Industry and Academia Partnership for Short-time High-level Qualification

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***Abstract*—This Innovate Practice Full Paper reports a Industry/Academia partnership to improve the qualification of both students and professionals. Consider the following scenario: a city located in a third world country, with one of the lowest countrywide educational performances, hosting an industrial pole based on Federal tax incentives aiming to develop a R&D cluster. The city has basic services issues, from health to urban violence, making the attraction of professionals from other locations unfeasible. As a consequence, the lack of professionals with R&D profile is now considered a relevant risk to the continuation of the city's industrial policies. Therefore, initiatives that shorten the qualification life-cycle of local professionals, while preparing senior students with real-world experience, are welcome. An example of such initiative, reported in this paper, was the software test residence, formed by professionals from the industry, and senior undergraduate and graduate students of a local university. The proposal consisted on defining a set of learning activities where students and professionals would be partners, but still being aware that they belong to different realities (with respect to timing, accountability and accreditation). The challenge can be summarized as follows: how to jointly qualify students and professionals, while respecting the peculiarities of both audiences. In order to address the issue in a short time period, representatives from a global company with R&D site in the city partnered with a local university to define a learning program inspired by the software residence approach. The university's course syllabus in Software Test was reviewed and customized to the on-the-job training subject of interest. Moreover, the approach was based on three nonnegotiable principles: Accountability, Excellence and Sustainability. The experience was successful, reaching 25 participants from four R&D organizations and the university. Results obtained include qualification of 23 participants (only two dropped off), the development of an open source educational material composed by a set of slides for testing automation classes, theory-practice of software testing targeting Test Maturity Model integration (TMMi) level 2, and the improvement in the collaboration between academia and industry for other projects. The paper will detail the experience, and list some lessons learned, including how to synchronize the schedules.**

Keywords - software test, STEM education, Industry/Academia Partnership

I. Introduction

Software test is a mandatory step to deploy new and complex products to the global market of consumer electronics and telecommunication sectors. Rework in the field is costly even considering software update over the air. If one just take a look at the Technology Readiness model, the upper levels, or product deployment levels, are basically composed by test activities [1].

The challenges are higher when considering the short development life-cycle imposed by the rapid demand of new, complex, and interesting features. Furthermore, current development paradigm is based on the integration of hardware and software artifacts from different suppliers into a single product. As a result, R&D teams of manufacturer's companies are under constant pressure to prevent that undesirable issues pop up at the user's hand.

Global companies tend to invest a relevant amount of human and financial resources in test teams, specially in DSD (Distributed Software development) approaches. Part of the investment is to develop test automation methodologies and tools, with benefits on time, cost and quality. Brazil is well positioned to offer test services, given its time zone proximity to Europe and US [2]. The symmetric positioning of Brazil with respect to Asia promotes a following-the-sun scheme based on system and functional tests.

In this context, Manaus, the capital of Brazilian state of Amazonas, could certainly be the perfect place to set-up a R&D test center, due to a tax incentive program known as the Informatics Law [3]. However, human-resources is an issue in the North region of Brazil; test automation professional is highly qualified and rare. Local R&D centers have several opened positions. The geographical isolation of the city, combined with its hot and humid weather and poor quality of life makes the attraction of professionals from other regions expensive and not effective.

Given this scenario, the subsidiary of a global tech company located in Manaus Industrial Pole partnered with a local university to define and run a program to quickly qualify a number of test automation professionals. The approach was based on three nonnegotiable principles: 1) when a professional is assigned to the program, company's stakeholders must be aware that this assignment is part of his job, and not just another on-the-job training; 2) the university will apply its best resources to provide a world class qualification; 3) the residence will be offered to the local R&D ecosystem, and not exclusively to the sponsoring company. These principles are named, respectively, as Accountability, Excellence, and

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Sustainability. The test automation qualification program was conceived and applied by one of the best research groups in Brazil and run in modules during five months.

The contributions of this work are two fold: Firstly, we present the report of experience of a successful Industry-Academia partnership, with detailed schedule, implementation methodology, and lessons learned based on our assessment of the participants experience. Secondly, all material created for this advanced training is available, for educational use, upon request (due to limitation of space in this paper). In summary, this paper proposes a high-level qualification that could be used by other higher-education institutions in other contexts.

