




Expectation vs Reality: Analyzing the Competencies of Software Testing Teams

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Abstract: Process and product quality are essential to maintain competitiveness in the software industry. Software testing is one of the activities to assess product quality, and its process permeates all phases of the development process lifecycle. However, this requires software testing professionals to master different technical skills and general skills. To reduce the skills gap required for the testing team, it is necessary to conduct a skills assessment of all team members. Given this, the objective of this research is to present the results of a competence assessment based on a competence mapping model aimed at software testing teams. To support this research, a questionnaire was applied to 25 industry professionals from a development company to assess the general and technical skills of all roles in the software testing process. As a result, we identified which competencies managers desire for their testing teams. In addition, we identified how professionals see themselves through a self-assessment based on this competence mapping model. After the evaluation, it was possible to identify which competencies need to be developed to reach the required levels for each role and increase the productivity and quality of the process and the product.

1 INTRODUCTION


With the exponential growth of demands for software products, the industry has been looking for increasingly qualified professionals with differentiated competencies. Conceptually, competencies can be defined as "a collection of skills, aptitudes and attitudes to solve a problem in a given context" (Holtkamp et al., 2015). Competencies and skills are different things. Skills tell us "what" professionals are able to do when it comes to a specific assignment. Competencies show the "how", that is, answer what is the process should be that the professional needs to go through to develop new learning, therefore, they can be acquired through training (Faria and de Castro Filho, 2014). In SWE-COM (Ardis et al., 2014) these competencies can be classified as technical skills and behavioral skills necessary for software engineers.


Many studies (Assyne et al., 2021; Ahmed et al., 2015; Holtkamp et al., 2015) seek to identify what are the essential competencies for software profes-


sionals and it was concluded that is important to study *soft skills* and *hard skills*, as both are considered two equally critical pillars of the *Software Engineering Competencies* (SEC). Researchers recommend that studies be carried out considering different points of view, from software professionals, educators to the industry, as it is necessary to pay more attention to both contexts: research and practice (Assyne et al., 2021).

A software testing process aims to structure the steps, activities, artifacts, roles and responsibilities of testing, allowing organization and control of the entire test cycle, minimizing risks and adding quality to the software (Pressman and Maxim, 2021). In software testing practice, successful testing often depends on the skills, intuition and experience of the tester (Kaner et al., 2011).

In view of this, this research aims to present an experience report in the analysis of the competence level of a software testing team in the industry, from the perspective of managers (expectation) and testing process professionals (reality). In this way, the skills gaps that professionals need to develop to reach the expected level are identified, enabling professional training, reduced turnover, increased productivity and product quality.

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2 THEORETICAL FOUNDATION

This research addresses concepts related to software engineering skill sets and knowledge described in the Software Engineering Competency Model, available on SWECOM (Ardis et al., 2014). SEC was also presented in a systematic mapping described in (Assyne et al., 2021). In this mapping, 60 primary studies have been analyzed, which sought to answer the following research question: *What can the current literature tell us about the evolution of Software Engineering Competencies?* As a result, the following were identified: 2 research areas (organizational and personal); 11 themes inside 49 core competencies; 14 models or *frameworks* – which, in turn, were classified according to the context: 5 *frameworks* focused on personal competencies and 9 *frameworks* focused on organizational competencies. The *framework* described by (Saldaña-Ramos et al., 2012), was chosen out of the 14, as it is aimed at mapping competencies of software testing teams, the focus of this research.

2.1 Competency Mapping Model

The framework presented by (Saldaña-Ramos et al., 2012) is used to mapping competencies focused on technical skills and general skills required for the testing team and was based on the main references on software testing: *The White Book* (Llorens-Garcia et al., 2009), Tmap® (Vroon et al., 2013), TMMi® (van Veenendaal et al., 2022), ISTQB® (ISTQB, 2022), SWEBOK (Abran et al., 2004). Among the different methodologies available to define a competency model, this *framework* (Saldaña-Ramos et al., 2012) adopted the methodology based on Job Analysis: it identifies the competencies from the characteristics of the job in terms of mission in the organization, objectives operational, evaluation criteria, organizational situation, areas of activity and level of autonomy and responsibility of the position.

