A study on assets applied in exploratory test design and execution: an interview application

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***Abstract*— This Research to Practice Full Paper presents that the Exploratory Test (ET) is evidenced in the specialized literature as an alternative used in the industry to meet the needs of agile and / or short-term test processes. However, there is still an understanding by professionals in the field that this agile test approach is informal, not considering the realization, mainly, of a strategy that can encompass ET project activities and execution in a systematic way. It is noted that the industry has been spreading the ET due to proposing an efficacy for quick feedback of the test process and not requiring great effort in documentation. However, the applicability of ET still faces challenges related to the definition of an adequate and effective strategy, mainly, to the design and execution of this approach. In view of this, this study aims to identify tools, techniques and / or methods, and work products relevant to ET design and execution activities used by professionals in the field in the industrial context adhering to the practices and goals prescribed in the TMMi (Test Maturity Model Integration). For this, a Survey was applied, by means of the interview technique with implementing professionals and / or evaluators of MPT.Br (Brazilian Testing Process Improvement), certified by TMMi and professionals without accreditation, as long as they are active in the Software Testing area, mainly with process improvement. The results were organized into three groups: 1) identification of the participants, 2) identification of tools, techniques and / or methods, and work products in the context of the ET design, and 3) identification of tools, techniques and / or methods, and work products in the context of ET execution. Thus, in group "1" all participants had more than 5 years of experience in Software Testing and with the ET approach, having their first contact with ET in the work environment or study on their own. In group "2" the Testlink and Jira tools are most used to support project activities, with risk analysis being the most cited technique for activities to identify and prioritize conditions and data for the test, also serving as a complement to the application of ET. As for work products, the most cited were the use of the test plan and results of previous test runs in which the ET was applied. In group "3", the Mantis and Jira tools were most cited to support the management and execution of the tests. Regarding the execution techniques, the use of ET with manual and automated strategy is noted, and in relation to the work products, the incidents report and matrix were the most cited. It is noted that a tool serves many activities related to the design and execution of ET, with risk analysis being a widely used technique and incident reports being important in the analysis to make decisions regarding the testing process. Finally, it is mentioned that this work together with another study previously carried out on the identification of assets in the international and Brazilian curricula for the use of teaching-learning test design and execution will serve to support the elaboration of a ET teaching plan.**

Keywords—interview, exploratory testing, test design and execution, software testing.

I. INTRODUCTION

With the need for fast delivery of products and services, it caused a growth in a more agile software development process. Consequently, new testing approaches considered agile in the specialized literature have become a protagonist in the industry so that products and services are offered with quality as their development occurs [1]. In this context, the use of Exploratory Testing (ET) has been widespread in the industry [2], however it is still understood by many professionals in the field (software engineers) as an informal approach, without any structured and organized procedures, thus not supporting management activities of the testing process [3].

It is noted that the applicability of ET still faces great challenges, which may be one of the original reasons for the misunderstanding of the concept itself, much less of management techniques of exploratory testing that proposes systematic procedures to assist the tracking of incidents, control, metrics, management of the testing process. Against this, it was observed by the author previously in a literature search that few activities are carried out in the test design phase, with the majority of the application of only execution activities correlating them to the software development cycle.

In view of this, there was a great potential for research on exploratory test education that encompasses theoretical and practical activities that are closer to reality, to train people with sufficient basic capacity to engage in the industry. Thus, this study aims to identify in the industry which tools, techniques and work products aligned to the Test Maturity Model integration (TMMi) to support the elaboration of an adequate and effective teaching-learning plan related to the Exploratory Test Design and Execution.

In addition to this introductory section, the paper is structured with the theoretical foundation in Section 2, in Section 3 the related Works are presented, in Section 4 the research methodology is defined, in Section 5 the planning and execution of the survey is presented, in Section 6 the results and discussion are presented and, finally, the Section 7 presents conclusion and future work.

II. BACKGROUND

In this section, the concepts of software testing are presented considering the types, techniques and levels to understand where the exploratory test approach is inserted. In addition, a description of the Test Design and Execution process area prescribed in the TMMi is presented.

A. *Software Testing*

Software testing is a process inherent in the software life cycle, whose main activity is to detect and correct defects in order to comply with specifications and thus guarantee the software quality [4, 5, 3]. However, the Verification and Validation (V&V) activities are not considered as simple, as it is impossible to guarantee that every system is free from defects, and the application of exhaustive tests is not feasible, even for the reason that it requires a lot of financial investment and time for this [6]. In these circumstances, several incident detection strategies and techniques have emerged in the literature in order to systematize the testing process, that is, this initiative aimed to minimize efforts and maximize the detection of incidents in a process involving Planning, Monitoring and Control, Analysis and Design, Execution and Closing activities [7].

