# Agile Requirements Engineering in a Distributed Environment : Experiences from the Software Industry during Unprecedented Global Challenges

Proceedings - 2024 IEEE 48th Annual Computers, Software, and Applications Conference, COMPSAC 2024

Li, Yishu; Keung, Jacky; Bennin, Kwabena Ebo; Ma, Xiaoxue; Zhang, Jingyu et al

https://doi.org/10.1109/COMPSAC61105.2024.00098

# Agile Requirements Engineering in a Distributed Environment: Experiences from the Software Industry during Unprecedented Global Challenges

Yishu Li
*Dept of Computer Science*
*City University of Hong Kong*
Hong Kong, China
yishuli5-c@my.cityu.edu.hk

Jacky Keung
*Dept of Computer Science*
*City University of Hong Kong*
Hong Kong, China
Jacky.Keung@cityu.edu.hk

Kwabena Ebo Bennin
*Information Technology Group*
*Wageningen University and Research*
Wageningen, Netherlands
kwabena.bennin@wur.nl

Xiaoxue Ma
*Dept of Computer Science*
*City University of Hong Kong*
Hong Kong, China
xiaoxuema3-c@my.cityu.edu.hk

Jingyu Zhang
*Dept of Computer Science*
*City University of Hong Kong*
Hong Kong, China
jzhang2297-c@my.cityu.edu.hk

Zhen Yang
*School of Computer Science and Technology*
*Shandong University*
Qingdao, China
zhenyang@sdu.edu.cn

2024 IEEE 48th Annual Computers, Software, and Applications Conference (COMPSAC) | 979-8-3503-7696-8/24/$31.00 ©2024 IEEE | DOI: 10.1109/COMPSAC61105.2024.00098

***Abstract*—Unprecedented global challenges such as the COVID-19 pandemic necessitated a widespread transition to Work-From-Home (WFH) arrangements for project teams, posing significant challenges in conveying requirements within agile Requirements Engineering (RE). While numerous studies have examined the impact of transitioning work routines during the pandemic, limited research exists on the specific challenges of agile RE operating within the WFH context. Given the pervasive shift in the software development ecosystem worldwide, where WFH is projected to persist even in the post-COVID era, it is imperative to ascertain the challenges associated with WFH-based agile RE.**

**During the pandemic, we collaborated with startups to conduct an industry-academia project. By adopting the methodology of action research, this study comprehensively analyzed agile RE practices and reported the key challenges encountered within the WFH context. To mitigate these challenges, several collaborative RE techniques were employed in three intervention cycles. Interviews were conducted to thoroughly analyze the results. This study also provides insights into collaborative RE techniques and valuable lessons learned.**

**Considering the increasing prevalence of WFH as a working mode in the post-pandemic era, this study equips the community with practical strategies to navigate agile RE challenges and better prepare for unprecedented challenges in the future.**

***Index Terms*—Agile requirements engineering challenges, Work from home, Software startup, Action research**

## I. Introduction

Requirements Engineering (RE) serves as the fundamental cornerstone of the software development process, providing the basis for effort management, architectural design, development framework construction, and definition of testing strategy. The quality of requirement pertains to the specific attributes of requirements that contribute to the successful and cost-effective realization of a system, addressing the user's needs [1, 2].

In recent years, the agile software development method has gained widespread adoption among both established small and large companies [3]. A comprehensive survey conducted by [3] revealed that startups operating in uncertain and rapidly changing environments often opt for agile methodologies. Startup companies, often operating with limited resources, strive to deliver innovative products and software-driven services [3]. Consequently, ensuring effective control over the quality of RE artifacts holds significant importance in the context of startup project development.

The significance of learning agile RE in the Work-From-Home (WFH) context has been underscored by the outbreak of the COVID-19 pandemic and subsequent lockdown measures, which necessitated a shift to remote work for software engineers in many companies [4, 5]. Agile teams heavily rely on collaboration, making the WFH conditions particularly challenging for requirements engineers [6]. Notably, the number of professionals working from home on a permanent basis is expected to continue increasing [7]. In fact, a CFO survey by Gartner reported that 74% of companies plan to transition some employees to permanent remote work arrangements after COVID-19 [8].

The primary objective of this paper is to gain a comprehensive understanding of the challenges faced by agile RE teams in startups operating within the WFH context, particularly when sudden constraints arise. To facilitate a deeper comprehension and offer practical recommendations for agile RE in various WFH work environments, it is imperative to examine real-world cases within the WFH conditions. The challenges faced by requirements engineers in Chinese startup software development companies were particularly pronounced due to the implementation of strict lockdown policies in China. We hypothesize that these

2836-3795/24/$31.00 ©2024 IEEE
DOI 10.1109/COMPSAC61105.2024.00098

challenges are highly susceptible to disruption caused by the abrupt transition to WFH. Drawing from these observations, our aim is to explore the ways in which collaborative RE techniques can effectively alleviate these challenges. To guide this study, three research questions are formulated as follows:

RQ1. What are the agile RE challenges a startup team faces under the WFH context of unprecedented global challenges?

RQ2. What collaborative RE techniques can help alleviate the observed challenges under the WFH context?

RQ3. To what extent can these RE techniques help to alleviate observed challenges?

In this study, we report the experience of a startup named ORG[1], which embraced agile as their software development approach and engaged in an industry-academia collaborative project throughout the COVID-19 pandemic. To address RQ1, we employed action research interventions and followed the agile RE challenges observation framework [9] integrating with the WFH context imposed by the pandemic, aiming to explore the RE challenges and risks in each intervention cycle. In the context of restricted WFH conditions, we introduced several collaborative RE techniques to address RQ2. Specifically, we investigated various collaborative RE techniques across multiple RE activities, including requirement elicitation, modeling, transfer, prioritizing, and demonstration. Through interviews, feedback collection from different stakeholders, and analysis of relevant documents, we observed the impact of the applied techniques outlined in RQ3.

This study provides a comprehensive account of the challenges and practices of agile RE within the WFH context of unprecedented global challenges. By conducting an in-depth analysis of a single case with shared WFH experiences, the findings can be generalized to other similar contexts of the uncertain distributed working environment.

