Beyond Technical Skills in Software Testing

Automated versus Manual Testing

Mary Sánchez-Gordón
Department of Computer Sciences
Østfold University College
Halden, Norway
mary.sanchez-gordon@hiof.no

Laxmi Rijal
Department of Computer Sciences
Østfold University College
Halden, Norway
laxmi.rijal@hiof.no

Ricardo Colomo-Palacios
Department of Computer Sciences
Østfold University College
Halden, Norway
ricardo.colomo-palacios@hiof.no

ABSTRACT

Software testing is not a purely technical, but rather socio-technical activity. Although there are a few studies on this topic, to the best of our knowledge there is a lack of research focusing specifically on skills, in particular soft skills needed for automated and manual testing. In both cases, software testing is a challenging task that requires considerable effort by practitioners. The aim of this study is to identify what are the most valued skills with regards to these different types of testing. To do so, a survey was applied among software practitioners and 72 responses were received. The questionnaire covers 35 skills grouped in technical (hard) and non-technical (soft) skills. The results of this exploratory study provide empirical evidence that reveals the importance that software practitioners give to hard and soft skills alike.

CCS CONCEPTS

• Social and professional topics~Professional topics~Computing profession

KEYWORDS

Software engineering, software testers, skills, automated testing, manual testing, empirical study

1 INTRODUCTION

In recent years, it is increasingly discussed in the software engineering community that technical, also known as hard skills, and non-technical, also known as soft skills, are equally important [11] as software is developed by people for people [24]. However, since the 1970s there is literature on the cross-section of human and technical factors [6]. Apart from soft, there are other frequently used terms that slightly differ in meaning, although they have been used as synonyms in the literature. These terms range from non-cognitive abilities, 21st century skills, intangible skills, human factors, interpersonal skills, generic competencies, to social & emotional intelligence and people skills [18]. Therefore, there is no consistent understanding of the widely used term "soft skills", but it is recognized by both researchers and practitioners that technical proficiency is no longer enough [6]. In spite of that, soft skills have not received the same degree of attention as hard skills, especially by instructors of technical knowledge [6,10].

In the case of software testing, the level of professionalism has been gradually increasing since the early 1970s until "Software Tester" became a recognized profession in the software industry when special qualification schemes emerged [25]. Actually, the importance of software testing is widely recognized [10,13,25] and there is an increasing concern in how to improve the accomplishment of the software testing process [13,16]. Although, testing involves significant costs [12], lack of testing could result in even more significant costs. In fact, testing has been identified as one of the top three important areas in Software Engineering education [11]. Additionally, Florea and Stray [9] by analyzing a profile of testers as requested by the current needs of the industry, concluded that automated testing is more demanded than manual testing and there is a strong preference for software testers with a broad technical expertise. These authors also emphasize that software testers need to be highly skilled in their job and they need to master a wide range of skills. In this context, the value of soft skills lies in the fact that they are used to approach work so that a toolbox of soft skills is required [26].

Testing work can be roughly divided into automated and manual testing [12]. In both cases, software testing is a challenging task that requires considerable effort from practitioners [10]. By conducting a multivocal literature review, Garousi and Mäntylä [12] found out that software testing is still an activity that requires a large participation of individuals, that is why skills levels of testers should be carefully considered when deciding when and what to automate. These authors also pointed out that automated testing requires different (and often additional) skills compared to manual testing, however only programming skills were emphasized. There are some previous studies on software testers' skills [5,7–9,16] and an increasing interest in automated testing [11,12,27], but an important issue which has not been explored yet is the skills needed under manual and automated testing, in particular soft skills.

In this paper, we aimed to provide empirical evidence of what are the most valued soft skills in manual and automated testing from software practitioners' perspective.

