Remote and Collaborative Software Development Projects: A Requirements Elicitation Exploratory Study

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Abstract: Remote and collaborative software development (RCSD) projects are gaining more relevance in the actual information technology (IT) industry. RCSD projects may carry many benefits, such as economic, velocity, and flexibility impacts to an IS project. Anyhow, RCSD might be complex, due to the team's geographic distribution, the issues of remote interactions, and other issues that might impact RCSD projects. One of the first aspects to be affected in RCSD is the software requirements given they are often at the project beginning. In this context, this research aims to analyse the factors that impact functional and non-functional requirements in RCSD projects. For this objective, we choose a case study with 59 participants that formed 11 teams of software development. As result, we find that, in this research context, three factors of those six had a positive association with the quality of RE. They are skills in software development, techniques of software development, and tools (adequate selection and usage). These finds are in line with the literature based on the triad People-Process-Tools. Our finds aim to contribute to the project management and software engineering theoretical bases relevant parts, mainly RE success factors, team management, and projects.

1 INTRODUCTION

The Software development process is no longer solitary or single-person-centered. Instead, it has been recognized as a collaborative process, where artifacts are shared constantly. This new paradigm has been named the remote and collaborative software development (RCSD) process. In RCSD, cooperation allows teams to better understand the information system (IS) and its requirements, such as functional and usability requirements. (Gallardo-López *et al*. 2016). However, new challenges impact distributed IS projects when this collaboration gains large scale, such as internationally distributed projects (Yadav, 2016).

RCSD projects are relevant because of many benefits, such as economic, velocity, and flexibility gains, although distribute projects might be complex. These benefits were most notably seen during the 2019-2021 pandemic period when the workforce had to quickly switch to a remote work environment (Stechert 2021). Many IS teams move forward to adopt the Agile development approach, even if they have not been adopted before. The hybrid approach also gained more momentum, given many project teams could work remotely, with no major quality impacts compared to the other alternatives then (Marek, Wińska & Dąbrowski 2021). On the other hand, Agile teams were thought to share physical environments. But when these projects are distributed among different places or regions, part of the teams' bounds are damaged (Stechert, 2021).

The remote environment challenges start to affect the project from its beginning. Requirements elicitation (RE) is one of the first aspects to be affected by a remote environment. Even before starting the software development phase as many project members might believe (Babar, Bunker, & Gill, 2018). RE might be defined as the discovery, gathering, and dissemination of user needs (Alexa e Avasilcai, 2018). Thus, one of the major flaws in software projects is related to incorrect and incomplete RE (Mishra, Mishra & Yazici, 2008). In this context, this research aims to analyse the factors

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that influence RCSD within virtual project teams. This main objective was narrowed down into two specific objectives: i) to identify factors that influence RE in virtual DCS projects with an agile approach, and ii) to analyse the influence these factors apply to the requirements quality. To perform this analysis, we investigated virtual teams which applied the Agile approach and the RCSD and that carried out RE activities.

2 THEORETICAL BASES

In this section, we detail two relevant concepts for this research. First, we define and classify the RE. We then detail RCSD.

2.1 Requirements Elicitation (RE)

In traditional (waterfall) software development projects, RE must be performed at the initial stage of software development, and all requirements must be gathered and correctly documented. However, in a constantly evolving environment like the actual one, requirements also change frequently, including during the development phase. Traditional methodologies might be difficult to be applied in a constantly changing environment. Thus, agile methodologies can improve the software development process by being more flexible to accommodate software requirements changes and this is one of the main reasons agile methodologies are chosen for remote and RCSD environments (Batool *et al*., 2013; Curcio et al., 2018).

The RE is often described as the initial phase of the software life cycle and it is considered the most critical and complex phase of a software project (Pandey, Suman, & Ramani, 2010; Fernandes et al., 2012; Buitron, Flores-Rios, & Pino, 2018). RE success is considered a prerequisite for software success, given RE delineates both the system's needs and its limitations, via communication with stakeholders (Curcio et al., 2018).

A common categorizing approach is to split requirements as functional requirements or non-functional requirements (Pandey, Suman e Ramani, 2010), as follows:

Functional Requirements (FR). They express the users' needs and the activities the software must perform, except those considered by the limitations. (Buitron, Flores-Rios, & Pino, 2018).

