

A Case Study in Requirements Engineering in Context of Agile

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Abstract

Requirements Engineering (RE) in agile is an evolutionary process which involves active customer involvement, continuous planning, requirement reprioritization and validation through incremental product delivery. This paper describes a case study in requirements engineering in the context of agile. In particular, this study investigates the challenges and best practices in agile RE and demonstrates how agile RE is taking place in five software product companies. Furthermore, this paper describes a new approach to study agile RE practices based on difference in business model, where the end customer is a business entity versus a consumer.

Keywords: Agile; Requirements engineering; User stories; Product owner;

INTRODUCTION

Requirements engineering (RE) in its simplest definition is the process of determining end user expectations from how software should function to achieve the intended goal for the user. The process consists of requirements elicitation, analysis, validation and management [1]. RE is considered to be one of the most critical phases in software projects [2]. Poorly implemented requirements engineering is a major risk for project failure [3]. Moreover, in an agile context RE is a continues process where requirements will evolve during agile iterations, unlike waterfall where RE is finalized before implementation and requirement changes are negotiated with the customer through a change management process. Several other studies [4][5][6] that highlight traditional RE challenges were: less customer involvement, over scoping requirements, requirements documentation and communication issues.

However, recent studies [7] [8] [9] demonstrate how agile RE practices [10]: customer involvement, continuous planning, acceptance test, requirements prioritization, requirements modeling and face-to-face communication resolved traditional RE challenges. Furthermore, challenges [10] [13] posed by agile RE practices themselves were: minimal documentation, customer unavailability neglecting non-functional requirements, inadequate requirements verification and customer inability. However, solutions across these challenges are reported in other studies, such as: “user goal” oriented user stories [9], creation of delivery stories to accompany user stories [14], surrogate customer [13] and iterative RE [13].

On the other hand, a recent study [15] recommends more empirical research is needed to better understand how agile RE takes place.

Through our case study, we have reached out to software practitioners involved in agile projects to understand how RE is being practiced in an agile context where requirements are evolutionary and driven by continuous delivery of valuable software.

Furthermore, we have categorized this study into two areas based on the companies’ business models by exploring how agile RE is practiced, the challenges faced and best practices derived.

The rest of the paper is structured as follows: second section provides the methodology of how the research was executed and third section provides the results of the case study. Fourth section discusses the results from a different point of view, based on companies’ business models. Finally, fifth section provides the conclusion.

METHODOLOGY

In this section, we describe the company profile, respondent information, questionnaire used in our case study and the steps conducted in our research.

A. Company profile

For this case study, we collected data from five software product companies with different business models. Company1 is a multinational that creates cloud storage software products for businesses. Company2 is multinational product and service company that provides loyalty programs for household users and small business to improve engagement. Company3 is a software product company with an online marketplace delivering personalized recommendations to millions of its subscribed users. Company4 is a global enterprise that provides an analytics platform for large business entities. Company5 is an e-commerce company that sells various cosmetic products to consultants and retail users.

Two of the companies have business entities as their end customers, operating only in the B2B space. Two of the companies have retail users as end customers, having a B2C model. One of the company has both retail users and small businesses as customers.

B. Respondent Information

The people that responded to the case study play different roles in the companies, namely product owners, UI designers, software engineers and Scrum masters. They are involved in the process of requirements gathering and creating user stories in an agile environment. The majority of the respondents have been practicing agile for more than seven years. Table 1 below shows the respondents’ information, namely: type of customer, respondent role in organization and years of experience in agile Scrum

Table 1: Summary of Respondents

Company pseudonym	Customer	Respondent role in organization	Year of EXP with Agile Scrum
Company1	Business entity	Product Owner	6
Company2	End Consumers	UI Designer	6
Company3	Business entity and end Consumers	Scrum Master	7
Company4	Business entity	Software Engineer	8
Company5	End Consumers	Product Owner	7

C. Questionnaire Design

The questions for this case study were designed on the basis of results and findings of a literature review of agile RE practices [15] [16]. The literature review focused primarily on these areas - customer involvement, face-to-face communication, requirements prioritization, continuous planning and requirements modelling. The findings provided good insight into how agile RE is being practiced in the software industry.

We considered the following aspects in order to come up with questions for this case study.

