A Conceptual Framework for Reducing Requirement Engineering Challenges in Industrial-Scale Software Projects

Hafsa Shareef Dar[1], Abdul Rahman[2]
[1]Department of Software Engineering, University of Gujrat, Pakistan
[2]Faculty of Engineering and Informatics, University of Bradford, UK
***Correspondence:** Hafsa Shareef Dar, hafsa.dar@uog.edu.pk

Citation | Dar. H. S, Rahman. A, "A Conceptual Framework for Reducing Requirement Engineering Challenges in Industrial-Scale Software Projects", IJIST, Vol. 6 Issue. 2 pp 698-712 June 2024
DOI | https://doi.org/10.33411/ijist/202462698712
Received | May 24, 2024 **Revised |** June 05, 2024 **Accepted |** June 09, 2024 **Published |** June 14, 2024.

Introduction/Importance of Study: Industrial-scale software development tends to create more business value and effective strategic capabilities in software industries. IT organizations are spending about 50% of the budget on software development to build faster software programs at minimal cost to achieve success in industrial-scale projects. The crucial part of developing industrial-scale software is deciding 'what is intended to be built'. If the problem is not tackled properly, this can result in serious errors that impact the entire Software Development Life Cycle (SDLC) and make it difficult and costly to repair in later stages. Similarly, challenges in industrial-scale development related to Requirements are complex including Requirement scope, elicitation, specification, validation, and management. The Requirement engineering challenges become bigger and harder to overcome in industrial-scale projects due to time and cost factors. The money spent on Requirement change may affect the overall development time of the project. The complexity of industrial-scale projects does not increase linearly, thus, impacting the development process.
Novelty Statement: Therefore, the need to address challenges in large IT projects comes with the reason of their economic value in local and international markets. Researchers have come up with the identification of challenges, but their studies lack the overall Requirement engineering process. There is a need to design a comprehensive solution to overcome the Requirement engineering challenges that contribute to project failure.
Material and Method: Therefore, the research is divided into three phases: "The Identification Phase", where the project challenges would be identified; "The Implementation Phase", where these factors would be shortlisted to design a framework; and "The Validation Phase", in which validation of the framework would be done using triangulation technique.
Result and Discussion: The outcomes will focus on facilitating the software development industry for addressing the Requirement of engineering challenges in industrial-scale projects to reduce the chances of failure.

Keywords: Industry-scale software ; Requirement engineering; Requirement challenges; software development.

Introduction:

Over the past several decades, industrial-scale software development has evolved through the adoption of new methods and techniques to keep projects within scope. This scale of development typically involves organizations with at least six software teams, each comprising around 50 members, dedicated to a single project [1]. The teams involved in industrial-scale development must collaborate to achieve common product goals or functionalities. These projects are crucial for organizations due to their significant role in rapid economic development. According to the statistics, large IT projects are 45% over budget, and 7% over time, and deliver a value of 56% less than expected. The average cost for industrial-scale software development projects is about $2,322,000 and almost $250 billion is spent on IT projects annually [2]. Companies tend to apply a variety of means to manage the project's cost to meet their objectives [3].

Requirement Engineering (RE) is the first step in software development that holds significant importance toward project completion. The studies have suggested that well-elicited and well-specified Requirements produce an efficient system [4]. According to IEEE, a requirement is [5], "A condition or capability needed by a user to solve a problem or achieve an objective". Thus, without fulfilling user needs, system success is hard to achieve. Another report by Standish Group [6] states that 20% of the projects fail and 50% of the projects get delayed due to low budgets and unclear Requirements in industrial-scale projects. RE goes beyond just fulfilling user needs. The industrial-scale projects involve hundreds of stakeholders and thousands of user Requirements. Managing the size, different versions, and changes in Requirements is a significant challenge in these projects [7].