2 RESEARCH APPROACH

To address the goal of this study, we adopt a qualitative research approach based on a questionnaire-based opinion survey that was

designed considering the survey guidelines in software engineering proposed by Molléri et al. [20]. The two first authors developed an initial version in the English language that is informed by published best practices as International Software Testing Qualifications Board (ISTQB) [21] and previous academic literature, e.g. [1,2,5,7,14–17,22]. Then, the third author reviewed it for face and content validity. As a result, 35 skills were categorized in seven categories as shown Table 1.

Table 1. Skills set

ScG-Cognitive Skills	1. Ability to think strategically	**SoP- Open and adaptable to change**	1. Ability to control yourself/ thinking before acting
	2. Analytical skills		2. Drive to work and succeed
	3. Creative		3. Influencing and persuading others
	4. Critical thinking		4. Understanding own strengths, weakness, and appearance among other
	5. Fast learner		5. Understanding other people's perspective from their views
	6. Good judgment	**HtC-Technical Knowledge**	1. Business domain Knowledge
	7. Problem Solving		2. Database Knowledge
	8. Trouble shooting / debugging		3. Programming language knowledge
ScM-Communication Skills	1. Active Listener		4. Software development process knowledge
	2. Good language / English and/or any other foreign language		5. Technical domain knowledge
	3. Oral Presentation Skills	**HtS-Testing Skills**	1. Ability to create and run acceptance tests
	4. Persuasive		2. Ability to create and run integration testing
	5. Written Skills		3. Ability to do automation test including scripting
SsC-Social Skills	1. Ability to build relationships		4. Ability to do nonfunctional testing
	2. Ability to work with people at all level of an organization		5. Ability to use Test Driven development (TDD)/Behavior Driven development (BDD)
	3. Leadership		6. Ability to write test plans and test cases
	4. Team Player		7. Ability to write useful testing documentation
HtL-Tools Knowledge			

In order to obtain as many responses as possible, and to not distract participants unnecessarily, survey questions were kept to minimum and personal characteristics such as positive attitude, self-motivation, and personality traits were left for further research. In the online survey, respondents rated their perceived importance of the skills in each type of testing. We identified on a five-point item from *1-Not at all important* to *5-Very Important*. The option "*0-I do not know it*" was also provided but removed during the statistical analysis. For *HtL-tools knowledge*, respondents listed the used tools in a textbox. Additionally, an open question encouraging respondents to voice other skills was included for the remaining categories. The questionnaire and data are available as an archived open data [23].

Once the initial version of the survey was developed, a pilot questionnaire was emailed to three experienced software testers from Nepal, India, and Norway. In general, the responses suggested that the questions were sufficiently concise, relevant and engaging with the exception of the open-ended question about *tools knowledge* that was reformulated in order to ensure clear and consistent understanding. The main strategy to disseminate the survey was to share the link of the survey through social networks. In fact, only few participants identified through prior personal and working relationships were invited to complete and further disseminate the survey. The survey was open for one month period (July 2019) and one reminder invitation was sent out after two weeks of the survey being open.

3 RESULTS

The data analysis was performed using Microsoft Excel and IBM SPSS statistical software.

3.1 Demographics and testing process

The sample consists of a set of 72 practitioners from 13 countries. However, the four countries that made up 80% of the participants were: Nepal (25, 35%), USA (14, 19%), India (11, 15%) and Norway (8, 11%). Although, most of the subjects were software testers (37, 51%), there were software developers (24, 33%), researchers (3, 4%) and other roles (8, 11%) such as project manager, software designer, team leader, and instructor. The most reported work experience was 1-3 years of experience (39, 54%), followed by 4-6 years of experience (22, 30%), less than 1 year (8, 11%), and 7-10 years of experience (3, 4%). With regards to demographic characteristics, the sample included 21 women (29%) and 51 men (70%). The sample is coherent with the gender imbalance reported in previous studies [4].