- Questions should be simple and clearly understood.
- The flow of questions should be logical and engaging.
- There should be a combination of objective and subjective questions.
- Terms and concepts used in questionnaire should be familiar to industry

We followed these steps to finalize the questionnaire:

1. Finalize the five main research questions
2. Finalize the sixteen sub-questions under the main research questions
3. Questions were reviewed by a few agile practitioners
4. Questions were updated as per the review comments and finalized

The questionnaire for the case study was structured in two sections. Section 1 consists of objective questions around organization profile, size, and agile maturity. Section 2 focuses on how requirement gathering is practiced, followed by some of the best practices being used and common challenges faced around RE. This information is collected through a series of sixteen subjective questions that condense into five research questions.

Table 2 shows the case study questionnaire organized as per the research questions.

Table 2: Case study questionnaire

Research Question	Sub Questions
RQ1: What entities are involved in the requirements gathering process of the project?	1. Is the Product Owner solely responsible for requirements gathering from the customer? If not, who interacts with the customer? 2. What is the mode and frequency of interaction with the customer during requirement gathering?
RQ2: How is customer communication managed as part of requirements engineering process?	3. How do you interact with your customer for discussing requirements (email, face-to-face, etc.)? 4. Does the customer provide accurate requirements definitions OR are a few rounds of discussions needed to derive requirements definitions? 5. Does a follow-up meeting with the customer take place to verify requirements and reprioritize them? 6. Is the customer involved throughout the project via Sprint review or only during project start and release? 7. If there are multiple customer representatives, how do you prioritize and build consensus over the requirements?
RQ3: How are User Stories defined?	8. What is the customer's involvement to assist product owner to define epics and user stories? 9. Are non-functional requirements captured as independent user stories? If not, how are they captured? 10. Once you write acceptance criteria for the stories, do you discuss them with customers?
RQ4: What are common challenges faced in the requirements engineering process?	11. What challenges do you face when the customer does not have knowledge of agile methods? 12. What challenges do you face in prioritizing requirements and are they negotiated with the customer? 13. What challenges do you face while creating user stories for the Scrum team? 14. What challenges do you face defining the interaction of end users with the software interface (UX Design)?
RQ5: How are requirements managed and changes tracked throughout the project cycle?	15. Where and how are requirements managed and tracked? Are the discussion notes with customers for requirements fine tuning also tracked? 16. How do you handle requirements traceability in order to track requirements later on? What challenges do you face in this process?

D. Case Study Execution

We used two approaches in gathering information from the respondents. In the first approach, we conducted face-to-face interviews. In the second approach, where in person meeting wasn't possible, we put the questionnaire in a web form created using a third-party service called Typeform and sent it to respondents for inputs offline. Follow-up to clarify the

responses was done by email or through telephonic communication. Face-to-face interviews lasted around 30 minutes, during which time handwritten notes of the interview were created. Interview questions were adjusted as per role of respondent and flow of topic. Online questionnaires required around 30 to 45 minutes to complete

RESULTS

In this section, we are presenting the analysis from the interviews in the form of research questions and answers received from respondents.

A. RQ1: What entities are involved in the requirements gathering process of the project?

Product owners primarily drive requirements gathering in all the companies, though are not solely responsible. UX designers, engineering leads, and marketing teams collaborate in the requirements gathering process. Interaction with the customer is frequent with most interactions taking place through teleconference, interviews, surveys, inputs from customer support and sales teams. During the course of the project, the product owner continues to interact with the customer as requirements evolve and calls upon Scrum team members on need basis.

B. RQ2: How is customer communication managed as part of the requirements engineering process?

For discussing requirements, face-to-face interaction with customers seem to work best for many respondents. For remote customers, video calls over WebEx is preferred. For indirect requirements gathering, interaction with customers is through remote studies, surveys. Preliminary requirements gathering requires a few rounds of discussion with the customer and is usually never completed in the initial discussion. Where there are multiple stakeholders on the customer side, prioritization and consensus building over the requirements takes place after engaging with customers on a one-to-one basis, analyzing the trend of inputs and then letting the product owner take the final call on requirements. Furthermore, customer interaction for most of the companies after the initial requirements gathering and UX design stage is during the feature releases across product demos and post-release validations.