In this context, ISO 29119 has presented some of these approaches generally have criteria that make them more suitable to be used in certain phases of the software development process, as shown in Figure 1 [8]. Basically, a test sub-process involves seemingly sequential testing activities and tasks, but which are often applied iteratively. Such activities are summarized in test planning, test monitoring and control, test analysis, test modeling, test implementation, test execution and test completion. In general, a test sub-process should be planned for each test level where appropriate types of tests can be used at the level in question. It is noteworthy that this entire sub-process must always accompany or adhere to the software development cycle. It is noteworthy that each test level is an instance of the test process, consisting of the aforementioned activities [8].

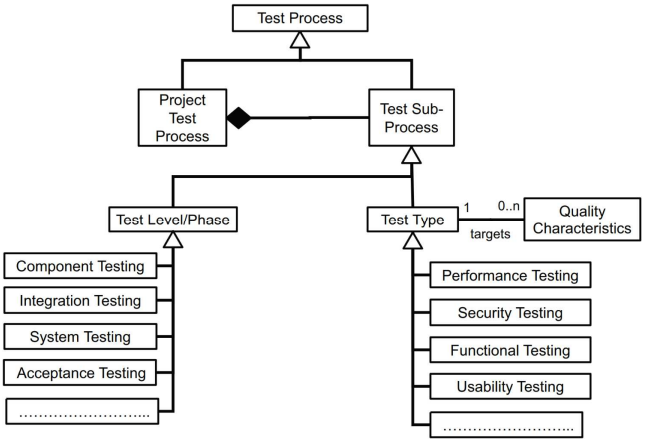

Fig. 1. The relationship between the generic test sub-process, test levels and test types [8].

In addition to what is represented in Figure 1, it stands out that there is the denomination of black box test being functional tests (directed to specifications) and white box test to the techniques directed to the structure. In addition, testing techniques are classified as static and dynamic, which represent testing on items examined without executable code and with executable code, respectively. In this context, some approaches are based on specific criteria, for example, errors (error guessing, mutation testing), the professional's intuition and experience (ad hoc, exploratory testing) [9].

B. *Exploratory Testing*

This kind of testing is an experience-based testing approach in which the tester spontaneously and freely designs and performs tests based on his acquired knowledge, prior exploration of the test item (including the results of previous tests) and heuristic "rules of thumb" about common behaviors of software and failure types [8, 10].

Exploratory testing is defined as learning, test design and execution simultaneously, that is, tests are not defined in advance in a test plan, but are dynamically designed, executed and modified. The effectiveness of the exploratory test depends on the knowledge of the tester, which can be obtained from many resources, such as, product behavior observed during the test, familiarity with the application or application domain, the platform, the failure process, the types of incidents already detected and the risk associated with a particular product, etc. [9].

According to [11], the exploratory test is an approach that also emphasizes the tester's autonomy, skill and creativity, which allows detecting incidents in which pre-defined test cases do not reach, being able to contribute to adjustments and elaboration of new test cases. In this way, unlike other techniques, exploratory testing consists of executing the test activities simultaneously, thus providing greater interactivity with the system.

In [12] the exploratory test is an agile test approach that can be applied in a way directed to what is proposed in the Quadrant of the Agile Test [13], where the tests are subdivided, increasing the participation and later quality of the professional who performs them, according to Figure 2.

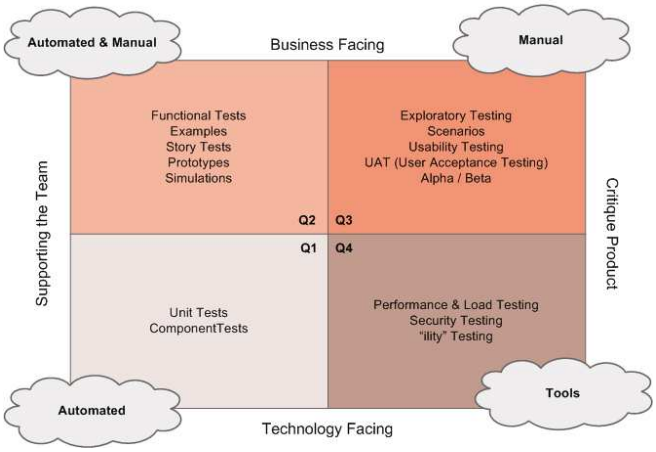

Fig. 2. Agile Testing Quadrants [12, 13].

