An empirical study of API Management and ISO/IEC SQuaRE: a practitioners' perspective

Eder dos Santos[1,2] and Sandra Casas[1]

[1] Instituto de Tecnología Aplicada - Universidad Nacional de la Patagonia Austral
http://www.uarg.unpa.edu.ar/ita
[2] Centro de Investigaciones Científicas y Técnicas(CIT) Santa Cruz - Consejo
Nacional de Investigaciones Científicas y Técnicas (CONICET) Río Gallegos, Argentina
{esantos,sicasas}@uarg.unpa.edu.ar

Abstract. APIs have become a cornerstone in software ecosystems: organizations have been increasingly connecting software applications to share complex digital assets. However, managing APIs is non-trivial and companies have been struggling with different quality-related issues in managing their APIs. Therefore, our goal aims to understand how practitioners perceive quality characteristics related to API management functions. To achieve it, we adopted the ISO/IEC 25010 (SquaRE) standard as the reference model and conducted a structured survey with professional developers, system administrators and software functional analysts based in Rio Gallegos City, Argentina. Questions were based on main API management capabilities discussed in current literature and their relation with the ISO/IEC 25010 quality characteristics. After running an anova analysis over 136 answered topics, results show that Functional Suitability and Security were perceived as the most critical quality capabilities, which can provide a basis for future research.

Keywords: API Management, Software Quality, SQuaRE

1. Introduction

In the last years, distribution models of information systems are evolving into XaaS [1] paradigms, in which organizations make their digital assets available to customers [2]. In this context, the microservices architectures are rapidly emerging as they provide a flexible architectural model [3] which allows the distribution of an organization's information systems into a highly-scalable set of services. In general, such services are supported by APIs that typically stand by REST [4] principles.

According to [5], APIs present both a technical side and a business side. The first one refers to "a technical answer to a business problem" and can be understood as a set of requirements that govern how applications can interact and exchange data, while the latter can be considered "a business enabler" as it determines how the organizations want to use their assets to deliver value not only across internal organizational units but also to external third parties. In this sense, the term API Economy is being used to describe the increasing movement of the industries towards new ways of expanding their business models by conceiving and commercializing solutions that expose their APIs as part of their service offering [6].

The API Economy scenario exerts additional pressure on the development, deployment and maintenance of information systems. Since APIs have gained a critical

aspect [7], organizations need to mitigate the risks of failure by managing their APIs through API management [5][8] platforms. API Management Platforms provide the basic capabilities to create, analyze, and manage APIs in a secure and scalable environment such as providing helpful documentation, controlling access to the API, as well as monitoring and analyzing its usage [8][9][10].

Notwithstanding the above, API management activities imply a series of challenges in both internal [5][11] and descentralized [12] software ecosystems. In this sense, software quality models comprise a set of characteristics and sub characteristics that makes up a platform on which quality assessments about software components can be performed, as a critical step in providing pragmatic solutions that can be readily adopted by software practitioners in industry. Quality models also allow for continuous monitoring of the quality of an organization's software components, which facilitates quick intervention when deviations are encountered. Therefore, it is crucial to inquire how practitioners in the software industry perceive quality characteristics related to common functions and capabilities of API management platforms, in order to help defining benchmarks and to provide insight into emerging trends at various stages of the software product's lifecycle.

In this direction, this paper shows the results of the first survey focused on a group of professionals based in the Santa Cruz province, Argentina. It is an initial exploratory instance aimed, in particular, at identifying the relationship between the quality characteristics established in the quality model described in the ISO/IEC 25010 standard and the API management main functions / capabilities.

This paper is structured as follows: Section 2 describes the methodology employed in designing and conducting the survey aimed at establishing itself as a preliminary study, which will serve as the basis for more specific works in the future. Results are detailed in section 3, and section 4 presents a brief discussion about API surveys, analysis of results, threats to validity, limitations, thoughts about the impact and significance of this work, and concluding remarks and future directions.

2. Materials and Methods

This section describes the methodology employed in conducting a survey aimed at establishing itself as a preliminary study, which will serve as the basis for more specific works in the future. The survey follows an exploratory approach based on the classification proposed by [14]. The purpose of the survey is to gather insights into the API management practices and assess the quality characteristics of API management platforms. The results obtained from this preliminary study will serve as a foundation for future research endeavors that delve deeper into specific aspects of API management.