Figure 1 depicts that respondents frequently use a variety of levels and techniques of testing [21]. Few respondents reported "*do not know them"* or "*never use them"*. Moreover, *regression testing* was reported as the main technique used for software testing while *acceptance testing* is the most used level. The reported frequency of use regarding the type of testing is in line with a previous study that pointed out a very large fraction of the overall testing is done manually [13]. In fact, a recent survey from organizations with more than 1000 employees [3], reveals that 28% out of 1725 executives reported having manual steps within automated test processes while only 6% automate all test cases in agile and DevOps developments.

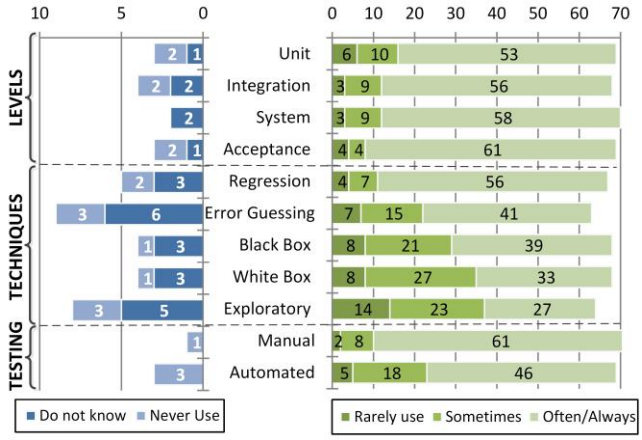

Figure 1: Frequency of use: levels, techniques and types of testing

3.2 Skills in Software Testing

Figure 2 depicts mean (μ) and standard deviation (σ) of the skills for both types of testing. For around two-third of these skills (Manual=22, 65% and Automated=23, 68%), the mean value is greater than 4 regardless the type of testing. Skills range from *moderately important* (3) to *very important* (5) and the results are right-skewed. Although most skills are rated more important for manual than for automated testing, those differences could merely reflect the higher incidence of natural −vs. automated− testing that respondents reported in this study (see Figure 1).

A first review of the results shows slight differences in skills between the both types of testing. Skills with higher mean values are *Ability to write test plans and test cases* "HtS.6" (Manual μ=4.7, Automated μ=4.6) and *Team player* "SsC.4" (Manual μ=4.6, Automated μ=4.5). These results are aligned to the demand for ability to conduct test planning and implementation [9] and the increasing need for team-playing skills [7]. Lower values are *Programming language knowledge* "HtC.3" (μ=3.4 for both testings) and *Database knowledge* "HtC.2" (Manual μ=3.5, Automated μ=3.6). Despite the fact that databases are heavily used in automated testing, demands for them were rare among the advertisers analyzed in [9] and therefore, in this context, the HTC.2 value makes sense. Furthermore, when the employers have technical demands for testers [9], they will most likely be related to programming. In fact, programming skills strongly support the ability to perform test automation tasks [19,26]. Thus, it may seem quite surprising that practitioners in this study scored *Programming language knowledge* only somewhat important for manual and automated testing. However, there is the possibility that "automated testing" for most of the respondents may only mean orchestrating very simple scripts in a tool for automated GUI tests. On the other hand, testers are asked by employers to be proficient in no more than two programming languages [9] and most of the practitioners in this study have more than 1 year of experience, so it is likely that they master the language(s). Therefore, further research is needed to better understand the reason behind these finding. By analyzing "*tools knowledge"*, one can see that practitioners master a large spectrum of testing tools in line with the demands of the software industry reported by [8].