It is emphasized that in 2015, James Bach launches a reformulation of the concept of exploratory testing, defining that such a test approach consists of evaluating a product by learning about it through exploration and experimentation, including to some degree: questioning, study, modeling, observation, inference, etc. [14].

According to [15], the flexibility of exploratory testing is a very significant factor in the testing process, as it is possible to be applied at any stage of the software life cycle, whether at the beginning of development or in regression testing. In this context, the authors in [16] state that due to some deficiencies that affect the management of processes there was the emergence of management techniques, such as Session-Based Test Management (SBTM), Thread-Based Test Management (TBTM), Risk- Based Test Management (RBTM). These management techniques propose more structured procedures to provide a systematic application of exploratory testing taking into account factors relevant to the effectiveness of the testing process.

C. *Test Design and Execution Prescribed at TMMi*

TMMi prescribes a process area focused on Test Design and Execution, which aims to improve the capacity of the test process during the activities of architecture development (design), tests execution and analysis from the establishment of technical specifications of architecture. Each process area is basically different in that it has in particular specific goals and practices, sub-practices and examples of work products [17].

In this context, TMMi proposes that activities (practices and their corresponding subpractices) be performed in a structured testing process, involving everything from the identification of test conditions to the management of incidents to closure. For that, test design techniques are mentioned to derive test conditions and procedures, for example, the elaboration of test charts in the application of exploratory testing [17].

All of these practices and sub-practices are described in order to meet the specific goal using well-structured procedures to achieve the effectiveness and efficiency of the testing process. In this case, it mentions the possibility of using tools to assist, both in practices aimed at test design (identification of conditions, test procedures and test data, as well as bidirectional traceability and elaboration of a test execution agenda) and in execution-oriented practices, considering process and incident management (incident reporting, reporting of incidents to stakeholders, evaluation of incidents for closure, regression testing and incident management) [17].

III. Related Works

In [3], a survey was applied to software engineers from the Estonia and Finland, aiming to study how software engineers understand and apply the principles of exploratory testing, as well as the advantages and difficulties they experience. The main findings are that most testers, developers and test managers using ET, (i) apply ET for critical usability, critical performance, critical security of software to a high degree, (ii) use ET in a very flexible way in all types of test levels, activities and phases, (iii) perceive ET as an approach that supports creativity during the test and that is effective and efficient and (iv) found that ET is not easy to use and has few support tools. It is noted that the authors do not present which procedures are applied in each phase or which tools are possible to be used as support.

In [18], a survey of the literature and interviews was conducted to investigate the strengths and weaknesses of ET and tests with a pre-defined script. The authors identified that the ET is not focused on documentation, it provides quick feedback and quick familiarization with the product. In addition, the evidence demonstrates that the flexibility of the ET process and its high degree of freedom makes testers more engaged, creative and responsible during testing. Regarding weaknesses, the unstructured and ad-hoc nature of the ET process causes difficulties, mainly in the management of the test process, in the prioritization and selection of the appropriate tests, as well as affecting the repetition of the tests. In addition, weaknesses are considered to depend on the skills, experience and knowledge of the domain of the testers, when the test object is quite complex. The authors present several interesting factors, in particular the execution of the exploratory test, but it is not investigated whether there is use of support tools or if someone uses (or at least intends to use) any structured testing process.

Therefore, it is highlighted that the studies found several factors relevant to prior knowledge for the exploratory test approach, however it is clear that the studies present quite comprehensive data, different from this study that directs its investigation in the identification of techniques or methods, tools and work products used in the Design and Execution stages based on the practices prescribed in the TMMi. Thus, this paper present which resources and procedures (practices or activities) applied are adherent to the international practical guide prepared by professionals with extensive experience in the test area.

IV. Research Methodology

The methodological approach applied to achieve the objective occurred as follows:

i) Definition of the study theme, occurred through a literature review, identifying a great potential for study on education regarding the subject of Test Design and Execution. For this, it was noticed the great revelation in identifying the tools, techniques and work products used in the industry to support a teaching plan directed to the corresponding subject,

ii) Definition of the target audience, established that the participants should be professionals in the software testing area accredited by national (Brazilian) and international institutions or professionals who obtained professional TMMi certification with experience in improving the testing process in order to obtain answers relevant to the elaboration of a teaching plan for Exploratory Test Design and Execution involving practical subjects closer to reality,

iii) Definition of the questions based on the Test Design and Execution process area prescribed in the TMMi, followed a strong adherence to the practices established in the TMMi as it is of an international level and based on the experiences of several professionals. Thus, it was possible to establish issues in line with industry practices,

iv) Application of the peer review to validate the questions for interview, where the questions were analyzed to certify that there was a coherent relationship with the Test Design and Execution practices prescribed in the TMMi, as well as evaluation of the target audience and guidelines established for the execution of the test interview,

v) Application of the interviews, the interviews were conducted remotely with each professional interviewed,

vi) Analysis of the data, the interpretation of the collected data occurred in order to present it in the form of charts to facilitate the visualization of the data.