Sampling Technique: The survey utilized a non-probabilistic sampling scheme, specifically convenience sampling, as suggested by [14][15][16]. Convenience sampling involves selecting participants based on their accessibility. In this study, subjects were selected from professionals based in the province of Santa Cruz, Argentina, who have an academic background in computer science and currently work

in the area, both in the public and private spheres. This specific sample was chosen due to their expertise and relevance to the study's focus.

Data Collection: The survey implementation and data collection were conducted using an online survey platform, ensuring ease of access and facilitating data capture.

Survey Design: To compile the survey questions, the study incorporated the eight main quality characteristics described in ISO/IEC 25010 and a set of 15 capabilities supported by API management platforms as outlined in the literature. The survey consisted of two main groups of prompts, detailed as follows.

The first group of prompts comprised five open-ended questions aimed at collecting demographic data and gathering information about the professional trajectories of the respondents. The purpose of these questions was to obtain comprehensive census data and gain insights into the respondents' backgrounds, focusing on their experiences within the API management domain.

The second group consisted of 15 closed-ended multiple-choice grid questions, with each question corresponding to one of the main API management capabilities [8][9][13]. Selected capabilities were: 1. Authentication; 2. Authorization (Access Control); 3. Identity mediation; 4. Data privacy through encryption; 5. Data privacy through masking; 6. Key and certificate management; 7. DoS protection; 8. Threat detection; 9. Consumption quota; 10. Spike arrest; 11. Usage throttling; 12. Traffic prioritization; 13. Format translation; 14. Protocol translation; and 15. Service and data mapping.

Each grid contained eight lines with Yes/No (Related / Not related) options, representing the ISO/IEC 25010 quality characteristics. This design allowed for the assessment of the extent to which each API management function aligned with each quality characteristic, and mandatory radio buttons were used. A sample question can be seen in table 1.

In total, each respondent should answer 125 questions, including both openended and closed-ended questions. The survey was made available for a period of two weeks to ensure a sufficient response rate and gather a representative sample. This duration allowed potential respondents, who are professionals based in the province of Santa Cruz, Argentina, with academic training in computer science and working in the area, both in the public and private spheres, ample time to access the survey and complete the questionnaire at their convenience.

1. Authentication: Authentication is the process of uniquely determining and validating the		
ISO Characteristic	Related	Not related
1. Functional Suitability		
2. Performance Efficiency		
3. Compatibility		
4. Usability		
5. Reliability		
6. Security		
7. Maintainability		
8. Portability		

Table 1. A survey's question sample format.

3. Results

The survey was conducted as a pilot experiment and involved a small sample of professionals working in the IT-related industry. A total of six participants took part in the study. The demographic and professional characteristics of the participants are summarized as follows:

Age: The age range of the participants varied from 27 to 42, with a mean age of 31 years.

Experience: The professional experience of the participants ranged from 4 to 20, with an average experience of 9 years.

In relation with labor sphere, It is important to note that some participants provided multiple answers for both the labor sphere and role questions, indicating their involvement in various domains or responsibilities within the IT-related industry. Results are detailed as follows:

Private Companies (28.57 %), Government Departments: (71.43 %).

Role (self-described): Developer (coding, full stack: 50.00 %), Help and Support: (25.00 %), Functional Analyst: (8.33 %), Project Management: (8.33 %), Research and Development (8.33 %).

Findings: As this study was a pilot experiment aimed at gathering preliminary insights, the findings emerged from the data collected can be seen in following figures 1 and 2. Figure 1 displays the survey responses for the "Authentication" capability. The responses are presented as a count (% of total responses), and a corresponding 3D bar graph is provided. The horizontal axis of the graph represents the quality characteristics described in the ISO 25010 standard, while the bars represent the responses. Additionally, error bars are incorporated into the graph.