The remainder of this paper is structured as follows: Section II provides an overview of the existing literature on related context. Section III details our action research approach. Section IV outlines the challenges identified and addressed throughout three intervention cycles, while Section V presents the key lessons learned from the study. In Section VI, we examine potential threats to validity, focusing on transferability and reflexivity in the evaluation of action research. Finally, Section VII concludes our study.

## II. Related Work

### A. Agile RE

Cao and Ramesh [10] conducted an empirical study on agile RE practice. Data from 16 organizations were collected to compare the differences between agile RE and traditional RE. The participants reported that intensive communication is the most vital RE practice between developers and customers [10]. Through experience reports and case studies extracted from 52 articles in the systematic literature review of industrial large-scale agile transformation, Dikert et al. [11] found 38% of teams met four main RE challenges: high-level requirements management largely missing in agile, requirement refinement challenging, creating and estimating user stories hard, and the gap between long and short term planning. They indicated a dedicated "requirement architect" can help to bridge the gap between development and requirement management. These studies show that the human factor plays one of the most critical roles in agile RE.

### B. RE in Startup

In the systematic mapping study of [12], 43 primary studies were identified and mapped to investigate software development in startup companies. The studies reported establishing an engineering process for collecting, defining, and managing requirements in a startup context is challenging. Paternoster et al. [12] found one of the most frequently reported contextual features of startups concerns the general lack of resources. Klotins et al. [13] examined 88 startup experience reports and indicated the root cause of startup failures is the three types of anti-patterns: 1) not getting the first product release, 2) not attracting customers to the product, and 3) challenges of scaling the product for new markets.

### C. RE and Global Software Engineering

Research on Global Software Development (GSD) has increased in the last few years [14, 15]. Herbsleb [16] described a globally-distributed project for large companies. This study [16] reveals dealing with unstable requirements is a big challenge, not only for end-user requirements but anything that specifies what a team should deliver. Ebert et al. [17] summarized the experiences and trends from the international conference on GSD. They indicated collaborative development environments and tools enable effective development. In the systematic literature review of [18], the authors explored the tools used in GSD. The authors found that the issue tracking system is the most frequently provided feature for requirements tools, which allows users to be aware of important issues or changes. Jalali and Wohlin [19] conducted a systematic review to investigate the GSD and agile practices. From the cases they reported, there were some success factors, such as distributed business relationships. The idea of GSD has evolved into the remote work we know today.

### D. RE during COVID-19 Pandemic

WFH under normal circumstances differs from WFH due to COVID-19 restrictions [7, 20]. The restricted COVID-19 WFH makes the engineers work under stress and with not fully provisioned home office [20]. Miller et al. [5] surveyed WFH during the COVID-19 pandemic and investigated how managers and leaders can support and sustain team productivity during times of crisis and beyond. They identified that communication, camaraderie, and team cohesion affect software development team productivity. One of the critical issues reported by the respondent is WFH, which leads to difficulties in communicating with teammates [5]. Smite et al.

[1] We named the company as ORG due to their wish to remain anonymous.

[21] illustrated the new trends in the demands for flexibility among company employees and modifications to work policies that are emerging in response to these demands. The authors found the demand for flexibility concerning the privilege to work from home apparent within the study. However, these studies did not discuss agile RE challenges and their consequent risks in-depth, especially in the WFH context of unprecedented global challenges.

## III. Methodology

Following the definition in [22, 23], we choose an AI-advisor platform development project (a cooperation project hosted by ORG and City University of Hong Kong) as our case for studying the agile RE challenges faced by startups during COVID-19 pandemic. One of our researchers participated in the project to make changes to RE activities. Wohlin and Rainer [23] argued that a study is regarded as action research if the study shares similarities with the case study research method while focusing on active participation for change. Therefore, our study is labeled as action research, and this article reports the lessons learned.

### A. Study Context

The industrial company ORG participated in an academia-industry research project for the development of an AI-advisor software. The project's main deliverable was to build an investment advisory platform integrated with an artificial intelligence engine.

Agile was adopted as the mainstream development approach in this cooperative project. Aligning with the productive structure of the agile team discussed in [24], the project team had 8 members involved as presented in Table I. All participants have at least two years of relative working experience. Due to the limited resources of the startup company, no particular testers were engaged. The role of a tester was performed by the Project Manager (PM), Business Analyst (BA), and stakeholders. The team members were mainly located in three regions in China's Greater Bay Area (i.e., Hong Kong, Macao, and Mainland China). Because of the strict border control and lockdown policy, the team members used the WFH shift during the project period. The last column in Table I summarizes each team member's WFH duration.

### B. Agile RE Evaluation Framework

In [9], the authors conducted an empirical study into agile requirements engineering practices. They applied grounded theory to identify six agile RE practices, which are listed and described as follows: face-to-face communication (P1); iterative RE (P2); constant planning (P3); extreme prioritization (P4); prototyping (P5); reviews and tests (P6).

Ramesh et al. [9] proposed a framework for evaluating the impact and appropriateness of agile RE practices by relating them to RE risks. Additionally, Ramesh et al. [9] consolidated nine distinct risks (with minimal overlap) and mapped them with agile practices and challenges. In the systematic literature review of [25], the authors summarized the four most common RE risks in GSD as follows: 1) knowledge sharing; 2) client and vendor relationship; 3) problems with process definition; 4) communication problems.

In our study, we followed the same framework proposed by [9] but integrated with and adapted to a WFH context to explore the challenges and risks exposed by the six agile RE practices. Based on observation and interview results collected, we mapped the challenges and most recurrent RE risks proposed in [25] by analyzing the relationships between practices, challenges, and risks to answer RQ1. The overall mapping is presented in Figure 1. In Section IV, we summarize and discuss them with details for each challenge and analyze its consequent risks for different action research intervention cycles.

