From Certifications to International Standards in Software Testing: Mapping from ISQTB to ISO/IEC/IEEE 29119-2

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Abstract. In today's software development industry, software testing allows one to ensure the quality but it cannot be done exhaustively and it requires selective and careful planning. That means a test process which is not only time-consuming but also useful and crucial because today, more than ever software is becoming part of our personal and professional life. Software testing is gradually gaining relevance among software practitioners and researchers. Due to that, several organizations, which offer personal certifications, have emerged and international standards have been developed. However, there is still a need to support software practitioners in gaining awareness and understanding about them. The aim of this study is to perform a mapping from all major activities of ISTQB Foundation Level Certification (CTFL), to corresponding processes of ISO/IEC/IEEE 29119-2. Thus an analysis has performed to identify the differences and overlap between the two approaches, which allows a better understanding of them. The findings show that the test process of ISTQB CTFL is largely covered by the ISO/IEC/IEEE 29119-2. In addition, a tailored conformance was also outlined to ISO/IEC/IEEE 29119-2.

Keywords: Software Testing, ISTQB CTFL, ISO/IEC/IEEE 29119, Mapping.

1 Introduction

Today, software is ubiquitous —software is everywhere— [1, 2]. Software is affecting all aspects of our personal and professional life [3]. As a consequence, software testing has become a mandatory part of software development [4]. Its importance is widely recognized [5, 6] and there is a growing concern in how to improve the accomplishment of this process [7]. Over the time, practitioners have been forced to develop and adopt better testing practices software due to code's rising size and complexity, greater demands regarding development speed and agility, increased heterogeneity and geographic distribution of software teams and their components [4]. Beginning in the early 1970s, the level of professionalism associated with software testing was gradually increased [8] until "Software Tester" became a profession and special qualification schemes have been emerged (e.g. ISTQB, see Table 1). Regarding

standards of software testing, there was a gap because they were either partial (such as ones proposed by IEEE and BSI) or were specific to particular and highly regulated sectors (such as ones related to aviation or health). This gap is intended to be covered by ISO/IEC 29119 Software Testing standard [9], which was published in 2013 and closely-supported by IEEE and BSI. Another standard that is relevant and defined specifically for ISO/IEC 29119-2 is ISO/IEC 33063 Process Assessment Model for Software Testing [10]. Additionally, a number of approaches has been specifically developed for that purpose but many of them have been adapted or extended from Test Maturity Model integration (TMMi) and/or Test Process Improvement (TPI) [11, 12]. Among the approaches that used other models, Test Spice deserves to be mentioned because it conforms to the ISO/IEC 15504 [13].

Despite decades of work by researchers and practitioners, test management (encompasses activities related to test management, e.g., planning, control, monitoring, etc.) had been reported by practitioners as a big challenge [5], and one of the areas of most importance to the practitioners, which requires further research [5, 6]. Although there are already available mappings, —such as ISO/IEC 12207:2008 to ISO/IEC/IEEE 29119-2 mapping [9] and a complete mapping between ISO-29119-2 and TMMi [14]— as far as the authors know, none of them are not focused on understanding the better of two worlds: personal certifications and international standards in software testing. Therefore, this paper aims to contribute to fill this research gap by presenting results of a process mapping study between the well-known ISTQB Certification and the ISO/IEC/IEEE 29110 standard. The authors targeted this study only for the software testing process by delimiting an adequate scope.

The remainder of this paper is structured as follows: Section 2 presents the background of this study and the ISO 29119 and ISTQB CTFL. In Section 3 authors outlines the research method and report on the results of the mapping while Section 4 summarizes a conclusion and future research.

2 Background

2.1 Certifications

Due to the growing importance of professionalism in software testing several organizations, which offer certifications, have emerged such as QAI Global Institute, American Society for Quality, International Software Quality Institute, International Software Testing Qualification Board, and International Institute for Software Testing (see Table 1). However, one of them has been gaining popularity among practitioner: ISTQB. According to its website, as of December 2016 the ISTQB certification is becoming popular in the global scale, having over 740,000 exams and issued more than 535,000 certifications in over 120 countries world-wide. This certification schema considers three levels: foundation [15], advanced [16] and expert [17].