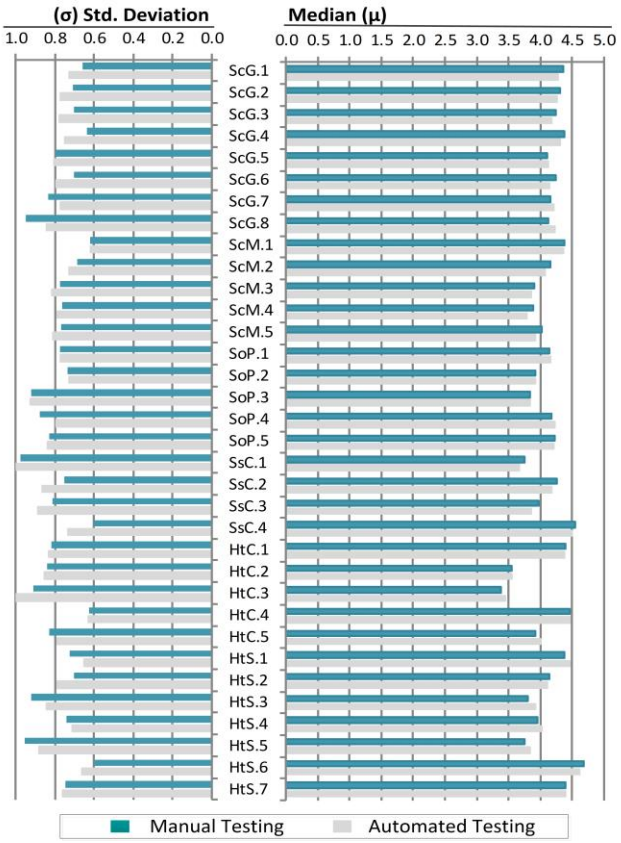

Figure 2: Descriptive statistics of perceived importance

For each of the 34 skills, we tested the null hypotheses H_0: μ_{Sx}(Manual) = μ_{Sx}(Automated) using Wilcoxon signed-rank test with Bonferroni-Holm correction. We used that non-parametric statistical test method because it does not require the data sets to follow a normal distribution. The results show that there is no significant difference in the respondents' perceived value of these skills between the testing approaches. Thus, the practitioners in this study rated skills in a similarly positive way.

4 CONCLUSIONS

By gathering 72 software practitioner opinions from mainly five different countries, our exploratory study provides an overview of skills currently valued in software testing. The main internal validity issue is the way in which we treated "*0-I do not know it*" answers while the main construct validity issue is related to the ambiguousness of some of the questions, in particular regarding the notion of automated testing.

Based on the empirical evidence, soft skills and hard skills are almost equally important from a practitioners' perspective. A participant in this study explicitly pointed out "*both of these [manual and automated testing] have its own importance and*

moreover [the] base for all automation testing and manual testing is [the] same". Software practitioners also consider software testing not only a skilled job but a highly skilled one as previously identified by [8] through an analysis of job ads for software testers. Despite that the profile of a tester sought by the employers has a tendency to be a technical profile, practitioners in our study regardless their gender emphasized soft skills in manual testing. In automated testing, although the differences are smaller only females emphasized hard skills.

A total of 35 hard and soft skills were analyzed in our study, but it is worth noting that it can be extended, given the diversity of this topic. For instance, one respondent missed a personal characteristic and pointed out "*every IT professional should have patience*". Likewise, the top few skills are a mix of both hard and soft skills but it should be noted that the distinction between them is far from canonical. It seems that a mix of these skills is important and one cannot isolate one from the other. In addition, test certification schemes such as ISTQB, consider automation as specialist area within testing, but automation is often used by practitioners in our study. Thus, new emerging trends result in changing types of soft skills requirements [8] so that a specialist area defined today may be a common requirement for knowledge and skills tomorrow [26].

Future work should be conducted to further explore our findings, in order to verify the causes. Further studies should also look which test-related skills are essential for a head start in the labor market and to what extend such skills could be developed by developers' roles in testing. Even the relative importance of each skill might vary, depending on the context and ranking skills, it might not always be very relevant. For instance, safety critical systems are usually highly regulated environments and distributed projects demand new ways of collaboration. In new environments, new skills could be needed. This leads to conclude that attention to skills should be differentiated according to practitioner' needs, i.e. where a tester is in her/his career. Therefore, not only the right balance of manual and automated testing deserves to be researched [12] but also the right balance of hard and soft skills in order to explore if the productivity of hard skills stems from their combination with soft skills.