Results obtained include qualification of 23 professionals of 4 different R&D private organizations and the university graduate program; development of an open source educational material composed by detailed set of slides for testing automation training/classes, and theory-practice of software testing targeting Test Maturity Model integration (TMMi) level 2; improvement in the collaboration between academia and industry for other projects based on this experience. Finally, the paper will also present a survey about the experience from the participants' perspective.

The remainder of this paper is organized as follows: Section II presents a short description of the issues and the organizations involved with the proposed solution; Section II-A details the problem, along with the goals and premises used to propose the methodology. Section III reviews the theory foundations, and related work, used in this work. Section IV presents the advanced training vortex, while Section V details its implementation to this specific situation. Section VI presents the benefits and the lessons learned so far, and, finally, in Section VII we conclude the paper.

II. Program Background

An important area of R&D centers located in Manaus is software testing and quality assurance. One of the main reasons is that test activities tend to create less resistance from decision makers to start a R&D site in the city, and still benefit from the tax incentive program. Despite that, the lack of qualified human resources is a severe issues. In general, computer science and software engineering majors do not provide a solid set of classes on testing. Usually, students are more interested on software development than on test. Also, testing professionals tend to be less valued than developers in the local market.

Giving the high demand for testing professionals in Manaus, researchers from USP (University of São Paulo), UFG (Federal University of Goiás) and ICOMP/UFAM (Institute of Computing of Federal University of Amazonas) started a joint collaboration with professionals of SIDIA (a private R%D center created by Samsung subsidiary in Manaus) to prepare and implement a methodology to speed-up the high level qualification of professionals in a software residence style.

A. Program Goals

The goal of the proposed qualification approach is to enable testing professionals to understand and to discuss how to improve the testing maturity level of their companies. The main goals of this project are:

- The qualification of professionals on software testing automation, in a way that the participants will be able to transfer the knowledge inside their organizations;
- The development of a detailed set of materials for testing automation training/classes including theory and practice targeting Testing Maturity Model integration (TMMi) level 2 [4];
- The improvement in the collaboration between academia and industry for other projects.

Given previous unsuccessful experiences of qualification of professionals while in their daily activities, a primary aspect here is to involve participant's stakeholders in the preparation since the beginning. It is important to note that this is not an on-the-job training, nor an university course, but something in between. The participants spend part of their time in the university, but most of the work is done in their respective organizations. Therefore, for not compromising the approach, we agreed on three nonnegotiable principles:

- **Accountability**: When a professional is assigned to the qualification program, company's stakeholders must be aware that this assignment is part of his job, and not just another on-the-job training;
- **Excellence**: The university will apply its best resources to provide a world class qualification;
- **Sustainability**: The residence will be offered to the local R&D ecosystem, and not exclusively to the sponsoring company.

Opening the program to other organizations made the process more complex, as it involved confidential issues, as well as differences of organizational cultures and management expectations. Thus, these principles were important to set the expectations and decision making criteria during the training.

III. Theory Foundations and Related Works

In [5] the author proposes the Student Involvement Theory, with five postulates:

1) Involvement refers to the investment of physical and psychological energy in various objects;
2) Regardless of its object, involvement occurs along a continuum;
3) Involvement has both quantitative and qualitative features;
4) Amount of learning is directly proportional to amount of involvement;
5) Effectiveness of a given policy is directly proportional to its capacity of increase involvement.

The author's focus is on the process of student's development, rather than on the developmental outcomes.

In [6] the author presents five key factors to the success of the students, that educators should always consider: expectations, support, assessment and feedback, and (again) involvement. The author points-out that every kind of support for those students who are academically unprepared are particularly important. In our scenario we can consider, by default, that the students are academically under-prepared.

Both approaches agree with the importance of involving the students on learning activities to promote the set of necessary skills. However, they did not discussed how to define and interconnect activities to promote a more effective learning experience.