Non-Functional Requirements (NR). The NFs limit software behavior through software-specific attributes, such as software security mechanisms, software distribution type, and software usage licenses (Younas et al., 2017). NFs are important parts such as technology selection, hardware allocation, and software development standards (Younas et al., 2017; Buitron, Flores-Rios, and Pinto, 2018)).

2.2 Collaborative Software Development (RCSD)

To detail the RCSD, we narrowed it down into three dimensions (Sardjono, Retnowardhani, & Budianto, 2021): people, processes, and technologies.

People. People is a dimension that may embrace many factors of human beings. For this research, we choose the factors 'motivation' and 'learning capability', for reasons detailed as follows.

Motivation is a critical factor for the success of a project given unmotivated people tend not to be engaged in project activities. On the other hand, project team members might be motivated mainly by two different motivation dimensions (Sardjono, Retnowardhani, & Budianto, 2021) expect internal rewards, such as developing his/her capabilities, and feel internally a sense of being able to. Extrinsically motivated team members might be interested in external rewards, such as financial rewards, the need for relations, or family and friends needs (Melo *et al*., 2011). Therefore, some behavioral attitudes may express positive team member motivation, such as delivering on time (punctuality) and delivering frequently (Grotta & Prado, 2021). Motivation is a critical factor for the success of a project given that team motivation reflects on customer benefits (Melo et al., 2011).

Team members' learning capability is another relevant factor. Given the constant changes in the environment and technology, both self-directed and collaborative learning as necessary skills for software development project members (Intayoad, 2014).

Process. We choose two of the available factors for the software development process – communication and RE techniques – for the following reasons. First, communication directs the collaborative interaction patterns in global software development teams. Both the communication mode and task type influence communication patterns (Serce et al., 2011). Thus, communication influences directly or indirectly the outcome of a project, which can be positive or negative outcomes. It includes conflict communication (Marshall and Gamble, 2015). The communication type to deal with interpersonal conflicts is highly related to RE outcomes (Liu et al., 2011).

The second factor is RE techniques. More specifically, this factor directly influences RE. Thus, different RE techniques might or might be appropriate in certain RE contexts (Alflen, Prado & Grotta, 2021).

Technology. This dimension relates to the IT resources of virtual DCS projects. There is a framework to analyse RCSD teams. It allows a unified view of how the stakeholders' communications occur by the means of the technology and how technology is used. The technologies scaffold the teams' communication given communication, as presented, is a critical factor in this type of project (L'Erario et al., 2020). The communication success/ effectiveness of geographically distributed teams is also related to the ability of team members to use and collaborate with the technology (Serce et al., 2011).

3 RESEARCH METHODOLOGY

This research aims to explore the factors that influence the quality of requirements in virtual DCS projects with an agile approach. Therefore, this is an exploratory study that may offer more information about the study object and scaffold the formulation of hypotheses for future research (Creswell & Creswell, 2021).

We adopted the case study as defined by (Eisenhardt, 1989), given the case study allows the researcher to respond flexibly to new findings when collecting primary data. In this research, for confidentiality reasons, the organization and the participants were anonymized. However, all other relevant information is presented.

3.1 Research Propositions

The research propositions are grouped according to the three dimensions detailed in the Theoretical Basis Section. In summary, we choose three dimensions, according to Figure 1 as follows, that resulted in six research propositions:

Dimension 1 – People dimension represents the characteristics of RCSD teams:

P1: Teams with higher **motivation** produce RE with better quality in DCS projects.

P2: Teams with better **software development skills** produce RE with better quality in DCS projects.

Dimension 2 – Process dimension represents the characteristics of RE processes:

P3: Teams with a better level of **communication** in software development processes produce RE with better quality in DCS projects.

P4: Teams that do the most proper use of ER **techniques** produce RE with better quality in DCS projects.

Dimension 3 – Resources dimension represents the technological resources used by team members:

P5: Teams with better IT **infrastructure resources** produce RE with better quality in DCS projects.

P6: Teams with better use of **collaboration tools** produce RE with better quality in DCS projects.

These propositions aim to establish the relationships between the research variables. The variables were divided into two categories, as detailed in the next Subsections: independent variables (3.2) and dependent variables (3.3).

3.2 Independent Variables

This research model is based on (Creswell & Creswell, 2021). It has six independent variables. Three variables were evaluated at the individual level: Motivation (V1), Skills (V2), and Communication (v3). The other three variables were evaluated at the group level: the usage of RE techniques (V4), IT Infrastructure (V5), and Project Tools (V6).

