Return of the QA: A Comparative Analysis of Competencies and Skills for Quality Analysts in Brazil (2021–2025)

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ABSTRACT

Background: The software industry has undergone rapid changes driven by agile methodologies, continuous delivery pipelines, and increased automation. As system complexity and quality demands grow, the role of Quality Analysts (QAs) has become increasingly critical. This shift is particularly relevant in the current context, characterized by the rapid evolution of QA practices, technological advancements, and the increasing adoption of AI-based tools that provide assisted support throughout the software development process. **Objectives:** This study aims to identify the key technical and behavioral competencies that characterize high-performing QAs, from the perspective of experienced practitioners in the Brazilian software industry. **Method:** We carried out two large-scale surveys involving Brazilian companies, conducted in 2021 and 2025, with a total of 169 participants. **Results:** The findings reveal a strong and growing demand for soft skills, especially communication and critical thinking, alongside solid technical foundations. Respondents emphasized the evolving and multidisciplinary nature of the QA role in modern software development contexts. **Conclusions:** This research offers a comprehensive and recent overview of industry expectations regarding QA analyst competencies in Brazil. The results provide actionable insights for those seeking to advance in the QA field, educators aiming to align curricula with market demands, and organizations aiming to strengthen their software quality assurance capabilities.

KEYWORDS

Quality assurance, Software testing, Soft skill, Survey study, Expectations of the Brazilian Industry

1 Introduction

The growing demand for software products increases complexity, and as a result, there is a need for strategies that improve the quality of these systems. Testing is essential for any software development effort, enabling developers to identify faults before releasing the software to customers [13]. Although software testing cannot ensure the absence of faults due to diverse constraints, it contributes to defining a quality criterion by which the application can be evaluated [2].

Quality Analysts (QAs) and software testing professionals play a crucial role in improving the quality and reliability of systems and applications in an ever-evolving technological market. Despite its importance, many aspiring professionals face significant challenges developing expertise in this field. Among the most common obstacles are the scarcity of specific content on software testing in undergraduate computing curricula [15], unclear job descriptions, and difficulties in identifying the key soft skills valued by experienced professionals in the sector.

The absence of dedicated software testing courses in academic curricula is a widely recognized issue in the literature. Studies such as those by Garousi et al. (2019) emphasize that in many educational institutions, the focus is on technical skills such as programming, architecture, and algorithms, relegating testing and quality assurance to a secondary role. This creates a significant gap in the training of future professionals, making it difficult for them to enter the QA and software testing market with a strong foundational knowledge [5].

Another challenge for aspiring professionals is the lack of clarity and standardization in job descriptions. Research, such as that by Kassab et al. (2021) [8], indicates that ambiguity in defining expected competencies for QA roles is prevalent, confusing candidates and complicating the transition for entry-level professionals. According to a survey conducted by Garousi et al. (2020) [6], this gap makes it challenging to plan professional development paths. It contributes to the uncertainty newcomers face in their career choices.

Effective communication, critical thinking, and problem-solving are essential soft skills consistently highlighted by experienced professionals in the software quality field. Furthermore, the techniques and tools used to enhance fault detection capabilities are continually evolving, requiring professionals to adapt to new practices. Given this context, two fundamental research questions arise:

*RQ*1: How can the QAs' profile in Brazil be defined in the software development life cycle?

*RQ*2: What are the most important skills to be an effective QA analyst and progress in this career?

To address these research questions, two large-scale surveys were conducted with software industry professionals in Brazil, in 2021 and 2025. These surveys gathered both quantitative and

qualitative data on the skills, attributes, and career trajectories of QA professionals. The collected data were compared to identify trends and changes over time, with particular emphasis on technical expertise, soft skills, certifications, and role responsibilities. This comparative analysis enabled a comprehensive assessment of the evolving expectations within the industry, highlighting the increasingly multidisciplinary nature of the QA role, particularly in the context of contemporary software development practices, such as agile methodologies, artificial intelligence, and test automation.

Building on this foundation, the article examines the primary challenges encountered by individuals seeking to specialize in QA and software testing, focusing on gaps in educational training, the absence of standardized market expectations, and the identification of the most highly valued soft skills in the field. Furthermore, it examines how perceptions of essential competencies have evolved between 2021 and 2025, taking into account different experience levels. By analyzing practitioners' insights alongside evidence from the literature, this study aims to enhance understanding of the QA professional profile and propose actionable strategies to address the identified challenges. By analyzing practitioners' perspectives alongside evidence from the literature, this study aims to enhance understanding of the QA professional profile and propose actionable strategies to address the identified challenges.

2 Related work

Durelli et al. [4] analyzed 2.164 job advertisements related to QA positions to identify the soft skills most frequently listed by software companies in Brazil. They extracted the data from the LinkedIn professional social networking platform and analyzed it using an inductive, data-driven approach. The results reveal that approximately 91% of these job advertisements emphasize the importance of soft skills. The authors identified 32 soft skills, with five standing out as the most sought after: communication-related skills, planning, innovation, collaboration, and written communication.

Lancetti et al. [10] analyzed data from 253 job advertisements from Brazilian companies. The analysis focused on identifying the most sought-after soft skills among QA professionals. The results reveal that approximately 72% of the job advertisements list at least one soft skill. The authors identified 35 soft skills, among which communication-related skills appear to be the most sought after. In addition, they found that companies of all sizes highly value communication skills for QA professionals at every career stage.

Kassab et al. [8] conducted a software testing data analysis in 1000 jobs ads to find competencies regarding the level of education, training, and experience; testing skills; technical skills; and soft skills. The study defined four research questions to investigate the current state of quality assurance practice in the U.S. job market. The findings show that knowledge in high-level testing is on high demand, i.e. creating and executing test cases to cover the main functionalities of a product. Furthermore, they highlight a high demand for professionals with competencies in the entire testing process, including automated testing, functional testing, and software testers with programming skills.