The *framework* aims to reduce the skills gap required for the testing team according to the main responsibilities of the following roles: **Test Contract Manager (TCM)**: Manage resources, contract services and control the project. Oversees the testing process and improves it, and maintains and enforces testing policies. **Test Manager (TM)**: Coordinate and manage the activities of the test team. It is responsible for ensuring the quality of products and processes, in addition to checking that the documentation is correct. Tracks activities related to testing, monitoring and estimating the time, schedule and costs required to run the tests. **Test Engineer (TE)**: Managing and maintaining the test plan, designing and reviewing

test cases, overseeing the test environment and performing reviews. **Tester (T)**: Create and execute the test cases, ensuring that they are executed with the data according to the requirements and documenting the results obtained from the execution of the tests.

The technical and general competencies and their proficiency levels required for each role of the software testing team, were identified through the competency mapping *framework*. The competency levels are: **Low (L)**: Member of the testing team does not have this competency; **Medium (M)**: Test team member is still learning. Competency has been partially acquired; **High (H)**: Team member is independent. Competency has been fully acquired. **Very High (VH)**: Team member masters this skill and practices steadily. More details about the *framework* are available in the supplementary material ¹ (Maia et al., 2023).

2.2 Related Works

Ahmed et al. (Ahmed et al., 2015) investigated which *soft skills* are most appropriate for each role within a software team and how the industry considers these *soft skills* during employee hiring. The authors concluded that the most critical *soft skills* for the role of software testing (communication, analytical and problem solving skills, interpersonal skills, ability to work independently and organization) does not reflect what the industry considered at the time of hiring. This study suggests that the industry pays more attention to the set of interpersonal skills and the ability to work independently, given that the role of software testing requires attention to details, at the same time that it is necessary to report the results to the developers – which requires communication and conflict resolution skills.

Given the above, this research aims to address some gaps not presented in the works previously mentioned: (i) which *soft skills* and *hard skills* are essential for the roles of the software testing team; (ii) which *soft skills* and *hard skills* are less developed and what action is needed to develop these skills to improve project deliveries; (iii) what is the influence factor of these competencies to increase the quality of deliveries.

3 METHODOLOGY

This research was based on the competencies mapping *framework* described in Section 2.1, which char-

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acterizes the levels of competencies according to a set of technical competencies and general competencies expected for each software testing team role. As testing professionals, it is understood that they are all those involved in the software testing process, according to the roles defined in Section 2.1. A questionnaire was applied to professionals from a company in order to answer the following research questions:

RQ1. *What technical competencies do the testing professionals consider important for each role?*

RQ2. *What general competencies do testing professionals consider important for each role?*

RQ3. *What are the desired competencies levels for each role from the managers' perspective? And from the test team's to?*

RQ4. *How do professionals evaluate themselves according to the levels of technical and general competencies?*

3.1 Questionnaire Specification

The questionnaire was divided into three sections: the first of sociodemographic characterization, with the objective of characterizing the profile of the participants; the second assessment of the levels of skills (general and technical) desired for each role of the testing team; the third self-assessment of skills levels (general and technical) according to their role within the testing team. The concepts about the roles and the definition of the levels of competency were made available in electronic form to facilitate the understanding of the participant.

Three objective questions were asked, using a 4-point Likert scale, where 1 means that the level of technical competency required is Low and 4 means that the level of competency required is Very High. An open question was also asked in order to assess whether the participants considered the questions satisfactory. The questionnaire has a total of 77 questions that map all competencies according to each role, that is, each competency was considered an objective question. It is worth noting that all participants agreed to participate in the study by signing a Free and Informed Consent Form (CF), thus guaranteeing the confidentiality of the data provided. The questionnaire was available during the first half of May 2022. More details about the CF and the full version of the questionnaire are available in the supplementary material (Maia et al., 2023).

3.2 Data Collection

The study was conducted at a company, which has units in different regions of Brazil. The questionnaire was applied through an online form, in a team that

works with software development, where the testing team is allocated with the development team, adopting practices of agile methodology, working in global software projects, and providing different contexts within the development and the testing process.

The profile of the participants was mapped according to age, gender, level of education, position, role and time of professional experience in the area of software testing. A total of 25 participants answered the questionnaire, who held the following positions: interns (36%); technicians, *trainees* and test analysts (52%); and project managers (12%). It was found that most participants (80%) have a maximum of 5 years of experience, 12% have 6 to 15 years of experience and 8% have more than 15 years of experience.