- **Motivation (V1).** This variable refers to the team's motivation specifically in the RE process. The motivation level of each team member was defined based on two criteria – attendance, punctuality, and self-assessment, which were done via a questionnaire. The composition of these three indicators defined a rational variable ranging from zero to 10. Team motivation was calculated from the arithmetic mean of team members' motivations.
- **Skill (V2).** This variable represents the skill of each team member in the software development activity. This ability was measured by academic grades obtained in disciplines related to software development. This variable is of the rational type ranging from zero to 10. The team's ability was calculated as the arithmetic mean of the team members' abilities.
- **Communication (V3).** This variable measures the quality of communication between the team members and the customer in the RE process. The communication level of each team member was defined based on their participation and interactions with the group. It was assessed by an individual questionnaire. The composition of these two indicators defined a rational type of variable ranging from zero to 10.

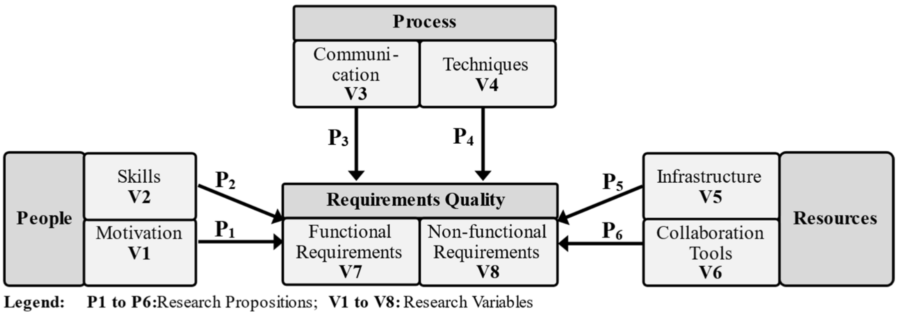

Figure 1: Research Propositions.

The team communication level was calculated as the arithmetic mean of the team members' communication levels. The other three independent variables were evaluated at the team level only. They are detailed as follows:

● **RE Techniques (V4).** It represents the proper usage of RE techniques. A five-point Likert-type ordinal scale was defined: 1 - very low; 2 - low; 3 - medium; 4 - high; 5 - very high. The top three most cited RE techniques were: interviewing, brainstorming, and prototyping.

● **Infrastructure (V5).** It represents the low-level infrastructure that is represented by both hardware and internet connection capabilities. It was assessed by the same Likert scale as presented in V4.

● **Tools (V6).** This variable represents the appropriate usage of collaboration tools (software) by the team. There was an ordinal three levels scale as follows: no collaboration tools; inappropriate collaboration tools; or proper collaboration tools.

3.3 Dependent Variables

As seen in Figure 1, the research proposition has two dependent variables as follows:

● **FR Quality (V7).** It refers to the functional requirements quality. It was measured by a prototype presentation, versus the client's requirements. To measure this variable, a three-level ordinal scale was defined as follows: **level 0**, low RE quality (33% of the FR, or less) was fully achieved; **level 1**, medium RE quality (more than 36% and less than 66% of the FR) were elicited with completeness and consistency; and **level** 2, high-quality RE (more than 66% of the FR) were elicited correctly.

● **NR Quality (V8).** It refers to the non-functional requirements quality and we utilized the same scale as we did in V7 but for NR.

3.4 Case Study Protocol

This Subsection details the case study protocol into eight steps, and its intermediary steps, from i) data collection policies to vii) data analysis procedures, as follows:

i) Data Collection Policies. The data collection policies were limited by the research objectives, propositions, and evidence sources, including those that support the threats to validity and conclusions.

ii) Data Source. This research collected three sources of evidence: observation carried out in meetings to follow up on the RE work of a DCS project; a questionnaire applied to team members; and a prototype of the software delivered by the teams. Data were collected from four different sources, to allow verification of evidence employing triangulation, according to (Yin, 2010):

iii) Participants. The case study was conducted in the first semester of 2022, with students of an IS undergraduate course. A total of 61 students participated in this study thought an entire semester. Beyond the course knowledge, many of the students also had work experience (previous or in progress).

iv) Data Sources. Data were collected based on the survey variables. Data were collected in the first half of 2022. One data source could be related to one or more research variables, as shown in Table 1.