Rabelo et al. [14] maps the current scenario of non-technical skills in software development. To this end, the authors conducted a two-phase study. Initially, they analyzed 566 job post advertisements to assess how often these skills are requested. Subsequently, Rabelo et al. interviewed 15 entry-level developers to determine the soft skills they deemed essential within their organizations and to gain a deeper understanding of how these soft skills play a fundamental role in daily software development practices. The results suggest that 98,9% of the job posts mentioned at least one non-technical skill, averaging 6.30 non-technical skills per job post.

Unlike prior studies based on job advertisements, this research conducts two large-scale surveys with Brazilian software professionals (in 2021 and 2025), mapping their skills, certifications, and career trajectories. The study reveals concrete changes in QA practice, emphasizing the growing multidisciplinarity.

3 Survey Planning and Execution

We conducted an exploratory survey to analyze the characteristics of QA professionals currently on the labor market. The survey was planned following the process proposed by Kasunic [9] and, Kitchenham and Pfleeger [1] for effective design of surveys for the software engineering area. In this sense, the study process included the following five steps. The survey was conducted in two rounds across 2021 and 2025, with participation from 126 and 43 professionals, respectively. The only distinction between such editions was the inclusion, in the most recent one, of questions addressing the growing integration of Artificial Intelligence into the software testing context, reflecting its widespread adoption as an assistive tool in QA activities.

3.1 Identification of research goals

We used the Goal-Question-Metric (GQM) [16] model to set out the objectives of the experiment that can be summarized as follows:

*"Identify **characteristics** for the purpose of **analyzing** with respect to **profile and skills** from the point of view of **QA professionals** in the context of **currently labor market**."*

To achieve this goal, we aim to investigate the two Research Questions (RQs) with the primary objective of defining the profile of a QA professional in Brazil and identifying the most essential skills they highlight. All these questions are presented in Table 1 in greater detail.

Table 1: Research Questions according to Survey Goal

Research Questions	Description
RQ1: How can the QAs' profile in Brazil be defined in the software development life cycle?	To answer this RQ, we identify the professional profile for Brazilians QAs taking into account their role and responsibilities.
RQ2: What are the most important skills to be an effective QA analyst and progress in this career?	This research question aims to identify essential technical and non-technical skills.

From these questions, the following metrics were defined: i) professional experience level (years in the role); (ii) educational background and certifications; (iii) tools used (by application type and testing level); iv) programming languages used for test automation; v) key technical and behavioral skills (distributed by level — junior, mid-level, and senior); vi) participation in software development life cycle stages; vii) challenges faced during training and sources of learning and viii) activities performed in the QA role.

3.2 Characterization of the target audience and sampling planning

The target audience of this survey comprises Brazilian professionals currently working in Quality Assurance roles across various states in the country. Once the target population was defined, the subsequent step involved selecting a representative sample.

The sample collection process was designed to follow a methodology that provided incentives for achieving a representative sample of the entire population. In this survey, we employ a non-probabilistic sampling method, in which participants are selected in a non-random order [9]. We employed the convenience sampling technique, where the sample was selected based on accessibility through media such as contact networks, electronic lists, emails, or interest groups (e.g., LinkedIn).

3.3 Planning and definition of questions

At this stage, we revisited the predefined objectives and established the procedures for collecting participants' data. Given that the target audience was reached through interest groups, email lists, and online communities, we opted to distribute the survey electronically via a web-based form. This form was developed in Portuguese using the Google Forms platform and organized into four sections. The complete set of questions is available[1]

The first section contains a presentation of the survey in which it is described the purpose of the same, the target audience, clarification on the importance of the participation of QA professionals working in the area, the period during which the survey would be made available to receive responses, and a consent form.

The second section aims to collect information that characterizes the personal and professional profile of participants, like gender, company size, localization, the highest academic degree, position or function in the organization, time experience, stacks, certifications, and job level. These data are also used to validate the participants because, with the questionnaire open, there was a risk that these participants were not active QAs' professionals.

The third section was intended to collect information on the knowledge and technical experience of QA professionals, like understanding of concepts (e.g., Behavior-Driven Development (BDD), Cucumber + gherkin and agile testing), knowledge of techniques types, levels of testing, test automation, test tools, programming languages for test automation and study materials and sources.

The fourth and final section of the survey aims to identify the profiles and activities of QA professionals. For this purpose, the questions were designed to collect information on skills, activities, participation in process steps, testing types, and testing levels performed by QAs. Additionally, an open question inquires about other activities performed during the software development process that were not covered in the form.

The survey included various question types, including multiple-choice, open-ended, and scale-based questions. For this type of question, we used a 5-point Likert scale [11] to assess the knowledge and technical experience of QA professionals.

[1]https://forms.gle/gBjg2ZKTsTbsbfEd9

3.4 Pilot execution

According to Kasunic (2005) [9], conducting a pilot survey is fundamental, as it allows for detecting potential problems, verifying that the questions are understandable, determining whether the right questions were selected to achieve the goal, and assessing how long participants take to complete the questionnaire. In this regard, the pilot study enhances the instrument's quality. The validity of an instrument is checked by evaluating its content [3], which consists of a subjective measure to identify how appropriate the items of an instrument are through expert opinion [12].

Therefore, we applied four open questions proposed by Hauck et al. [7] to evaluate survey content, such as (1) Does the questionnaire contain everything that is expected to meet your goal?; (2) Does the questionnaire contain unnecessary information for the context and purpose of the survey?; (3) Did you adequately understand the questions?; and (4) Are there any errors or inconsistencies in the questionnaire?