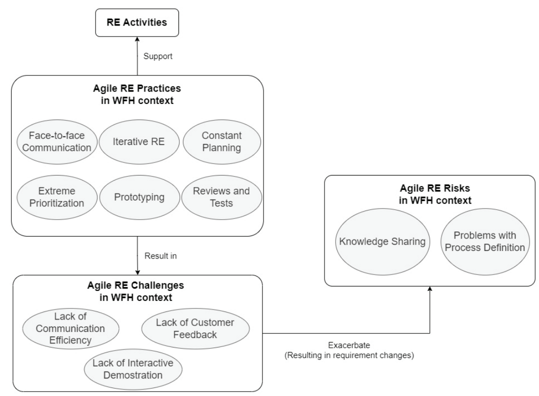


Fig. 1: Evaluating challenges and risks exposed from RE activities. Adapted from [9] and integrated observations under WFH context

### C. Action Research

*1) Research Activities:* Kalenda et al. [26] adopted a 5-step process to carry out an action research, which includes diagnosis, action planning, action taking, evaluation, and specifying learning. Staron [27] recommended to follow a 5-step cycle to guide the action research in software engineering. Following the action research process presented in [26, 27], we adopted the 5-step action research cycle in each development phase, conducted the evaluation, and specified the learning steps concurrently in the next phase or at the end of the project period.

To observe the challenges and provide improvement on the WFH-based RE practices, the researchers made interventions that are tailored to the local practice. The project schedule was divided into three phases of development. Following the project schedule and agile sprint practice, our research activities were split into three problem-solving cycles, aligning with the project development phase. Table II presents the detailed intervention period. The evaluation and reflection steps of Phase I intersect with the diagnosis and planning step in Phase II. The setup ensures the previous changes are further improved in the next iterative changes.

TABLE I: Team Structure and Background of Developers for ORG

| Role | Qt. | Background | Working Location | WFH Duration |
|---|---|---|---|---|
| Stakeholders | 2 | Over 10-year relationship manager experience on global bank | Macao, Hong Kong | Project Period |
| Project Manager (PM) | 1 | Over 10-year experience of financial IT project management | Shenzhen | Project Period |
| Business Analyst (BA) | 1 | 3-year business requirement analysis experience on global bank | Hong Kong | 5 Months |
| Data Scientist (DS) | 1 | 2-year experience of data analysis on bank | Hong Kong | 4 Months |
| Developer | 2 | 3 to 5 years' development experience on IT products | Hong Kong | 4 to 7 Months |
| UI Designer | 1 | Freelancer with 3-year UI design experience | Tianjin | Project Period |
| Tester | 0 | Holding concurrent post by PM, BA and stakeholders | Mixed | Mixed |

Project Period (15 months): September 2020 to November 2021

TABLE II: Intervention Cycles in Project Development

| Intervention | Step | Period |
|---|---|---|
| Cycle I | Diagnosis (PP I) | 09/2020 - 10/2020 |
| | Planning (PP I) | 09/2020 - 10/2020 |
| | Changes (PP I) | 11/2020 - 02/2021 |
| | Evaluation and Reflection (PP II) | 01/2021 - 03/2021 |
| Cycle II | Diagnosis (PP II) | 01/2021 - 03/2021 |
| | Planning (PP II) | 01/2021 - 03/2021 |
| | Changes (PP II) | 04/2021 - 07/2021 |
| | Evaluation and Reflection (PP III) | 06/2021 - 08/2021 |
| Cycle III | Diagnosis (PP III) | 06/2021 - 08/2021 |
| | Planning (PP III) | 06/2021 - 08/2021 |
| | Changes (PP III) | 10/2021 - 11/2021 |
| | Evaluation and Reflection (PP III) | 12/2021 - 06/2022 |

PP - Project Phase

*2) Industrial-academia Collaboration:* To gain an in-depth understanding of the problem, authors in action research conducted participant observations [28]. Following the practice of [29], one of our authors worked as the BA in the development team for the whole project period. Following [27], SE practices (i.e., organization and product performance improvement) and SE theories (i.e., concepts of "industry as a lab") are taken as input for the diagnosing steps. The five steps of action are collaboratively conducted by both the industry and the research team. The development activities were conducted by the BA and the development team. The activities of collecting evidence, such as observations, were conducted by the rest of the research team. Working in a cross-functional role, the BA took part in the research activities for solution discussion.

### D. Data Collection

[30] presents multiple data collection techniques in a case study research. In our study, the main techniques applied are *observation*, *reflection*, *interview*, and *relevant documents*. The practical experiences we report in this article are based on the data collected to answer the three formulated research questions. Below, the different data collection methods used for our study are presented.

*1) Observation:* In the diagnosis period, the observation was planned, where the research team participated in the sprint discussion and review meetings and conducted informal interviews with the development team. The BA took responsibility for requirement analysis in the project development. The rest of the researchers participated in observing the requirements-related activities, such as requirement elicitation, daily meetings for requirement delivery, and product demonstrations. These activities were held in sprint meetings.

*2) Reflection:* Apart from the planned observation, we interviewed the other team members to reflect on requirements-related challenges reported by the BA. This was to mitigate the bias raised by a single participant. Such reflections are presented combined with the analysis to answer RQ1.

*3) Interview:* Other essential feedback and information were mainly collected through unstructured interviews and semi-structured interviews with different parties, i.e., stakeholders, developers, PMs, and potential customers. The unstructured interviews were held during the sprint review meetings of reflection. No prearranged questions were prepared for the unstructured interviews, which allowed for in-depth discussion of a topic to capture more informative feedback. The semi-structured interviews employed a set of feedback questions as presented in Table III, allowing the order of questions to vary to fit the conversation and interviewee's roles. When evaluating the adopted RE techniques to answer RQ3, we analyzed the feedback collected from the respondents. The main questions used for the interviews are presented in Table III. IQs 1, 2, and 8 were delivered to the interviewers iteratively in each intervention cycle, which is supportive evidence of analysis from the research team to answer RQ1. IQs 3 to 7 were delivered to the interviewers during the evaluation and reflection period, which targets to answer RQ3.

*4) Relevant Documents:* With permission from ORG, we collected all requirement documents, project performance reports, architecture design specifications, and others. Our analysis and discussion in Sections IV and V are based on these documents. During the 3 phase development period, 25 major requirement change requests were raised during development. In the acceptance test for each sprint, 120 defects were identified and reported in total.