Table 1. Software testing certifications.

Organization	Certifications

QAI Global Institute	Certified Associate in Software Testing (CAST) Certified Software Tester (CSTE) Certified Manager of Software Testing (CMST)
American Society for Quality (ASQ)	Certified Software Quality Engineer (CSQE) Quality Assurance Management Professional (QAMP)
International Software Quality Institute (iSQI)	Certified Agile Tester (CAT) Certified Agile Test Driven Development Mobile App Testing - Foundation Level (CMAP) CMAP Mobile App Test Automation CMAP Mobile App Performance Testing
International Software Testing Qualification Board (ISTQB)	Foundation Level and its extensions (Agile Tester, Model-Based Tester) Advanced Level (Test Manager, Test Analyst, Technical Test Analyst, Security tester, Test Automation Engineer) Expert Level (Improving Test Process, Test Management)
International Institute for Software Testing (IIST)	Professional Testing Certifications (CSTP) Agile Testing Certifications (CASTP) Test Automation Certification (CSTAS) Test Manager Certifications (CSTL) Mobile Test Certifications (CMSTP) Quality Management Certifications (CSQM)
European Certification & Qualification Association (ECQA)	Provisional Assessor TestSPICE Competent Assessor TestSPICE

2.2 ISTQB Fundamental Test Process

The ISTQB is a world-wide organization widely accepted among practitioners which provides a fundamental test process. The following briefly describes the fundamental test process [15]: planning and control; analysis and design; implementation and execution; evaluating exit criteria and reporting; and test closure activities.

- Test planning is the activity of defining the objectives of testing and the specification of test activities in order to meet the objectives and mission. Test planning takes into account the feedback from monitoring and control activities. Test control is the ongoing activity of comparing actual progress against the plan, and reporting the status, including gaps.
- Test analysis and design is the activity in which general testing objectives are transformed into tangible test conditions and test cases. The first task is to review the specification of what should be tested. The specification should be concrete and clear enough to develop test cases and test procedures. Other key tasks are to evaluate testability of the requirements and system, and design the test environment.
- Tests implementation and execution is the activity where test procedures or scripts are specified by combining the cases in a particular order and including any other information needed for test execution. Furthermore, the environment is set up and the tests are run.
- Evaluating exit criteria is the activity where test execution is assessed against the defined objectives. Exit criteria should be set and evaluated for each test level. Finally, a test summary report for stakeholders should be written.

- Test closure activities collect data from completed test activities to consolidate experience, including checking and filing testware, facts and numbers. For instance, when a particular milestone is achieved or when software system is released.

These activities in the test process may overlap. Testing also comprises reviewing documents (including source code) and carrying out static analysis.

2.3 ISO/IEC/IEEE 29119

The aim of ISO/IEC/IEEE 29119 is to define a generic process model for software testing that can be used within any software development life cycle [9]. The model specifies test processes that can be used to govern, manage and implement software testing in any organization, project or testing activity. Currently, there are five parts but this study is focused in the second part (29119-2-2013). It describes the software testing process that is composed of several layers; the top layer is the Organizational Test Process Level, which defines the testing policy and the testing strategy of the entire organization. The second layer is the Test Management Processes, which defines the test activities in projects. On this level, test plans are defined and maintained based on the given organization level policies and strategies. The last level is the Dynamic Test Processes, which defines the actual testing work [18].

3 Method: Mapping

This section outlines the research method implemented for this study. Model mapping or gap analysis is the key component of the proposed approach. An understanding of the differences between the models involved in the assessment is a must-have to conduct a complete assessment and get valuable results. Thus, a mapping allows the detection of differences and similarities between these approaches. Two researchers were involved in this study and discussed the reliability threats early in the design phase and agreed on the procedure, considering activities to mitigate the effect of one researcher's bias. Consequently, an protocol was adapted from the guidelines proposed by Baldassarre et al. approach [19], it is also worthy to note that the guidelines had been followed in previous studies [20–22].

The protocol describes the plan for the review and ensures that the study is undertaken as planned while reduces the possibility of researcher bias. It includes the steps of: 1) Analyze the models; 2) Design the mapping; 3) Carry out the mapping; 4) Present the outcomes and analyze the results. In what follows, the mapping performed is described using the method provided.