In order to characterize the roles according to the definition adopted in the competency mapping model, it was asked which role is closest to the responsibilities currently exercised by the participants. Of the 25 participants, 52% identified most with the roles described in the Software Tester role, followed by 32% Test Engineer, 12% Test Contract Manager and 4% Test Manager.

4 RESULTS AND DISCUSSIONS

4.1 The Technical Competencies

The competency mapping model used offers a set of specific technical competencies (TCs) for the testing team. From this, the participants assessed what competency level is needed for each role presented in Section 2.1. We will highlight the results obtained that were different from the baseline presented by the framework.

Test Contract Manager (Figure 1:) TC1 and TC6 were evaluated with a **High** level, whereas the TC2, TC3, TC4, TC5 competencies should be at **Very High** level. Comparing the result obtained with the *baseline*, there was divergence only in TC6 (knowledge in business processes), where the level indicated was Very High and the participants consider the **High** level as sufficient.

Test Manager (Figure 2:) the competencies that must to be at **Very High** level was: TC1, TC2, TC4, TC5, TC9, TC10; and the competencies TC3, TC6, TC7, TC8 just need to be at the **High** level. The main differences refer to the increase in the level of knowledge expected for the Test Manager in the themes of software engineering practices (TC1), project management (TC4) and technical programming knowledge (TC7), which went from Medium/High to Very High. There was a decreases in TC3 (knowing the

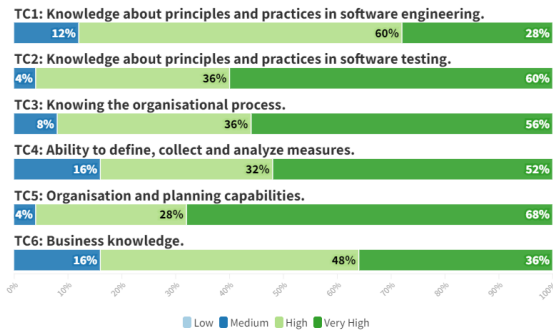


Figure 1: Technical Competencies - Test Contract Manager.

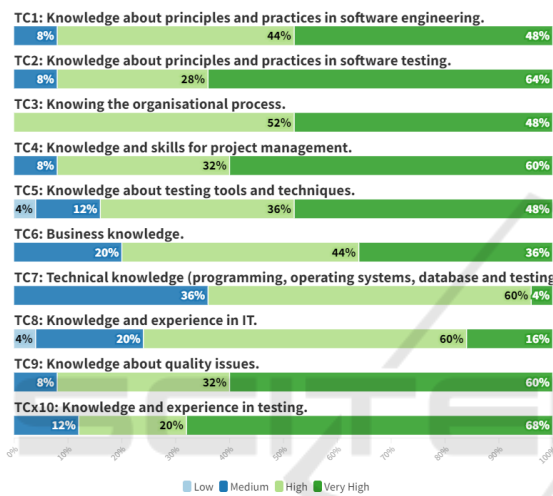


Figure 2: Technical Competencies - Test Manager.

organizational process), it went from Very High to High.

Test Engineer (Figure 3:) only the TC3 competency was considered as a **High level**, whilst all others were assigned a **Very High level** (TC1, TC2, TC4, TC5). When comparing the levels indicated by *baseline* it was noticed that there was an increase in the level of knowledge expected by Test Engineers in TC4 and TC5, which went from High to Very High. However, there was a reduction in the expected level for TC3, which went from Very High to High, referring to the mastery of revision techniques.

Software Tester (Figure 4:) all technical competencies were evaluated by the participant with a **High level** as sufficient. Through the comparative analysis of the levels indicated in baseline, it was possible to verify that there was an increase in the level of knowledge of TC4 (programming knowledge), which went from Medium to High. However, there was a reduction in the level of knowledge expected in TC6, which went from Very High to High, with regard to knowledge about test automation.