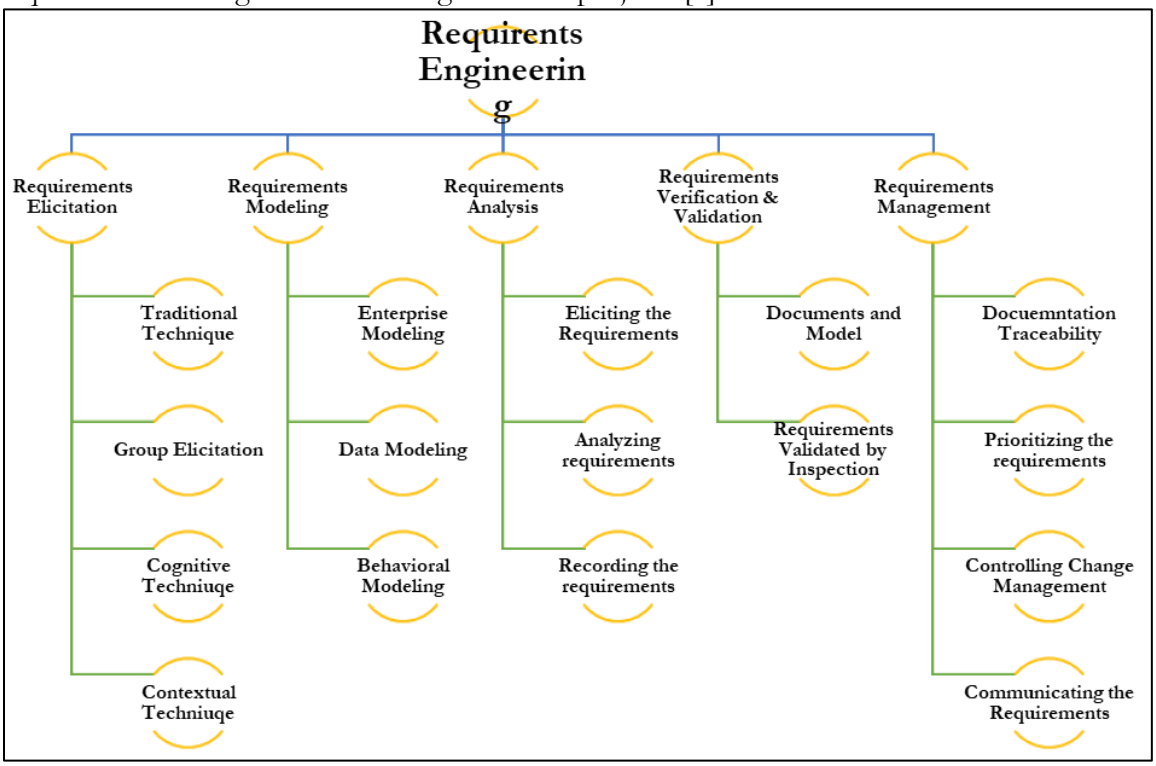

Figure 1: Various RE activities [8]

Being the first phase of the development life cycle, RE employs a systematic approach towards collecting Requirements: functional and non-functional [9]. It is incremental and iterative, working parallel to other phases like analysis, design, and testing. Traditionally, three different types of artifacts; domain-related statements independent of the machine, Requirement statements involving the machine, and specification statements describing the machine's needs to fulfill the Requirement [10]. According to the CHAOS report [2], when a survey was

conducted on IT project success factors, 'clear requirement statements' were the third important success factor, with 13% of respondents highlighting its significance. Hence, RE plays an important role in the success of any software project, especially those on an industrial scale.

Requirement engineering acts as an umbrella over the system with its sub-processes involved at every stage of software development. RE sub-processes are elaborated in literature by several researchers. RE state-of-the-art categories include elicitation, analysis, planning, specification, checking, negotiation, and management [11]. A treelike structure in [8] gives insight into various activities involved in it. Figure 1 [11] shows the flow of RE sub-processes and activities. The activities include Requirement elicitation, Requirement modeling, Requirement analysis, Requirement V&V (verification and validation), and Requirement management.

Unfortunately, there are limitations to the current practices of RE [12][13], for instance, Requirement elicitation is an important sub-process of RE that impacts the system even after its completion [14]. If the elicitation process remains erroneous, it will also affect the rest of the SDLC phases. Similarly, software projects may fail due to a lack of understanding of the RE process including modeling the Requirement, analysis, validation of Requirement, and Requirement management [8].

Objectives:

This study aims to propose a solution to cover Requirement-related challenges. The following are the objectives:

- It is a comprehensive review of the literature and study of RE challenges
- The study aims to gather RE challenges from IT organizations and software houses. The in-depth analysis of RE challenges is aimed to be performed in this study based on the data identified and gathered in objective 1.
- After identifying the challenges and respective practices from the industry Requirement engineering framework would be designed.
- A comparative analysis will also be conducted to present the improvements gained by the framework.

Novelty Statement:

One of the major RE challenges is the identification and management of dependencies among Requirements. Setting a scope in industrial-scale software projects is a time-consuming task because of continuous negotiations and conflict management in RE process. The prioritization gets settled according to the industry predictions and estimation of efforts on them [15][16]. Therefore, Requirement engineers attempt to overcome these challenges with the help of RE tools, techniques, and practices. Little effort is spent on designing a comprehensive solution to these problems for industrial-scale software development [13][17]. The solution not only communicates knowledge but also manages it about a user and the system being developed. The goal of this work is to align the RE process in industrial-scale software development in the form of a Requirement engineering framework. This framework would be beneficial because it would provide support to the practitioners and researchers.

Background and Motivation:

The concept of Requirement engineering emerged in the early 60s [18] when architecture of complexity was focused on. Over time, it covered several variations and with the object-oriented approach in 1991, it was given the foremost importance in software development. RE is the area within Software Engineering (SE) [9] that focuses on the goals for functionalities and constraints applied to them [19]. The relationship among these factors helps to specify the behavior of software and its evolution over time. The difficult part in development is to decide 'what to build' which makes the refinement of requirements a more crucial part of the development [8].

Undoubtedly, RE has accommodated improvisations over time. However, it still faces significant challenges that can lead to project failure. There are three categories of projects i.e. successful, challenged, and impaired [2]. The challenged and impaired projects are the categories that fail to meet the success criteria due to function features, budget, or time. Poor requirements are the reason why function features don't work well for large projects. This challenge has been further elaborated in terms of people and process factors for large-scale agile software development where one of the major challenges is the absence of proper Requirement documentation [16]. This gap often arises due to team distribution, resulting in incomplete documentation. To address this, it is suggested to increase team collaboration, reduce misunderstandings and gaps, and use documentation tracking tools. In industrial-scale projects, software development is often misaligned with the organizational processes [20], leading to unclear project functional features and requirements. The qualitative study represents that changing requirements have always been a major issue in large-scale projects. Another highlighted challenge is a technical dependency on software artifacts including requirements that produce uncertainty, conflicts, and misunderstanding in the project [21]. Experience-based studies also highlight that ineffective handling of Nonfunctional Requirement (NFR) can lead to disastrous outcomes in later phases, such as time and cost overruns [22][23]. The motivation for conducting this study is to propose a solution that would be useful to the software development team, aiming to develop industrial-scale projects with minimum chances of failure. The solution will help to overcome RE-related challenges in industrial-scale software development.

Literature Review:

This section has been divided into two sub-sections. The identified challenges in industrial-scale software development and related work are presented as follows.

RE Challenges in Industrial-Scale Projects:

The common RE challenges faced by almost every software development team include dealing with unknown, changing, understanding, extracting, and placement of requirement [24]. However, these are not the only concerns of RE in industrial-scale software development. Table 1 shows RE challenges in industrial-scale projects mentioned in the literature.