Table 1: Data sources by variables.

ID	Variable	Type*	Data Source
V1	Motivation	I	Quiz
V2	Skills	I	Grades
V3	Communication	I	Interactions
V4	Techniques	I	Interactions
V5	Infrastructure	I	Interactions
V6	Tools	I	Interactions
V7	FR quality	D	Prototype
V8	NF quality	D	Prototype

* Variables**:** **(I)** - Independent or **(D)** - Dependent

v) Participants' Objective. To observe the phenomenon of RE, the students were grouped into teams. Each group had the main objective as follows: to elicit the system requirements and then to produce and present a working prototype.

vi) Influence of the Researcher. All projects were developed using RCSD. Beyond the observation, the researcher also played the role of product owner, which is the person in charge of defining product requirements for the development team.

vii) Data Analysis Procedures. The most relevant interactions were recorded and then transcribed into text. These results allowed the analysis of the group members' discourse via a semantic content analysis (Bardin, 2011). Questionnaire data and grades were analyzed using descriptive statistics. Finally, the researcher – in the role of Product Owner – analyzed all prototypes and compared the results obtained by the teams regarding RE deliveries compared to their original definition.

4 RESULTS

In this Section, we first contextualize the case study. We then present the results outline. Finally, presents the evaluation of research propositions with data grouped by teams' results, as seen in Table 2:

4.1 Context of the Case Study

This case study was conducted in the first semester of 2022. The IS undergraduate program has a minimum duration of four years. It is in the São Paulo state, Brazil. The select course of that program was from the 7th semester, thus those students were considered Seniors. The course was mainly offered during the night period. Therefore, many students were working during the day, such as internships or full job contracts.

In this research, we tried to keep as much as possible the same conditions for all participants for the same context, as follows: (i) the requirements were presented to the teams in the same manner; (ii) the researcher conducted the same activities for all teams; (iii) the duration of the activities was the same for all teams, divided into four interactions; (iv) the evaluation was the same for all teams.

A total of 59 students formed eleven teams for the software development project, according to Table 2. Each team worked on one single academic only. This case study was focused on observing the students and their projects. The semester project was first divided into two phases: first, perform the requirements elicitation; second, produce and present a project, and

Table 2: Motivation, Skills, and Communication.

Team[1]	M[2]	H[4]	C[4]	Members	M	H	C	Members	M	H	C	Members	M	H	C
E1	8,3	5,1	5,3	M01	9,0	6,0	6,2	M03	8,0	6,0	4,8	M05	7,4	6,0	3,4
				M02	8,0	5,0	4,8	M04	8,8	3,5	6,2	M06	8,5	4,0	6,2
E2	6,9	4,4	6,0	M07	7,4	4,5	7,6	M09	6,9	4,0	6,2	M11	6,9	3,0	6,2
				M08	6,9	5,5	6,2	M10	5,6	4,3	2,0	M12	7,4	5,0	7,6
E3	8,3	7,2	5,9	M13	9,0	9,0	7,6	M15	8,8	7,5	7,6	M17	6,9	7,5	2,0
				M14	8,0	4,5	4,8	M16	9,0	7,5	7,6				
E4	7,1	8,3	6,4	M18	7,4	8,5	7,6	M20	6,6	10,0	4,8	M22	6,9	6,0	6,2
				M19	7,4	8,0	7,6	M21	6,9	9,5	6,2	M23	7,4	8,0	6,2
E5	8,7	6,1	8,2	M24	9,0	6,5	9,0	M26	8,5	5,5	7,6	M28	8,5	6,5	7,6
				M25	9,0	6,0	9,0	M27	8,5	6,0	7,6				
E6	4,0	9,4	6,8	M29	4,0	9,0	6,2	M31	4,1	9,5	7,6	M33	3,6	9,5	4,8
				M30	4,1	9,5	7,6	M32	4,1	9,5	7,6				
E7	2,3	5,3	5,7	M34	2,3	4,5	6,2	M36	2,0	7,0	2,0	M38	2,5	4,0	7,6
				M35	2,3	5,0	4,8	M37	2,3	5,5	6,2	M39	2,5	5,5	7,6
E8	3,9	8,3	6,9	M40	4,1	8,0	9,0	M42	4,0	9,0	7,6	M44	3,3	9,0	2,0
				M41	4,1	8,5	9,0	M43	4,1	9,5	9,0	M45	3,5	6,0	4,8
E9	2,4	5,2	7,6	M46	2,5	5,5	7,6	M47	2,5	4,0	9,0	M48	2,3	6,0	6,2
E10	8,7	6,6	6,8	M49	9,0	8,0	7,6	M51	9,0	7,0	7,6	M53	8,5	5,5	6,2
				M50	8,0	4,1	4,8	M52	9,0	8,5	7,6				
E11	2,3	6,7	5,3	M54	2,3	7,5	4,8	M56	2,2	3,5	3,4	M58	2,5	7,0	7,6
				M55	2,3	7,5	6,2	M57	2,3	6,5	4,8	M59	2,3	8,0	4,8

