The definition of a testing process to small-sized companies: the Brazilian scenario

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Abstract—Producing high-quality software has been one of the greatest challenges of the development market in the last few years. The software testing is the essence of the quality assurance, but the implementation of this activity is still difficult due to many factors. This paper presents some factors that influence on the adoption of a testing process. Some of these factors were outlined in the literature, and others were selected empirically based on the work experience obtained in a large company. Besides, this paper presents the results of a survey carried out to identify factors that make difficult the implementation of software testing process in small-sized software organizations and a proposed approach of a testing process to them.

Keywords-testing process, software process improvement; software quality

I. INTRODUCTION

Due to the importance of the Information Technology to all the economic sectors, it is very important to consider some goals on the software development: (i) How fast was it?, (ii) What was the level of quality of it? and (iii) what was the budget predictability? So the quality of the software became one of the main aspects on the world’s software industry. Software testing is one of the disciplines that have the capability of providing assistance to improve the quality of an organization’s products, because its goal is to evaluate how the product meets the clients’ requirements through a controlled execution of the software.

According to [7], software test is an activity used to guarantee the products’ reliability, complementing the reviews and the formal and rigorous specification techniques. Besides, it is very relevant to eliminate the persistent software errors. Due to some inherent characteristics of the software product, like: (i) flexibility to change, (ii) complexity and (iii) vagueness, the test activity can not be considered trivial. Besides, many factors can compromise the success of this activity: (i) time limitations; (ii) resource limitations; (iii) lack of skilled professionals; (iv) insufficient knowledge in test planning, procedures, techniques; (v) subjectivity of requirements and test specifications; and (vi) increase of the system complexity [14]. According to survey carried out by [15], in 1993, approximately 60% of the companies that consult the Institute present failures on the Quality Assurance area, which could create high risks to their business. Nevertheless, it is important to consider the wide variety of combinations of input and output and the many ways of use that prevent the execution of all possible Test Cases. Test Case is the definition of a specific condition to be tested and its structure is based on input values, running constraints and a results or expected behavior [4]. The amount of Test Cases required to evaluate a product is one of the main factors that can influence the cost of test activity, since each Test Case requires the allocation of resources for its planning and running [10].

As reported by [13] the cost to prevent an error on the maintenance phase is 60 to 100 times greater than the cost to correct it during the development phase. Despite the relevance of the quality assurance, its cost is high on the software development [2]. According to [16] 50% of the costs of the software development are related to software testing. However, the lack of investment on quality can cost a lot amount of money, because the correction of a defect is more expensive when it is found out on the final phases [12]. This paper presents factors that can be considered barriers to implement a test process on small-sized companies, where the resources are scarce.

II. BIBLIOGRAPHIC REVIEW

According to [5], to guarantee the quality of a software, we should use a test strategy oriented by a well defined test process, which must be included on a continuous process of improvement, proportional to the system evolution. The author said that the existent test process models have limitations and problems that make difficult their implementation to a specific domain, for example, the military systems. The author’s work proposed a new maturity model for software testing, named MND-TMM, that can be adapted effectively to military systems. The model is supported by an ontology named MND-Ontology TMM, which supports the software organizations to create a test and process improvement strategy, aiming to develop high level of quality software products.

According to [1] to perform an effective test requires a deep knowledge of the domain and of the system. Besides, it requires an effective conception method of test and a suitable infra-structure. He also said that nowadays it is inexistent the worry about the evolution of the models and specifications related to test and that this kind of concern could simplify the test process. So, he emphasizes an integrated top-down
approach, that uses the test data generated, reinforces the verification, promotes the reuse of knowledge of the domain and testware to a systematic test approach become effective. The work presented by [6] includes issues, like: Why a test process is necessary and how the same test process can be suitable to different projects’ life cycle. The author advocates that a test process based in the system’s life cycle, when clearly understood by the stakeholders will permit a successful execution of the test. Three distinct project’s life cycle are analyzed, but only one test process is proposed, because he presumes that the approach can be effective on the three life cycle models.

The approach proposed by [18] includes a model of a test process based on estimation, aiming to improve the planning and management of the test process. The proposed model came by the analysis of others models and considers re-work factors, that present impact on the duration of the tasks which compose the test process. The authors also present a comparative analysis between the different models.