Due to the extensive nature of the survey, which covered 15 capabilities, the data from all positive responses has been synthesized and presented in Figure 2. To enhance the visualization and understanding of the results, a color scale similar to that used in Figure 1 was adopted, with the midpoint set at the 20th percentile. The figure includes the average and median values for reference.
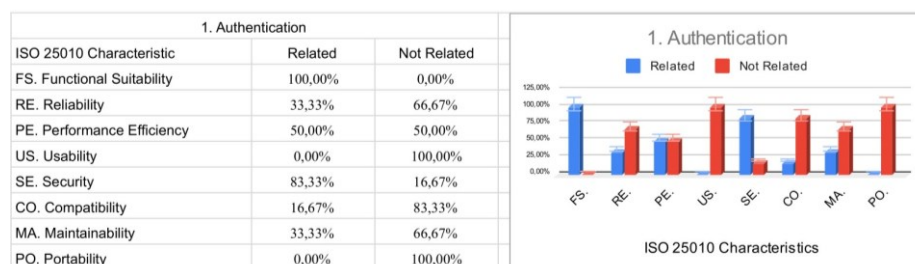
1. Authentication		
ISO 25010 Characteristic	Related	Not Related
FS. Functional Suitability	100,00%	0,00%
RE. Reliability	33,33%	66,67%
PE. Performance Efficiency	50,00%	50,00%
US. Usability	0,00%	100,00%
SE. Security	83,33%	16,67%
CO. Compatibility	16,67%	83,33%
MA. Maintainability	33,33%	66,67%
PO. Portability	0,00%	100,00%

Fig.1. Survey results for capability 1 - Authentication - and its relation with ISO 25010 quality characteristics.

4. Discussion

The utilization of surveys directed towards API practitioners is a commonly employed initiative by industry-leading organizations. These surveys result in influential guiding documents for both the web API production and consumption sectors. In our study, we have incorporated select items from the RapidAPI survey to enrich our analysis.

On a global scale, "The Rapid Developer Survey" [23] garnered 850 responses from over 100 different countries. A substantial majority of respondents identified as professional developers, with over 85% reporting active programming as part of their vocation or educational pursuits. The survey participants represented a diverse spectrum of organizational sizes, experience levels, and industries. Furthermore, the company Smartbear annually publishes their report titled "State of Software Qualit - API" [24] with the goal of "Identifying the latest benchmarks and gaining insights into the trajectory of the API industry." This report collates information on "the latest methodologies, practices, and tools used by software teams across the world." The survey responses encompassed more than 1,100 API practitioners and customers, spanning various industries, and ranged from startups to large enterprises in terms of company size. Finally, within an argentinian perspective, [25] presented the outcomes of the first-ever survey specifically targeting developers in Argentina. The primary objective of this investigation was to comprehend the usage patterns and challenges faced by software developers when consuming web APIs within the Argentinean context.

Despite the existence of prior surveys, there is still a dearth of evidence pertaining to investigations specifically targeting the perceived quality of stakeholders in the industry, as proposed in this current work and our ongoing research agenda. Our focus is on characterizing quality aspects concerning API management requirements, capabilities, and best practices, utilizing the ISO 25010 / SQuaRE standard as our quality reference model.

It is important to note that these findings should be interpreted with caution due to the small sample size and the exploratory nature of the pilot experiment.