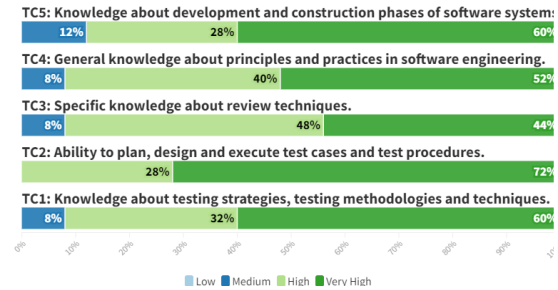


Figure 3: Technical Competencies - Test Engineer.

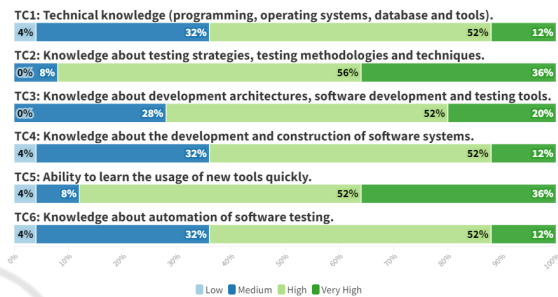


Figure 4: Technical Competencies - Tester.

In general, there were no major divergences in the baseline comparative analysis in relation to the results found, when we consider the perspective of all participants. The main divergences could be due to the fact that currently the roles of the testing process have received new responsibilities, increasing the degree of complexity of their activities, such as: (i) the Test Manager should have greater control of project management ; (ii) the Test Engineer needs to have more knowledge about software and product engineering; (iii) the Software Tester must have more knowledge about programming.

4.2 The General Competencies

The competency mapping model used offers a set of general competencies (GCs) that are applied to all test team roles. From this, the participants assessed what competency's level is needed for each role.

In **Figure 5** it is possible to observe that for the role of **Software Tester**, this same competence (GC19) is being considered at a **Very High level**, that is, creativity is a very important competence for the execution of the tests, as well as communication (GC3), teamwork (GC07), being self-taught (GC9), working in a variety of environments (GC16) and commitment to quality (GC20). Other General Competencies were considered High (GC1, GC2, GC5, GC11, GC13) or tied with Very High (GC6, GC8, GC10). Knowledge of the English language, moti-

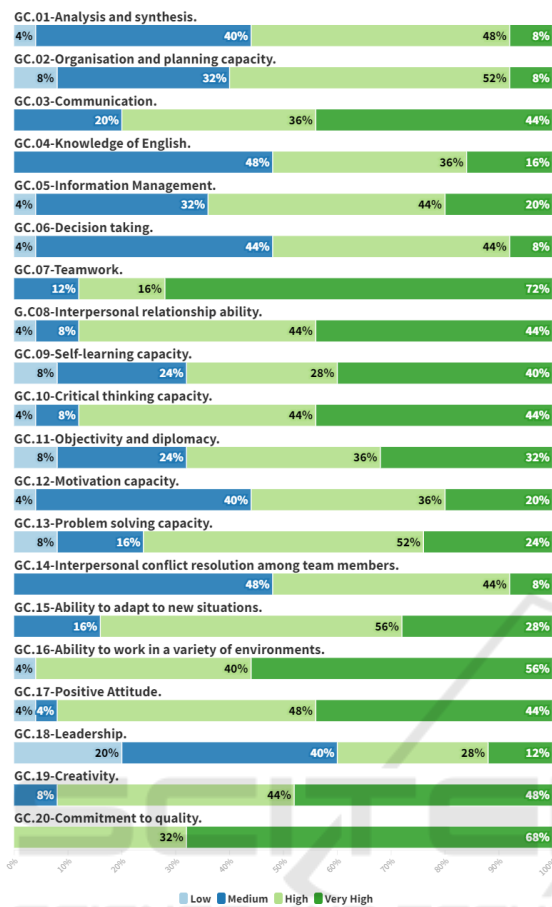


Figure 5: General Competencies - Tester.

