

Identifying Knowledge Gaps in Requirements Engineering: An Empirical Study with Professionals in the Brazilian Software Industry

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Resumo The rapid evolution of information technology in the software industry has led to challenges in Requirements Engineering, impacting the academic landscape. Recent studies identify risks to system quality and project success due to industry-specific processes. Professionals trained in academia face a disparity between market practices and academic teachings, resulting in significant knowledge gaps. To address this, a study engaged requirements engineers from Brazilian software development companies. Their experiences were gathered through a survey, focusing on requirements documentation problems and the challenges newcomers face. The study also identified specific knowledge areas that require reinforcement. The findings underscore the need to address significant knowledge gaps. It was concluded that industry practices in requirements engineering differ from documented literature, affecting professional training. Additionally, there is a demand for greater transparency within the industry, and professionals expressed a strong interest in bridging the gap and improving the current situation.

Keywords: Requirements Documentation · Knowledge Gaps · Industry.

1 Introduction

The correct application of Requirements Engineering (RE) is crucial for the success of product or service development, with RE considered the core of Software Engineering (SE) and the most critical step in the development process. RE aims to specify, document, validate, negotiate, and manage requirements, ensuring their quality based on established standards [1,2]. Challenges in requirements engineering, including ambiguity and incompleteness in natural language descriptions, can significantly impact software quality and project outcomes [3,4,5]. Requirements play a pivotal role in system success and failure, forming the foundation of software construction [2]. However, knowledge gaps exist, particularly in academia, where students often lack proficiency in RE due to the disparity between theoretical learning and practical experiences demanded by the industry [9,7,8]. Bridging these gaps is crucial to enhance the application of RE and meet the evolving demands of software engineering [3].

In light of these scenarios, it becomes evident that research is needed to explore the requirements documentation processes adopted by companies, the challenges they face, problems encountered by newcomers in the industry, and the knowledge gaps they experience.

Through the presentation of data and results, this study aims to improve training programs for students and future professionals in the field. Additionally, it seeks to address the identified knowledge gaps within the industry. This work aligns with other researchers' efforts to enhance the Requirements Engineering process based on observations in the software market [10].

This paper is organized as follows: Section 2 presents the related works. Section 3 provides context on the relationship between the industry and academia, along with the challenges faced in practice and content. Section 4 describes the research methodology and data collection process. Section 5 presents the analysis of the participants' data, followed by a discussion and conclusion in Section 6. The paper concludes with a discussion of the research's limitations and threats to its validity.

2 Related Words

Several papers in the literature have addressed challenges and necessary skills in Requirements Engineering (RE), highlighting the deficiencies of industry professionals in fundamental concepts taught in academic courses [11,12,13]. Our research focuses on requirements documentation due to its critical role in software development and the identified risks associated with this activity. Another study investigates the preparedness of graduates for the job market, revealing deficiencies in the area of requirements [14]. Our research collaborates with industry professionals to identify knowledge gaps in Brazilian industries, contributing to future improvements in academic programs. A study on Latin American industries in RE [6] found a gap between academia and industry practices, and our work provides updated data for Brazil, along with analysis of professionals' perspectives on newcomers and their challenges, highlighting disparities between academia and industry.

3 Requirements Engineering: Academy and Industry

Teaching Requirements Engineering (RE) can be challenging due to the complexity of abstracting system properties for real-world situations, leading to a curriculum that covers fundamental concepts and activities [1,15]. Despite research efforts, failures in systems related to requirements activities persist, including challenges with incompleteness, understanding, change management, validation, communication, documentation, and requirement quality [5,16,17]. These challenges highlight the need for knowledge and preparation among requirements engineers in the industry, necessitating an examination of academia and industry practices [3].

4 Methodology

The survey was conducted as an empirical research method to gather data from various individuals and obtain a decentralized analysis of the state of practice of requirements documentation, challenges faced, and knowledge gaps in the industry. The survey consisted of 18 questions, including open-ended questions to encourage participants to provide detailed statements and unforeseen stories. The anonymity of participant identification was ensured to promote honest responses and prevent potential exposure of weaknesses or degradation of the participants' context. By utilizing the survey instrument, valuable insights were gathered from companies in different states, contributing to a comprehensive understanding of requirements documentation practices [18,19].

5 Results

The survey allowed us to know the vision of professionals and characteristics of the interviewed ones, subjects of requirements documentation, challenges faced, and the engineers' point of view about the training and preparation of professionals in the academy.