V. Survey Planning And Execution

First, details about the survey planning that were important to the execution of the survey are presented.

A. Survey Planning

According to [19], the survey is a procedure for collecting primary data from individuals. The data can be assigned to obtain data or information about characteristics, or opinions of a certain group of people, intended for a target population. It is important to highlight that in this type of research the respondent is not identifiable, which is one of the main characteristics of opinion polls about a certain attribute.

In this study, initially, the research problem was defined, about what we want to investigate. Therefore, this phase is of great importance to establish how the study will meet its objectives. The definition of the problem contributes to the elaboration or construction of the data collection instrument, that is, the questionnaire, which consists of a set of questions on a certain topic, which will be later presented to the research participants, called respondents [20].

Thus, the questions elaborated (as can be seen in Table I) for this research was a questionnaire with subjective questions, organized in 3 (three) groups: Identification of contributors, Context of exploratory test design and Context of exploratory test execution. It is emphasized that such issues are in line with the specific practices in the area of Test Design and Execution prescribed in the TMMi.

i) Group I (G I) composed of 4 questions to characterize the participants,

ii) Group II (G II) composed of 8 questions to identify tools, techniques and work products in an exploratory test design,

iii) Group III (G III) composed of 7 questions to identify tools, techniques and work products in an exploratory test execution.

It is emphasized that the questions directed to the context of Design and Execution were organized according to the specific practices structured for each specific goal present in the TMMi. Such specific goals (SG) are: SG1 - Perform Test Analysis and Design using Test Design Techniques, SG2 - Perform Test Implementation, SG3 - Perform Test Execution, SG4 - Manage Test Incidents to Closure. As for specific practices (SP), they are: SP1.1 - Identify and prioritize test conditions, SP1.2 - Identify and prioritize test cases, SP1.3 - Identify necessary specific test data, SP1.4 - Maintain horizontal traceability with requirements, SP2.1 - Develop and prioritize test procedures, SP2.2 - Create specific test data, SP2.3 - Specify intake test procedure, SP2.4 - Develop test execution schedule, SP3.1 - Perform intake test, SP3.2 - Run test cases, SP3.3 - Report test incidents, SP3.4 - Write test log, SP4.1 - Decide disposition of test incidents in configuration control board, SP4.2 - Perform appropriate action to fix the test incident and SP4.3 - Track the status of test incidents.

TABLE I. Questions included in the Questionnaire

G I	Questions About Caracterization of Participant	TMMi
Q1	What role do you perform?	-
Q2	How long have you been active in the area of software testing?	-
Q3	When was your first contact with the exploratory testing approach?	-
Q4	How long time do you have experience with the exploratory testing approach?	-
G II	**Questions about Specific Goal 1 and Specific Goal 2**	
Q1	What software tools, techniques, and work products are used to identify and prioritize test conditions?	SP1.1
Q2	What software tools, techniques, and work products are used to identify and prioritize test cases?	SP1.2
Q3	What software tools, techniques, and work products are used to identify necessary specific test data?	SP1.3
Q4	What software tools, techniques, and work products are used to maintain horizontal traceability with requirements?	SP1.4
Q5	What software tools, techniques, and work products are used to develop and prioritize testing procedures?	SP2.1
Q6	What software tools, techniques, and work products are used to create specific test data?	SP2.2
Q7	What software tools, techniques, and work products are used to specify intake test procedures?	SP2.3
Q8	What software tools, techniques, and work products are used to develop the test execution schedule?	SP2.4
G III	**Questions about Specific Goal 3 and Specific Goal 4**	
Q1	what software tools, techniques, and work products are used to perform intake test?	SP3.1
Q2	what software tools, techniques, and work products are used to execute test cases?	SP3.2
Q3	what software tools, techniques, and work products are used to report test incidents?	SP3.3
Q4	what software tools, techniques, and work products are used to write test log?	SP3.4
Q5	what software tools, techniques, and work products are used to decide the disposition of test incidents?	SP4.1
Q6	what software tools, techniques, and work products are used to perform appropriate actions to fix the test incident?	SP4.2
Q7	what software tools, techniques, and work products are used to track the status of test incidents?	SP4.3

Subsequently, there was a need to define how the data collection instrument would be applied. The forms of application of the instrument, as [19] fall into two broad categories: i) administration of the questionnaire for the respondent to answer (self-administered) and ii) interview. The self-administered questionnaire includes postal and electronic surveys. The interview, on the other hand, involves direct contact with the respondent, who is interviewed in person with the person present, by telephone or in dialogue by computer.