Table 1: RE challenges in Industrial-scale Software Development (a)

Categories	RE Challenges	References
Elicitation	Requirement Elicitation	[25][26][27]
Management	Changing Requirement	[7][28][2][20][9][23][29][21][24][30][31]
Elicitation	Customer Involvement	[3][32][27]
Management	Requirement Reuse	[7][13][27][30]
Management	Requirement Documentation	[33][23][34][35]
Analysis	Incomplete Requirement	[2][36][9][37][38]
Elicitation, Analysis	Customer Requirement	[36][32][27]
Management	Requirement Traceability	[35][27][30]
Validation	Inaccurate Requirement	[39][23][27]

*Only a few challenges have been mentioned here. Other factors are given in the results and discussion section.

Table 1 presents the RE challenges identified from the literature. The studies have been mentioned to show the frequency of failure occurring due to challenges, whereas all factors have been categorized according to RE sub-processes.

Whereas, in Table 2, the failure due to RE challenges in industrial-scale projects has been mentioned along with their impact in terms of time, cost, and purpose. The industrial-scale projects, worth millions and billions, failed majorly due to different RE challenges.

Table 2: Failed Industrial-scale projects due to RE

Project Title	Country	Year	Project Purpose	Time overrun	Cost overrun	Reasons of Failure
Nationwide IT Project in NHS	UK	2011	UK government National Program for IT in the NHS	9 Y	$ 18.7 B	Requirement Understanding Requirement Change Requirement Scope
City Time Project	USA	2011	This payroll system collapsed to meet the Requirements and objectives.	4 Y	$ 760 M	Lack of Management Commitment (overall)
Digital Media Initiative	UK	2013	Aimed to modernize the BBC's production and archiving by using digital production systems.	6 Y	$ 100 M	Requirement Understanding Consistently changing scope
over Oregon	USA	2014	Healthcare exchange website	3 Y	$ 200 M	Requirement Understanding Inconsistency of functionality with requirement Lack of Management Commitment (overall)
SIREN	UK	2013	Crime & criminal intelligence logging system	4 Y	$ 18.8 M	Requirement Understanding Consistently changing scope

Related Work:

Previous studies have focused on a 'one-for-all solution' as recommendations, guidelines, frameworks, or a models to overcome RE challenges. Due to the complex nature and size of large-scale projects, scaling up Requirement engineering practices is a tough job. To scale up the Requirement according to the project complexity and size, issues related to scalability were identified in the findings after interviewing three large companies [17]. According to the findings, Requirement tagging and grouping are identified as efficient ways of minimizing complexity in projects; whereas, adopting the standardized structure of Requirement was a scalable solution, required for different sizes of the project.

Similarly, possible improvements were suggested in Requirement management for large-scale software development [15]. Three Requirement management activities including scope, variability, and consolidation were considered aiming to provide effective methods when their complexity and size affect development time and efforts. By using qualitative and quantitative approaches, improvements were reported and evaluated on experimental studies from the industry. Agile methods are known for catering to the change in the development process, which makes it different from traditional development. Despite having this benefit, change is a major challenge even in agile methods and must not be overlooked by the project managers. A few recommendations were given as a solution to team collaboration and knowledge sharing, project

documentation, verification of the system, validation, and decision-making [16]. The recommendations addressed multiple activities of the software development process. It was recommended to switch the roles and responsibilities; improve team collaboration methods; and track tools for documentation, in large-scale development during teamwork.

A qualitative study was conducted to investigate the issues arising from technical dependency and communication in large-scale agile software development. The challenges significantly impact the software product and process quality. It was recommended to break the dependency circle, where a challenge in one activity affects the other [20]. These dependencies lead to changes in Requirement and time overrun which makes it difficult to identify the main causes of unwanted dependencies. Moreover, table 3 represents more relevant work presented with proposed work, activity, work limitations, and details of the project or work.

Table 3: Relevant work

Reference	Proposed Work	Relevant Activity	Limitations	Project Details
[10]	The proposed work was in the form of guidelines in RE Platform	Requirement dependency identification, Requirement reuse strategy	Information overload was one of the mentioned limitations of their work	In about 3 different cases, more than 100 employees, most of the employees were not RE trained, and Requirements vary from hundreds to thousands
[27]	The adapted work was Nidumolu's Contingency Model	Requirement uncertainty was the relevant activity mentioned	Not a validated model, the scope is small, collected data was based on SLR	Beginner-level project team, purposive sampling, no. employees and other project details are not provided
[28]	The proposed work was in the form of guidelines	RE challenges identification	Alignment of RE model with practices	Multiple case studies, 20 interviews, 5 focus groups, and 2 workshops
[40]	The proposed work was in the form of guidelines. These guidelines were further divided into 4 categorized	Communication, management, and other issues	More evidence is needed to support the guidelines, repeated data collection source	CRM, the case spanned 2 years, 3 sessions of interviews, other project details were not present
[41]	The proposed work was in the form of recommendations	Communication, flexibility, coordination	Complete removal of these challenges may be difficult, all recommendations	13 agile based cases from the past 15 years were taken to observe

			are not feasible to implement	
[42]	The proposed work TORUS was in the form of a traceability framework	Scalable Requirement traceability	The framework lacked validation and how it could be effectively used in people's context	1 Case of the cyber-physical system was used
[43]	Conducted a case study to understand how Requirements relate to each other	Requirement modeling, agile methods	The work only presents results from a case study. No further solution is provided	A single case study covering Requirement modeling in agile methods
[40]	Used a grounded theory approach for performing an extensive literature review	Requirement engineering, project management	Extensive literature review, covered datasets	Data collected and analyzed after conducting 34 interviews

Other than the above-mentioned studies, Table 3 shows the literature that addresses RE challenges in different forms. It can also be seen that the scope of work is limited, and little effort has been made to cover the whole RE process. Industrial-scale software development presents unique challenges when synchronized with other activities in the development process [1], which can lead to project failures. However, limited work has been done to address these challenges [44]. Therefore, this study aims to identify the challenges that occur due to RE framework for industrial-scale software development to overcome these failures. A requirement engineering framework would help the software development community, practitioners, and researchers in handling the RE challenges to achieving project success.