III. THE MAIN IDENTIFIED FACTORS

In the bibliographic review, we identified a lot of factors that influence on the execution of the test activities and on the adoption of a test process model. Some works present important and necessary factors to the success of a test process, while others present factors which make difficult the implementation of the test process.

This work’s focus is to identify the factors that make difficult the adoption of a test process on small-sized companies. So, we selected the factors described as impeditive or obstacle on the literature and the important ones to a good execution of the test activities. If these last factors are not present in a company, they make difficult the implementation of a test process.

In this bibliographic review, the following factors were the most mentioned: lack of specialized professionals in test of software, great variety of techniques related to test, lack of knowledge to execute adequately the test activities, and difficult to adapt the test maturity model to an organization’s specific environment. On the next section, we present all the factors used on the survey.

IV. SURVEY

The survey carried out to know the factors that influence on a test process implementation comprised of many steps. In the first step of the survey, the systematic review, we selected relevant papers related to test of software and from them, we listed the factors and grouped those with the same meaning. Some others factors, that were not referenced on Table 1, were inserted. They came from the professional experience of one of the authors with test of software. At the end, we had 17 factors as we can see on Tab. 1.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Few importance of a test process [8]</td>
<td>The company does not consider the test process an essential phase in the software development, considering it dispensable.</td>
</tr>
<tr>
<td>Not familiar to test methodologies [14] [19]</td>
<td>Not familiar to test methodologies which can be applied on the organization/application context.</td>
</tr>
<tr>
<td>Planning [14]</td>
<td>Lack of planning and/or adequate methodology.</td>
</tr>
<tr>
<td>Low level of users involvement</td>
<td>Low level of users’ involvement in test activities when they are required.</td>
</tr>
<tr>
<td>Test environment [1]</td>
<td>The quality of the test environment, including the capacity to simulate the production environment.</td>
</tr>
<tr>
<td>Lack of managers’ commitment</td>
<td>The lack of the managers’ commitment in all levels.</td>
</tr>
<tr>
<td>Artifacts’ quality [6]</td>
<td>The quality of the system’s artifacts, specially the requirements.</td>
</tr>
<tr>
<td>Engagement of the test’s team in the project’s final phase [6]</td>
<td>The engagement of the test’s team only in the final phases of the projects, instead in the project’s construction phase.</td>
</tr>
<tr>
<td>Lack of budget</td>
<td>The company does not have budget to test activities.</td>
</tr>
<tr>
<td>Lack of tool support [8]</td>
<td>Lack of tools to support the test activities from the planning to the execution.</td>
</tr>
<tr>
<td>Difficult to control and to manage projects with a lot of tests [19]</td>
<td>Difficult to control and to manage projects that require many types of tests in different levels.</td>
</tr>
<tr>
<td>Size of the test’s team</td>
<td>The low level of operational capacity of the test’s team due to the size of the team.</td>
</tr>
<tr>
<td>Test’s team productivity</td>
<td>Low level of productivity of the test’s team.</td>
</tr>
<tr>
<td>Absence of artifacts</td>
<td>Absence of software’s artifacts.</td>
</tr>
<tr>
<td>Lack of time [14] [19]</td>
<td>The time to execute the test activities is not allocated.</td>
</tr>
</tbody>
</table>

After the selection of the factors, we defined a questionnaire to the organizations’ managers and directors evaluate the level of influence of each factor in the institutionalization of a test process. Firstly, we carried out a pilot survey with a professional that works with tests, a project manager and a university professor, that contributed to the elaboration of the final version of the questionnaire. Then, we adjusted and divided it in three sections: organization’s characterization, test process definition and evaluation of the factors.
The section “Characterization of the organization” collected data related to the companies: type of services (product driven or software factory), amount of collaborators, life time and amount and type of assessments (CMII [3], MPS.BR [9] or ISO 9001 [11]). This section also collected information about the knowledge of the organization of the Test Maturity Models listed by the authors on the systematic review.

The section defined to characterize the interviewee identified some characteristics: the role (director or project manager), the time of experience in the role and type and amount of certifications (PMI, Microsoft, IBM, Sun, Test).