The present study used / selected the interview to apply the collection instrument, containing subjective questions in its structure, aiming to collect qualitative data through structured interviews and applied remotely. Where the interviewee's research objectives were previously informed and the interview opportunity was verified, that is, the interviewee's availability to provide the interview, which was scheduled in advance.

In order to ensure that these participants provide reliable information for the research, some inclusion and exclusion criteria were defined according to Table II. In addition, it is emphasized that for such reliability in the first scheduling contact for the interview, it was previously mentioned that the personal information provided by the participants would

be kept confidential, safeguarding the privacy of the participants.

TABLE II. INCLUSION AND EXCLUSION CRITERIA

Inclusion Criteria	Considerations
Consultant and / or Appraiser of MPT.Br and / or TMMi	Participants who exercise the role of consultant and / or appraiser accredited by MPT.Br and / or TMMi.
Professionals with TMMi professional certification and working in the software testing area, mainly with experience in improving the test process.	Participants in the software testing area with experience in improving the testing process and having professional TMMi certification.
Exclusion Criteria	**Considerations**
Participants who are not motivated to participate in the survey.	Unmotivated participants, the possibility of obtaining untrue responses is increased.

In view of the above, the survey was directed to consultants and / or appraisers of MPT.Br, certified by TMMi, as well as to professionals without accreditation, as long as they are active in the area of Software Testing, mainly with process improvement, with the in order to ensure responses that are closer to the reality experienced daily in the industry.

B. *Survey Execution*

The interviews were first scheduled by means of e-mails, where each participant was informed about the reason for the research, the anonymity of the respondents, with the delivery of the Consent and Confidentiality Term, as well as the dates and the times to perform. After scheduling, the interview process began, remotely, with the participants, this process took place over a period of 2 months due to the availability schedule of the interviewees.

At the beginning of each interview, the participant was thanked, given the important role attributed to them for carrying out the work, due to their contribution in answering the questions of this research. Then the self-presentation was carried out, in order to present the interviewee with knowledge about the Researcher and also inform about the purpose of the work. Subsequently, permission was requested to record the interview, which is important for further documentation and analysis and the estimated duration of the interview (45 to 60 minutes) was also informed.

After the interviews were finished, the data collection stage ended, which enabled the analysis of the results obtained, involving a total of 7 interviewees. Regarding the results, it is possible to observe them in the sections according to the established group.

VI. RESULTS AND DISCUSSION

The data are presented according to the groups established as the organization of the questions.

A. *Identification of Participants*

Regarding the role played by the participants (as can be seen in Figure 3), it should be noted that the answers were obtained from the perspective of the people who implement MPT.Br and / or TMMi, when considering professionals who perform a dual function in addition to those who only implement it. In addition, it is noteworthy that professionals holding professional certification from TMMi reported exercising the position of Quality Assurance Manager (QA). Thus, it was possible to collect data in line with reality, with regard to the use of strategies for approaching exploratory testing in the industry.

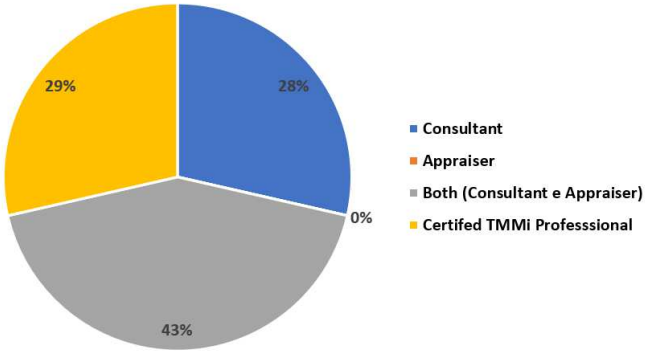

Fig. 3. Role played by the participants

It is noteworthy that all participants reported having more than 5 years of experience, both in the area of Software Testing, as a whole, and using the exploratory test approach. In this way, it is classified as a very experienced professional, due to the fact of observing the roles played, which are only obtained with extensive experience in the industry, in this case, being a quality assurance manager and appraisers (Figure 3).

As for the first contact with the exploratory test approach (as can be seen in Figure 4), it is observed that there was no contact in the undergraduate course or even in complementary courses, and when they needed to know, the interviewees preferred to conduct a study on their own. In addition, it is noteworthy that professionals first encountered the approach of exploratory testing in the work environment in projects to implement a quality area in question.