The pilot involved 54 QA professionals of diverse genders and seniority levels (junior, mid-level, and senior) from medium and large-sized companies. Such diversity provided representative feedback that supported the refinement and validation of the questionnaire. The invitation to participate in the pilot study was sent by email, and participants were selected based on their availability and proximity to the authors of this paper. The professionals answering the questions defined Hauck et al. [7] and rated them as positive with the following suggestions: *(i)* reduce the number of questions; *(ii)* leave some questions as non-mandatory; *(iii)* includes at least an open-ended question; (iv) contemplates the software development process phases; and *(v)* several types of tools.

3.5 Questionnaire Distribution

Based on the professionals' opinions, adjustments were made in the survey to be distributed for sampling. The questionnaire was distributed through emails and social networking communities. This distribution occurred between June 1 and 30, 2021, and again between February 3 and March 10, 2025. After the end of the periods during which the survey was available for responses, the collected data were analyzed to identify the characteristics of QA professionals.

The survey was disseminated using the same outreach strategy in both data collection periods. However, the 2021 edition attracted more participants than the 2025 edition. Although the reason for this discrepancy remains unclear, it is plausible that professionals were less willing to engage with the research in the more recent cycle.

The survey was conducted anonymously. When answering the questionnaire, participants were not prompted to identify themselves or provide any information that could potentially reveal their identity. Due to the large scale of participation, it was not possible to infer who provided the information. The survey only contained questions necessary to establish a profile of these QA professionals over time and to generalize this knowledge in the most organized way possible.

The use of a survey was an essential part of the research development, as it allowed the research to have a large sample size. A total of 169 participants were collected over the years the survey was

open. This revealed very varied and significant data for building a profile of these professionals, thus attempting to generalize and condense it in the best possible way during the study. The survey also enabled the necessary questions to be asked of participants for the profile development, thereby creating groups and categories for these professionals.

3.6 Questionnaire Validation

Considering the extensive amount of information gathered from the survey, handling the data solely within the Google Forms platform would be challenging and offer limited filtering and visualization options. Therefore, to enable a clearer projection of the data, with the help of Python libraries to organize it for presenting the study's information with greater clarity, a repository was created in Google Colab. This allowed for easier handling and organization of the data into tables and graphs.

The survey data was stored in a CSV file and processed using the Colab[2] platform to filter responses. This approach allowed the inclusion of answers beyond predefined options. Table 2 shows all study questions except for question ID 29, which appeared only in the 2025 round. The study prioritized SC and MC formats, also including an "Other" (O) option, open-ended (OE) questions, and a 5-point Likert Scale (LS) to assess knowledge in testing techniques. The use of OE questions was essential for advancing the study, revealing the diversity of responses and opinions among participants and highlighting divergences within the field — something that would not have been possible with closed-ended questions alone.

4 Results

4.1 Subjects Characterization

To carry out the general characterization of the research subjects, it is necessary to develop participants' profiles and to understand what these data and profiles reflect, primarily to elucidate how these most prevalent data apply in society, especially to QA professionals. The less expressive but still significant data will also be reported to highlight other scenarios and provide an open space for discussion.

The best way to describe the profile of QA professionals is to present the most notable data from each survey question and synthesize the key elements highlighted. This profile will serve as a basis for discussing and comparing the general profile with those of professionals at each respective level (junior, mid-level, and senior).

When analyzing the gender composition of QA professionals from a Brazilian perspective, it is evident that the field has been predominantly male over the years, with a significant number of men in the field. According to the survey, 110 participants identified as men, while 59 identified as women, indicating a larger number of men.

A comparison of the 2021 and 2025 survey data shows a significant drop in participation among both men, from 79 to 31, and women, from 47 to 12. However, this trend shifts at the junior level, where female participation surpassed that of males. In contrast, male respondents continued to dominate the mid-level and senior categories.

[2]https://colab.google.com/

4.2 Central findings

- Location: When analyzing the location of these QA professionals, it is notable that most of them are concentrated in areas with large urban populations, such as the major metropolitan areas of São Paulo, Minas Gerais and Rio de Janeiro. These are regions with high economic activity that attract these professionals and create job openings in the technology field, explaining the large number of QA professionals in these regions.

In 2021, São Paulo and Minas Gerais had the highest participation, with 44 and 37 respondents, respectively. By 2025, Minas Gerais remained the most represented (16), while Pernambuco, Santa Catarina, and São Paulo each had 4. The 2025 survey also included three international participants, showing some global engagement.

- Education: The survey highlights the importance of higher education in the QA field, especially among those who have completed or are pursuing a degree. Senior professionals are mostly those with completed higher education or a specialization. In comparison, Mid-level and Junior professionals tend to have either completed or incomplete higher education, indicating a clear educational progression across levels.

These data reflect that higher education can be a decisive factor in becoming a Senior professional in the field and acquiring more knowledge. That graduation is a differentiating factor among these participants. However, it is still possible to reach high levels, such as Senior, in the field with incomplete higher education. Although these professionals stand out in the survey with less prominence, there is still a significant number of Seniors who have incomplete higher education. The complete data, including evidence from two years of study and differentiation by level, can be viewed in Table 3, where it is evident that the less prominent educational backgrounds include postgraduate degrees and incomplete postgraduate studies.

Table 3: Academic Qualifications by Professional Level

Education Level	2021	2025	Senior	Mid-level	Junior
Completed Higher Education	91	27	40	34	15
Postgraduate Certificate / Specialization	30	8	19	7	4
Incomplete Higher Education	32	6	11	7	11
Completed Postgraduate Degree	14	2	6	7	0
Incomplete Postgraduate Degree	2	0	1	1	0

- Size of the organization in which the professionals work: Analyzing the size of the organizations where QA professionals work, it can be considered that the majority of professionals in the market work in large companies (with more than 500 employees) and medium-sized companies (with up to 500 employees). This highlights that large and medium-sized companies are the most concerned with testing and software quality, showing the hiring of a large number of Quality Assurance employees to meet the needs of their software and users. When analyzing small and micro companies, the survey shows that fewer QA professionals work in these companies.