More recently, in [7] the authors further developed the Student Involvement Theory by proposing the concept of *Vortexes*, a set of correlated, and interconnected involving activities under the same background, with a common and well defined goal: to build a desired professional profile, including hard and soft skills. The authors formally defined a *Vortex* as "an involvement activity defined in one or more cycles, with a self-contained subject, and connected to another Vortex in such a way to contribute either in depth of knowledge or in number of persons to the whole Program".

Concerning related case studies, we identified two reports of experiences on Software Residence implemented in Brazil. The expectations was that they could bring interesting ideas while reducing possible cultural barriers. The first report, a residence for software product line, may be fund in [8]. The experiments took just three to five working days, including an opening seminar, and the elaboration of reports. Although interesting, the extremely short period was insufficient to become a basis for a learning activity.

A similar experience is the software residence course offered by the Federal University of Pernambuco [9], which is on its 20th edition. As in the present work, this software residence is also executed in partnership with the industry, has its focus on software test, and the target class is of around 20 students. However, that course endures a full year, with classes in the university Campus in one period of the day (morning) and residence in the other period (afternoon). It was possible because the sponsor has an in-campus laboratory. In the present work, the qualification cycle should not exceed six months, and the residence site is outside the university campus. Moreover, the classes follows an academic syllabus, while we are more interested on a market-oriented content.

IV. METHODOLOGY

This Section presents the underlined methodology. First, the overall program that this residence is part of. Second, the residence content.

A. Vortex and The Involving Learning Experience

This advanced training program was executed in the context of a broader program denominated PROMOBILE (Large Scale Qualification **PRO**gram on **MOBILE** Technologies), created to promote the qualification of around four hundred professionals in three years time frame on different aspects of software development for mobile devices. The program follows the learning vortexes methodology [7].

The principle behind a vortex is that any educational action is more effective when the student is aware of his qualification as a whole, and be challenged to get the next step towards his career opportunity. Table I summarizes each activity's role on promoting the target qualification (in quantity and quality).

TABLE I. IMPLEMENTED LEARNING VORTEXES.

#	Vortex	Quality	Quantity	cycle
1	Optional Subjects	medium	medium	semester
2	Talent Devel. Progr.	high	medium	year
3	Short-term events	low	high	semester
4	**Advanced Training**	**high**	**low**	**year**

B. The Testing Maturity Model Integration

The methodology used to implement the *Advanced Training on Test Automation* is based on Testing Maturity Model integration (TMMi) [4] and also in the ISO/IEC 29119 standard, parts 1 [10], 2 [11], and 3 [12]. It is a well-known testing maturity model, complementary to CMMI [13], and composed by five levels of maturity: 1) Initial; 2) Managed; 3) Defined; 4) Management and Measurement; and 5) Optimization. For each level there are different process areas which the organization must satisfy to reach maturity.

We focus the training on TMMi Level 2 as, according TMMi Framework [4], "at TMMi level 2, testing becomes a managed process and is clearly separated from debugging". The discipline of process promotes the compliance with the good practices even during times of stress (testing is perceived by many stakeholders as project phase that follows coding).

In the context of improving the process of test, a company-wide or program-wide strategy is established. Test plans are defined, along with their respective approaches, which is based on the result of a product risk assessment. Risk management techniques are applied to identify the threats to the final product based on documented requirements. Commitments are established with stakeholders and are revised as needed. Testing is monitored and controlled to ensure it is being run according to plan; actions may be taken if deviations occur. The status of the work packages and the delivery of testing services are visible to management. Test design techniques are applied for deriving and selecting test cases from specifications. In TMMI level 2, testing is multi-layered: there are component, integration, system and acceptance tests, each with specific goals. As mentioned before, in this TMMi level the processes of testing and debugging are differentiated.

The process areas at TMMi level 2 are:

- PA 2.1 – Test Policy and Strategy: the purpose is to develop and establish a test policy, and an organization-wide or program-wide test strategy in which the test levels are unambiguously defined. To measure test performance, test performance indicators are introduced.
- PA 2.2 – Test Planning: the purpose is to define a test approach based on the identified risks and the defined test strategy, and to establish and maintain well-founded plans for performing and managing the testing activities.
- PA 2.3 – Test Monitoring and Control: the purpose is to provide an understanding of test progress and product quality so that appropriate corrective actions can be taken when test progress deviates significantly from plan or product quality deviates significantly from expectations.