Research Questions:

The following questions have been formulated to address the objectives of this study.

RQ 1: What are the challenges related to Requirement engineering in industrial-scale software development?

RQ 2: How the Requirement engineering challenges can be addressed in industrial-scale software development to reduce the chances of project failure?

Material and Methods:

The research methodology helps in systematically answering the research questions. The research methodology of this study is discussed and shown in Figure 2 below.

Data Collection:

Data collection is a significant part of this study. The evaluation of the conceptual framework largely depends on the streams of data from which it is collected. Firstly, the data was collected from the literature, focused on the RE challenges in industrial-scale projects as reported by the researchers. During the preliminary literature review, we selected 45 studies and 28 challenges related to RE. These challenges will be further scrutinized to conduct industrial surveys from the practitioners. Their feedback will not only help us in identifying the gap between literature and practical implementation but also in designing the framework for reducing RE challenges in industrial-scale software projects.

Search Strategy and Analysis in Literature Review

The goal of the literature survey is to investigate the different RE-related challenges in industrial-scale software development. A literature survey will be conducted to find out the current challenges of Requirement engineering being faced in different large-scale projects.

Furthermore, computing databases (such as IEEE, ACM, Springer, Science Direct, etc.) and search repositories were used to access relevant material.

For conducting the literature review, we designed a search strategy consisting of search strings, a selection of data sources and studies, and inclusion and exclusion criteria. The strategy would help in scrutinizing the studies for data synthesis. The search string designed based on keywords taken from both research questions is as follows: -

- (Problems OR Issues) AND (Very large scale OR Industrial scale)
- (Problems OR Issues) AND (Very large scale OR Industrial scale) AND (software projects) AND (Project loss OR Project crash OR Project Breakdown)

This search strategy would further help in refining the relevant studies from the selected data sources or databases as mentioned in the section literature review. The criteria were used on data sources to either include or exclude any study.

- The studies from the research area of software engineering, Requirement engineering, and software project management were focused.
- Research articles related to the aims and objectives of this study and book chapters were included.
- The language of selected studies was English due to avoid any lingual complexities.
- The articles that are freely available in full-text form in the Higher Education Commission (HEC) repository were selected.
- Letters, posters, and magazines were not included.
- The papers whose full text is not available were not selected.

After designing the search strategy, data analysis will be performed, which is discussed in the next section. The data analysis was performed on a literature review. After careful selection and finalization of studies, fulfilling the review protocol, irrelevant studies were eliminated. The studies selected after the final filter were analyzed and presented graphically. Each challenge associated with requirement in an industrial-scale project was analyzed against frequency of occurrence. The identified challenges are then used to design surveys that was conducted on industry practitioners.

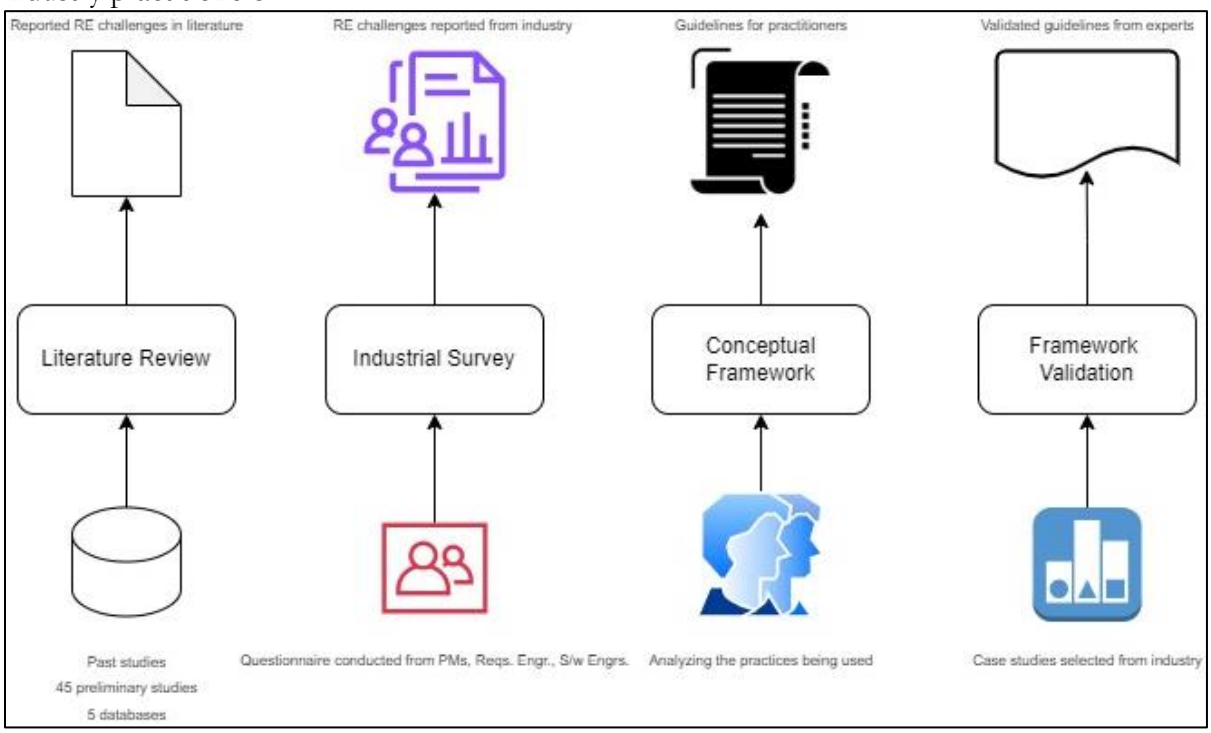

Figure 2: Flow of Methodology

Search Strategy and Analysis in Industrial Survey:

The major goal of this step is to get the practitioner's feedback on the identified challenges in the literature review. A survey from the software industry was conducted to achieve this goal. Following are the details of the industrial survey:

Survey Instrument:

The survey instrument is the 'Questionnaire'. It is expected to have an initial list of some RE-related challenges, thus, the questionnaire consisted of comparatively more close-ended questions rather than the open-ended ones. The analysis and extraction was done once data was collected. The pre-testing of the questionnaire would be performed by the target audience of the survey i.e., practitioners including project managers, Requirement engineers, etc.

Survey Sampling Method and Approach:

The snowball sampling technique will be used as the sampling method. Particularly, software development houses and teams have not been selected at this stage. Survey distribution and response were collected via multiple channels such as in-person, email, and web. The reason for selecting the snowballing technique is its suitability to the study. In the snowballing method, where people are hard to reach, some units recruit new units to form part of the sample. As we are trying to reach the maximum number of technical persons/roles, we believe snowballing would help to collect more diverse data.

Survey Participants:

Population: Project Managers, Requirement Engineers, and other roles in Software development houses developing industrial-scale software projects.

Statistical Analysis:

Statistical analysis will be performed on the survey data collected from the participants. We will perform a simple regression test on the data. According to the regression test:

$$y = \beta_0 + \beta_1 X + \epsilon$$

Where **y** is the dependent variable of any independent variable **x**, **Bo** is the predicted value of **y** when **x** is **0**. **B1** is the coefficient of regression and **e** is the error of the estimate of the regression coefficient.

Conceptual Framework and Validation:

In this step, the framework would be designed according to the data extracted from surveys. The framework will comprise of three major steps that are: identification, implementation, and validation. In identification, an exploratory study will be used to identify different challenges for requirement engineering that influence project failure. These factors would be shortlisted according to their severity and importance in projects in the implementation phase, and the framework would be designed according to these challenges. The unit of analysis in this study is industrial-scale software projects, thus, validation of the framework will be based on the triangulation technique.

Figure 3 shows the detailed execution of the Requirement engineering framework. As shown in the figure, step 1 is about surveying the different search engines, databases, and repositories. The industrial survey will be conducted and collected in step 2 from project managers, Requirement engineers, and developers. In step 3, RE framework will be designed. Comparative analysis would be performed in step 4, to know how better the results are after applying the framework.

Comparative Analysis:

Comparative analysis is an important unit of the framework for reducing RE challenges in industrial-scale projects. With the help of comparative analysis, not only the significance of the proposed framework will be highlighted but it will also help us in analyzing the cause-effect relationship between practices adopted in the past and lessons learned to move forward. The comparative analysis will be performed on the cases selected during the validation step.

Comparative analysis = without implementing framework AND with implementing framework

The following metrics will help to compare the results

- Total number of challenges identified without using framework (or previous approach)
- Total number of challenges resolved without using framework (or previous approach)
- Total number of challenges identified using the framework
- Total number of challenges resolved using the framework

Once the results are compared, guidelines will be proposed based on the findings of this study. These guidelines will help practitioners in choosing the correct approaches and strategies for reducing Requirement challenges.

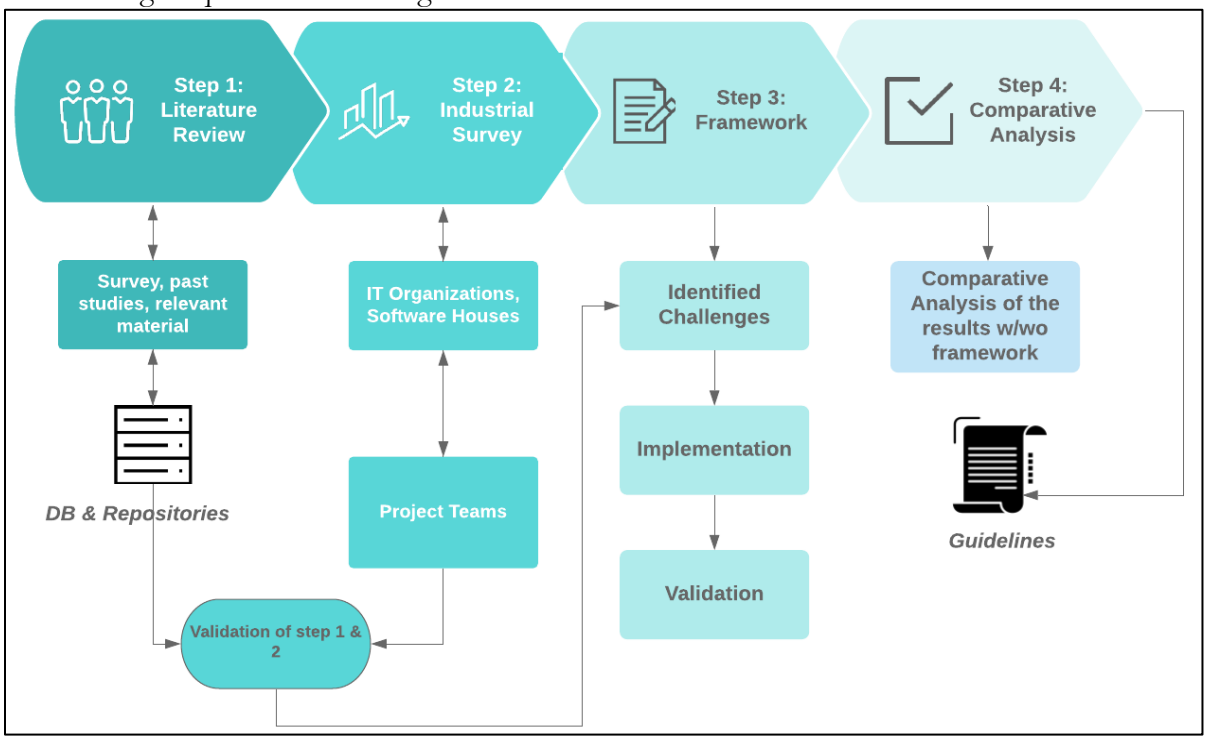

Figure 3: Requirement Engineering Framework

Results and Discussion:

In research methods, RQ1 plays an important role in conducting a survey and data collection. For RQ2 framework was designed to answer the RQ2. Hence, the outcome of this study is in the form of a framework to overcome RE challenges of industrial-scale software development and provide guidelines to practitioners and researchers. The results collected from 45 studies show that RE has a greater impact on the projects either in the form of success or failure. The initial results show that some recommendations are more focused on reducing Requirement errors such as ambiguity, incompleteness, and conflicts through formal specifications. Formal specifications also help in reducing Requirement errors by conducting detailed analysis at the initial stages and formalization of Requirement. Results from the preliminary investigation show interesting insights into the challenges of RE in industrial-scale projects. Table 4 here presents the rest of the RE challenges.

Table 4: RE challenges and categories (b)

Categories	RE Challenges	References
Analysis	Requirement Refinement	[1]
Management	Requirement Communication	[3][45]
Validation	Requirement Compatibility	[7]
Analysis	Blurred Requirement	[41]
Elicitation, Analysis	Quality Requirement	[41]
Analysis	Requirement Dependency/Interdependency	[13][45]

Analysis	Requirement Analysis	[13][39]
Elicitation, Analysis	Legal and Regulatory Requirement	[28]
Management	Requirement Specification	[2][24]
Management	Shared Understanding	[35]
Management	Feedback and Requirement Clarification	[35]
Analysis	Uncertain Requirement	[34][45]
Elicitation, Modeling	Inefficient User Stories	[35][27]
Analysis, Validation	Ineffective dealing with NFR	[22][27]
Management	Inappropriate RE process	[9][27]
Validation	Difficult Identification of Requirement	[9]
Analysis	Missing Requirement	[9]
Validation	Unclear Requirement	[9][37]
Analysis	Unstable Requirement	[37][27]
Validation, Analysis	Erroneous Requirement	[38]

We have further broken down these challenges in Table 5 according to the RE categories mentioned in Table 1 and Table 4.

Table 5: Number of RE challenges

Categories	RE Challenges	f
Elicitation	Customer involvement, customer Requirement, quality Requirement, legal and regulatory Requirement, insufficient user stories	5
Analysis and Modeling	Incomplete Requirement, customer Requirement, Requirement refinement, blurred Requirement, Requirement dependency/interdependency, uncertain Requirement, ineffective dealing with NFR, missing Requirement, unstable Requirement, erroneous Requirement, inefficient user stories	12
Validation	Inaccurate Requirement, Requirement compatibility, ineffective dealing with NFR, difficulty in identification of Requirement, unclear Requirement, erroneous Requirement	6
Management	Changing Requirement, Requirement reuse, Requirement documentation, Requirement traceability, Requirement communication, Requirement specification, shared understanding, feedback and Requirement clarification, inappropriate RE process	9
Total Challenges		32

Table 5 is presenting the major categories of RE with collective 32 RE challenges, among which 4 challenges are discussed in each sub-area of RE including customer Requirement, insufficient user stories, ineffective dealing with NFR, and erroneous Requirement. For step 2, we will consider 28 RE challenges due to the repetition of challenges in step 1. We have also observed that Requirement analysis is a sensitive area that holds a maximum number of RE challenges, followed by Requirement management.

After performing step 1 of research methodology, we can partially answer RQ1 which is 'What are the challenges related to Requirement engineering in industrial-scale software development?'. The challenges related to RE in industrial-scale software development are 28 in number covering insufficient user stories, erroneous Requirements, blurred and incomplete Requirements, and many more (presented in Table 5).

Researchers have identified various factors of project failures in industrial-scale projects such as undefined scope, poor Requirement engineering, less user involvement, lack of proper planning, and others [3][2][7][13][28][41][44]. Previously, few studies have been conducted to

address the factors of RE failure, some of these focused on the identification of challenges and their impact on industrial-scale software development [13][41][44][35]. The proposed framework would cater to the project teams and researchers as a guideline to overcome RE challenges in industrial-scale development. The research contribution of this study is:

- The identification of RE challenges by deeply studying literature.
- The collection of RE challenges from the software industry.
- The development of a framework that will overcome RE challenges in industrial-scale software development.
- The validation of the framework with the help of a case study.

Furthermore, it would be beneficial for both practitioners and researchers to know the flaws in previous systems or to expand the study in the future.

Author's Contribution: Authors 1 and 2 equally contributed towards idea refinement, paper write-up, designing framework, and reference management.

Conflict of interest: There exists no conflict of interest for publishing this manuscript in IJIST.

Recommendations: Researchers have come up with an identification of challenges, but their studies lack the overall Requirement engineering process. There is a need to design a comprehensive solution to overcome the Requirements and engineering challenges that contribute to project failure.

References:

[1] K. Dikert, M. Paasivaara, and C. Lassenius, "Challenges and success factors for large-scale agile transformations: A systematic literature review," J. Syst. Softw., vol. 119, pp. 87–108, Sep. 2016, doi: 10.1016/J.JSS.2016.06.013.