When analyzing the data collected over both years of the study, we observed a significant shift in the size of companies that employ QA professionals. In 2021, the majority of respondents (108

Table 2: Questions from the Survey Applied to QA Professionals

ID	Question	Type
01	Gender	SC + O
02	Location	OE
03	Education	SC + O
04	Organization size	SC + O
05	What is your experience in your current role?	SC + O
06	According to your position, what is your level?	MC + O
07	Do you hold any certification related to your current role?	OE
08	Have you always worked in the Tech area?	OE
09	What is your position or role in the organization?	SC + O
10	Which stacks have you worked with and/or are currently working with?	MC + O
11	I understand the functional (black-box) testing technique, its criteria, and I can apply it in practice	LS
12	I understand the structural (white-box) testing technique, its criteria, and I can apply it in practice	LS
13	I understand the defect-based testing technique, mutation analysis criteria, and I can apply it	LS
14	I have experience with software test automation and I can apply it	LS
15	I understand the fundamentals of BDD	LS
16	I understand and use Cucumber + Gherkin	LS
17	I understand and apply the concepts of agile testing	LS
18	Regarding your experience with tools for mobile application testing, mark those you use or have used.	MC + O
19	Regarding your experience with tools for web application (front-end) testing, mark those you use or have used.	MC + O
20	Regarding your experience with tools for REST API (back-end) testing, mark those you use or have used.	MC + O
21	Which programming languages have you used for software test automation?	MC + O
22	During your learning process, did you face difficulties in finding study materials related to software quality?	SC + O
23	What sources do you usually use to improve your skills?	MC + O
24	What are the most important skills for an efficient QA?	MC + O
25	What activities do you perform as a QA in your organization?	MC + O
26	Which stage(s) of the software development process do you participate in?	MC + O
27	Which level(s) of testing do you apply during the software development process?	MC + O
28	What type(s) of testing do you perform during the software development process?	MC + O
29	What is your perception about the use of intelligent assistants and LLMs for generating test data? Advantages, disadvantages, and whether they help in complex logic scenarios?	OE

participants) reported working in large companies, followed by medium-sized companies (36), small companies (20), and micro-enterprises (3). However, in 2025, this distribution changed notably: only 26 professionals reported working in large companies, while 10 were from medium-sized companies, 5 from small companies, and just 1 from a micro-enterprise.

- Experience and level of professionals: The analysis of QA professionals' experience reveals that most have between 1 and 3 years of experience in the field, a range typically associated with mid-level professionals. This reflects a moderate degree of expertise—more advanced than novices, but still relatively recent. In addition, a significant portion of respondents reported 4 to 7 years and 8 to 11 years of experience, characterizing the senior level and highlighting a clear leap in expertise compared to earlier stages. For junior QA professionals, most have less than one year of experience, confirming their status as the most recent entrants to the field. The full breakdown of experience by professional level, as well as the distribution across the two survey years, is presented in Table 4. The data emphasize that senior professionals consistently represent the most experienced group, with a noticeable concentration of respondents reporting four or more years of experience in both 2021 and 2025.

When analyzing the survey, it becomes clear that, to the positions they hold, the majority of these professionals identify themselves as

Table 4: Comparison of Experience Time by Professional Level

Experience	2021	2025	Senior	Mid Level	Junior
Less than 1 year	17	4	1	3	17
1 - 3 years	51	4	10	34	11
4 - 7 years	24	21	28	16	4
8 - 11 years	27	9	17	5	1
12 - 15 years	5	4	9	7	11
More than 15 years	2	1	2	1	0

senior professionals. That is, most of the study participants already have considerable experience in their fields, which ensures more reliable answers, as they will be contributions from professionals who have a significant journey in the QA field, actively participating in their respective roles, presenting important information to show how they think and stand out from junior and mid-level professionals in the market and their skills.

Presenting the numbers collected from the survey, senior professionals represented 77 participants, 58 participants reported being at the mid-level, and 30 reported being at the junior level. Another 3 participants reported to the survey that they are specialists, which are considered professionals who have a high level of experience, even above senior professionals who already have significant qualifications in the field. Thus, it is a study that guarantees the

participation of a range of professionals from various levels, thereby providing more diverse and valuable data to facilitate comparisons between them and generate a discussion based on the data.

A comparison between the two survey years shows that in 2021, most participants were senior professionals (54), followed by mid-level (43), junior (26), and 3 specialists. In 2025, participation declined across all levels, with 23 seniors, 15 mid-level, and only 4 junior professionals.

- **Career Backgrounds and Transitions into QA:** When analyzing whether QA professionals have always worked in the tech field, it can be observed that the majority of these professionals have traditionally been associated with a technology area, and few have migrated from other fields. This reveals that most professionals were introduced to the technological area and showed interest in the QA field throughout their journey, during their learning, forming a solid career path in software engineering. The minority comes from other areas, without direct relation to technology, and sees it as a possibility for a promising career. This means that technology areas are becoming increasingly attractive over the years, to the point of encouraging specific individuals to change fields to satisfy their prospects for a better career that meets their work goals and interests.

The survey revealed that 114 professionals have consistently worked in technology-related roles throughout their careers, while 55 participants transitioned into the tech field from other areas of expertise. This distinction underscores the relevance of both pathways: approximately one in every three QA professionals surveyed began their careers outside the technology sector and later shifted focus. A longitudinal analysis reveals that, in 2021, 83 participants reported a continuous background in technology, whereas 43 had migrated from various fields. By 2025, the numbers declined to 31 and 12, respectively. These findings suggest a persistent trend of career transition into QA, even as overall participation decreased in the more recent cycle.