3.1 Models Analysis

The first activity is to analyze each reference model involved in a mapping process. ISTQB CTFL and ISO/IEC/IEEE 29119 were chosen for this study based on their

relevance. Both of them were studied in detail and an overview of them is described in the background section of this paper.

3.2 Mapping Design

The purpose is to perform a step-by-step comparison and a mapping of the reference models. To do that, authors carried out the following activities:

1. Identification of elements to be compared: all major tasks of ISTQB CTFL, and the clauses of each requirement of ISO/IEC/IEEE 29119-2 standard. There are a different number of clauses by requirement, e.g. 6.2.4.1 in Table 2 has four clauses (a,b,c and d) and 7.2.4.1 has only three (a, b and c).
2. Direction of the comparison: The direction is from ISTQB CTFL to ISO/IEC/IEEE 29119-2.
3. Comparison scale definition: The scale has been used in previous works [19, 20]. It contains the following four elements: strongly, partially, weakly and non-related.
   - Strongly related (●), the process is especially named in the standards and the process has many concepts in common and many of them have the same process steps.
   - Partially related (◑), the process is not especially named, but there are one or more activities in the standard which lead to the implementation of the process defined in the other standard.
   - Weakly related (◔), the process is not especially named, but there is a process or a process concept which can/should be adapted in an activity in the other standard.
   - Non-related (○), no relationship can be identified.
4. Comparison template definition: All these values are analyzed and checked from a holistic point of view and authors determine to what extent ISO/IEC/IEEE 29119-2 activities and tasks are fulfilled.

3.3 Mapping Execution

This mapping is an iterative process in which authors analyze the ISTQB process against ISO/IEC/IEEE 29119 process. The first step to do when comparing both processes is to map their basic, constituent components. For each process all activities are studied. The objective is not to set a naïve approach between activities' names. In this mapping, authors also analyze whether specific activities and task are also met. In order to carry out the mapping, a first high level relationship between the reference models is defined. Then, a drilling down process analyzing in detail these relationships helps the authors to identify fine grained relationships. In order to check the consistency of the results, a test-retest approach and re-evaluation were carried out as well. All these mapping are managed by using several spreadsheets where ISTQB activities are displayed as rows, and ISO/IEC/IEEE 29119 clauses are displayed as columns. However, due to the limited space of this paper, the outcomes are presented in five tables (see **Table 2**, **Table 3**, **Table 4**, **Table 5** and **Table 6**) where each of

them is represented one of the ISTQB activities and their tasks are described in the text but not displayed in the table.

3.4 Outcomes

Coverage of Testing Practices. As already stated above, a detailed and extensive study has been performed. The first step in the study was done starting from the test processes defined by ISTQB CTFL and trying to find a corresponding layer within ISO/IEC/IEEE 29119. **Fig. 1** shows the layers of the test process model which include varying numbers of test process. Certainly, finding a corresponding process does not imply they provide the same level of coverage on test practices, but it can be a good first step towards comparing both processes and provides a structure for subsequent studies to be carried out. **Fig. 1** provides an overview of ISTQB fundamental process to ISO/IEC/IEEE 29119-2 high-level mapping. The five activities of ISTQB fundamental process are drawn-up in the middle section and the corresponding process of ISO/IEC/IEEE 29119-2, are provided (with arrows) in gray on the left and right side.

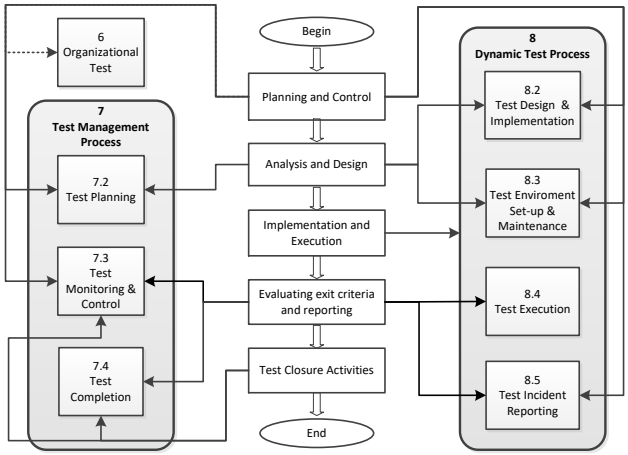

Fig. 1. ISTQB CTFL to ISO/IEC/IEEE 29119-2 high-level mapping.