Legend: (1) Team average; (2) Motivation; (3) Skill; (4) Communication review requirements whenever necessary. In the first interaction with the class, the teams were formed, and the main activities and deliverables were planned. All team members were very engaged. Although before the end of the semester, two students dropped their course enrollment, thus they are not listed in Table 2.

4.2 Results Outline

As seen in Table 2, the variable *motivation* was the one that had both the lowest average and the highest difference among the teams. The mean of the teams was 5.7 with a standard deviation of 2.7. According to Mukaka (2012), the preliminary data analysis showed three variables were positively aligned with the RE: *skills*, *techniques*, and *tools*. This is because the teams that stood out in the RE were also superior in these three variables. Furthermore, these three variables indicated a correlation with the FR and NR, because as their level grows, the quality level of FR and NR also grows. We then verified the correlation between independent and dependent variables via Spearman's correlation as shown in Table 3.

Table 3: Variables Spearman Correlation.

Dimensions	P	Variables		
		Independents	Dependents	
			FR*	NF*
People	P1	Motivation	*0,545*	0,145
	P2	Skills	**0,945**	*0,6*
Process	P3	Communication	0,4	0,173
	P4	Techniques	**0,8**	0,455
Tools	P5	Infrastructure	*0,6*	0,291
	P6	Tools	**0,836**	0,409

* **Bold**=Strong or Very Strong Correlation;
Italic = moderate Correlation

Positive associations between independent and dependent variables were those with strong or very strong correlations, as shown in Table 3. According to Mukaka (2012), values between 0 and 0.3 represent negligible correlations, between 0.31 and 0.5 weak, between 0.51 and 0.7 moderate, between 0.71 and 0.9 strong, and 0.9 or greater represent very strong. We highlight the four independent variables that had in Table 3 strong and/or moderate correlation with the dependent variable, as follows:

- **Skills** had the strongest positive association with FR (very strong) and the NF (moderate) requirements. This indicates that the teams' skills were the most relevant independent variable to be considered for the elicitation of requirements.
- **Tools**; **Techniques:** A strong level of correlation was found for both tools and techniques independent variables. This indicates that, beyond the skills, Teams also need to select and have access to the appropriate tools, while they also had to utilize the most appropriate techniques, towards achieving FR needs.
- **Infrastructures:** Finally, this independent variable was the only one to have a moderate correlation with FR. Thus, in this research context, the availability of good infrastructure, if not all, at least in parts affects the quality of the final FR.

4.3 Research Propositions Evaluation

Finally, table 4 summarizes the tests of research propositions by grouping the data by teams. The top performers' teams were E3, E6, E7, and E8, which represent 30.8% of the teams. They elicited requirements with a good level of completeness and consistency. These teams scored an average of 8.8 on the ER. The top performers were superior to the other teams concerning three variables: *skills*, *techniques*, and *tools.*

The average performers teams E1, E2, E4, E5 and E10. These teams scored an average of 5.0 on the ER. Finally, teams E9 and E11 had an unsatisfactory performance, given they scored less than 2.5 for FR and zero for the NR requirements. This indicates that the motivation was very different among the teams. On the other hand, the variable *communication* and *skills* had a higher average when compared to the motivation. They also had fewer standard deviations.

5 DISCUSSIONS

In this Section, we first perform an analysis of the propositions, followed by a description of the research limitations.

5.1 Analysis of the Propositions

To research validity, we choose to state as a *confirmed proposition* only those that have a *strong* or *very strong* Spearman Correlation, as described in Table 2. Thus, we could confirm propositions P2 (Skills), P4 (Techniques), and P5 (Tools) regarding FR. On the other hand, we could not confirm any proposition regarding NR. Most importantly, each confirmed proposition belongs to one specific dimension, from where we can state all three dimensions influence FR, as described in the theoretical bases of this research. The result confirms the validity of the *people-process-technology*

Table 4: Evaluation of Research Propositions by Teams.