		ISO 25010 Characteristics							
		Functional Suitability	Reliability	Performance Efficiency	Usability	Security	Compatibility	Maintainability	Portability
API Management Capabilities	1. Authentication	100,00%	33,00%	50,00%	0,00%	83,00%	17,00%	33,00%	0,00%
	2. Authorization	100,00%	33,00%	67,00%	33,00%	100,00%	17,00%	17,00%	0,00%
	3. Identity mediation	100,00%	17,00%	50,00%	17,00%	100,00%	67,00%	83,00%	17,00%
	4. Data encryption	100,00%	17,00%	67,00%	50,00%	83,00%	17,00%	17,00%	0,00%
	5. Data masking	100,00%	50,00%	17,00%	33,00%	100,00%	17,00%	0,00%	0,00%
	6. Keys and certificates	100,00%	83,00%	0,00%	67,00%	100,00%	17,00%	17,00%	17,00%
	7. DoS protection	100,00%	50,00%	83,00%	0,00%	100,00%	17,00%	17,00%	17,00%
	8. Threat detection	100,00%	50,00%	50,00%	0,00%	100,00%	17,00%	17,00%	0,00%
	9. Consumption quota	50,00%	50,00%	100,00%	67,00%	83,00%	17,00%	0,00%	0,00%
	10. Spike arrest	50,00%	67,00%	100,00%	0,00%	83,00%	17,00%	0,00%	0,00%
	11. Usage throttling	83,00%	50,00%	100,00%	17,00%	100,00%	67,00%	0,00%	0,00%
	12. Traffic prioritization	100,00%	67,00%	100,00%	33,00%	33,00%	0,00%	0,00%	0,00%
	13. Format translation	100,00%	17,00%	0,00%	83,00%	0,00%	100,00%	50,00%	33,00%
	14. Protocol translation	100,00%	17,00%	100,00%	50,00%	0,00%	100,00%	50,00%	17,00%
	15. Service and data mapping	83,00%	0,00%	0,00%	100,00%	0,00%	67,00%	17,00%	0,00%
	Average	91,07%	40,07%	58,93%	36,67%	71,00%	36,93%	21,20%	6,73%
	Mean	100,00%	50,00%	67,00%	33,00%	83,00%	17,00%	17,00%	0,00%

Fig.2. Positive results API Management capabilities and their relation with ISO 25010 quality characteristics.

They provide initial insights that can guide further research in this area. In this study, our primary objective was to identify which quality characteristics were perceived as related to API Management capabilities, according to the opinions of the participants. The evaluation encompassed 15 API management capabilities, and participants were asked to indicate their relevance to the eight ISO 25010 quality characteristics.

The quality characteristic of Functional Suitability received the highest average percentage of related responses at 91.07%. This suggests that a significant portion of the evaluated API Management capabilities align well with meeting the intended functionality and user needs. The mean value of 100% further supports the strong association between the capabilities and the quality characteristic of functional suitability. We hypothesized that capabilities, serving as functional requirements of API Management software products, would exhibit a high rate of functional suitability. The results strongly support this hypothesis.

Security obtained a relatively high average percentage of related responses, at 71%. This indicates that a substantial number of the API Management capabilities included in this study contribute to ensuring security aspects within the platforms. The mean value of 83% further confirms the strong alignment with the security quality characteristic.

Reliability garnered an average percentage of related responses at 40.07%. Though lower than Functional Suitability, the results still indicate a moderate relationship between API Management capabilities and reliability. The mean value of 50% implies that half of the evaluated capabilities are considered relevant to ensuring the reliable performance of API management platforms.

Participants attributed an average percentage of 58.93% to Performance Efficiency, indicating that many API Management capabilities contribute to efficient performance. The mean value of 67% signifies that a significant portion of capabilities supports the quality characteristic of performance efficiency.

Usability received an average percentage of related responses at 36.67%. This suggests that some API Management capabilities are associated with the userfriendliness and ease of use of the platforms. The mean value of 33% indicates a moderate level of relevance between the capabilities and the usability quality characteristic.

Compatibility received an average percentage of related responses at 36.93%. This suggests that certain API Management capabilities contribute to compatibility with external systems and technologies. The mean value of 17% indicates a relatively lower level of relevance with the compatibility quality characteristic. Maintainability garnered an average percentage of related responses of 21.2%. This implies that some API Management capabilities relate to the ease of maintenance and updates. The mean value of 17% reinforces the moderate level of alignment with the maintainability quality characteristic.

Portability obtained the lowest average percentage of related responses, with only 6.73%. This suggests that very few API Management capabilities are seen as related to portability. The mean value of 0% confirms the limited alignment with the portability quality characteristic.

These findings provide valuable insights into the perceived associations between API Management capabilities and the ISO 25010 quality characteristics. It is essential to consider these results when designing, developing, and enhancing API management platforms to better meet user needs and ensure high-quality performance.

4.1 Threats to Validity and Limitations

When conducting surveys, it is important to consider the potential threats to the validity of the results. In this sense, the sample and population size can be particularly considered as potential threats to the validity of survey results. Specifically, two types of threats related to sample and population size are worth considering: a) Sampling Bias [17][18] can limit the generalizability of the findings and lead to inaccurate conclusions about the broader population. b) Limited Statistical Power [19] [20]: the study may lack sufficient statistical power to detect meaningful relationships or differences, which can increase the likelihood of Type II errors (false negatives) and limit the ability to draw accurate conclusions from the data.