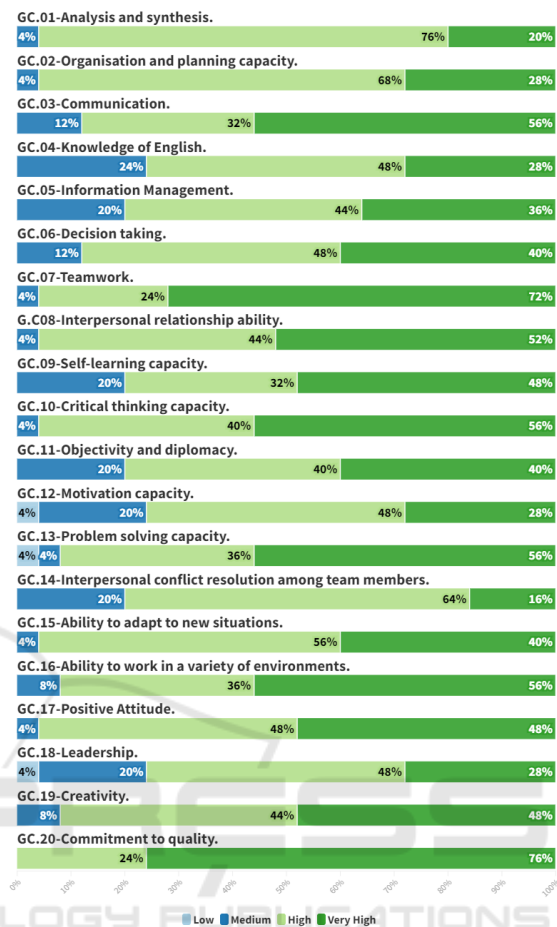


Figure 6: General Competencies - Test Engineer.

vation, conflict resolution and leadership were skills required as an Intermediate level for Testers.

According to **Figure 6**, the general Competencies for the role of the **Test Engineer** presented the following Competencies as a **Very High** level: communication (GC3), teamwork (GC7), interpersonal relationships (GC8), being self-taught (GC9), critical thinking (GC10), problem solving (GC13), creativity (GC19) and commitment to quality (GC20). A divergence was noticed when analyzing GC12, GC14 and GC18, which was considered of High level for Test Engineers and Low (GC12, GC14) and Medium (GC18) for Testers. Such Competencies, as they are *soft skills* more focused on roles with greater responsibilities within the team, justify these differences in results, however, when considering a possible promotion, they are important skills to be developed.

4.3 The Desired Competencies Levels

Based on the results presented in sections 4.1 and 4.2, an analysis was carried out based on the categoriza-

tion of respondents by roles. The responses of the Testing Contract Manager roles were analyzed separately in relation to the other roles, considering that they are responsible for hiring the testing team.

The **Technical Competencies** desired for the **Test Engineer** are: TC1 and TC2 were considered Very High level from both sides perspective. There was a divergence in TC3, where the managers considered it to be a Very High level and the other team members considered it to be a High level, on the other hand, they believed that the TC4 and TC5 skills need to be of a Very High level, whilst the managers considered them only to be of a High. In this sense, it is desired that the Test Engineer has mastery over the test process, strategies and techniques. An important finding when comparing *baseline* results with managers and team members is that knowledge about revision techniques (TC3) is considered Very High by managers and by *baseline*, while members of the team consider only High, perhaps because they don't really know what review techniques are about.

Analyzing the **General Competencies** from the perspective of managers in relation to the **Test Engineer**, it is clear that the expectation has to be a Very High level in the following skills: GC4, GC5, GC7, GC9, GC10, GC11, GC13, GC15, GC16, GC17, GC19 and GC20. Whilst the testing team considers just the following competencies on High level: GC4, GC5 and GC13. In this sense, it is worth mentioning that the managers have a very high expectation that the Test Engineer has fluency in the English language, autonomy for problem solving and teamwork, while the other members see the High level for such skills. This result can be associated with the characteristics of this organization, which operates in projects at a global level. Analyzing another divergence, it was noticed that GC3 and GC8 were considered a High level by the managers and a Very High level by the test team, which may mean that the test team recognizes the importance that the role of Test Engineer has in communicating and having a good interpersonal relationship. This is due to the fact that the Test Engineer is in constant contact with the other members of the software development process and acts as an interface between the requirements and the developers.