REFERENCES

[1] Faheem Ahmed, Luiz Capretz, Salah Bouktif, and Piers Campbell. 2013. Soft Skills and Software Development: A Reflection from the Software Industry. *J. Inf. Process. Manag. IJIPM* 4, 3 (May 2013), 171–191. DOI:https://doi.org/10.4156/ijipm.vol14.issue3.17

[2] Faheem Ahmed, Luiz Fernando Capretz, and Piers Campbell. 2012. Evaluating the Demand for Soft Skills in Software Development. *IT Prof.* 14, 1 (January 2012), 44–49. DOI:https://doi.org/10.1109/MITP.2012.7

[3] Capgemini and Sogetti. World Quality Report 2019-20. Retrieved from https://www.sogeti.com/explore/reports/world-quality-report-2019/

[4] Ricardo Colomo-Palacios, Terje Samuelsen, and Cristina Casado-Lumbreras. 2019. Emotions in Software Practice: Presentation vs. Coding. In *Proceedings of SEmotion 2019*, 23–28. DOI:https://doi.org/10.1109/SEmotion.2019.00012

[5] Anca Deak. 2014. What Characterizes a Good Software Tester? – A Survey in Four Norwegian Companies. In *Proceeding of ICTSS 2014*, Springer Berlin Heidelberg, 161–172. DOI:https://doi.org/10.1007/978-3-662-44857-1_11

[6] Luiz Fernando Capretz. 2014. Bringing the Human Factor to Software Engineering. *IEEE Softw.* 31, 2 (March 2014), 104–104. DOI:https://doi.org/10.1109/MS.2014.30

[7] Raluca Florea and Viktoria Stray. 2018. Software Tester, We Want to Hire You! an Analysis of the Demand for Soft Skills. In *XP 2018*, Springer International Publishing, Cham, 54–67. DOI:https://doi.org/10.1007/978-3-319-91602-6_4

[8] Raluca Florea and Viktoria Stray. 2019. A Global View on the Hard Skills and Testing Tools in Software Testing. In *Proceedings of ICGSE 2019*, 143–151. DOI:https://doi.org/10.1109/ICGSE.2019.00035

[9] Raluca Florea and Viktoria Stray. 2019. The skills that employers look for in software testers. *Softw. Qual. J.* (August 2019), 1–31. DOI:https://doi.org/10.1007/s11219-019-09462-5

[10] Vahid Garousi, Michael Felderer, Marco Kuhrmann, and Kadir Herkiloğlu. 2017. What Industry Wants from Academia in Software Testing?: Hearing Practitioners' Opinions. In *Proceedings of EASE'17*, ACM, New York, NY, USA, 65–69. DOI:https://doi.org/10.1145/3084226.3084264

[11] Vahid Garousi, Görkem Giray, Eray Tüzün, Cagatay Catal, and Michael Felderer. 2019. Aligning software engineering education with industrial needs: A meta-analysis. *J. Syst. Softw.* 156, (October 2019), 65–83. DOI:https://doi.org/10.1016/j.jss.2019.06.044

[12] Vahid Garousi and Mika V. Mäntylä. 2016. When and what to automate in software testing? A multi-vocal literature review. *Inf. Softw. Technol.* 76, (August 2016), 92–117. DOI:https://doi.org/10.1016/j.infsof.2016.04.015

[13] Vahid Garousi and Mika V. Mäntylä. 2016. A systematic literature review of literature reviews in software testing. *Inf. Softw. Technol.* 80, (December 2016), 195–216. DOI:https://doi.org/10.1016/j.infsof.2016.09.002