[2] S. Group, "The Standish Group report - Chaos," 2015, [Online]. Available: https://www.standishgroup.com/sample_research_files/CHAOSReport2015-Final.pdf

[3] G. Fridgen, J. Klier, M. Beer, and T. Wolf, "Improving Business Value Assurance in Large-Scale IT Projects—A Quantitative Method Based on Founded Requirement Assessment," ACM Trans. Manag. Inf. Syst., vol. 5, no. 3, Aug. 2014, doi: 10.1145/2638544.

[4] A. R. Asghar, A. Tabassum, S. N. Bhatti, and A. M. Jadi, "Impact and challenges of Requirement elicitation & prioritization in quality to agile process: Scrum as a case scenario," Int. Conf. Commun. Technol. ComTech 2017, pp. 50–55, Oct. 2017, doi: 10.1109/COMTECH.2017.8065749.

[5] H. Dar, M. I. Lali, H. Ashraf, M. Ramzan, T. Amjad, and B. Shahzad, "A systematic study on software Requirement elicitation techniques and its challenges in mobile application development," IEEE Access, vol. 6, pp. 63859–63867, 2018, doi: 10.1109/ACCESS.2018.2874981.

[6] M. A. Akbar, Nasrullah, M. Shameem, J. Ahmad, A. Maqbool, and K. Abbas, "Investigation of project administration related challenging factors of Requirement change management in global software development: A systematic literature review," 2018 Int. Conf. Comput. Electron. Electr. Eng. ICE Cube 2018, Jan. 2019, doi: 10.1109/ICECUBE.2018.8610966.

[7] P. Lombriser, F. Dalpiaz, G. Lucassen, and S. Brinkkemper, "Gamified Requirement Engineering: Model and Experimentation," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 9619, pp. 171–187, 2016, doi: 10.1007/978-3-319-30282-9_12.

[8] "An Insight into Requirement Engineering Processes", [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-642-35615-5_48#:~:text=Requirement Engineering (RE) determines the,%26 validation%2C and

Requirement management.
[9] S. Ouhbi, A. Idri, J. L. Fernández-Alemán, and A. Toval, "Requirement engineering education: a systematic mapping study," Requir. Eng., vol. 20, no. 2, pp. 119–138, Mar. 2015, doi: 10.1007/S00766-013-0192-5/METRICS.
[10] A. Bennaceur, T. T. Tun, Y. Yu, and B. Nuseibeh, "Requirement Engineering," Handb. Softw. Eng., pp. 51–92, Feb. 2019, doi: 10.1007/978-3-030-00262-6_2.
[11] S. A. Fricker, R. Grau, and A. Zwingli, "Requirement Engineering: Best Practice," Requir. Eng. Digit. Heal., pp. 25–46, Jan. 2015, doi: 10.1007/978-3-319-09798-5_2.
[12] T. E. Fægri and N. B. Moe, "Re-conceptualizing Requirement engineering: Findings from a large-scale, agile project," ACM Int. Conf. Proceeding Ser., vol. 25-29-May-2015, May 2015, doi: 10.1145/2764979.2764983.
[13] D. Fucci et al., "Needs and Challenges for a Platform to Support Large-scale Requirement Engineering. A Multiple Case Study," Int. Symp. Empir. Softw. Eng. Meas., Aug. 2018, doi: 10.1145/3239235.3240498.
[14] H. Shareef Dar, S. Imtiaz, and M. I. Lali, "A Proactive Approach to Reduce Requirement Ambiguity via Gamify4Req," vol. 19, Accessed: Jun. 03, 2024. [Online]. Available: http://xisdxjxsu.asia
[15] "Understanding and supporting large-scale Requirement management." Accessed: Jun. 03, 2024. [Online]. Available: https://lucris.lub.lu.se/ws/portalfiles/portal/3588635/1566591.pdf
[16] A. M. H. Al-Said Ahmad, "Agile Large-Scale Software Development: Success Factors, Challenges and Solutions," i-manager's J. Softw. Eng., vol. 8, no. 3, pp. 1–12, Mar. 2014, doi: 10.26634/JSE.8.3.2807.
[17] K. Wnuk, B. Regnell, and B. Berenbach, "Scaling Up Requirement Engineering – Exploring the Challenges of Increasing Size and Complexity in Market-Driven Software Development," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 6606 LNCS, pp. 54–59, 2011, doi: 10.1007/978-3-642-19858-8_6.
[18] "A Historical Perspective on Requirement Engineering." Accessed: Jun. 03, 2024. [Online]. Available: https://www.scenarioplus.org.uk/papers/historical/historical.htm
[19] P. Zave, "Classification of research efforts in Requirement engineering," ACM Comput. Surv., vol. 29, no. 4, pp. 315–321, 1997, doi: 10.1145/267580.267581.
[20] N. Sekitoleko, F. Evbota, E. Knauss, A. Sandberg, M. Chaudron, and H. H. Olsson, "Technical Dependency Challenges in Large-Scale Agile Software Development," Lect. Notes Bus. Inf. Process., vol. 179, pp. 46–61, 2014, doi: 10.1007/978-3-319-06862-6_4.
[21] H. Taherdoost and A. Keshavarzsaleh, "A Theoretical Review on IT Project Success / Failure Factors and Evaluating the Associated Risks," 2015.
[22] "Experiences from Measuring Learning and Performance in Large-Scale Distributed Software Development", [Online]. Available: https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1143810&dswid=-4702
[23] S. Madhavan, "Delays and Failures in Projects Final.pdf," Proc. 22nd World Multi-Conference Syst. Cybern. Informatics (WMSCI 2018), Jan. 2018, Accessed: Jun. 03, 2024. [Online]. Available: https://www.academia.edu/38369185/Delays_and_Failures_in_Projects_Final_pdf
[24] K. H. Rolland, "'Desperately' seeking research on agile Requirement in the context of large-scale agile projects," ACM Int. Conf. Proceeding Ser., vol. 25-29-May-2015, May 2015, doi: 10.1145/2764979.2764984.
[25] "Identifying the Reasons for Software Project Failure and Some of their Proposed Remedial through BRIDGE Process Models 8 . 1," 2017.
[26] D. Pimchangthong and V. Boonjing, "Effects of Risk Management Practice on the

Success of IT Project," Procedia Eng., vol. 182, pp. 579–586, Jan. 2017, doi: 10.1016/J.PROENG.2017.03.158.