### E. Data Analysis

Data analysis was conducted parallel to the data collection approach of [31]. In each of the intervention cycles,

TABLE III: Sample Questions of Semi-Structured Interview

| Q# | Interview Questions | Interviewer(s) | Period |
|---|---|---|---|
| IQ1 | What type of requirements changes are mainly raised in this project? | stakeholders, PM | Cycle I, II, III |
| IQ2 | What are the causes for requirements changes? | stakeholders, PM, developers | Cycle I, II, III |
| IQ3 | How do you think constant collaboration helps with understanding requirements? | stakeholders, PM, developers | Cycle I |
| IQ4 | How do you initially capture the requirements for the platform? | developers | Cycle II |
| IQ5 | How do design thinking activities help with your understanding of requirements? | stakeholders, developers | Cycle II |
| IQ6 | How does mixed language help with your understanding of requirements? | developers | Cycle II |
| IQ7 | How do you think the roster customer testing work in your project? | stakeholders, PM, customers | Cycle III |
| IQ8 | To what extent does the product meet your expectations? | stakeholders, customers | Cycle I, II, III |

we conducted a diagnosis based on our observations and reflections. Montgomery et al. [2] conducted a systematic mapping study of empirical research on requirements quality. From the 105 relevant primary studies, the authors found that empirical requirements quality research has primarily focused on "requirements" with little attention given to other artifacts such as use cases, user stories, or issues in issue trackers. They suggest that future research can consider insights as this field grows. Following the suggestion, requirements changes, user stories, and defect lists are considered for data analysis in the diagnosis step in each intervention cycle.

Based on the diagnosis, the research team developed collaborative RE techniques to answer RQ2. In the evaluation and reflection phases in each intervention cycle, we compared the defect lists linked to each technique and interviewed the project teams to collect further feedback to answer RQ3. In the discussion in Section V, the lessons learned are analyzed using defect tracking and respondent feedback.

## IV. Intervention

In this section, we report the challenges observed from each intervention cycle, which answers RQ1. Then, we discuss the planning and changes in the cycle to answer RQ2, respectively. Table IV presents the challenges and risks diagnosed from each intervention cycle.

### A. Cycle I

*1) Diagnosis:* **Lack of communication efficiency (C1).** Face-to-face communication is one of the key agile manifesto principles because such communication is the most effective and efficient method to convey information within a development team [32]. Another important agile manifesto principle is "Business people and developers must work together daily throughout the project" [32]. Therefore, in intervention Cycle I, the research team mainly observes agile practice P1.

This project was conducted during the pandemic, with team members in three regions under locked-down restrictions. The project team could only communicate online during the WFH period, precluding any possibility of face-to-face interactions. With agile practice, the team was to have regular meetings for each sprint. For requirement clarification, it wasn't easy to explain with details without face-to-face communication. The BA pointed out the lack of efficiency when communicating with WFH team members. Compared with practicing working in the office, the BA must spend more time on online discussions to convey the requirements. The BA found it less efficient to communicate with stakeholders because they were WFH for the whole project period. For clarification on each requirement, they spent more time discussing whether it was expected. Instead, the communication efficiency improved when the BA worked with other developers in the same working location.

Intersected in agile practices P3 and P6, the research team conducted informal interviews with the development team to observe their feelings on the WFH working procedure. During the sprint reflection interview, the developers identified significant gaps in understanding when relying solely on online communication methods. Both front-end and back-end developers reported that the effectiveness of integration development was diminished under these conditions, as it necessitated the coordination of multiple engaged parties, which proved challenging in a purely virtual environment.

For answering IQ1 and IQ2 in Cycle I, the respondents reported the requirement changes mainly caused by the understanding gap. Evidently, communication remains a significant challenge in agile RE during the pandemic.

The challenges C1 reported above reveal that the understanding gap was enlarged under a strict WFH context with a lack of communication efficiency during the pandemic. The limited understanding of the requirements makes obtaining a shared understanding in the team difficult. Furthermore, observations indicate that C1 has heightened the frequency of adjustments to requirement planning, thereby posing a substantial risk to requirements management.

*2) Planning:* **Constant Communication.** Compared to traditional development methods, agile methods rely on extensive collaboration, i.e., face-to-face communication [6]. Inayat et al. [6] discussed how agile RE could resolve five challenges compared to traditional RE in the systematic review. Agile methods depend on tacit knowledge and frequent face-to-face communication to support knowledge sharing [6]. To emphasize the importance of face-to-face communication in agile RE and concerning challenge C1, we propose to define some rules on WFH communication.

*3) Changes:* **Quick review meetings.** Since the project faced instant communication and demonstration difficulties during the pandemic, more regular online requirement discussion meetings were held between BA and stakeholders. At the beginning of the day, the BA held half an hour meeting

TABLE IV: Diagnosis in Intervention Cycles

| Interventions | Challenges | Practices | Causes | RE Risks |
|---|---|---|---|---|
| Cycle I | C1: lack of communication efficiency | P1, P3, P6 | understanding gap | RS1: knowledge sharing<br>RS2: problems with process definition |
| Cycle II | C2: lack of interactive demonstration | P5, P6 | | |
| Cycle III | C3: lack of customer feedback | P2, P3, P6 | customer inability<br>rapid market change | |

for requirements delivery to ensure developers clarified the detailed requirements. At the end of the day, another quick review meeting lasting for 15 minutes allows BA to review the daily progress and verify whether the development fits the requirements.

**Regular response for instant group messages.** During WFH, the team could not discuss the issues face-to-face, and the communication was shifted to online discussion. The team members were located in different areas, as presented in Table I, and various daily chat tools were used in these areas. The PM requested team members to report queries to the group chat for instant discussion. The BA regularly checked the group message in working time so that reported issues could be discussed in time.

**Ad-hoc discussions.** Apart from these periodic updates, the ad-hoc discussion was used to assist with communication and to mitigate the communication gap and delay. If the team found any issues requiring multi-members for discussions, the ad-hoc meeting would be held for a quick and short discussion engaging all related members.

