant process model been used, iii) 60% of reported challenges caused by the issues that originated from the client context, and iv) focus future research on ways to manage requirements changes, requirements validation, and new RE method that can increase work productivity and

reducing cost and time. As part of our future work, we plan to replicate this study in several other countries to see if findings generalise.

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