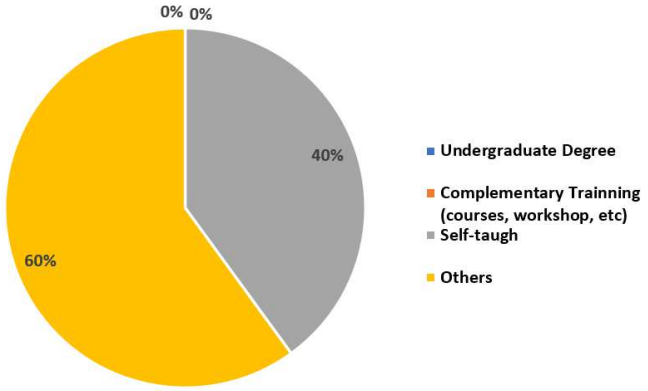

Fig. 4. First contact with the Exploratory Test approach.

B. *Identification of Tools, Techniques and Work Products in Exploratory Test Design*

TestLink and Jira were the most cited tools to assist in activities related to test analysis and design, mainly to assist in the identification and prioritization of test conditions (Q1) and test cases (Q2). In addition, it is pointed out that some interviewees do not yet use a tool for traceability, even though they use TestLink, and in some cases, they do not use the bidirectional tracking feature provided by the referred tool (Q4). On the other hand, there was an interviewee who mentioned having already used the RequisitePro, DOORS and CALIBER-RM tools in the same project (Q4).

It can be seen that also in Table III all respondents have already used Testlink and Jira at the same time. This fact can be understood by the fact that Jira needs to be paid and therefore uses some features of TestLink, since it is free software.

TABLE III. AMOUNT OF TOOL QUOTE RELATED TO PERFORM TEST ANALYSIS AND DESIGN USING DESIGN TECHNIQUES

Perform Test Analysis and Design Using Design Techniques				
Software Tools	Q1	Q2	Q3	Q4
TestLink	7	7		4
Jira	7	7	4	
RequisitePro				1
DOORS				1
CALIBER-RM				1
Not Aplicable	0	0	3	2

It should be noted that the Jira has been widely used to support the activities directed to the test implementation (Table IV), being the most common Testlink in the identification and prioritization of test procedures (Q5) and generation of a testing schedule (Q8). It is also noted that in some cases we still used spreadsheets to orzanize and manipulate the data to be used in the test (Q6). Another relevant fact was that they cited the use of several queries to extract data into data repositories in order to obtain data directed to the tests to be applied (Q6).

TABLE IV. AMOUNT OF TOOL QUOTE RELATED TO PERFORM TEST IMPLEMENTATION

Perform Test Implementation				
Software Tools	Q5	Q6	Q7	Q8
TestLink	5			5
Jira	7	6	5	7
Queries		1		
Spreadsheet	2	2		
Not Aplicable	0	0	2	0

In relation to the techniques used in the test analysis and design activities (Table V), the use of exploratory test is remarkable and other black box test approaches as a way to identify new possible test cases (Q2) and data required test (Q3). It is also highlighted that the majority does not apply any technique aimed at the identification of test conditions (Q1). In addition, it becomes clear that they do not constitute different tracking techniques between requirements and other work products (Q4), sometimes not even using to what a tool offers, as observed in Table III.

TABLE V. AMOUNT OF TECHNIQUES QUOTE RELATED TO PERFORM TEST ANALYSIS AND DESIGN USING DESIGN TECHNIQUES

Perform Test Analysis and Design Using Design Techniques				
Techniques	Q1	Q2	Q3	Q4
Estrategy of Martin Pol	1			
Exploratory Testing		4	4	
Black Box		2	2	
Based on Business Risk		1		
Traceability by cross-reference				5
Not Aplicable	6	0	1	2

In Table VI, it should be noted that they do not apply any technique to create specific test data (Q6) and establish procedures for intake test (Q7). Most mentioned that they use the exploratory test and other black box techniques to support the elaboration of test procedures (Q5), as well as to understand well the domain of the test system to have a notion of time to determine an execution schedule of new tests (Q8).