### B. Cycle II

*1) Diagnosis:* **Lack of interactive demonstration (C2).** The platform was developed for both web and mobile usage, incorporating interactive functions that necessitate touch interactions on the mobile client. From observation of P5, prototyping is a key activity in the early phase of the project development, which offers a better understanding for project team members. This activity mainly relies on the engagement of the BA and the UI designer. The UI designer is located in Tianjian, which must WFH all the project time. The BA reported it difficult to express the underlying interactive requirements without face-to-face communication (such as informal conversations) when discussing with the UI designer.

The development team reported difficulties demonstrating interactive requirements in RE practices of P5 and P6. The front-end developer specifically mentioned that interactive behavior implementation was challenging to clarify in online discussion mode in a WFH environment because such requirements cannot be demonstrated through virtual communication.

Through answering IQ1 and IQ2 in Intervention Cycle II, the development team reported that the major requirement changes were mainly caused by the understanding gap. Analyzing these changes reveals two significant requirements that were requested to update the interactive behavior in the platform. The absence of interactive demonstrations emerged as a critical challenge, contributing to the understanding gap among various stakeholders and leading to changes in the initial requirements.

The challenges C2 reported in Cycle II reveal that the understanding gap was enlarged with a lack of interactive demonstration. The constrained demonstration of requirements significantly impedes the establishment of knowledge sharing within the team. Similar to the risk delineated in C1, C2 has augmented the frequency of adjustments to requirement planning, which is a massive risk to requirements management.

*2) Planning:* **Online Design Thinking.** Design Thinking (DT) is a process that emerged from design areas. Carell et al. [33] studied two cases to explore how software companies adopt DT in development. A key finding is that it is helpful for requirement engineers to adopt the mindset of designers to deal with the challenges of digital transformation projects [33]. DT approach with development context is based on four principles as follows: users' needs take center stage; deep understanding rather than large numbers of cases; interdisciplinary team; and following a clear process ("understand, empathize, define, ideate, prototype, and test") [33]. Penzenstadler [34] argued that focusing on the technical perspective requires a deeper look at the social implications of the technology. She suggested stepping back to explore "why" we are undertaking the project or program [34]. Inspired by these two prior studies, we propose to adopt design thinking in WFH prototyping to alleviate C2. To evaluate the effectiveness of the changes, we recorded some informal interviews during the changes. Additionally, for the communication between the UI designer and the BA, the changed versions are recorded and compared.

**Mixed Language Presentation.** In agile software development, the most used technique is user story [35]. Some researchers argued user stories must be written following business language [36]. However, Bjarnason et al. [37] found software requirement specifications with more technical language may reduce the effort for coding, testing, and maintenance. The study in [6] indicates non-functional requirements are neglected if user stories satisfy system or product features only. We adopted the mixed language technique to present online to alleviate C2 and its consequent risks.

*3) Changes:* **Online brainstorming.** The project was to build an AI-advisor platform that includes major investment-related features. In the understanding phase, the main focus was understanding the problem and its elements. Following the vital principle (i.e., user's needs take center stage) of DT presented in [33], we stepped into the users and held some online activities based on a human-centered design approach. We invited 8 people from various professions (i.e., two relationship managers in the bank, three experienced investor users, one software architect, one web developer, and one UI designer) for online brainstorming, which gave the project team a deeper understanding of the user behavior and day-to-day business use of the platform.

**Online demonstration.** We studied four competitive products to help empathize with users and determine expected functionalities. Based on ideas extracted from these activities, the BA built and demonstrated the prototype to potential users. During the online demonstration, all participants run the same product to ensure all are on the same line. These prototypes offered the team the possibility of clarifying and testing the interaction.

**Write user stories with technical acceptance criteria.** To reduce the risk of enlarging the knowledge gap, the BA in our collaborative project adopted the user-story model proposed in [37] and [6], using both "acceptance criteria" and "technical aspects" when drafting user stories. Some requirements, like web client and back-end server communication, contain functional and technical aspects. When writing user stories for such cases, user behavior acceptance criteria and API definition were considered to assist with coding and testing.

**Demonstrate with technical data examples.** A mixed-language technique was adopted when demonstrating the requirements to the developers. The BA presented technical examples (e.g., API tokens) to developers to convey the expected data requirements.

### C. Cycle III

*1) Diagnosis:* **Lack of customer feedback (C3).** Customer involvement is one of the principles of agile practice [32]. However, the project was performed during the pandemic, and the customer could only engage online at the beginning of the brainstorming and testing stage. This limitation of constrained involvement in sprint meetings (P2, P3, and P6) became evident that some feature implementations failed to align with user expectations, particularly those featuring interactive design elements. From the review of requirements changes, two major causes were the customer's inability to participate in sprint User Acceptance Testing (UAT) and rapid market change. As a startup team, ORG did not have a large customer group for preliminary testing to investigate the most popular user behavior. The BA reported insufficient customer involvement, which made the user experience less than expected.

Apart from the user experience problem, the lack of customer involvement made the platform less market-sensitive. The platform was built for an investment portfolio recommendation. The contagion effect exists in the US and China stock markets during the pandemic [38], making the data-related requirement frequently change to fit the market trend. Moreover, the project's objective entailed the development of AI-driven financial products, necessitating the integration of rapidly evolving machine learning models tailored for financial systems, such as [39]. The WFH policy makes delivery lack instant market-related feedback from customers during development, leading to a proportion of later requirements changes.

C3 results in the lack of knowledge sharing between the customer and the agile team. It has the potential to precipitate changes in requirements, thereby constituting an additional risk to requirement management and the subsequent product release.

*2) Planning:* **Roster Customer.** Customer involvement is one of the principles of agile practice [32]. However, this project was not entirely market-driven. The customer could only engage at the beginning of the brainstorming and testing stage. The insufficiency of customer involvement led to some implementations failing to meet user expectations, particularly regarding interactive features. As a startup team, the project team did not have a large customer group for preliminary testing to investigate the most popular user behavior. To alleviate the challenges in C3, team members were invited to consider themselves as customers to test the deliverables.

*3) Changes:* **Testing using our staff as end-user.** The BA, PM, and stakeholders conducted the UAT in each iterative review and testing activity. Additionally, the stakeholders occasionally demonstrated the deliverables to potential customers to collect instant feedback from potential customers.