- **Role definitions and Terminology Challenges in QA:** It is possible to state that the majority of QA professionals hold positions such as Quality Assurance (QA), Test Analyst, and Software Quality Engineer within their companies. However, upon conducting a more detailed analysis of the participants' responses reported in the survey, it becomes possible to state that the area faces a problem of standardizing job titles, which hinders the creation of a clear description of the function of each of these workers.

Due to this action, confusion and a lack of understanding arise regarding the actual functions that professionals are performing. While the terms they use are similar in writing, they can represent different work functions and specialties in practice, making it impossible to infer with certainty whether some positions represent the same functions. This becomes a very detrimental obstacle for these professionals because they are not entirely sure if their job title and its corresponding nomenclature accurately reflect the function they are performing. It is also a barrier to regulating the area, as there is no standard name for each position and what it represents, which delays the formation of laws in the technology sector, the standardization of salaries and functions, the qualification of professionals for specific positions, and the mapping of these professionals.

Table 5: Comparison of QA Activity by Technology Stack

Technology Stack	2021	2025	Senior	Mid-level	Junior
Web	112	39	68	52	27
Back-end	82	29	59	38	10
Mobile	75	33	53	34	17
Desktop	5	3	4	2	2
Hardware	1	1	2	0	0
Accessibility	1	0	1	0	0
Firmware	1	0	1	0	0
Embedded	2	0	1	1	0
Games and Simulators	0	1	0	1	0

Other positions that showed some prominence in the study were Test Automation Analyst and Software Development Engineer In Test (SDET). There were many other attributions present in the survey, but in smaller quantities, and were answered by a maximum of one participant. These, in comparison to the positions mentioned earlier, are not as significant for the study's analysis.

- **Technology Stack:** QA professionals predominantly work with the Web Stack, reflecting its substantial presence in daily activities, especially given the large number of companies focused on websites and user support. Back-end development is also highly relevant, as it is crucial for ensuring proper system behavior in integration with the Front-end. Additionally, Mobile development has gained importance, driven by the growing use of smartphones and the expansion of mobile applications.

Table 5 highlights the most prominent stacks reported in the study, with a breakdown by year of participation and professional level, providing a clearer view of how stack preferences evolve or remain stable across different experience levels and timeframes.

- **Certifications:** Regarding certifications, most QA professionals reported holding at least one, suggesting that formal qualifications remain an essential means of differentiation in the job market, enhancing both credibility and trust in their expertise. A closer analysis at the professional level reveals that junior professionals are less likely to hold certifications, reflecting an ongoing process of skill development early in their careers. This distinction highlights the contrast between newcomers and more experienced individuals who already possess a broader knowledge base. When comparing data across the two survey years, in 2021, 71 participants reported not having any certifications, while 48 indicated that they did. In contrast, the 2025 data show a more balanced distribution: 26 respondents stated they lacked certifications, while 17 reported having them. Although the overall number of participants was lower in 2025, the proportion between certified and non-certified professionals was more evenly distributed in that year.

- **Programming Languages:** The data indicate that the majority of QA professionals currently rely on Java and JavaScript, both of which are widely recognized for their ease of use in web development. Java, in particular, stands out for its versatility, as it is extensively applied in both front-end and back-end testing activities. Python follows closely, recognized for its flexibility and

Table 6: Comparison of Programming Language Usage by Professional Level

Programming Language	2021	2025	Senior	Mid-level	Junior
Java	93	24	63	35	17
JavaScript (JS)	58	32	49	28	11
Python	50	25	46	18	9
Ruby	35	11	28	14	3
C#	23	12	24	8	2
Kotlin	9	9	10	6	1
No Lang	6	1	0	3	4
Swift	1	2	3	0	0
PHP	2	0	1	1	0

applicability across different layers of software systems. This language distribution aligns with the stack preferences reported by the professionals, especially those working within both front-end and back-end environments. Table 6 presents these findings in detail, with a breakdown by survey year (2021 and 2025) and professional level (junior, mid-level, and senior), allowing for a comparative analysis of language preferences across different career stages and over time.

- **Testing Tools:** The most frequently used tools by QA professionals for software testing across back-end, mobile, and front-end domains are presented in Figure 1. With it, it is possible to verify that QA professionals have a strong affinity with Back-end tools. Among these, the one that stands out the most is Automation with Postman. Furthermore, other professionals state that they use Postman strictly manually for Back-end test automation. Other frequently reported tools were REST Assured, Robot Framework, and HTTParty. Regarding tools for mobile test automation, QA professionals vastly prefer the use of the Appium tool. Other professionals report that they do not use any tools for testing in the mobile environment. Other tools that also stand out for these professionals are XCUITest and Espresso. For performing tests on the Front-end, professionals show a preference for the Selenium and Cypress tools, which were the most frequently highlighted tools during the study. Others that also stood out for their performance in tests, more specifically on the Front-end, were the Robot Framework, Capybara, and Protractor tools.

With the aid of the figure, it is possible to conclude that some professionals do not use test automation tools and prefer to perform tests manually. This indicates that there are professionals who have no interest in automating software tests or lack the necessary knowledge of a tool to do so.

- **Learning Sources:** For QA professionals, the main learning sources include online course platforms and YouTube channels, which provide accessible content to support ongoing development. Peer interaction through communities and social networks is also highly valued, enabling knowledge sharing based on real-world experiences. Additionally, professionals often turn to written resources, such as Medium articles, scientific publications, and books, that cover topics in software engineering and quality assurance.

A detailed analysis of the learning sources reported by QA professionals reveals that none of the participants mentioned university education as a contributor to their knowledge in software testing. This absence raises concerns about how software testing is being addressed in computer science curricula, potentially indicating a lack of depth or emphasis on the topic in higher education. Table 7 summarizes the main learning sources cited by professionals to enhance their skills.