5.1 Data of the participants

Twenty-five requirement engineers participated in the survey. Among those that identified themselves (a total of 15): 13 large companies with several subsidiaries throughout the country and two small ones participated in the research. The experience time of those participants can be summarized as follows: two of them had less than a year of experience; eleven participants had a time of experience from 1 to 5 years; eight other participants had experience from 5 to 10 years; while four others had over ten years of experience. In addition, seven of the participants had some specialization in requirements engineering.

5.2 Regarding documentation in the companies

During our study, we found that 21 participating companies have a standard documentation practice, which is crucial for organized and high-quality specified requirements. The documentation process is carried out continuously throughout the system's life cycle in 19 cases, while others follow a typical cascade model, performing documentation only at the beginning of the process before system implementation. Approximately half of the participants reported spending more than 5 hours on documentation activities.

To ensure availability, companies employ various methods. Sixteen participants mentioned using tools specifically designed for documentation purposes, including project management tools, commit tools, and custom-developed tools. Other methods mentioned were email, a company file cloud, and intranet networks. In terms of customer-specific availability, 16 participants stated that

developers and customers have access to the same documentation, while nine participants highlighted a difference between what is offered to customers and what is used internally within the company.

Fifteen participants emphasized the importance of verifying the documentation to eliminate inconsistencies due to the changing nature of requirements and their variations throughout the project. The most commonly mentioned types of documentation produced by the companies were functional requirements, followed by business requirements, nonfunctional requirements, interface requirements, solution requirements, quality requirements, project requirements, and stakeholder requirements. Other types of documentation included interface prototypes, use case diagrams, user stories, unspecified UML diagrams, and business process management charts, all of which have a direct impact on the requirements.

Regarding the level of description in the documentation, seven participants highlighted the absence of certain elements that they deemed crucial for improving the understanding of requirements and enhancing the quality of documentation. These missing elements included quality requirements attributes, the relationship between requirements and testing, solution architecture, mapping information with business processes, business rules, traceability, and cost estimates for each requirement.

5.3 Challenges faced in the companies

Among the challenges faced by companies were identified points related to the occurrence degree within companies. Table 1 presents the summary of them.

Tabela 1. Challenges identified in the survey

R01 Absence of a crucial requirement
R02 Error in the requirements specification
R03 Documentation is not usually well understood
R04 Requirements specified incorrectly
R05 Difficulty in understanding templates

For this, we realized that:

- 76% of the participants reported facing problems related to missing crucial requirements in the documentation, which were nevertheless implemented in the system.
- 84% of the participants encountered issues with requirements that were documented in a non-implementable or non-evolutionary manner.
- 40% of the participants indicated that the documentation needs to be better understood by those involved in the project.
- 9% of the participants experienced problems with incorrectly specified requirements.

- 52% of the participants noted that some team members struggle to understand the chosen documentation template for the projects.
- 84% of the participants emphasized that documentation poses a significant challenge in software development.

5.4 The vision of the professionals regarding the academy and a company newcomer

The survey results highlight the differences between academic teachings and industry practices regarding requirements documentation. Participants noted that their academic knowledge did not always directly align with the industry's documentation needs, although the knowledge gained was still valuable. Specific UML diagrams taught in academia were found to be rarely used in industry practices, while Use Case Diagrams and User Stories were highly valued. There was a need for academia to emphasize that documentation is an ongoing process and to address resistance towards holistic documentation approaches.

The research also revealed that newcomers in the industry face challenges related to documentation. They often lack familiarity with documentation standards and require assistance in adhering to them. They may struggle with describing business solutions and have limited experience in understanding documentation practices. Additionally, they may have knowledge gaps in UML diagrams and need a better understanding of the level of detail required in requirements and business terminology. These findings highlight the importance of providing support and training for newcomers in the industry to improve their documentation skills.

The participants highlighted several crucial points concerning the knowledge gaps observed in newcomers to the industry. Figure 1 illustrates the subjects mentioned by the participants and their interrelationships. These subjects include: Presentation of more ways to document, especially through specific tools for this purpose, Prioritization of requirements in order to hand a value work to the customer, Relation of the requirement with the test case, Requirements management, Versioning of the requirements, Traceability, Documentation in agile environments, Use Cases, Improvement in the interpretation of requirements, Requirements gathering Practices, Use of real cases in the classroom, Importance of documentation in software development, Teaching of function points.