- **First day of the module**
  - 08:00am to 06:00pm - Coordination meeting
- **Second to penultimate day of the module**
  - 08:00am to 09:00am - Local assistance
  - 09:00am to 12:00pm - concepts, methods and tools
  - morning coffee break from 10:30am to 10:45am
  - 02:00pm to 05:00pm - Hands-on
  - evening coffee break from 03:30pm to 04:00pm
  - 05:00pm to 06:00pm - Local assistance
- **Last day of the module**
  - 08:00am to 09:30am - Module overview, doubts clarification, activities for next two weeks (distance learning)
  - 09:30am to 10:00 - coffee break
  - 10:00am to 12:00pm - module evaluation test

Fig. 1. Planning activities for each module.

- PA 2.4 – Test Design and Execution: the purpose is to improve the test process capability during test design and execution by establishing test design specifications, using test design techniques, performing a structured test execution process and managing test incidents to closure.
- PA 2.5 – Test Environment: the purpose is to establish and maintain an adequate environment, including test data, in which it is possible to execute the tests in a manageable and repeatable way.

V. Implementation

The proposed software residence aims to establish a basic level of knowledge on software testing, and to cover the interest of the industry partner on specific contents, related to test automation. Below we list each topic with a brief description of its contents and possible testing tool explored. We divided the content on three modules of 74 hours each of classroom and other 20 hours for distance learning.

The general structure about how the content of each module during classroom is taught follows the schema in Figure 1.

a) Module I: provides the most basic concepts on software testing, including functional and structural testing (control-flow testing criteria), software testing process, basic metrics for measuring testing progress and tools for management of test cases, test case documentation and automatic execution, capture & playback tools, and coverage measure tool. See Appendix A for more details;

b) Module II: covers advanced testing criteria, such that data-flow and mutation testing. The emphasis is to demonstrate the strength of different testing criteria and how they should be combined in an incremental testing strategy. Some domain specific testing for mobile and web applications are also covered. Some testing tools which support these testing criteria are used to demonstrate its applicability and how they can evolve previous generated test sets presented in Module I (see Appendix B);

c) Module III: provides information about non-functional testing, such as usability and security testing. Additionally, we explore the concepts of Evidence-based Software Engineering [14] emphasizing the importance of experimental studies on demonstrating the feasibility of testing criteria and/or tools for each specific domain. Participants were also motivated to conduct a controlled experiment evaluating different functional testing criteria in terms of coverage of control-flow testing and fault detection capability using mutation testing as a fault model [15] (see Appendix C).

The residence schedule was prepared to harmonize the course activities with professional's daily work, avoiding impacts in the productivity. The authors selected the participants from local universities and companies. The main criteria were proven interest/experience in the career of software testing, and acceptable academic records. The course started with 25 participants, 5 more than expected, from 1 universities and 4 local private organizations. Since the early hours of training the instructors imposed a strong rhythm to set the expectations about the quality of the course. Interesting to note that, despite most of the participants have their professionals activities, 23 participants concluded the residence, with a drop-off of less than 10%. In the last module the participants performed a joint test experiment with students of the hosting university enrolled in an optional discipline on software testing.

A. Coaching and Performance Evaluation Methodology

The participants were separated in teams according to their organizations. The instructors were also the team coaches, being responsible to follow-up their progresses, assign specific activities, provide feedback, and, if necessary, to dismiss.

The training material was given in two moments: the modules and the residence. During the two on-site full time working week (the modules moment), the participants were immersed in the hosting university laboratory. The interaction with the instructors was intense, and the participants had the opportunity to present to their coaches actual problems from their respective organizations. In this case, the team could use one of the university's meeting room to discuss confidential topics.

The second moment was the weeks between modules (the residence), composed by six to eight weeks were the teams had specific assignments and were pushed to apply the training in their organization environment. During those weeks the coaches interacted with the teams by email or Skype.