Fig. 1 shows an important finding regarding coverage relationship (arrows). Basically, the layers of Test Management and Dynamic Test (ISO/IEC 29119-2 standard) are required to provide coverage of the ISTQB CTFL. The clauses of the Organizational Test Process of ISO/IEC 29119-2 are hardly dealt with within ISTQB CTFL. The aim of the Organizational Test Process is to define a process for the creation and maintenance of organizational test specifications, such as organizational test policies, strategies, processes, procedures and other assets. One can therefore conclude that ISTQB CTFL does not address test practices at this layer but one of the tasks of the test leader in its syllabus points out “write or review a test strategy for the project, and test policy for the organization”. Therefore, Planning and Control is very weakly related to ISO/IEC 29119-2 (dotted line) and the scope of ISTQB is fundamentally limited to Test Management and Dynamic Test.

ISTQB CTFL is largely covered by the ISO/IEC 29119-2. Consequently, a more detailed analysis was carried out. The analysis was extended to a study on the level of detailed test practices. Just having a corresponding ISTQB CTFL process does not mean that all clauses and requirements (i.e. shall statements) of ISO/IEC 29119-2 are covered by ISTQB CTFL process. The study of the five activities of the fundamental test process within ISTQB CTFL is described in more detail in what follows.

Planning and Control. Table 2 presents the "Planning and Control" to ISO/IEC/IEEE 29119-2 mapping. This activity, which is defined in Chapter 5 of ISTQB CTFL syllabus, includes six major sections: "Test Organization", "Test Planning and Estimation", "Test Progress Monitoring and Control", "Configuration Management", "Risk and Testing" and "Incident Management". Each of them is described below.

Table 2. Planning and Control (ISTQB) to ISO/IEC/IEEE 29119-2 mapping

ISO/IEC/IEEE 29119-2 Clause		a	b	c	d	e	f	g	h	i	J
6.2.4.1	Develop Organizational Test Specification	○	◔	○	○						
7.2.4.1	Understand Context	●	◑	○							
7.2.4.2	Organize Test Plan Development	●	○	○	○						
7.2.4.3	Identify and Analyze Risks	●	●	●	●	●	●				
7.2.4.4	Identify Risk Mitigation Approaches	◑	●								
7.2.4.5	Design Test Strategy	◑	◑	●	●	○	◑	◑	◑	○	○
7.2.4.6	Determine Staffing and Scheduling	◑	●	○							
7.2.4.8	Gain Consensus on Test Plan	●	○	○	○						
7.3.4.1	Set-Up	◑	◑	◑							
7.3.4.2	Monitor	●	●	◑	◑	○					
7.3.4.3	Control	●	○	●	◑	○	○	○	○		
7.3.4.4	Report	◔	○								
8.2.4.3	Derive Test Coverage Items	◑	○	○	◑						
8.3.4.1	Establish Test Environment	◑	◔	○							
8.5.4.1	Analyze Test Results	◑	●	◑							
8.5.4.2	Create/Update Incident Report	●	●								

"Test Organization" is strongly related to 7.2.4.5 Design Test Strategy (d) and it is very weakly related to 6.2.4.1 Develop Organizational Test Specification (b), as already mentioned in the section 3.4.1. Moreover, "Test Organization" indicated that "…the effectiveness of finding defects by testing and reviews can be improved by using independent testers…" and it provides options for independence but this approach is not contemplated within the ISO/IEC 29119-2 standard.