Teams	Motivation	Skills	Communication	Techniques	Infrastructure	Tools	FR	NR	Quality
E3	8,3	7,2	5,9	5	4	1	2	2	Superior
E8	3,9	8,3	6,9	5	5	2	2	2	
E6	4	9,4	6,8	5	4	2	2	1	
E7	2,3	5,3	5,7	4	4	1	1	2	
	4,6	7,6	6,3	9,5	8,5	7,5	**8,8**	**8,8**	
E1	8,3	5,1	5,3	5	5	1	1	1	Average
E2	6,9	4,4	6	4	5	2	1	1	
E4	7,1	8,3	6,4	5	4	1	1	1	
E5	8,7	6,1	8,2	5	5	1	1	1	
E10	8,7	6,6	6,8	4	4	1	1	1	
	7,9	6,1	6,5	9,2	9,2	6	**5**	**5**	
E11	2,3	6,7	5,3	5	2	1	1	0	Unsatisfactory
E9	2,4	5,2	7,6	2	4	1	0	0	
	2,4	6	6,5	7	6	5	**2,5**	**0**	

structure, often applied in IS system development, as presented in the theoretical basis of this research.

People. This dimension is composed of two propositions: P1 and P2. Although the first one, motivation, was not verified, the second one, skills, was verified (with a very strong correlation). This result is in line with Intayoad (2014), which states ‘skills’ is an important attribute for professional success. In the context of this research, professional skills were highly relevant for RE success.

Process. This dimension is composed of two propositions: P3 and P4. Although the first dimension (communication) was not verified, the second one (techniques) was verified. Proposition P4 associates the adequate use of RE techniques with the improvement of the quality of the RE and it was verified as described in Table 1.

Resource Dimension. This dimension is composed of two propositions: P5 and P6. Similarly, from the other two dimensions, only one was considered valid. This means that hardware technological resources were not associated with better RE quality. On the other hand, proposition P6 (tools) had a strong correlation with FR elicitation. This result is in line with the work by Serçe et al. (2011), who argue that the success and effectiveness of geographically distributed teams are more sensitive to the ability of team members to use these tools and technology to collaborate. In other words, our findings suggest that the ability to use collaboration tools improves the quality of RE in virtual DCS projects.

5.2 Research Limitations

The research limitations were assessed according to (Yin, 2010). We identified and safeguarded against three limitations at least, as follows.

Data Collection Process: we considered the research bias in the observations or interpretation of team members’ data; for this limitation, the researcher was an expert in its area, which decreased that bias.

Generalization of Results: we highlight that it is not possible to generalize our results, given this is a single-shot case study. Anyhow, case studies support other future research, in this case, the knowledge of the factors that influence the quality of RE.

Data Analysis: Data were collected through interactions conducted by the researcher. But at least one other researcher supported the interpretation of the participants’ results to avoid any biased from the observation process. Lastly, to avoid participants’ negative selves-influence, inter or intra-group, all results were assessed against plagiarism, and participants were stimulated to do fair play.

6 CONCLUSIONS

The objective of this research was to analyse the interaction of IS teams working remotely in collaborative software development (RCSD) projects. For this objective, we conducted a case study with 59 participants divided into 11 teams. In conclusion:

Research Objectives. Recovering that the main objective of this research was to analyse the factors that influence RCSD within virtual project teams. The first specific objective was to identify factors that influence RE in virtual DCS projects with an agile approach. We identified six factors that were categorized into three dimensions. The specific objective was to analyse the influence these factors apply to the requirements quality. In this research context, three of six factors had a positive association with the quality of RE: skills [in software development], techniques [of software development], and tools [adequate selection and usage of].

Practical and Theoretical Contribution. This research contributes to the RCSD practices in remote, virtual, and/or distant working environments. We present RE success factors in this research context. Particularly, the team's most relevant aspect was 'skills. By using the most appropriate process, the teams that were able to select and use the most appropriate were also able to successfully elucidate and implement software requirements. The research aims to contribute to the project management and software engineering theoretical bases. For future research, we plan to investigate the gap in hybrid environments.

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