C. RQ3: How are user stories defined?

Once initial requirements are identified, the product owner creates high level epics and works with the engineering lead to define user stories in the form of features. The customer's role in user story creation and review is very limited for most of the respondents. We asked the respondents whether acceptance criteria for the epics and stories is being discussed with the customer after their definition. Most of the respondents mentioned that the acceptance criteria are not usually discussed with the customers, but agreed that it would be useful to do so. For non-functional requirements, there is no standard practice followed by respondents. A few respondents

mentioned that non-functional requirements are discussed with customer and defined as independent user stories, while a few respondents mentioned they are usually defined by the product owner and addressed towards the end of the project cycle.

D. RQ4: What are common challenges faced in the requirements engineering process?

One challenge a few respondents pointed out is the customer's lack of knowledge of agile product development methods. Most respondents indicated that though agile methods are for internal development, the customer's knowledge of agile helps manage expectations about incremental deliveries and sets an expectation of more involvement in refining requirements and validations through product demos at feature completion.

Another challenge is negotiating the priority of the requirements with the customer. All respondents mentioned that prioritization does take place, but that they also faced the challenge of finding a balance between business and customer goals. Customers may

have prioritized a big requirement, but it will be deprioritized if it doesn't generate significant revenue. Respondents mentioned that they used the incremental delivery model of agile to counter this challenge, where they renegotiate requirement priorities and timelines during the project, based on project parameters (of resource, scope, cost) prevailing at that time.

Furthermore, another challenge identified by a few respondents has been the increase in scope of work once the UX design is done, since it results in the discovery of additional details. The estimate and date commitments based on initial scoping in those scenarios fall apart, requiring the product owner to renegotiate feature delivery timelines with the customer.

Respondents were also asked about challenges faced in creating user stories during requirements gathering. A few respondents mentioned that the user stories are too granular or too high level, based on the individual style of product owners. Additionally, due to the evolving nature of requirements, the UX design may at times not be ready when stories are taken up for backlog grooming, resulting in dependencies or impediments during the sprints.

E. RQ5: How are requirements managed and changes tracked throughout the project cycle?

Regarding managing and tracking of requirements from customers, all respondents used JIRA, Confluence or Rally. Though the initial requirements are being documented, only a few of the respondents are tracking follow-up discussions on the requirements or feedback received on the requirements. Most respondents mentioned that requirement traceability is difficult to maintain because documentation is not kept up to date and tends to get outdated as requirements evolve throughout the course of the project. The alternative is to keep the user stories updated and in sync with customers' requirement changes.

DISCUSSION

Based on the responses to the case study from the software industry practitioners investigated, the practice of agile RE can be categorized into two categories based on the organization's business model. In the first category, end customers represent another business entity (a vendor, partner and/or consumer). In the second category, end consumers interacting with the software product (online retail customers) represent the end customer. Since the end customer entities are different in both cases, the practice of agile RE is also seen to be different.

In this section, we discuss how agile RE is being practiced, the types of challenges faced and best practices being followed across the two categories.

A. Agile RE practices where end customer represents business entity

1. How is RE practiced?

In this case, the product owner is primarily responsible for requirements gathering from the customer, though the tech lead and QA also participate in the interaction with the customer (a business entity). The frequency of interaction with the customer during the first few iterations of requirements gathering can be anywhere from once in two to three weeks.

Initial meetings are done face-to-face, followed by a WebEx or telecon for follow-up discussions. The communication method that works best for most of the respondents is video conferencing. In most cases, one or two rounds of discussions with customers is sufficient to create accurate requirement definitions, but at times a few additional rounds are required.

A follow-up meeting with customers takes place for high complexity projects, mainly to verify and reprioritize the requirements. Customer involvement was observed, throughout the project, in the form of refinement of requirements, sprint demos and incremental feature releases.

If there are multiple customer stakeholders involved, each customer is individually engaged on a one-to-one basis, and prioritization of requirements then takes place, based on the business importance.

2. User story creation

After the first iteration of requirements gathering is completed, the product owner is responsible for creating user stories. In addition to functional requirements being written as user stories, the non-functional requirements are most frequently captured as independent user stories by all the respondents. Once the product owner defines the acceptance criteria for the stories, some respondents said that they discuss them with customers while some said this practice was not required to be followed.

3. Challenges faced in RE

Customer's lack of agile knowledge presents a certain challenge to the agile team. Most respondents found it useful to explain to the customer in the initiation meeting that interaction over the course of the project needs to be frequent, involving regular discussions on requirements and feedback on product incrementally through product demos.