[14] Philipp Holtkamp, Jussi P. P. Jokinen, and Jan M. Pawlowski. 2015. Soft competency requirements in requirements engineering, software design, implementation, and testing. *J. Syst. Softw.* 101, (March 2015), 136–146. DOI:https://doi.org/10.1016/j.jss.2014.12.010

[15] Joonas Iivonen, Mika V. Mäntylä, and Juha Itkonen. 2010. Characteristics of High Performing Testers: A Case Study. In *Proceedings of ESEM '10*, ACM, New York, NY, USA, 60:1–60:1. DOI:https://doi.org/10.1145/1852786.1852862

[16] Tanjila Kanij, Robert Merkel, and John Grundy. 2015. An Empirical Investigation of Personality Traits of Software Testers. In *Proceedings of CHASE '15*, IEEE Press, Piscataway, NJ, USA, 1–7.

[17] Ling Liang. 2018. Investigating the skills and capabilities that software testers need: A New Zealand study. Thesis. Auckland University of Technology. Retrieved from https://openrepository.aut.ac.nz/handle/10292/11566

[18] Gerardo Matturro, Florencia Raschetti, and Carina Fontán. 2019. A Systematic Mapping Study on Soft Skills in Software Engineering. *J. Univers. Comput. Sci.* 25, 1 (2019), 16–41.

[19] Deepti Mishra, Sofiya Ostrovska, and Tuna Hacaloglu. 2017. Exploring and expanding students' success in software testing. *Inf. Technol. People* 30, 4 (January 2017), 927–945. DOI:https://doi.org/10.1108/ITP-06-2016-0129

[20] Jefferson Seide Molléri, Kai Petersen, and Emilia Mendes. 2016. Survey Guidelines in Software Engineering: An Annotated Review. In *Proceedings of the 10th ESEM '16*, ACM, New York, NY, 58:1–58:6. DOI:https://doi.org/10.1145/2961111.2962619

[21] Klaus Olsen, Meile Posthuma, and Stephanie Ulrich. *Foundation Level Syllabus*. ISTQB. Retrieved from https://www.istqb.org/downloads/category/2-foundation-level-documents.html

[22] Leah Muthoni Riungu, Ossi Taipale, and Kari Smolander. 2010. Software Testing as an Online Service: Observations from Practice. In *2010 Third International Conference on Software Testing, Verification, and Validation Workshops*, 418–423. DOI:https://doi.org/10.1109/ICSTW.2010.62

[23] Mary Sánchez-Gordón, Laxmi Rijal, and Ricardo Colomo-Palacios. 2020. Online appendix: Skills in Software Testing. *Figshare*. Retrieved from https://doi.org/10.6084/m9.figshare.11637729.v3

[24] Mary-Luz Sánchez-Gordón. 2017. Getting the Best out of People in Small Software Companies: ISO/IEC 29110 and ISO 10018 Standards. *Int. J. Inf. Technol. Syst. Approach* 10, 1 (January 2017), 45–60. DOI:https://doi.org/10.4018/IJITSA.2017010103

[25] Mary-Luz Sánchez-Gordón and Ricardo Colomo-Palacios. 2018. From Certifications to International Standards in Software Testing: Mapping from ISQTB to ISO/IEC/IEEE 29119-2. In *Proceedings of EuroSPI 2018*, Springer International Publishing, Cham, 43–55. DOI:https://doi.org/10.1007/978-3-319-97925-0_4

[26] Erik van Veenendaal. 2020. Next-Generation Software Testers: Broaden or Specialize! In *The Future of Software Quality Assurance*, Stephan Goericke (ed.). Springer International Publishing, Cham, 229–243. DOI:https://doi.org/10.1007/978-3-030-29509-7_18

[27] Kristian Wiklund, Sigrid Eldh, Daniel Sundmark, and Kristina Lundqvist. 2017. Impediments for software test automation: A systematic literature review. *Softw. Test. Verification Reliab.* 27, 8 (2017), e1639. DOI:https://doi.org/10.1002/stvr.1639