The managers' perspectives in relation to the testing team diverged in almost all **Technical Competencies** for the **Tester**, with the exception of TC4 (knowledge about software development and construction), where both considered the High level. This divergence can be due to the fact that managers do not know in depth the practical activities of testers, to the point of identifying the complexity of each one of them. For the testing team, all competencies of the Tester role are considered High. When answering about TC1 and TC5, the managers themselves did not reach a consensus on which level was expected, where each one answered Medium, High and Very High, respectively. The TC3 and TC6 competencies were considered Medium by the managers, which may mean that there is not much expectation in the field of programming and automation on the part of the testers.

Analyzing the divergences between **General Competencies** expected for the **Tester**, managers want these professionals to have a Very High level in the ability to adapt to new situations and a positive attitude (GC15 and GC17), and High in the knowledge of English and resolution of interpersonal conflicts (GC4 and GC14). Such skills were considered High and Medium by the team members, respectively. In general, there was a consensus that for the role of Tester, it is expected that they have a Very High level in the following competencies: GC7, GC9, GC16, GC19, and GC20. That is, the Tester is expected to

know how to work well in a team, be able to learn alone, adapt well to different environments, be creative, and have a commitment to quality.

In addition to the objective questions about general and technical skills, an **open question** was asked, and it was possible to observe that 8% of the participants answered that test automation is an essential competence also for the Test Engineer and not only for the Tester, as presented in the *baseline*.

4.4 Competencies Self-Assessment

This section will compare the levels of technical and general competencies available in the *baseline* with the results of self-assessments. This analysis only considers the self-assessment of the roles of Test Engineers and Testers, given that the mapping of competencies aims to identify gaps between the competencies desired by managers and the competencies that professionals have in practice. The results from the managers' perspective have already been presented in Section 4.3, but the gaps in the professionals' self-assessments will now be discussed.

Table 1: Technical Competencies - Test Engineer.

ID	Baseline's Framework	Manager's Expectation	Self-evaluation
TC1	VH	VH	H
TC2	VH	VH	H/VR
TC3	VH	VH	M
TC4	H	H	H
TC5	H	H	H

Table 2: Technical Competencies - Tester.

ID	Baseline's Framework	Manager's Expectation	Self-evaluation
TC1	H	M/H/VH	M
TC2	H	VH	M
TC3	H	M	M
TC4	M	H	M
TC5	H	M/H/VH	H
TC6	VH	M	M

In the **Table 1**, when comparing the *baseline* with the perspectives of the managers, there were no divergences regarding the desired levels of competencies for the Test Engineer. When analyzing the result of the self-evaluations, it is observed that the competencies TC4 and TC5 coincide both with the expectations of the managers and with what is presented in the *baseline*, all with the High level. This means that the managers have a good understanding of the role and responsibilities of the Test Engineer and that the professionals attend to what is expected of their role. This alignment is beneficial for the organization, as it will not be necessary to carry out negotiations for the development of such competencies. However, TC1, TC2, and TC3 competencies need to be developed to reach managers' expectations, moving from the High to the Very High level. The TC3 was divergent: while

Table 3: General Competencies – Test Engineer.

ID	Baseline's Framework	Manager's Expectation	Self-evaluation
GC1	H	H	H
GC2	H	H	H
GC3	H	H	H
GC4	M	VH	H
GC5	M	VH	H
GC6	M	H	H
GC7	VH	VH	H
GC8	H	H	H/VH
GC9	H	VH	H
GC10	VH	VH	VH
GC11	H	VH	H
GC12	H	H	H
GC13	H	VH	H
GC14	M	M/H/VH	H
GC15	H	VH	H/VH
GC16	H	VH	H
GC17	H	VH	H
GC18	M	H	H
GC19	VH	VH	H
GC20	VH	VH	VH

the managers considered it as a Very High level, in the self-assessment it appears with a Medium level. Therefore, there is a need for investment in training for Test Engineers to develop this competency focused on specific knowledge of review techniques, in addition to improving the technical knowledge of programming, testing techniques, and software architecture.

In the **Table 2**, regarding the comparison of the *baseline* with the perspectives of the managers, it is noticed that there were divergences regarding the desired levels of competencies for the role of Software Tester. However, when analyzing the result of the self-assessments, it is observed that the TC3 and TC6 competencies meet the managers' expectations. The expectation of the levels of TC4 and TC5 competencies were not accurate, given that there was no consensus on the part of the managers, however, the result of the self-assessment coincided with the *baseline*, whose level of TC4 is Medium and TC5 is High. The TC2 competency needs to be developed to reach the expectations of managers, moving from the Medium to the Very High level, focusing on training testing strategies, methodologies, and techniques for testers. In addition, the greatest divergence was about TC6 (knowledge about test automation), which was considered Medium by both managers and testers, but *baseline* suggests a Very High level. Therefore, there is a need for a better understanding of the activities of the Tester, to enable an alignment of expectations and better targeting of demands.