TABLE VI. AMOUNT OF TECHNIQUES QUOTE RELATED TO PERFORM TEST IMPLEMENTATION

Perform Test Implementation				
Techniques	Q5	Q6	Q7	Q8
Exploratory Testing	4			3
Black Box	2			2
Based on Business Risk	1			
Not Aplicable	0	7	7	2

It stands out in the Table VII the case of the interviewees to always cite the use of the test plan and results of other tests already executed to identify new test conditions (Q1) and test specific data (Q3). In addition, the case of no understanding mentioned use of other work products to identify test cases related to the exploratory test. This reinforces the understanding that it becomes common the industry still does not use some resources (diagrams, architecture, prototype, etc.) as support for exposure test application, and the use of a more free or informal approach (Q2) is remarkable.

TABLE VII. AMOUNT OF WORK PRODUCTS QUOTE RELATED TO PERFORM TEST ANALYSIS AND DESIGN USING DESIGN TECHNIQUES

Perform Test Analysis and Design Using Design Techniques				
Work Products	Q1	Q2	Q3	Q4
Test Plan	7		5	
Test Cases - CTs	3		4	
CTs Outcomes	5		7	
Not Aplicable	0	7	0	7

It is also noted in Table VIII the constant use of the test plan, test cases already performed and other test scenarios as a basis for assisting in the preparation of test procedures (Q5). In addition, it is cited that the use of test cases and data recipository has been critical to specify test data, being the test plan commonly used to support the elaboration of the test schedule. It is also highlighted that it practically does not apply previous tests (intake test) to observe the main functionalities, with an approach being applied involving a comprehensive test coverage (Q8).

TABLE VIII. AMOUNT OF WORK PRODUCTS QUOTE RELATED TO PERFORM TEST IMPLEMENTATION

Perform Test Implementation				
Work Products	Q5	Q6	Q7	Q8
Test Cases - CTs	5	3	2	3
CTs Outcomes	6	5	2	
Test Scenario	6			
Data Repository to Run Tests		5		
Test Plan				5
Testing Proceedures				2
Not Aplicable	0	0	5	0

In general, it is mentioned that the interviewees provided extra information that considered relevant on the activities performed on the design and execution of exploratory

testing. In this context, it is worth mentioning that the interviewees reported not using such specific techniques or activities in the test process to meet the exploratory test, as they usually have a test process encompasses many approaches. The fact that it is possible to perceive in front of these data presented in the tables of this subsection, being noticeable that they do not carry out a broad planning directed only to the exploratory test, but an aminary chart with other approaches widely.

Another factor indentified in these extra comments, was that in the testing process generally use the exploratory test approach as a way to better understand the domain of the system, observe what types of data can be accepted in certain functionalities focus on the tests, without establishing project procedures or even proerate material resources (work products to run). In this way, it is observed that the industry still uses quite the free form of the exploratory test not following systematic procedures to this approach or even a practical guide, such as an example, the TMMI.

C. *Identification of Tools, Techniques and Work Products in Exploratory Test Execution*

In relation to the activities inherent the implementation of the tests (Table IX), it is highlighted that Jira and Mantis became evident, mainly to support the log writing and incident report. In addition, it is quoted that two interviewees do not first apply the intake test, that is, there are no prior verification procedures for key features and consequently perform all the necessary or planned tests in the software as a whole in the available functionality.

TABLE IX. AMOUNT OF TOOLS QUOTE RELATED TO PERFORM TEST EXECUTION

Perform Test Execution				
Software Tools	**Q1**	**Q2**	**Q3**	**Q4**
TestLink				2
Jira	5	7	4	4
Mantis			3	3
Not Aplicable	2	0	0	0

The Jira and Mantis tools are also quoted to meet the activities aimed at the direction of incidents to the closing (Table X). It is noted that they do not always use the same tool to similar activities, this can be caused by the process used and other factors related to the limitations of available functionalities. In the latter case, it is exemplified that a tool can offer a resource more easily manupulation certain procedures and data being strongly aligned with the test process in question.

TABLE X. AMOUNT OF TOOLS QUOTE RELATED TO MANAGE TEST INCIDENTS TO CLOSURE

Manage Test Incidents to Closure			
Software Tools	**Q5**	**Q6**	**Q7**
Jira	7	7	7
Mantis	7	7	7
Not Aplicable	0	0	0

In relation to the use of testing techniques (Table XI), the exploratory test approach (Q1 and Q2) and other interviewees mentioned using Kanban to assist in the application of the tests or even not use some specific technique to apply the exploratory test (Q1 and Q2). In this way, it is understood that the application of the exploratory test has been without a protrusion of procedures (ad hoc). It is also worth noting that the incidents reporting were expressed in general as a manual or automated, this is related in the very writing form of the test logs, as sometimes some logs are collected or written automatically from the execution inspection and reported manually.