The participants were evaluated and graded:

1) By the hit rate of the practical exercises during the presentation of the module and test tools. At each module the participants were introduced to new test methodologies, along with a software test tool;
2) By an standard exam applied in the end of each module. This exam had the goal to evaluate the fundamental concepts and it was elaborated based on the TMMi level 2 test;
3) By the completion rate of the activities assigned to be done during the weeks between modules (the residence). For the last module, the participants performed a controlled test experiment that exercised the most important skills supposed to be acquired during the training.

The final grade was the average of each partial grades.

VI. Execution, Evaluation and Improvements

There was a high interest to enroll in the test qualification program from the local community. This was due to the previous Vortex (see Section IV-A), a short-term event on software test, and to the high quality of the Instructors (two of the best known Brazilian researchers on the field).

The initial participants profile were:

- 18 from 4 private organizations, with 2 teams of 5 (one of them was the sponsor), 1 team of 6 and 1 team of 2 participants. 7 participants came from the university graduate program on Computer Science;
- 15 participants were men and 10 women.
- All of them had some experience on software test.

It is important to highlight that, despite the heavy workload, and high expectations set by the instructors, the participants could manage to finish the training successfully. The two dropouts were related to the changing on their career path, which explained the reason to abandon the course.

By the end of the program two university participants were hired by one of the private organizations. As a result, the percentage of private participants increased.

It is also interesting to mention that, although the participation of women on STEM related careers tend to be low, in this training they were quite balanced.

Finally, the participants' performance were very regular. The instructors could give specific feedback to the teams managers, as they were separated by organizations.

The material produced for this training is available under Creative Commons CC BY-NC-SA license. The participants were encouraged to replicate this experience in their own companies. This initiative was only possible due to the collaboration between industry and academia. Academia has the knowledge that should be disseminated and the industry needs high qualified people to add more value to their processes and products. By funding R&D projects, the industry supports the development of high quality training materials. Furthermore, it gives to the academic community challenging problems.

The authors submitted to the participants an evaluation questionnaire. The answers provided interesting inputs about the value added perception of the training. The questions, detailed Table II, were divided into 4 sections: course content, instructor, infrastructure, and participant performance.

Fig. 2 to 5 present the answers after the second and third (final) modules. The triad in each table entry is the number of participants that answered, from top to down, "YES", "REASONABLY YES" and "NO", to each question. We also quoted selected participants' commentaries.

TABLE II. Evaluation Questionnaire

Section A: Course content	
A.1	Is the 3 modules division adequate?
A.2	Is the proposed content adequate?
A.3	Is the quality of materials satisfactory?
A.4	Is the theory-practice balance satisfactory?
A.5	Is the content aligned with your professional needs?
A.6	Are the test automation tools presented relevant?
Section B: Evaluation Questionnaire: Instructor	
B.1	Did the Instructor showed domain of the content?
B.2	Was the Instructor objective?
B.3	Did the Instructor applied suited teaching techniques?
B.4	Was the interaction with the Instructor smooth?
B.5	Did the Instructor followed the time scheduled?
B.6	Did the Instructor followed the presential and distance agendas?
Section C: Evaluation Questionnaire: Infrastructure	
C.1	Were the course facilities adequate?
C.2	Were the multimedia resources satisfactory?
C.3	Was the distance learning environment adequate?
Section D: Evaluation Questionnaire: Participant performance	
D.1	Did you finish all your training workload?
D.2	Did you get a good domain of the presented content and tools?
D.3	Were you in all presential classes?
D.4	Did you participate in the distance learning sections?
D.5	Did you interacted with other participants?

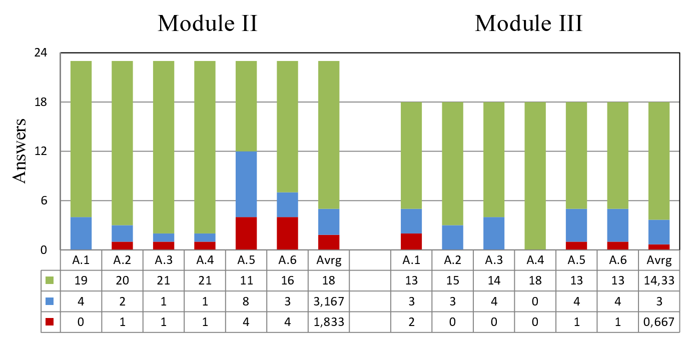

Fig. 2. Questionnaire answers - Section A: Course Content: green (YES), blue (REASONABLY YES), red (NO).