The section “Evaluation of the factors” presented a list of factors, aiming to identify those that influence more negatively the institutionalization of a test process in small-sized organizations.

Each factor was evaluated according to the following scale: Low negative influence (0), Medium negative influence (1), High negative influence (2). Seven organizations from Ceara, a state of the northeast of Brazil, participated of the survey.

V. RESULTS

In this section, we will present the results obtained from the data analysis of the questionnaires.

The factor that was considered as the minor influent was “Low level of users’ involvement”. We may conclude that, possibly, the users have supported the execution of test activities which they are involved.

A. Profile of Surveyed Companies

The questionnaire was applied in 7 (seven) organizations, where 2 (two) are product-driven and 5 (five) were software factory. From the sample, 3 (three) have more than 9 (nine) years of existence and the others have less than 3 (three) years. Only 1 (one) was assessed by CMMI [3], 4 (four) were assessed from MPS.BR [9], and 2 (two) have certification from ISO 9001 [11]. So, many of them are investing in software process.

B. Profile of the interviewees - companies' managers and directors

In this section, we will present the results obtained from the data analysis of the questionnaires that was answered only by companies’ managers and directors to obtain the point of view of the collaborators who make decisions in the organizations. So, 57.14% were managers and 42.85% were directors. Only 28.57% of the participants had more than 9 years of experience and 71.42% had less than 6 years of experience in the role. All the participants were graduated, but only 28.57 had any kind of specialization or master. Besides, 57.14% had official certification from some industry, but none related to test of software. In relation to the Test Process Models, described on the systematic review, the Test Process Improvement (TPI) and Software Testing Maturity Model (SW-TMM), only two organizations knew them, but they do not use them. The others ones did not have heard about them. So, we believe the Software test is still a few considered subject in the organizations that participated in the survey.

C. Factors that influence more negatively in the implementation of Test Process

Firstly, we chose to analyze only the main factors that influence more negatively in the institutionalization of a Test Process. Observing the Tab. 2, we can see that the factor that influences more negatively was: Lack of time.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Factor</th>
<th>Quantity</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lack of time</td>
<td>5</td>
<td>71.42</td>
</tr>
<tr>
<td>2</td>
<td>Few importance of a test process</td>
<td>4</td>
<td>57.14</td>
</tr>
<tr>
<td>3</td>
<td>Artifacts’ quality</td>
<td>4</td>
<td>57.14</td>
</tr>
<tr>
<td>4</td>
<td>Lack of tool support</td>
<td>3</td>
<td>42.85</td>
</tr>
<tr>
<td>5</td>
<td>Engagement of the test’s team in the project’s final phase</td>
<td>3</td>
<td>42.85</td>
</tr>
<tr>
<td>6</td>
<td>Size of the test’s team</td>
<td>3</td>
<td>42.85</td>
</tr>
<tr>
<td>7</td>
<td>Lack of managers’ commitment</td>
<td>3</td>
<td>42.85</td>
</tr>
</tbody>
</table>

We believe that this result is related to the fact that most of the projects do not deliver the product on time. Because of this the time allocated to tests are almost always sacrificed. The factor “Few importance of a test process” was other factor mentioned. It can be related to the anterior factor: Lack of time. Many organizations see the test activities as dispensable. The artifacts’ quality factor, specially the requirements, also was evaluated as a barrier. Really, the systems’ artifacts are indispensable entries to the execution of the test activities.

Other factor mentioned as of great relevance was “Lack of tool support”. The most of the tools that support the Test Process are not free and their cost is higher, making difficult their utilization.

The “Engagement of the test’s team in the project’s final phase”, related to the involvement of the test’s team only in the final phases of the Project, instead of during the development, was another factor that makes difficult the test activities execution, because the time necessary to the test team to understand the business which the software intends to support will be higher. Probably the time is reduced if the test’s team is involved since the beginning of the project.

The “Size of the test’s team” was another important factor. According to [10], the amount of test cases required to evaluate the product is one of the factors that can influence the cost of the test activities, because it requires resources allocation to planning and to execute them.
Finally, the “Lack of managers’ commitment” was also considered one of the main barriers to the implementation of Test Process.