"Test Planning" is strongly related to 7.2.4.1 Understand Context (a). The above is also supported by the next two sentences within ISTQB CTFL syllabus: "… tailoring these main activities within the context of the system and the project is usually required" and "Principle 6 Testing is context dependent". Furthermore, "The Psychology of Testing" within ISTQB CTFL syllabus points out that "… People tend to align their plans with the objectives set by management and other stakeholders, for example, to find defects or to confirm that software meets its objectives. Therefore, it is important to clearly state the objectives of testing". In consequence, it is strongly related to 7.2.4.8 Gain Consensus on Test Plan (a) and it is partially related to 7.2.4.1

Understand Context (b). Additionally, “Test Organization” highlights tasks of the Test Leader and Tester and “Test Planning Activities” states that “… making decisions about what to test, what to test, what roles will perform the test activities, how the test activities should be done, and how the test results will be evaluated” therefore it is partially related to 7.2.4.6 Determine Staffing and Scheduling (a) and, when considering “Entry Criteria and Exit Criteria”, it was found that it is strongly related to 7.2.4.2 Organize Test Plan Development (a) as well.

“Test Planning and Estimation” is partially related to 7.2.4.5 Design Test Strategy (a) and it is strongly related to 7.2.4.6 Determine Staffing and Scheduling (b). Likewise, “Test Strategy, Test approach” is strongly related to 7.2.4.5 Design Test Strategy (c) and it is partially related to 7.2.4.5 Design Test Strategy (f and h).

“Test Progress Monitoring and Control” is strongly related to 7.3.4.2 Monitor (a and b) and 7.3.4.3 Control (a and c). It is also partially related to 7.3.4.1 Set-Up (a, b and c), 7.3.4.2 Monitor (c) and 8.2.4.3 Derive Test Coverage Items (a). And it is weakly related to 7.3.4.4 Report (a).

“Configuration Management” is partially related to 8.3.4.1 Establish Test Environment (a) and it is weakly related to 8.3.4.1 Establish Test Environment (b). In turn, “Incident Management” is strongly related to 8.5.4.1 Analyze Test Results (b) and it is partially related to 8.5.4.1 Analyze Test Results (a and c). And it is also strongly related to 8.5.4.2 Create/Update Incident Report (a and b).

“Risk and Testing” is strongly related to 7.2.4.3 Identify and Analyze Risks (a, b, c, d, e and f) and 7.2.4.4 Identify Risk Mitigation Approaches (b), while it is partially related to 7.2.4.4 Identify Risk Mitigation Approaches (a) and 7.2.4.5 Design Test Strategy (b). It is also weakly related to 7.3.4.2 Monitor (d) and 7.3.4.3 Control (d).

Furthermore, the test development process of ISTQB CTFL syllabus points out that “… can be done in different ways, from very informal with little or no documentation, to very formal …” and “... establishing traceability from test conditions back to specifications and requirements enables both effective impact analysis when requirements change, and determining requirements coverage for a set of test...”, that means it is partially related to 7.2.4.5 Design Test Strategy (g) and 8.2.4.3 Derive Test Coverage Items (d), respectively.

Test Analysis and Design. This activity has seven major tasks. Only one of them “evaluating testability of the test basis and test objects” is apparently non-related to any particular clause within the ISO/IEC/IEEE 29119-2 because the term “testability” is not made explicit on it. However, it could be achieved by the ways that the requirements of ISO/IEC/IEEE 29119-2 standard are fulfilling.

Table 3. Test analysis and design (ISTQB) to ISO/IEC/IEEE 29119-2 mapping.

ISO/IEC/IEEE 29119-2 Clause		**a**	**b**	**c**	**d**	**E**	**f**	**g**	**h**	**i**	**j**
7.2.4.5	Design Test Strategy	○	○	○	○	●	○	○	○	○	○
8.2.4.1	Identify Feature Sets	●	○	○	○	○	○				
8.2.4.2	Derive Test Conditions	◑	◑	●	○	○					
8.2.4.4	Derive Test Cases	◑	◑	●	◑	○					
8.2.4.6	Derive Test Procedures	○	◑	○	○	○	○				