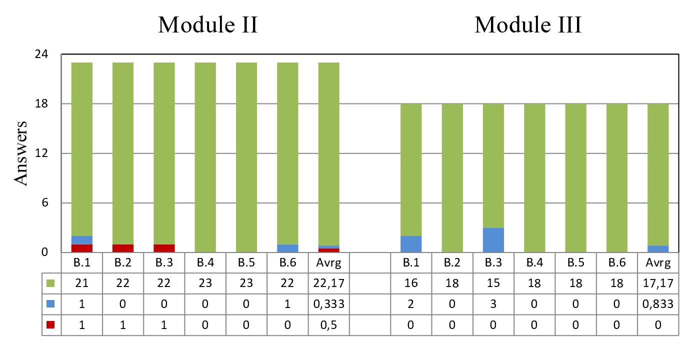

Fig. 3. Questionnaire answers - Section B: Instructors: green (YES), blue (REASONABLY YES), red (NO).

Selected participant's commentaries:

- **After second module** "Excellent course. Several subjects could be properly addressed in so little time"; "I expected to have learned more about test automation"; "In my opinion this part of the course did not have a good support material"; "Great set of support material: slides, tutorial and articles, both theory and practice"; "Excellent Instructor. Clear and right to the point. Well balanced theory and practice"; "Infrastructure was reasonable, however, the Internet issues disturbed the training".
- **After third module** "Despite the superficial approach on specific topics, the course material have very good quality"; "In this module we did not have either computers or tables to plug our notebooks. This chairs

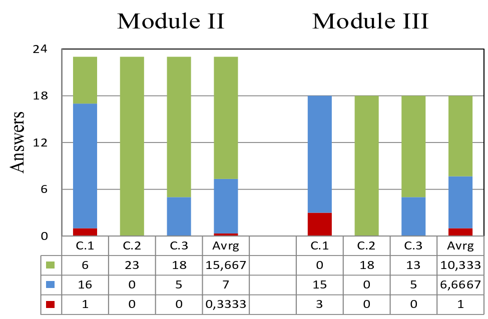

Fig. 4. Questionnaire answers - Section C: Infrastructure. green (YES), blue (REASONABLY YES), red (NO).

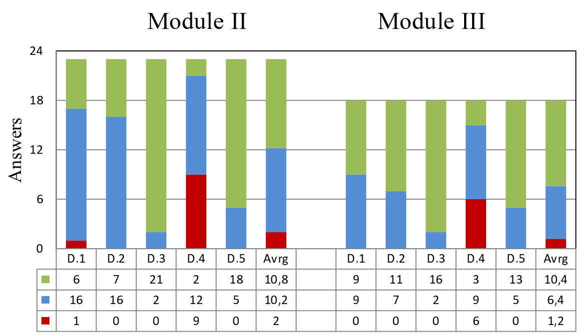

Fig. 5. Questionnaire answers - Section D: User performance evaluation. green (YES), blue (REASONABLY YES), red (NO).

with right arm support are not suited for this kind of training"; "Instructors are very good. Special note to the invited speakers"; "The instructor performed very well. Always interested to be sure that the student is getting a good learning experience".

Based on the participant answers, we highlighted the following remarks:

1) One of the most important remarks is that, contrary to our expectations, the participants did not find the infrastructure so determinant to a successful training. The second module was applied in a standard undergraduate lab, with just few obsolete machines, and always-overloaded Internet connection, while the third module took place in an auditorium. It seems that the participants valued much more the quality of the content and the expertise of the Instructors above the infra difficulties. This is important, as we have the intention to reproduce this course on other *campi*, with similar infrastructure issues.
2) Also contrary to our first expectations, the participants preferred the on-site experience rather than the residence learning experience. At first we thought that they would use the on-distance training to overcome their difficulties to conciliate their daily work activities with the training workload. However, what we have learned is that IT professionals have a difficulty to isolate their daily pressure, and this behavior can be also seen in this mixed on-site-on-distance training.
3) We had an improvement form Module II and III with respect to the overall participant performance, although the rate of YES when compared to REASONABLY YES are the lower ones. This is expected, as it reflects, on one hand, that the demands from the Instructors were high, and on the other hand, that the participants not only responded positively, but also they were progressing satisfactorily.