With regards to requirements prioritization, respondents face the challenge of reprioritizing the requirements after having committed to delivering them to end customer. The reprioritization may occur if the engineering team comes across complexity or technology constraint that makes delivery unviable in committed time frame.

4. Best practices followed in RE

A few of the best practices followed are –

- a. Defining business goals according to requirements, which helps Scrum team to keep desired outcome in mind.
- b. The skill to communicate with the customer is very important and it's one which the product owners in their company strive to improve continuously.
- c. Multiple feedback sessions with the customer during UX design process.
- d. In large organizations with complex systems where business analysts (BA) are involved in requirements engineering, templates with required inputs and outputs are created by BA. They, in coordination with the product owner, work with customers to define requirements.

B. Agile RE practices where end customer is a consumer

1. How is RE practiced?

Companies that fall into this category have consumers who interact with the product over the company website. In these companies, the product owner is solely responsible for requirements gathering and defining product direction. Also, this is a collaborative exercise with engineering leads, UX teams, research and analytics teams and peers from other departments. Direct interaction with end consumers is very limited. The data points for requirements gathering in this case come from surveys, interviews, feedback forms hosted on websites, net promoter score (NPS), inputs from customer support and consumer analytics team.

To verify requirements and then to prioritize them, the product owner gets together with the Scrum team and other stakeholders in the company for feedback sessions on the product features using high fidelity mocks and interactive prototypes. End customer involvement throughout the project lifecycle is mainly after a feature is released to market, where feedback from end customers is sought indirectly through data analytics and customer support feedback.

In this model, prioritization of requirements is done by the product owner based on inputs from business and customer support teams who have a good idea about the needs of the primary customer and what will provide maximum return on investment to business.

2. User story creation

Once initial requirements are identified from multiple channels, the product owner creates epics and works with the engineering lead and Scrum master to define user stories. These are then reviewed with business and leadership and solidified. Product

owners usually capture non-functional requirements as independent user stories and tie them into the feature epics.

As part of a user story definition, the product owner writes the acceptance criteria which are mainly used for dev/QA team to focus on delivery. Most respondents mentioned that it would be good practice to have them reviewed by marketing. The product owner also creates product roadmaps and feature releases which would be released incrementally.

Prioritization of requirements is being done by balancing new feature development work with improvements that are required for released features as per inputs from customer support. Also, requirements are constantly evolving and are captured as user stories in the product backlog.

3. Challenges faced in RE

In this model, one of the major challenges faced by the product owner according to respondents is defining interaction of end users with the software interface (UX Design), since feedback from end customers is not immediate and indirect. It is a challenge to constantly improve user experience while making sure the users are not confused due to big changes in user interaction with the application.

Another challenge is when user interface across new features is not completely defined and development starts across those features nonetheless, which introduces development overheads. A common problem mentioned, is that requirements documents get outdated as they are not updated as requirements emerge. The solution used is to capture new requirements as user stories and update them as needed during the backlog grooming process.

4. Best practices followed in RE

A few of the best practices followed are –

- a. A/B testing (or split testing) by rolling out a functionality to a select set of users and
- b. Using analytics to collect feedback.
- c. Usability lab to share product concepts and seek feedback from team members on the requirements.
- d. Additionally, requirements are documented along with wireframes and workflows to help engineers understand overall objectives throughout the course of the project.

CONCLUSION

Our case study confirms that for RE to be successful in agile projects, a collaborative mindset is required among customer, product owner and the team. Throughout this case study, we understand how agile RE is being practiced where requirements are always evolving and there's a continuous delivery of valuable software. The study also described differences in RE practices in the B2B model where the end customer is a business entity, versus a B2C model where the end customer are consumers. The case study investigates the best practices adopted by agile practitioners as well as the challenges faced in agile RE practices.

The present finding from the case study will help agile RE practitioners to improve their RE practices and will provide valuable inputs to implementers of requirements management tools in refining requirements management functionality.

Further empirical studies are required in areas where agile RE practitioners are facing challenges: customer's involvement in defining user stories and acceptance criteria, managing requirements reprioritization and requirements traceability throughout the duration of the project.

As part of future work, we intend to create an agile requirements management tool that will incorporate these findings and be used by the customer, product owner and the Scrum team to collaborate on requirements. The tool will also provide the customer visibility on user stories, non-functional requirements along with a mechanism for feedback and validation.

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