According to the data presented in the **Table 3** referring to the general skills expected for the Test Engineer, it can be seen that there was a consensus both between the data pointed out by the *baseline*, as well as those obtained in this research: GC1, GC2, GC3, GC12, GC20. There was a divergence in the level managers' expectations about what was

Table 4: General Competencies – Tester.

ID	Baseline's Framework	Manager's Expectation	Self-evaluation
GC1	M	H	M/H
GC2	H	H	H
GC3	M	H	VH
GC4	H	H	H
GC5	M	H	M
GC6	M	M/H/VH	H
GC7	H	VH	VH
GC8	M	H	VH
GC9	VH	VH	H
GC10	M	H	VH
GC11	M	H	H
GC12	M	M/H/VH	H/VH
GC13	M	H	H
GC14	L	H	H
GC15	H	VH	H
GC16	VH	VH	VH
GC17	H	VH	VH
GC18	M	M	H
GC19	VH	VH	H
GC20	H	VH	VH

suggested by the *baseline* and with the results of the self-assessments of the following competencies: GC4, GC5, and GC15. That is, managers expect Test Engineers to have a Very High level of knowledge of the English language, information management, and the ability to adapt to new situations, while *baseline* considers such skills to be Medium to High, and participants self-assessed at a High level. In this sense, it is suggested that professionals develop such skills to reach the level desired by managers.

The General Competencies for the Tester are presented in **Table 4**. It can be seen that there was a consensus both between the data indicated by the *baseline*, as well as those obtained in this research only for the competencies: GC2 and GC4. Considering the competencies GC7, GC11, GC10, GC13, GC14, GC16, GC17 and GC20, the professionals already meet the desired requirements for their role. Though the GC3 and GC18 competencies were self-rated above the desired, that is, they have communication and leadership skills above what managers expect. However, it is necessary to develop the competencies GC5, GC9, GC15, and GC19, which were considered from a High to Very High level by the managers, while the Testers self-assessed at a Medium or High level. In this sense, Testers need to improve their competencies: information management, ability to learn, ability to adapt to new situations, and creativity.

5 LIMITATIONS AND THREATS TO VALIDITY

This section presents the limitations and threats to the validity of the study conducted with software industry professionals. The main ones are: (i) applied ques-

tionnaire; (ii) sample representativeness and size; (iii) understanding of roles by the team. To minimize (i), the questionnaire used was based on the Competency Mapping Model already established in the (Saldaña-Ramos et al., 2012) literature. As for (ii), because it is a study conducted in a single software development team, limiting the variety of roles to only 3 managers and 22 members of the testing team, this study was limited to only one context. And in (iii) we asked the participants which role was closest to their main attributions, they answered according to their perceptions, which can generate a bias of interpretation or understanding of their own responsibilities. A mapping of the roles was carried out in relation to the positions, roles, and time of experience. A divergence was perceived in terms of experience level and the role answered by the participant. Therefore, the role declared by the participant was considered.

6 CONCLUSIONS

This work presented the analysis of the competencies levels of a testing team in an R&D Company from the perspective of managers and team members regarding all the roles involved in the testing process. As a result, we noticed that the professionals believe they have more competencies than those needed to carry out their activities. Some general competencies the participants already meet the manager's expectation. This research contributes to the industry by establishing the competency levels expected by contractors and comparing them with the professional's results, which facilitates interviews, career planning, and investment in training. For the academy, it's important to develop the themes that need to be improved during graduation, forming professionals who are better prepared for the job market. As future work, we highlight the need to apply the *framework* in larger teams, with a greater variety of roles, in addition to considering a better refinement when assigning a role to the participant, which corresponds to their position. In addition, it is important to carry out a study of how these skills can be developed, given that professionals need to meet the expectations of managers, in addition to complying with the demands of the projects.

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