## V. Discussion

To answer RQ3, we applied the comparative analysis for each technique proposed. The diagnosis and planning period is construed as the pre-treatment period, while the duration subsequent to the implementation of the change is designated as the post-treatment period. For each of the intervention cycle, we conducted some informal interviews with the participants. Additionally, semi-structured interview discussions targeting IQ3 to IQ8 were conducted to assess the efficacy of each technique. Furthermore, the defect list related to each challenge was analyzed for the effectiveness of the applied collaborative techniques. In this section, we provide the lessons learned ("+" indicates positive practice and "-" refers to the negative practice) from the analysis of the responses to questions in Table III.

### A. Constant Collaboration

The constant WFH collaboration allows rapid requirement validation and changes to fit market changes. During the project, the sprint increment was demonstrated to all, allowing stakeholders to figure out unsatisfied deliverables and adjust the subsequent sprint plan to include those requirement change requests. Stakeholders, in their response to IQ3, noted that ongoing collaboration empowers them to promptly respond to market fluctuations and modify requirements accordingly.

When answering IQ8, the stakeholders assign a satisfaction rating of 4 out of 5 to development, signifying that the majority of the implementation aligns with the acceptance criteria. Participants perceived that the compensatory constant collaborative activities facilitate the management of requirement changes, enabling the team to respond promptly, even within a fully distributed environment. Stakeholders posit that the rapid adjustment of requirements accommodates market changes, thereby maximizing business value.

**Lessons learned 1 (+) :** Increasing constant collaboration and defining communication rules allows the agile team to keep the alignment in requirement understanding under the WFH context, which can narrow the understanding gap on requirements.

### B. *Online Design Thinking*

In addressing IQ4 and IQ5, developers expressed a challenge in acquiring a thorough understanding of the business flow during Project Phase I, which hindered their grasp of the project requirements. They noted that the application of design thinking methodologies proved instrumental in gaining valuable insights into the conceptualization of the product's essence and attributes during Project Phase II, particularly within the post-treatment phase of Intervention Cycle II. Specifically, the back-end developer emphasized that participating in brainstorming discussions facilitated a clearer comprehension of the project's intricacies.

Moreover, stakeholders responding to IQ5 affirmed that despite alterations to certain requirements during the project's duration, the deliverable ultimately adhered to the predetermined expectations. They emphasized that the management of these changes remained well-controlled, effectively addressing market fluctuations.

In contrast to the defects documented in Project Phase I, a reduced number of issues emerged concerning the functionalities that had been discussed during the design thinking stage of Project Phase II development. During the reflection discussion, the stakeholders and potential users reported that most of the deliverables met their expectations. The developers stated the online brainstorming discussion and prototype demonstration cultivated a cognitive framework, facilitating their comprehension of the business flow. The feedback reveals that design thinking contributes to requirement transfer and narrows the understanding gap in the subsequent development stage.

**Lessons learned 2 (+) :** The integration of design thinking into agile RE within the WFH context serves as a supportive mechanism for team members, facilitating an understanding of the business flow and contributing to the enhancement of associated business value.

### C. *Mixed Language Presentation*

From the feedback of the developers, user stories with technical descriptions narrowed part of the understanding gap and accelerated their coding process. Developers recommended this practice as a positive approach to mitigate re-engineering resulting from knowledge gaps. In responding to IQ6, both front-end and back-end developers argued that the adoption of a mixed language technique could prove beneficial in bridging the comprehension divide. The front-end developer further reflected that employing mixed language techniques aided in capturing a more comprehensive understanding for design purposes.

Combining the analysis of the defect lists, it was determined that, during the pre-treatment period, 14 out of 49 defects (28.6%) were raised concerning integration functionalities, whereas in the post-treatment period, 8 out of 71 defects (11.3%) were identified. This observation implies that including technical descriptions in user stories could help alleviate the understanding gap among the development team and contribute to coding and testing.

**Lessons learned 3 (+) :** Utilizing a combination of different concerns in online requirements communication can assist with transferring from requirements to coding and testing.

In most software projects, providing the user stories with business acceptance criteria and technical description, as proposed in the study [37], does not imply successful implementation and delivery. Most often, a small proportion of features will have to be modified during the latter stages of software development because of the non-functional requirements being neglected. The project team faced a similar challenge during the WFH pandemic. Developers highlighted a specific instance wherein the API design was prematurely finalized in an early sprint, only to require updates in subsequent sprints due to limited discussion opportunities during WFH conditions.

Non-functional requirements, such as those pertaining to system performance, often face inadvertent oversight during the design phase, particularly within a startup team with a lack of instant communication among different parties. The PM reported that oversight of non-functional requirements necessitates adjustments or modifications to planning in subsequent sprints, thereby diminishing the overall effectiveness of agile management.

**Lessons learned 4 (-) :** The WFH context, characterized by reduced communication, has a tendency to result in the inadvertent neglect of non-functional requirements.

### D. *Roster Customer*

As a startup team, the development team faced constraints in conducting extensive preliminary testing due to the limited size of the customer group available. A retrospective analysis of the defect list revealed instances where certain defects were identified by customers only in the later stages of the development process. For example, one requirement necessitated modifications approximately six months into the project when a potential customer participated in the integration testing for the initial milestone deliverable. Although the requested enhancement was minor, rendering the system more user-friendly, it was unfortunately overlooked at the early phase of the development.

During demonstrations to potential customers, the majority of functionalities were perceived to align with market needs and business objectives. However, discrepancies between user expectations and observed behaviors were noted. In response to IQ7 and IQ8, one customer highlighted that requisite changes were raised in later sprints, attributing this delay to the absence of early engagement in UAT.

In Intervention Cycle III, the proposed actions of roster customers yielded limited enhancements. Consistent feedback from customers remained similar during both the pre-treatment and post-treatment periods. Upon reflection, it is evident that increased customer engagement within agile practices has the potential to enhance user experiences during the initial stages of development.

**Lessons learned 5 (-) :** The omission of customer engagement poses a challenge for WFH-based agile RE, resulting in a user experience that deviates from the anticipated expectations.

## VI. Threats to Validity

Action research should be assessed with the following criteria: *reflexivity*, *credibility*, *resonance*, *usefulness* and *transferability* [40]. This section discusses the threats to the validity of the results presented.