To mitigate this threat, we have implemented various strategies as described in [21]. These strategies include utilizing personal networks, constructing a sample based on convenience, authority, and credibility. Given that our study is an academic research project conducted by a national university, we included all necessary research details in the questionnaire. Additionally, we designed a brief and concise survey, carefully considering the type and number of instructions provided. Moreover, it is worth noting that the sample size in our study is comparable to other surveys targeting software developers using APIs, as reported in the literature. For instance, in [22], the sample consisted of 6 participants.

Additionally, to mitigate the risk of false negatives and eliminate errors due to ambiguous responses, the survey questions were designed as mandatory radio button selections. This design choice aimed to ensure clear and unambiguous choices between

"Related" and "Not Related" options, reducing the potential for misinterpretation or inaccurate responses.

While the study provides valuable contributions, it is not without limitations. Given the pilot nature of the experiment, it is essential to acknowledge the limitations inherent in the study design. These limitations include: a) Small sample size: The study involved only six participants, which may limit the generalizability of the findings. b) Lack of diversity: The sample consisted of a reduced group of participants, which may not be representative of the broader population of professionals in the IT-related industry. c) Preliminary nature: The study aimed to gather preliminary insights and may not provide definitive conclusions.

4.2 Impact and Significance

The findings of this study have significant implications for the field of API management and software development. Understanding the relationships between API Management capabilities and ISO 25010 quality characteristics provides valuable insights into the design, development, and enhancement of API management platforms as software products. The study's insights on the associations between capabilities and ISO 25010's quality characteristics can guide platform providers in making informed decisions to improve specific aspects of their API management offerings. By addressing the identified gaps and weaknesses, developers can work towards creating more robust, efficient, and user-friendly API management platforms that meet users' expectations and industry standards.

Additionally, the study's results can help API management platform users, developers, and decision-makers make informed choices when selecting or customizing platforms to align with their specific needs and quality requirements. The understanding of which capabilities contribute significantly to each quality characteristic empowers stakeholders to make data-driven decisions in their platform evaluation and adoption processes. In this sense, confirming the identified high rate of functional suitability and security among capabilities through wider surveys may indicate that developers and organizations can prioritize and invest in functionalities that align well with user needs and overall system functionality.

4.3 Concluding Remarks and Future Directions

In conclusion, this study successfully identified the quality characteristics that participants perceived as related to API Management capabilities. The high rate of functional suitability among capabilities confirms our hypothesis, emphasizing the platforms' strong alignment with meeting functional needs and user requirements.

The results of this study contribute to the existing body of knowledge in API management and software development. While the study has its limitations, such as the relatively small sample size, the findings lay the groundwork for future research in this domain. For instance, the high rate of security relatedness may establish new hypothesis in future work.

The moderate associations found between capabilities and other ISO 25010 quality characteristics present opportunities for improvement. Addressing the identified gaps

can lead to enhanced API Management functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability, and portability.

We recommend that future studies explore these associations with larger and more diverse samples to enhance the generalizability of the results. Additionally, considering other factors that may influence participants' perceptions, such as their experience with API management platforms, could provide further insights into quality characteristic prioritization.

In conclusion, the insights gained from this study offer valuable guidance to API management platform providers, developers, and users, promoting the continuous improvement and adoption of high-quality API management software products that meet the evolving needs of the software industry.

Based on the preliminary findings and the identified limitations, future research in this area should consider the following directions: a) Increase sample size: It is important to address the potential threats by carefully considering the sample size and ensuring that it is appropriate for the research objectives and the target population. Conducting the study with a larger and more diverse sample would enhance the generalizability of the results, as larger sample sizes can help improve the representativeness of the sample and enhance the statistical power of the study, reducing the risk of sampling bias and increasing the likelihood of detecting meaningful effects. b) Explore additional variables: Investigate other factors or variables that may influence the observed patterns to gain a more comprehensive understanding. c) Additional statistycal analisys through multivalued analysis and other techniques.

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