TABLE XI. AMOUNT OF TECHNIQUES QUOTE RELATED TO PERFORM TEST EXECUTION

Perform Test Execution				
Techniques	**Q1**	**Q2**	**Q3**	**Q4**
Exploratory Testing	5	5		
KANBAN		3		
Manual Approach			5	
Automated Approach			3	
Incident Tracking Meetings			1	
Monitoring the Execution of TCs				5
Incident Report				2
Not Aplicable	2	2	0	0

As for the use of techniques related to incident closing management (Table XII), it is noted that the incident arrangement (Q5) and dissemination or screening of the status are discussed in meetings (Q7). In this context, we highlight the action of requesting new data to developers or other stakeholders to support decision-making on incident correction actions. In addition, the use of prioritization always makes something common to take appropriate incident correction actions (Q6).

TABLE XII. AMOUNT OF TECHNIQUES QUOTE RELATED TO MANAGE TEST INCIDENTS TO CLOSURE

Manage Test Incidents to Closure			
Techniques	**Q5**	**Q6**	**Q7**
Incident Tracking Meetings	5	3	5
Taxonomy of Incidents	1		1
Request more info about the incident	3	3	3
Priorization of Incidents	2	7	4
Not Aplicable	0	0	0

Regarding the use of work products to assist testing activities (XIII), it cites that less than half uses some support resource for intake test (Q1). It becomes more evident the use of test cases already performed to support the exploratory test application (Q2), also being evidenced the use of automation procedures (scripts) as a basis for exploring the test system, which may be an industry convergence effect in the search for increasingly automated tests. In addition, the use of incident report already drawn up as a basis for elaborating new incident reports (Q3), it is noticed that this fact also occurs with the test logs and other test accompanying reports (Q4). These cases can be understood as a form of attempting to standardize incident reports to prevent a prejudice of communication already established as successful among stakeholders.

In Table XIV, it is noted that the incidents prioritized in conjunction with the established date for incident correction are fundamental to define the disposal of appropriate incidents and actions for correction of these incidents (Q5 and Q6), being the incident matrix a work product

commonly used to also support the discussion of incident status (Q7).

TABLE XIII. AMOUNT OF WORK PRODUCTS QUOTE RELATED TO PERFORM TEST EXECUTION

Perform Test Execution				
Work Products	**Q1**	**Q2**	**Q3**	**Q4**
Test Cases - CTs	1			
Exploratory Testing Outcomes	3			
Procedures Applied on Automated CTs		3		
CTs Outcomes		5		
Incidents Report			7	
Test Log				5
Test Run Tracking Report				3
Not Aplicable	4	0	0	0

TABELA XIV. QUANTIDADE DE CITAÇÕES DOS PRODUTOS DE TRABALHO RELACIONADOS A MANAGE TEST INCIDENTS TO CLOSURE

Manage Test Incidents to Closure			
Work Products	**Q5**	**Q6**	**Q7**
Incidents Report			3
Priorization of Incidents	5	7	
Due Date Analysis to Fix Incident	2	4	
Incidents Matrix			4
Not Aplicable	1	1	1

In general, participants also exposed relevant comments on the activities related to exploratory testing. In this context, also fimrelated that many tools, techniques, and work products are used during the application of other test approaches.

In addition, it was perceived that the test results, whether in the exploratory way or tests cases with pre-defined scripts and the incidents prioritization have been necessary to support the decision of actions to be taken to the closure of the incidents. It is noted that the exploratory test does not follow procedures planned but is inherent in the test process as one of the considerable test approaches to be used.

VII. CONCLUSION AND FUTURE WORK

This study aimed to identify tools, techniques and work products used in the exploratory testing process being aligned with the practices of the Test Design and Execution process area prescribed in the TMMI. It is observed that the industry still does not develop activities directed to the exploratory test application in a structured manner, and the use of tools and techniques that attend not only the exploratory test approach.

Through the resources, it was noticeable that the exploratory test is still used in free or informal form, being complementary to other test approaches in the process in question. Some interviewees even do not use some structuring techniques, perhaps because they do not understand the possibility of applying the exploratory test having design and execution activities more organized, perhaps induced by the concept presented in SWEBOK [9]. Against this, the authors in [3] evidence that the ignorance of the concept itself by professionals in the area. In this way, the importance of this study is cited to support future work directed to the elaboration of a teaching plan directed to the Exploratory Test Design and Execution following procedures that structure such an approach to empower students at basic level in the industry, even breaking the paradigm of understanding of an approach to be only free.

Therefore, the next stage will be constructing a syllabus being consist of some of these tools, techniques, and work products to keep it adhering to industry practices. In addition, other assets identified in the literature will be used to compose this syllabus as well.

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