6 Discussion

The analysis of participants' data provided insights into the documentation culture in software development companies, with a focus on improving documentation quality. Adherence to documentation standards was identified as crucial for capturing system attributes and reducing omissions of important project requirements. The study also observed variations in documentation practices based on development methodologies, with agile methodologies being commonly adopted. Companies primarily relied on in-house tools and processes for documentation,

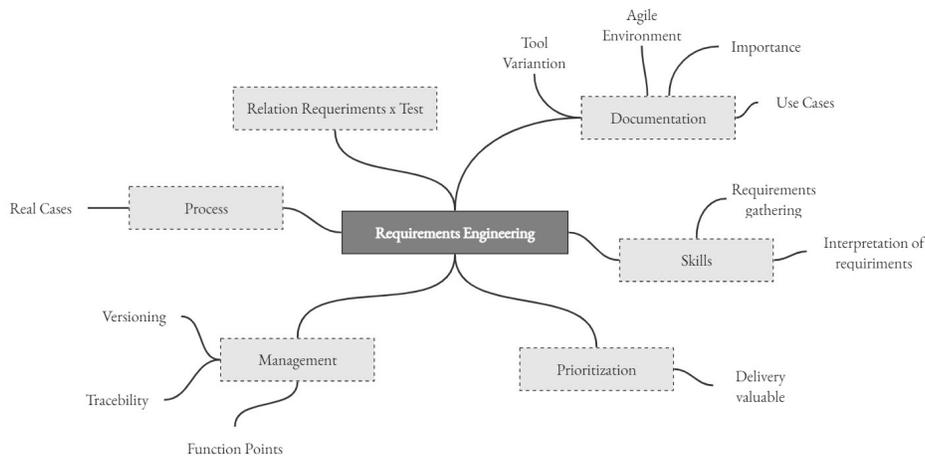


Figura 1. Mental map of participants' answer

though some used commercially available tools or developed customized software. Participants recommended teaching documentation practices using tools to address tool unfamiliarity, while acknowledging licensing cost limitations in universities. The preference for functional and business requirements documents among companies aligned with previous studies [20,6].

Participants in the survey emphasized the importance of Use Cases, User Stories, and prototypes for creating comprehensive and effective documentation. They also highlighted the influence of academic studies on their understanding of requirements and documentation quality, despite limited application in industry practices. The resistance to adopting certain content that positively impacts software development raises questions about the reasons behind this resistance and the need for increased awareness regarding the importance of documentation. Documenting remains a significant challenge for many companies, leading to rework and project setbacks. There is a need for improved awareness and education in academia to motivate students and raise awareness about the relevance of documentation. Bridging the gap between academia and industry in Requirements Engineering (RE) is crucial, as it contributes to delivering products that meet customer needs. Collaboration between academia and industry can enhance company processes, but there is a need for better communication and willingness to change the existing scenario, addressing the knowledge gap that hinders business progress.

One limitation of this study is that the data was collected through a survey, which restricts the ability to address doubts or obtain further information on emerging subjects. However, the participants' responses were consistently clear and detailed, mitigating doubts or ambiguities. The anonymity of participants introduces a risk that not all participants were engineers, but most had significant industry experience, which was relevant for analyzing issues in the field.

Another limitation is the inability to draw conclusions about the number of hours required for requirements documentation activity due to the lack of information about the company's development process. The study cannot determine whether the allocated time is sufficient based on existing literature. It is important to note that the theories, hypotheses, and discussions presented in the study are based on the obtained results and cannot be generalized due to the sample size. However, considering the diversity and distribution of participating companies, the study provides a valuable perspective on the subject.

7 Conclusion

This research aims to bridge the knowledge gaps and strengthen the relationship between industry and academia by investigating the state of practice in requirements documentation, the challenges faced in this area, and the knowledge gaps related to documenting requirements. The survey involved requirements engineers from the software industry in Brazil and analyzed their perspectives on the documentation process and the education of new professionals. The findings highlight the preference for functional requirements documents, business rules, prototypes, Use Cases, and User Stories diagrams, while also identifying challenges such as specification problems, missing critical requirements, and the need for consensus on documentation templates within organizations. The results emphasize the importance of transparency and collaboration between industry and academia to improve requirements engineering processes.

The academic community plays a crucial role in researching and evolving Requirements Engineering processes, and increased transparency and information sharing are essential. As software engineering practices evolve rapidly in the industry, there is a need for academia to stay updated and collaborate with industry to improve these processes. The opinions expressed by participants in this research do not limit academia's focus solely to industry but also highlight the importance of teaching and training professionals in software development companies. Future work could include investigating requirements tools and their suitability for different contexts, understanding professors' perspectives on requirements documentation in universities, and exploring best practices for integrating the documentation environment into the classroom, as suggested by participants.

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