Table 7: Comparison of Learning Sources

Learning Source	2021	2025	Senior	Mid-level	Junior
Online platforms	113	38	69	54	27
YouTube channels	104	38	60	52	27
Communities and social networks	90	30	53	38	26
Medium	75	19	51	27	12
Academic articles	37	11	27	12	7
Books	29	12	20	13	6
Searches on Google, GitHub, or Stack Overflow	5	0	4	1	0
Guided mentoring	2	1	2	0	1
Events	1	0	1	0	0
Artificial intelligence	0	1	0	1	0
Tool documentation	0	1	1	0	0

- **Fundamental Skills:** Regarding the fundamental skills that professionals highlight as necessary for every QA to build a career in the field, it is notable that the primary skill reported by them is the ability to communicate effectively. This need arises mainly from the need to communicate with clients and other professionals to report bugs and describe how tests are being carried out. An interesting fact of this analysis is that the majority of junior professionals did not consider being communicative as the primary fundamental skill to be cited. This may indicate a shift in thinking between generations or a lack of preparation among these professionals, who often have less experience in meeting the job market's demands for these soft skills. Other skills mentioned were thinking technically like the user, being analytical, and being detail-oriented. For a complete visualization of all the skills cited by professionals already working in the market and their proportion among the participants' levels. Table 8 presents the most relevant skills identified as essential for quality assurance professionals.

- **Activities Performed:** Core activities performed by QA professionals include verifying compliance with requirements, reporting bugs and defects, executing various levels of testing, and designing test scenarios. These tasks collectively reflect the central role of QAs in ensuring test quality and software reliability. While most respondents confirmed engagement in these responsibilities, only a few reported contributing to unit test coding, indicating that such involvement is not widespread. Over time, some shifts in emphasis are observable: in 2021, the most frequently cited activities were ensuring requirements were met (97 mentions), reporting faults (87), and executing test levels (81). In 2025, professionals primarily highlighted defect reporting (33), requirement validation (31), and scenario definition (27), suggesting a possible refinement or narrowing of QA focus in recent years.

- **Software Engineering Stages:** An analysis of the stages in the software engineering lifecycle where QA professionals are most active reveals a consistent emphasis on System Integration Testing. This stage was the most frequently cited by participants, followed

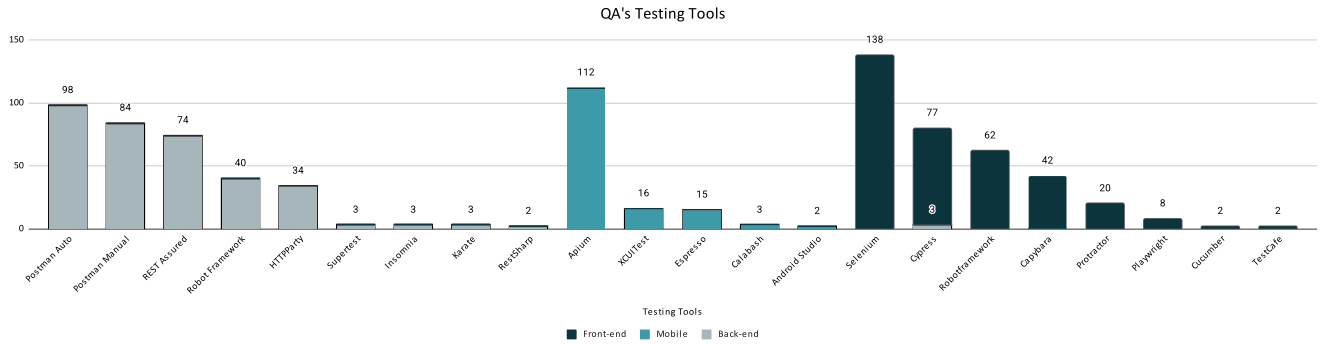

Figure 1: QA's Testing Tools.

Table 8: Distribution of key skills reported by QA professionals in 2021 and 2025.

Skill	Description	2021	2025
Being communicative	A QA must effectively communicate bugs, test results, and suggestions to developers, product owners, and stakeholders.	87	32
Thinking like a technician and a user	Balancing technical knowledge with user experience allows a QA to identify issues from both perspectives.	82	34
Being analytical	QA professionals must analyze test results, logs, and system behavior to understand and isolate problems.	83	27
Being detail-oriented	Small bugs can cause big problems. Being detail-oriented means catching what others miss.	73	27
Being curious	A curious QA explores beyond the obvious, finding hidden issues.	72	24
Being proactive	A proactive QA identifies risks early and suggests preventive measures.	65	21
Being investigative	A QA reproduces bugs, finds root causes, and gathers data for devs.	65	20
Having technical knowledge	Knowing code, APIs, databases allows for better testing and automation.	55	11
Learning quickly	A QA must adapt to new tools and frameworks quickly.	41	19
Having empathy	Empathy helps advocate for a better user experience.	43	7
Being flexible	A QA must adapt to changing requirements and priorities.	35	12
Being a good listener	Listening helps a QA understand expectations and context.	31	11
Being self-confident	A QA must report issues confidently even when controversial.	12	2
Being organized	Organization is key for managing tests, bugs, and documentation.	1	0

by Requirements Definition, Software Design, Operation and Maintenance, and finally, Unit Test implementation.

When examining the data for both years of the study, in 2021, the implementation of system integration tests was highlighted by 112 respondents, the definition of requirements by 88, the design of software by 68, the operation and maintenance by 65, and the implementation of unit tests by 44. In 2025, the same pattern was observed, though with lower absolute numbers: 38 respondents indicated System Integration Testing as their primary area of involvement, followed by 24 for Requirements Definition, 22 for Operation and Maintenance, 20 for Software Design and 13 for Unit Tests.