Concerning its transferability, which implies the possibility of plausibly applying it to other circumstances, our study is limited in two aspects. The first issue is related to the limitation of generalization. The lessons learned in Section V should be considered in light of the limit of our study. Like most qualitative research, our analysis does not support statistical generalization from a sample to a population. We study a single case in depth, with a common shared WFH background. The results can be transferable to other circumstances with similar contexts. The second limitation to transferability pertains to the application of agile methodologies. Similar to many startups, the project team exhibits deficiencies in adhering to certain processes integral to agile practices. In the reported project, some role configurations deviate from established agile practices. Despite these deviations, the project team endeavored to align with predominant agile practices concerning requirements activities, thereby mitigating potential repercussions on the agile RE process.

With regard to reflexivity, which is related to reflection on potential biases, the main limitation is the analysis, which mainly relies on the reflection of the project team members. In this study, we designed interview questions (Table III) to obtain information from the perspective of different interviewees to alleviate the threat. In addition, when diagnosing the challenges in Section IV, we integrate the analysis on requirement changes to reduce the bias from the observation of the research team. When discussing the lessons learned in Section V, the defect lists are combined to reduce bias from the views of respondents.

Considering the resonance, one limitation relates to the project period. The project was performed during the COVID-19 pandemic, with a strict and uncertain WFH context. The majority of the countries have canceled the border restriction post-pandemic. We will not be able to apply the action research on more startups. However, WFH has an increasing trend in software development companies. The insights gleaned from this experience report provide a practical reference for the RE community, facilitating an exploration of solutions towards mitigating challenges inherent in agile RE within the context of WFH, particularly in instances of uncertainty.

## VII. Conclusion

This paper presents an industrial experience report from a startup company that implemented the agile development method during the COVID-19 pandemic. By analyzing the agile RE practices and related documents, we identified three key challenges specific to agile RE within the WFH context: lack of communication efficiency, lack of interactive demonstration, and lack of customer feedback. These challenges further exacerbate two RE risks: knowledge-sharing difficulties and issues with process definition. To mitigate these challenges, the company implemented various collaborative practices. The effectiveness of these practices was evaluated based on feedback obtained from interviews, and valuable lessons were derived from the action research.

One positive practice that emerged from the study was the increased emphasis on constant collaboration and the establishment of clear communication rules, which helped bridge the understanding gaps in requirements. Another positive practice observed in the case study was the integration of design thinking principles into WFH-based agile RE, allowing the team to better comprehend the business flow. Additionally, the utilization of mixed language presentations proved to be beneficial in conveying requirements for coding and testing.

Conversely, the study also revealed two negative lessons. Firstly, the WFH context made non-functional requirements more prone to being neglected, thus exacerbating the risk of knowledge-sharing difficulties. Secondly, the inability to engage customers effectively in user acceptance testing resulted in a misalignment between the product's user experience and user expectations, representing a significant risk.

The ongoing trend of professionals transitioning to permanent WFH arrangements is anticipated to witness a continuous rise [7]. This shift poses significant challenges for startups engaging in agile RE practices within the WFH paradigm. While limited research studies exist on WFH-based agile RE, this report aims to contribute practical experience to the RE community.


## Acknowledgment

This work is supported in part by the General Research Fund of the Research Grants Council of Hong Kong and the research funds of the City University of Hong Kong (6000796, 9229109, 9229098, 9220103, 9229029).


## References


[1] A. Davis, S. Overmyer, K. Jordan, J. Caruso, F. Dandashi, A. Dinh, G. Kincaid, G. Ledeboer, P. Reynolds, P. Sitaram *et al.*, "Identifying and measuring quality in a software requirements specification," in *[1993] Proceedings First International Software Metrics Symposium*. Ieee, 1993, pp. 141–152.

[2] L. Montgomery, D. Fucci, A. Bouraffa, L. Scholz, and W. Maalej, "Empirical research on requirements quality: a systematic mapping study," *Requirements Engineering*, pp. 1–27, 2022.

[3] J. Pantiuchina, M. Mondini, D. Khanna, X. Wang, and P. Abrahamsson, "Are software startups applying agile practices? the state of the practice from a large survey," in *International Conference on Agile Software Development*. Springer, Cham, 2017, pp. 167–183.

[4] D. Russo, P. H. Hanel, S. Altnickel, and N. Van Berkel, "The daily life of software engineers during the covid-19 pandemic," in *2021 IEEE/ACM 43rd International Conference on Software Engineering: Software Engineering in Practice (ICSE-SEIP)*. IEEE, 2021, pp. 364–373.

[5] C. Miller, P. Rodeghero, M.-A. Storey, D. Ford, and T. Zimmermann, "" how was your weekend?" software development teams working from home during covid-19," in *2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE)*. IEEE, 2021, pp. 624–636.

[6] I. Inayat, S. S. Salim, S. Marczak, M. Daneva, and S. Shamshirband, "A systematic literature review on agile requirements engineering practices and challenges," *Computers in human behavior*, vol. 51, pp. 915–929, 2015.

[7] R. E. de Souza Santos and P. Ralph, "A grounded theory of coordination in remote-first and hybrid software teams," in *Proceedings of the 44th International Conference on Software Engineering*, 2022, pp. 25–35.

[8] J. Lavelle, "Gartner cfo survey reveals 74% intend to shift some employees to remote work permanently," *Gartner Newsroom*, vol. 3, 2020.

[9] B. Ramesh, L. Cao, and R. Baskerville, "Agile requirements engineering practices and challenges: an empirical study," *Information Systems Journal*, vol. 20, no. 5, pp. 449–480, 2010.

[10] L. Cao and B. Ramesh, "Agile requirements engineering practices: An empirical study," *IEEE software*, vol. 25, no. 1, pp. 60–67, 2008.

[11] K. Dikert, M. Paasivaara, and C. Lassenius, "Challenges and success factors for large-scale agile transformations: A systematic literature review," *Journal of Systems and Software*, vol. 119, pp. 87–108, 2016.

[12] N. Paternoster, C. Giardino, M. Unterkalmsteiner, T. Gorschek, and P. Abrahamsson, "Software development in startup companies: A systematic mapping study," *Information and Software Technology*, vol. 56, no. 10, pp. 1200–1218, 2014.