**D. Profile of the interviewees – test analist**

Only 47.05% of the respondents has more than 3 (three) years of experience in the activity of the software test and 52.95% of the respondents has up to 3 years of experience in the job. It is apparent then, that in the profile of test analyst, there are many people who do have much experience. From the surveyed professionals, 23.59% has an official certificate of software test and only 35.29% has any kind of specialization. In relation to the Test Process Models the Test Process Improvement (TPI) and Software Testing Maturity Model (SW-TMM), 76.47% of the interviewees knew them, but they do not use them. The others ones did not have heard about them.

**E. Factors that influence more negatively in the implementation of Test Process in a Test Analyst View**

The main factors that influence more negatively in the institutionalization of a Test Process in a test analyst view are presented below. It is important to note that the criteria Few importance of the test process, Engagement of the test’s team in the project’s final phase, Artifacts’ quality and Lack of managers’ commitment were cited by both classes of respondents. However, some other criteria were considered relevant in view of the performers of software testing activities. Observing the Tab.3, we can see that the factor that influences more negatively in a test analyst view was: Absence of artifacts.

<table>
<thead>
<tr>
<th><strong>Rank</strong></th>
<th><strong>Factor</strong></th>
<th><strong>Quantity</strong></th>
<th><strong>%</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Absence of artifacts</td>
<td>13</td>
<td>76.47</td>
</tr>
<tr>
<td>2</td>
<td>Few importance of a test process</td>
<td>13</td>
<td>76.47</td>
</tr>
<tr>
<td>3</td>
<td>Lack of managers’ commitment</td>
<td>11</td>
<td>64.70</td>
</tr>
<tr>
<td>4</td>
<td>Lack of planning and/or adequate methodology</td>
<td>11</td>
<td>64.70</td>
</tr>
<tr>
<td>5</td>
<td>Engagement of the test’s team in the project’s final phase</td>
<td>8</td>
<td>47.05</td>
</tr>
<tr>
<td>6</td>
<td>Artifacts’ quality</td>
<td>8</td>
<td>47.05</td>
</tr>
<tr>
<td>7</td>
<td>Lack of qualified human resources</td>
<td>8</td>
<td>47.05</td>
</tr>
</tbody>
</table>

This leads us to believe that possibly the documentation made available to the test team is not sufficient to run the activity.

There are many techniques and test methodologies and often the choice of technique best suited for the execution of the test in a given context is not a trivial task. This may have influenced the choice of criterion *lack of planning and/or adequate methodology* as one of the most negative influences for adopting a test process.

The *lack of qualified human resources* in the area of software testing is, according to [14], one of the factors that may prevent the success of the test activity.

**VI. THE PROCESS**

The test process comprises a set of activities and tasks related to planning and running the tests. The software test process includes the execution of two activities (Fig.1).

- Planning the test: the purpose of this activity is to define the test plan to the software project, identifying the products that will be evaluated, the techniques and types of tests to be performed, the test environment and the acceptance criteria. If this activity is executed early, it may help to solve or reduce the impact caused by some factors presented in the survey, for example:
  - Lack of time: probably the team will not be overloaded only on the product delivery phase and this may dilute the wasted time in the course of the project.
  - Engagement of the test’s team in the project’s final phase: the team responsible for the test will participate in all the phases of the software development process, capturing knowledge related to the project’s objectives, facilitating the execution of the test process activities.
  - Lack of planning and/or adequate methodology: the planning of the test has a task “Select techniques and types of test”, that will support the compliance of the used methodology on the test execution. This task will be described bellow.
  - Artifacts’ quality: the engagement of the test team on the beginning of the project may improve the project’s documentation with the feedback of them, which may evaluate the absence of relevant information to the development of good work products and software.
Running the test: the purpose of this activity is to test the products that were selected on the anterior activity applying the techniques and types of test on the defined environment, according to the test plan. This activity may improve the scenario of some software organizations, as we can see below:

- Few importance of a test process: the result of the activity “Running test” before the delivery of the product to the client improve the quality of the product and as a consequence the client satisfaction. Besides, it may contribute to the “Lack of managers’ commitment” because the managers will perceive the benefits of this activity execution in relation to the relationship with the clients and with the prospecting of new businesses.