8.3.4.1	Establish Test Environment	●	○	○							

The tasks “Reviewing the test basis (such as requirements, software integrity level* (risk level), risk analysis reports, architecture, design, interface specifications)” and “Designing the test environment set-up and identifying any required infrastructure and tools” are strongly related to 8.2.4.1 Identify Feature Sets (a) and 8.3.4.1 Establish Test Environment (a). Likewise, the task “Identifying necessary test data to support the test conditions and test cases” is linked with four requirements: one of them is strongly related to 7.2.4.5 Design Test Strategy (e), two of them is partially related to 8.2.4.4 Derive Test Cases (a) and the 8.2.4.6 Derive Test Procedures (b), and the last task is strongly related to 8.3.4.1 Establish Test Environment (a). While, the task “Identifying and prioritizing test conditions based on analysis of test items, the specification, behaviour and structure of software” is partially related to 8.2.4.2 Derive Test Conditions (a and b). In turn, “Creating bi-directional traceability between test basis and test cases” is partially related to 8.2.4.4 Derive Test Cases (d) and “Designing and prioritizing high level test cases” is partially related to 8.2.4.4 Derive Test Cases (a and b) as well. According to ISTQB “…the ‘Standard for Software Test Documentation’ (IEEE STD 829-1998) describes the content of test design specifications (containing test conditions) and test case specifications” therefore it is strongly related to 8.2.4.2 Derive Test Conditions (c) and 8.2.4.4 Derive Test Cases (c) as **Table 3** shows.

Test Implementation and Execution. This activity presents ten major tasks. Table 4 shows, as might be expected that “Dynamic Test Process” in ISO/IEC/IEEE 29119-2 is related to them. At first glance, Test Execution (8.4) is more related than other clauses (8.2, 8.3 and 8.5). On the one hand, there are four tasks that support it. Moreover, one of them “Reporting discrepancies as incidents and analyzing them in order to establish their cause (e.g., a defect in the code, in specified test data, in the test document, or a mistake in the way the test was executed)” is also partially related to 8.4.4.2 Compare Test Results (b) and 8.5.4.1 Analyze Test Results (a), and it is also strongly related to 8.5.4.2 Create/Update Incident Report (a).

Table 4. Test Implementation and Execution (ISTQB) to ISO/IEC/IEEE 29119-2 mapping.

ISO/IEC/IEEE 29119-2 Clause		**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**
8.2.4.4	Derive Test Cases	○	◑	○	◑	○					
8.2.4.5	Assemble Test Sets	◑	○	○							
8.2.4.6	Derive Test Procedures	◑	◑	◑	●	○	○				
8.3.4.1	Establish Test Environment	◑	○	○							
8.3.4.2	Maintain Test Environment	●	○								
8.4.4.1	Execute Test Procedures	●	●	●							
8.4.4.2	Compare Test Results	●	◑								
8.4.4.3	Record Test Results	●									
8.5.4.1	Analyze Test Results	◑	◑	○							
8.5.4.2	Create/Update Incident Report	●	○								

On the other hand, the task “Repeating test activities as a result of action taken for each discrepancy, for example, re-execution of a test that previously failed in order to confirm a fix (confirmation testing), execution of a corrected test and/or execution of

test in order to ensure that defects have not been introduced in unchanged areas of the software or that defect fixing did not uncover other defects (regression testing)" is partially related to 8.5.4.1 Analyze Test Results (a and b). The remainder tasks are also partially related to 8.2.4.4 Derive Test Cases (b and d), 8.2.4.5 Assemble Test Sets (a), 8.2.4.6 Derive Test Procedures (a, b and c) and 8.3.4.1 Establish Test Environment (a). Additionally, according to ISTQB "…during test implementation the test cases are developed, implemented, prioritized and organized in the test procedure specification (IEEE STD 829-1998) …", so it has a strongly relationship with 8.2.4.6 Derive Test Procedures (d) as well.

Evaluating Exit Criteria and Reporting. This activity includes three major tasks. **Table 5** shows, as one of them "Checking test logs against the exit criteria specified in test planning" is strongly related to 7.3.4.2 Monitor (b) and it is partially related to 7.3.4.3 Control (h). Whereas other task "Assessing if more test are needed or if the exit criteria specified should be changed" is partially related to 8.5.4.1 Analyze Test Results (b) and the 8.4.4 Test Execution (particularly see NOTE 2). The last task "Writing a test summary report for stakeholders" is also partially related to 7.4.4.4 Report Test Completion (a and b).

Table 5. Evaluating exit criteria and reporting (ISTQB) to ISO/IEC/IEEE 29119-2 mapping.