[13] E. Klotins, M. Unterkalmsteiner, and T. Gorschek, "Software engineering antipatterns in start-ups," *IEEE Software*, vol. 36, no. 2, pp. 118–126, 2018.

[14] J. D. Herbsleb and D. Moitra, "Global software development," *IEEE software*, vol. 18, no. 2, pp. 16–20, 2001.

[15] J. D. Herbsleb, A. Mockus, T. A. Finholt, and R. E. Grinter, "An empirical study of global software development: distance and speed," in *Proceedings of the 23rd International Conference on Software Engineering. ICSE 2001*. IEEE, 2001, pp. 81–90.

[16] J. D. Herbsleb, "Global software engineering: The future of socio-technical coordination," in *Future of Software Engineering (FOSE'07)*. IEEE, 2007, pp. 188–198.

[17] C. Ebert, M. Kuhrmann, and R. Prikladnicki, "Global software engineering: Evolution and trends," in *2016 IEEE 11th International Conference on Global Software Engineering (ICGSE)*. IEEE, 2016, pp. 144–153.

[18] J. Portillo-Rodríguez, A. Vizcaíno, M. Piattini, and S. Beecham, "Tools used in global software engineering: A systematic mapping review," *Information and Software Technology*, vol. 54, no. 7, pp. 663–685, 2012.

[19] S. Jalali and C. Wohlin, "Global software engineering and agile practices: a systematic review," *Journal of software: Evolution and Process*, vol. 24, no. 6, pp. 643–659, 2012.

[20] A. Nolan, R. White, M. Soomro, B. C. Dopamu, M. Yilmaz, D. Solan, and P. Clarke, "To work from home (wfh) or not to work from home? lessons learned by software engineers during the covid-19 pandemic," in *Systems, Software and Services Process Improvement: 28th European Conference, EuroSPI 2021, Krems, Austria, September 1–3, 2021, Proceedings*. Springer, 2021, pp. 14–33.

[21] D. Smite, N. B. Moe, J. Hildrum, J. G. Huerta, and D. Mendez, "Work-from-home is here to stay: Call for flexibility in post-pandemic work policies," *Journal of Systems and Software*, vol. 195, p. 111552, 2023.

[22] C. Wohlin, "Case study research in software engineering—it is a case, and it is a study, but is it a case study?" *Information and Software Technology*, vol. 133, p. 106514, 2021.

[23] C. Wohlin and A. Rainer, "Is it a case study?—a critical analysis and guidance," *Journal of Systems and Software*, p. 111395, 2022.

[24] C. Melo, D. S. Cruzes, F. Kon, and R. Conradi, "Agile team perceptions of productivity factors," in *2011 Agile Conference*. IEEE, 2011, pp. 57–66.

[25] J. Nicolás, J. M. C. De Gea, B. Nicolas, J. L. Fernandez-Aleman, and A. Toval, "On the risks and safeguards for requirements engineering in global software development: Systematic literature review and quantitative assessment," *IEEE Access*, vol. 6, pp. 59 628–59 656, 2018.

[26] M. Kalenda, P. Hyna, and B. Rossi, "Scaling agile in large organizations: Practices, challenges, and success factors," *Journal of Software: Evolution and Process*, vol. 30, no. 10, p. e1954, 2018.

[27] M. Staron, *Action research in software engineering*. Springer, 2020.

[28] J. Lazar, J. H. Feng, and H. Hochheiser, *Research methods in human-computer interaction*. Morgan Kaufmann, 2017.

[29] A. Ananjeva, J. S. Persson, and A. Bruun, "Integrating ux work with agile development through user stories: An action research study in a small software company," *Journal of Systems and Software*, vol. 170, p. 110785, 2020.

[30] G. Shanks and N. Bekmamedova, "Chapter 7 - case study research in information systems," in *Research Methods (Second Edition)*, second edition ed., K. Williamson and G. Johanson, Eds. Chandos Publishing, 2018, pp. 193–208. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B9780081022207000078

[31] M. B. Miles and A. M. Huberman, *Qualitative data analysis: An expanded sourcebook*. sage, 1994.

[32] K. Beck, M. Beedle, A. Van Bennekum, A. Cockburn, W. Cunningham, M. Fowler, J. Grenning, J. Highsmith, A. Hunt, R. Jeffries *et al.*, "Manifesto for agile software development," 2001.

[33] A. Carell, K. Lauenroth, and D. Platz, "Using design thinking for requirements engineering in the context of digitalization and digital transformation: a motivation and an experience report," in *The Essence of Software Engineering*. Springer, Cham, 2018, pp. 107–120.

[34] B. Penzenstadler, "When does design help thinking, and when does design thinking help?" *IEEE Software*, vol. 37, no. 2, pp. 6–9, 2020.

[35] G. Lucassen, F. Dalpiaz, J. M. E. van der Werf, and S. Brinkkemper, "Improving agile requirements: the quality user story framework and tool," *Requirements engineering*, vol. 21, no. 3, pp. 383–403, 2016.

[36] M. Cohn, *User stories applied: For agile software development*. Addison-Wesley Professional, 2004.

[37] E. Bjarnason, K. Wnuk, and B. Regnell, "A case study on benefits and side-effects of agile practices in large-scale requirements engineering," in *proceedings of the 1st workshop on agile requirements engineering*, 2011, pp. 1–5.

[38] D. T. Nguyen, D. H. B. Phan, T. C. Ming *et al.*, "An assessment of how covid-19 changed the global equity market," *Economic Analysis and Policy*, vol. 69, pp. 480–491, 2021.

[39] Z. Yang, J. Keung, M. A. Kabir, X. Yu, Y. Tang, M. Zhang, and S. Feng, "Acomnn: Attention enhanced compound neural network for financial time-series forecasting with cross-regional features," *Applied Soft Computing*, vol. 111, p. 107649, 2021.

[40] P. Ralph, S. Baltes, D. Bianculli, Y. Dittrich, M. Felderer, R. Feldt, A. Filieri, C. A. Furia, D. Graziotin, P. He *et al.*, "Acm sigsoft empirical standards," 2020.