These findings suggest that QA professionals in Brazil are predominantly engaged in the later stages of the development cycle, particularly during integration and validation activities. Their limited involvement in early phases, such as unit testing, may indicate a prevailing perception that quality assurance is a downstream task. This reinforces the need to promote a shift toward more proactive QA participation from the outset of the development process, especially in activities such as Test-Driven Development.

- **Software Testing Techniques:** QA professionals report that they most commonly conduct black-box testing, manual testing, automated testing, performance testing, and white-box testing. Therefore, it is noticeable that these professionals tend to perform these types of tests. The Figure 2 summarizes the responses for questions 11 to 17. Note that the distributions follow the Likert scale (1-5). For instance, Question 11 assessed the participants' self-reported ability to apply black-box testing techniques. A total of 113 respondents rated themselves at the highest level (5) on the Likert scale, 42 selected level 4, 11 chose level 3, 2 selected level 2, and only 1 respondent rated themselves at the lowest level (1).

  Considering only the participants who rated themselves at level 5, a clear predominance is observed in black-box testing proficiency, with 113 respondents indicating the highest level of confidence. Following this, 89 participants reported full proficiency in the fundamentals of BDD, 80 in agile testing concepts, 71 in software test automation, 69 in Cucumber + Gherkin, 60 in white-box testing and 52 in defect-based testing techniques.

- **LLMs and intelligent assistants for testing activities:** Although recent advances in LLMs and intelligent assistants have raised expectations for accelerating test data generation, our findings indicate that QA professionals remain cautious about their effectiveness

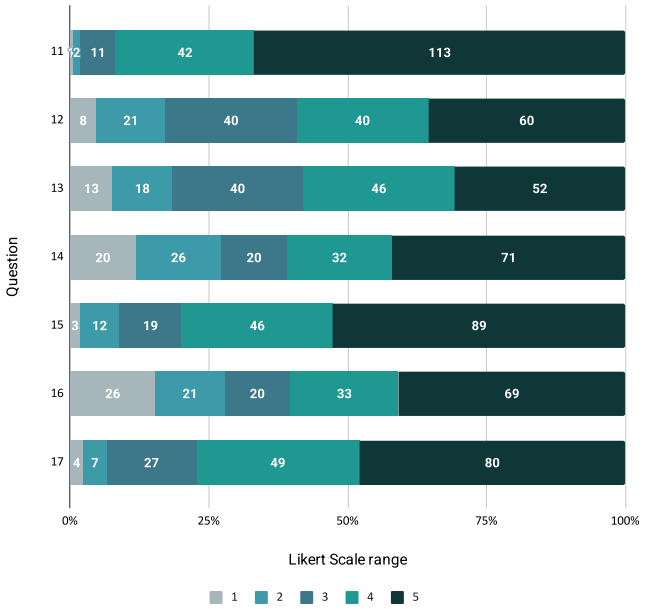

Figure 2: Responses to questions 11–17 regarding QA professionals' knowledge and ability to apply testing techniques

in complex, real-world testing contexts. Participants' comments illustrate this perspective:

S158 :"...they can be very useful to accelerate the creation and variety of test data — as long as they are combined with the tools and processes that the QA currently uses. One drawback is that even with a well-crafted prompt, there may be a lack of understanding of the business rules, as well as risks of data leakage."

S128 :"...Advantages: fast test generation, increased coverage, explanation and documentation, improved test data. Disadvantages: logic accuracy sometimes fails, difficulty with specific rules, need for human validation, and occasionally it depends on prior training."

S155 :"It reduces the time and effort spent on test data generation. A drawback is that it depends on the level of knowledge of the QA using the tool. If they don't know what they're doing, it can compromise the entire quality assurance chain. Moreover, the assistant needs to be well-trained, with clear and precise inputs. It can help with complex logic, as long as the professional breaks the logic into smaller steps and understands what they're doing."

S150 :"I think intelligent assistants and LLMs are very helpful in generating test data because they speed up the process and increase scenario coverage. However, depending on the logic's complexity, they may not be 100% accurate, so it's still important to have human validation to ensure the data makes sense. Overall, I believe they're a great tool to optimize the work!"

The primary challenges of using AI for fault detection include complexity, interpretability, and data quality issues. AI systems require high-quality, representative data to function effectively, and their decision-making processes can be opaque, making it difficult to comprehend how faults are identified.

Differences between traditional QA activities and using assistants for testing activities center on automation and adaptability. AI-driven fault detection leverages techniques such as machine learning and NLP (Natural Language Processing) to analyze large codebases, logs, and user behavior, enabling autonomous test case generation, real-time fault prediction, and adaptive test maintenance. Traditional methods rely heavily on manual scripting and static test cases, which are less scalable and more prone to oversight.

AI improves software testing by increasing fault detection, speeding up test execution, and expanding coverage. It minimizes manual effort, accelerates regression cycles, and enhances defect prediction, leading to more reliable and maintainable software.

5 Discussion

RQ1: *How can the QAs' profile in Brazil be defined in the software development life cycle?*

The profile of QA professionals in Brazil has evolved significantly between 2021 and 2025. In 2021, QA roles were still predominantly tied to later stages of the development cycle, such as validation and acceptance testing, especially for junior professionals. However, by 2025, the data show an increased integration of QA professionals—particularly at the senior level—throughout the entire software development life cycle, including requirements analysis, design discussions, and even development support.

This shift denotes a clear shift away from the traditional "gatekeeper" role of QA towards a more proactive, cross-functional presence within development teams. Senior QAs now emphasize their responsibility not only for testing but also for promoting quality practices from the earliest stages of development. Conversely, junior QAs, while still primarily engaged in final-stage activities, have begun to take part in earlier phases—albeit more modestly—indicating a gradual cultural and organizational transformation.