After this first initiative, some improvements are underdevelopment, including:

- The writing of a book on SW Testing Automation;
- The improvement of the current material including more examples, specially the ones from industry;
- The development of additional modules for training such as, model based, and test of concurrent programs;
- The translation of the training materials, making it useful for international audience.

A. *Training Legacy*

This paper was written after several months the realization of the residence, and a long-term impact can be found in the sponsor organization. Theirs participants replicated all the training, concepts and knowledge to others employees. As a result the company built a test automation team of 20 members, more than tripling the original team during the residence.

Furthermore, the sponsor company started an internal program of incentives, inspired in the qualification principles, for all members of the test team (which is composed of up to one hundred employees). Currently 56% of the test team are foundation-level certified, and 5% are advanced-level certified by the ISTQB (International Software Testing Qualifications Board)[16].

In summary, the qualification indeed changed the organization culture and processes with respect to software testing.

VII. Conclusion

This work described a case study of a partnership between academia and industry on promoting the qualification of professionals on the field of software test automation. This work is in the context of a larger program aiming to develop critical mass on various software development disciplines in Manaus.

The authors believe that the success of the experience was mainly due to the high degree of commitment of all involved actors, including the company sponsor, the instructors and the participants. The 23 students and professionals that finished the training are now multiplier agents to increase the availability of software testing professionals in the region, an important area in any R&D, specially for those off-shore centers that intends to get more work packages in future global projects.

This work presented a new module-based software residence as a joint effort between Academia and Industry. Its novelty consists in a hands-on qualification course that allows both professionals and students to team-up, experiencing an actual industry environment. The participants had the opportunity to bring their daily work packages as case study. The intention was that they could profit from the training not only in terms of qualification, but also in terms of work progress. Of course, managers did not allow them to bring work packages to the on-site moment due to confidential issues.

The results were very positive. In addition to the low drop-off rate, we had a high commitment until the end of the course. Even the participants with heavier workload could manage to satisfactorily complete the course activities. We concluded that the pace imposed had the effect to show to all participants that their effort would be paid back in term of long-lasting know-how. By the way, the course was totally financed by the industry partner, being free of charge to the participants.

After the residence realization it is possible to perceive its impact in the sponsor, with a relevant increase of the test team, in both quantity and quality. The test automation team alone, which did not exist, started with six member during the residence and after three years increased to 20 members, almost a new team per year.

We believe that this experience is easily reproducible in similar scenarios, where the lack of infrastructure can be compensated by good instructors and materials. This is true in most third world countries, where the lower cost of human resources attracts global companies, and the demand of qualified professionals is high.

As a lesson learned, in future training the instructors intend to use a secure laboratory, with a suited network infrastructure. The objective is to allow professionals to bring their daily work to the training, so that they could benefit from work progress during the module moment. Also, we intend to replicate the training in others local universities to promote critical mass in software testing for Manaus industrial ecosystem.

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Appendix

This appendix presents the structure and a brief description of each module. Each class is organized balancing theory and practice. The participants received bibliographic references, recommended reading material, and also executed exercises during class, as well as hands-on practice every evening.

A. Module I

This module covers the basic concepts of software testing, the idea is to provide the knowledge related to the process area of Test Maturity Model integration – TMMI level 2 [17].