[27] S. N. Kumari and A. S. Pillai, "Requirement elicitation issues and project performance: A test of a contingency model," Proc. 2015 Sci. Inf. Conf. SAI 2015, pp. 889–896, Sep. 2015, doi: 10.1109/SAI.2015.7237247.

[28] I. Inayat, L. Moraes, M. Daneva, and S. S. Salim, "A reflection on agile Requirement engineering: Solutions brought and challenges posed," ACM Int. Conf. Proceeding Ser., vol. 25-29-May-2015, May 2015, doi: 10.1145/2764979.2764985.

[29] K. M. Whitney and C. B. Daniels, "The Root Cause of Failure in Complex IT Projects: Complexity Itself," Procedia Comput. Sci., vol. 20, pp. 325–330, Jan. 2013, doi: 10.1016/J.PROCS.2013.09.280.

[30] W. Alsaqaf, M. Daneva, and R. Wieringa, "Quality Requirement challenges in the context of large-scale distributed agile: An empirical study," Inf. Softw. Technol., vol. 110, pp. 39–55, Jun. 2019, doi: 10.1016/J.INFSOF.2019.01.009.

[31] K. Conboy and N. Carroll, "Implementing Large-Scale Agile Frameworks: Challenges and Recommendations," IEEE Softw., vol. 36, no. 2, pp. 44–50, Mar. 2019, doi: 10.1109/MS.2018.2884865.

[32] V. N. Vithana and S. Lanka, "Scrum Requirement Engineering Practices and Challenges in Offshore Software Development," Int. J. Comput. Appl., vol. 116, no. 22, pp. 975–8887, 2015.

[33] "A Reflection on Why Large Public Projects Fail", [Online]. Available: https://www.jbs.cam.ac.uk/wp-content/uploads/2020/08/a-reflection-on-why-large-public-it-projects-fail---kjetil--mark-thompson-s-chapter.pdf

[34] A. Alami, "Why Do Information Technology Projects Fail?," Procedia Comput. Sci., vol. 100, pp. 62–71, Jan. 2016, doi: 10.1016/J.PROCS.2016.09.124.

[35] R. Kasauli, G. Liebel, E. Knauss, S. Gopakumar, and B. Kanagwa, "Requirement Engineering Challenges in Large-Scale Agile System Development," Proc. - 2017 IEEE 25th Int. Requir. Eng. Conf. RE 2017, pp. 352–361, Sep. 2017, doi: 10.1109/RE.2017.60.

[36] T. Dyba and T. Dingsoyr, "Agile Project Management: From Self-Managing Teams to Large-Scale Development," Proc. - Int. Conf. Softw. Eng., vol. 2, pp. 945–946, Aug. 2015, doi: 10.1109/ICSE.2015.299.

[37] "Influencing Factors for IT Software Project Failures in Developing Countries — A Critical Literature Survey - Volume 11 Number 11 (Nov. 2016) - Journal of Software." Accessed: Jun. 03, 2024. [Online]. Available: https://www.jsoftware.us/index.php?m=content&c=index&a=show&catid=174&id=2702

[38] "Scope management complexity in software projects." Accessed: Jun. 03, 2024. [Online]. Available: https://www.researchgate.net/publication/265015432_Scope_management_complexity_in_software_projects

[39] S. C. P. Ardhendu M., "Identifying the Reasons for Software Project Failure and Some of their Proposed Remedial through BRIDGE Process Models," Int. J. Comput. Sci. Eng., vol. 3, no. 1, pp. 118–126, 2015.

[40] E. Sońta-Drączkowska and A. Krogulec, "Challenges of scaling agile in large enterprises and implications for project management," Int. J. Manag. Proj. Bus., vol. 17, no. 2, pp. 360–384, Apr. 2024, doi: 10.1108/IJMPB-11-2023-0244/FULL/XML.

[41] T. Dingsøyr, N. B. Moe, T. E. Fægri, and E. A. Seim, "Exploring software development at the very large-scale: a revelatory case study and research agenda for agile method adaptation," Empir. Softw. Eng., vol. 23, no. 1, pp. 490–520, Feb. 2018, doi:

10.1007/S10664-017-9524-2/TABLES/6.

[42] W. Scacchi, "Winning and losing in large-scale software development: A multi-decade perspective," Computer (Long. Beach. Calif)., vol. 51, no. 10, pp. 58–65, Oct. 2018, doi: 10.1109/MC.2018.3971348.

[43] A. Sadovykh, B. Said, D. Truscan, and H. Bruneliere, "An iterative approach for model-based Requirement engineering in large collaborative projects: A detailed experience report," Sci. Comput. Program., vol. 232, p. 103047, Jan. 2024, doi: 10.1016/J.SCICO.2023.103047.

[44] D. Zowghi, F. Da Rimini, and M. Bano, "Problems and challenges of user involvement in software development: An empirical study," ACM Int. Conf. Proceeding Ser., vol. 27-29-April-2015, Apr. 2015, doi: 10.1145/2745802.2745810.

[45] S. L. Lim and A. Finkelstein, "StakeRare: Using social networks and collaborative filtering for large-scale Requirement elicitation," IEEE Trans. Softw. Eng., vol. 38, no. 3, pp. 707–735, 2012, doi: 10.1109/TSE.2011.36.