The activity “Planning the test” can be divided in five tasks:

1. Identify the products that will be tested: this task consists in identifying and prioritizing the products to be tested;
   - Input artifacts: List of developed products
   - Output artifacts: Test plan.
   - Entry criterion: List of products to be tested has been concluded.
   - Exit criterion: Products to be tested have been identified.
   - Essential role: Project team.

2. Select techniques and types of test: this task consists in identifying adequate techniques and types of tests to the product. Besides, the tools that will be used to support the tests.
   - Input artifacts: List of techniques and types of tests to be executed
   - Output artifacts: Test plan.
   - Entry criterion: Selection of the products to be tested has been concluded.
   - Exit criterion: Techniques and types of test have been selected.
   - Essential role: Test team.

3. Identify the acceptance criteria to tests: this task consists in defining the acceptance criteria of the tested products, for example: the acceptable boundaries of detected defects.
   - Input artifacts: List of acceptance criteria already used.
   - Output artifacts: Test plan.
   - Entry criterion: Selection of the products to be tested has been finished.
   - Exit criterion: List of acceptance criteria to tests has been defined.
   - Essential role: Project team.

4. Identify essential roles: this task consists in defining the essential roles for the software tests.
   - Input artifacts: List of collaborators that participate on the project.
   - Output artifacts: Test plan.
   - Entry criterion: Selection of the products to be developed has been finished.
   - Exit criterion: Essential and Contributing roles have been identified.
   - Essential role: Project manager.

5. Define the receivers of the defect reports: this task consists in identifying of the collaborators that will analyze the defect reports.
   - Input artifacts: List of collaborators that participate on the project.
   - Output artifacts: Test plan.
   - Entry criterion: List of products to be developed has been finished.
   - Exit criterion: Receivers of the reports have been identified.
   - Essential role: Project manager.

6. Define the test environment: this task consists in identifying and setting up the adequate environment to execute the software tests. This environment must be a mirror of the development ones.
   - Input artifacts: Requirement specification document.
   - Output artifacts: Test plan.
   - Entry criterion: The project’s environment has been defined.
   - Exit criterion: The test environment has been defined.
   - Essential role: Project manager.

The activity “Running the test” can be divided in three tasks:

1. Test the product: this task consists in carrying out the tests applying the techniques and types of tests selected and defined on the test plan.
   - Input artifacts: List of developed products, list of techniques and types of tests to be used, List of acceptance criteria.
   - Output artifacts: Test plan.
   - Entry criterion: Products to be tested have been developed.
   - Exit criterion: Tests have been finished.
Essential role: Test team.

2. Send the test reports to receivers: this task consists in sending the tests’ defect reports to the receivers defined on the test plan.

   Input artifacts: Test plan, Defects report.
   Output artifacts: None artifacts must be developed during this task execution.
   Entry criterion: Products have been tested.
   Exit criterion: Defects Report have been sent to the receivers.
   Essential role: Test team.

3. Analyze the test results: this task consists in analyzing the test results presented on the defects report, comparing the expected results with the obtained results. Then, the products that were not in accordance to the specified requirements must be identified and corrective actions must be defined and monitored until their conclusions.

   Input artifacts: Defects report.
   Output artifacts: Action plan.
   Entry criterion: Defects report have been prepared.
   Exit criterion: Analysis of the test results have been concluded and the corrective action plan have been defined, if necessary.
   Essential role: Project manager.

VII. CONCLUSION AND FURTHER WORKS

In the small-sized organizations scenario, few companies execute test software activities, because they have difficulties to implement and use them effectively.

They do not execute a Test Process because of, mainly, the lack of resources, including qualified human resource, time, budget, support tool or also due to the lack of knowledge about the relevance and benefits obtained with the test of software, when executed adequately.

As further works, we see the importance to create a knowledge repository to support the test activities execution. This repository may help the small-sized companies in disseminating knowledge related to software test, creating a culture of test and permitting that some activities can be executed by members of the project team that do not have experience in this area. These software organizations, in the most of the time, do not have collaborators able to execute test activities as we could see in the survey’s results, for example: “Lack of qualified human resources” e “Size of the test’s team”.

Another work that we are going to carry out is the execution of the proposed test process in a small Brazilian company to validate the approach.

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