However, the persistence of inconsistent job titles and overlapping responsibilities across companies continues to blur the boundaries of QA roles. This ambiguity, more pronounced at the junior level, hinders the formation of well-defined career paths and may delay the full integration of QA into all phases of the software development life cycle.

In 2021, QA roles were primarily focused on testing and validation, with limited involvement in earlier stages such as requirements gathering and design. By 2025, however, a notable shift toward broader, cross-functional engagement had occurred—particularly among senior QA professionals—reflecting an increased maturity in agile practices and a stronger understanding of quality as a shared responsibility across the development team.

RQ1 Answer: Most QA professionals are integrated across all phases of software development, especially senior-level professionals, while juniors tend to focus more on final testing. The role has shifted from isolated testing to a collaborative, quality-driven approach, though job role definitions remain unclear. Strong technical skills, combined with effective communication, define the modern Brazilian QA profile.

RQ2: *What are the most important skills to be an effective QA analyst and progress in this career?*

The expectations for QA professionals in Brazil have evolved to encompass a broader, more integrated set of skills. While soft skills, such as communication, critical thinking, and proactivity,

continue to be viewed as indispensable, especially for collaboration in agile teams and effective stakeholder engagement, the role now also demands deeper and more strategic technical capabilities.

In 2021, the most frequently cited soft skills were communication (87 mentions), analysis (83), and thinking like both a technician and a user (82). These remained important in 2025, but with fewer mentions (e.g., communication dropped to 32). Notably, junior professionals in 2025 were less likely to identify communication as a critical skill, suggesting a lack of experience or awareness of its importance in real-world QA contexts, particularly in agile and cross-functional environments. Still, across experience levels, the consensus remains: **QA excellence relies heavily on behavioral competencies that foster collaboration, fault reporting and proactive quality advocacy**.

From a technical perspective, QA professionals in 2021 already demonstrated familiarity with core testing concepts and techniques, including black-box, white-box, and defect-based testing, as well as test automation practices. By 2025, there is an apparent intensification in the use of automation frameworks and programming languages, with a growing emphasis on how they are applied rather than just which ones are known.

Regarding the testing tools, Selenium and Cypress remained dominant for front-end testing, while Postman (both manual and automated) and REST Assured were leading tools for back-end testing. Ultimately, Appium excels in mobile testing. Considering the Testing Techniques and Methodologies, concepts such as Behavior-Driven Development (BDD) and Agile Testing were more familiar in 2025, indicating increased maturity in testing practices. Senior QAs are more likely to apply advanced techniques and participate in the design of test strategies, while juniors remain focused on execution tasks.

In 2025, the survey introduced a new dimension: the perception of LLMs and AI-based tools. Although many professionals recognize their potential to accelerate test data generation, concerns persist about accuracy, business rule coverage, and data leakage. This calls for a new layer of competence: the ability to validate and complement AI-generated artifacts, a skill set still under development in the field.

RQ2 Answer: An effective QA analyst in Brazil requires a dual foundation: 1) Soft Skills - communication, analytical thinking, curiosity, and proactivity remain essential, especially for navigating agile environments and collaborating across roles. 2) Technical skills - fluency in test automation, testing techniques, and programming languages are increasingly critical, particularly for senior roles. As AI becomes more embedded in testing workflows, the ability to critically interpret and augment AI outputs will define the next leap in QA professionalism.

6 Threats to Validity

Construct Validity: One of the main initial challenges during data validation was interpreting the intended meaning behind certain participants' responses, particularly regarding their job titles and sources of learning.

Internal Validity: A potential source of bias initially stemmed from how open-ended responses and "Other" options were analyzed and categorized. This was mitigated through a structured data standardization process and collaborative review involving multiple researchers, who reached a shared consensus on ambiguous cases. These measures ensured a consistent and transparent interpretation of participants' answers.

External Validity: Concerns regarding the sample size and representativeness were addressed by broadening the survey's dissemination to professional communities and social networks. This allowed the study to reach a large and experienced pool of software testing professionals, increasing the external validity of the findings.

Conclusion Validity: Through the combination of clearer survey design, standardized data handling, and a broader participant base, the study successfully reduced previously identified threats. While the analysis focused on descriptive patterns rather than statistical testing, the results now reflect a higher degree of consistency and trustworthiness.

7 Conclusion

This study aimed to address a fundamental question in the software quality field: what distinguishes a great QA professional? Based on the analysis of data collected from 169 Brazilian professionals, we conclude that technical knowledge alone is not enough. A successful QA analyst is characterized by a combination of strong technical foundations, mastery of good testing practices and techniques, and, above all, highly developed soft skills such as communication, critical thinking, curiosity, and attention to detail.

Our results indicate that QA professionals seeking to advance their careers must actively pursue continuous learning opportunities through reputable sources, certifications, and participation in professional communities. Experience in different phases of the software development cycle, combined with adaptability and the ability to collaborate with multidisciplinary teams, has proven essential. Although tools like Postman, Selenium, and Appium are highly demanded, our findings highlight that tool mastery must be accompanied by a critical application of best practices to generate relevant test cases and maximize fault detection. Additionally, the emergence of intelligent assistants and LLMs opens new possibilities for optimizing testing activities. Still, it underscores the importance of human validation, given the complexity and criticality of the testing context.

Ultimately, this work reinforces that building a solid career in software quality requires a proactive attitude, an eagerness to evolve with the technological scenario, and the ability to work not only with technology but also with people. We hope that these findings contribute to the development of more robust educational programs and clearer career paths for current and future QA professionals.

ARTIFACTS AVAILABILITY

All study data are available in the repository, including instructions in the directories starting from the *README* file.
https://anonymous.4open.science/r/qa_survey/README.md

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