- Day 1: Coordination meeting
- Day 2: Introduction
- Definitions and Terminology
  - Basic concepts: Mistake, Fault, Error, Failure
  - Verification, Validation and Testing: Static and Dynamic Analysis
  - Testing Technique and Criteria, Test Requirement, Test Case
  - Test Phase
  - Fault Classification
  - Software Testing Documentation: JUnit
  - Class Exercises
  - Hands-on: JUnit
- Days 3 and 4
  - Software Testing Process
    - Introduction
    - Software Testing Standards
    - Testing Maturity Models
    - Fault Tracking
  - Black-box Testing Technique
    - Introduction
    - Equivalency Class Partition
    - Boundary Value Analysis
    - Decision Table

        - Unit Testing Automation Frameworks
        - Hands-on
            * Test Plan Automation: TestLink
            * Bug Tracking: Mantis
            * Unit Testing Framework: JUnit

- Day 5
    - Exploratory Testing in Small
    - Exploratory Testing in Large
    - Record & Playback tools
    - Hands-on: Practice on Exploratory Testing
        - Record & Playback tools: Selenium, Sikuli
- Day 6: Agile Testing
    - Test in Scrum
    - Test Driven Development (TDD)
    - Behavior Driven Testing (BDT)
    - Hands-on: TDD with JUnit
- Day 7: Metrics and Static Analysis
    - Basic Concepts
    - Automation support: Sonarqube: FindBugs, PMD, Checkstyle
    - Hands-on: Sonarqube
- Days 8 and 9: White-box Testing Technique
    - Introduction
    - Control-Flow based Testing Criteria
    - Control-Flow Testing Automation
    - Incremental Testing Strategy
    - Class Exercises: Search for coverage testing automation tool
    - Hands-on: Cobertura, Emma (Eclemma)
- Day 10
    - General overview, doubts, activities for the next two weeks (distance learning)
    - Module evaluation testing

B. Module II

This module covers advance testing criteria, such that data-flow and mutation, aiming at emphasizing the complementary idea of testing criteria and how they should be combined in an incremental testing strategy to maximize the defect detection rate. Moreover, risk based testing, automatic test data generation, web testing and mobile testing are also covered in this module.

- Day 1: Coordination meeting
- Day 2: White-box Testing Technique
    - Introduction
    - Data-Flow based Testing Criteria
    - Data-Flow Testing Automation
    - Incremental Testing Strategy updated: Subsume Relation: theoretically and empirically
    - Class Exercises
    - Hands-on: JaBUTi
- Days 3, 4 and 5: Fault-based Testing Technique
    - Mutation Testing – Mutation Analysis and Interface Mutation
    - Incremental Testing Strategy updated
    - Mutation Testing Automation
    - Testing Criteria Evaluation: theoretically and empirically
    - Hands-on: MuJava, Proteum/IM
- Day 6: Risk-based Testing
    - Hands-on: Risk-based Testing
- Day 7: Automatic Test Data Generation
    - Random Testing
    - Test Data Generation based on Testing Criteria
    - Hands-on: Handoop, CodePro, Guitar
- Day 8: Web Application Testing
    - Overview
    - Basic Concepts
    - Hands-on: Selenium
- Day 9: Mobile Application Testing
    - Overview
    - Basic Concepts
    - Hands-on: Sikuli, AndroidGuitar, Robotium
- Day 10
    - General overview, doubts, activities for the next two weeks (distance learning)
    - Module evaluation testing

C. Module III

This module cover additional testing activities focusing on non-functional testing and software testing experimentation such that participants are able to understand and conduct a controlled experiment or case study aiming at evaluating a given testing criteria or automated testing tools [14].

- Day 1: Coordination meeting
- Day 2: Usability and Accessibility Testing
    - Overview
    - Basic Concepts
    - Hands-on:Usability and Accessibility checklist
- Day 3: Security Testing
    - Overview
    - Basic Concepts
    - Vulnerabilities
    - Types of Attacks and Prevention
    - Hands-on: SQL Injection tool
- Day 4: Experimental Studies
    - Overview
    - Fault Classification
    - Examples of Experimental Studies
    - Hands-on: Experimental Package: Training Step
- Day 5: Final Project Specification
- Days 6 to 9
    - Presentation and Conduction of Experimental Study evaluating the Cost and Efficacy of Functional Testing Criteria
- Day 10
    - General overview, doubts, activities for the next two weeks (distance learning)
    - Module evaluation testing