ISO/IEC/IEEE 29119-2 Clause		a	b	c	d	e	f	g	h	i	j
7.3.4.2	Monitor	○	●	○	○	○					
7.3.4.3	Control	○	○	○	○	○	○	○	◑		
7.4.4.4	Report Test Completion	◑	◑	○	○						
8.4.4	Test Execution - Note 2	◑									
8.5.4.1	Analyze Test Results	○	◑	○							

Test Closure. This activity has seven major tasks but only one of them is not made explicit in the ISO/IEC/IEEE 29119-2: "handing over the testware to the maintenance organization". The task "finalizing and archiving testware, the test environment and the test infrastructure for later reuse" is strongly related to 7.4.4.1 Archive Test Assests (a and b) (see **Table 6**). However, it is worth noting that this task could be considered related to 7.4.4.2 Clean Up Test Environment (a) "the test environment shall be restored to a pre-defined state on completion of all testing activities" if it is being taken into account when "finalizing … the test environment …". Likewise, the task "Checking which planned deliverables have been delivered" is strongly related to 7.3.4.2 Monitoring (b) and the task "Analyzing lessons learned to determine changes needed for future releases and projects" is partially related to 7.4.4.3 Identify Lessons Learned (a and b). Also, the task "using the information gathered to improve test maturity" has been considered partially related to 7.4.4.3 Identify Lessons Learned (a) because this could be achieved by recording "recommended improvements to the testing and other processes". Regarding the task "Closing incident reports or raising change records for any that remain open" and "Documenting the acceptance of the system", they are strongly related to 7.4.4.4 Report Test Completion (a, c and d) and they are partially related to 7.4.4.4 Report Test Completion (b). Finally, 7.4.4.1 Ar-

chive Test Assets (c) could be achieved if "the availability of reusable test assets shall be recorded and communicated to the relevant stakeholders".

Table 6. Test closure activities (ISTQB) to ISO/IEC/IEEE 29119-2 mapping.

ISO/IEC/IEEE 29119-2 Clause		a	b	c	d	e	f	g	h	i	j
7.3.4.2	Monitor	○	●	○	○						
7.4.4.1	Archive Test Assets	●	●	○							
7.4.4.2	Clean Up Test Environment	○									
7.4.4.3	Identify lessons learned	◑	◑								
7.4.4.4	Report Test Completion	●	◑	●	●						

4 Conclusions

This paper studies two well-established software testing process paradigms, namely ISTQB CTFL and ISO/IEC/IEEE 29119 standard. The mapping is defined following Baldassarre et al. approach [19]. In fact, a protocol was made which includes a test-retest approach and re-evaluation in order to gain reliability. As a result, the test process of ISTQB CTFL is largely cover by the ISO/IEC 29119-2. However, key concerns about "Handing over the testware to the maintenance organization" and "improving the test process by using independent testers" is not directly aligned with the ISO/IEC/IEEE 29119-2 standard. Furthermore, "evaluating testability of the test basis and test objects" seems to be overlooked because the term "testability" is not made explicit within the ISO/IEC/IEEE 29119-2 standard but it could be achieved by the ways of its requirements are fulfilled. Despite the fact that "the test development process [ISTQB] can be done in different ways, from very informal with little or no documentation, to very formal …", it would not be so obvious what to do. Although this current mapping does not cover 100% of the ISTQB CTFL syllabus the insights of this study indicate that an approach like this can be designed for achieving tailored conformance to the ISO/IEC/IEEE 29119-2. However, justification should be provided whenever a process defined in Clauses 6, 7, and 8 of ISO/IEC/IEEE 29119-2 is not followed. In fact, all tailoring decisions should be on the one hand recorded with their rationale, including the consideration of any applicable risks, and on the other hand, it should be agreed by the relevant stakeholders. This paper may contribute to a better understanding ISTQB CTFL and ISO/IEC/IEEE 29119-2 and therefore gain clarity regarding their relevance. In addition, it might help practitioners to use either of the two approaches for improving their software projects if they do not use these approaches as a checklist without sense [23]. Consequently, practitioners can use it as a source of inspiration, where each model represents a tool box as it points out by SPI Manifesto [23], to enrich their test processes by adopting the relevant test practices of the previous approaches. For organizations, it provides a more complete view on test process in general. For researchers, this paper provides an analytical deconstruction of both approaches through a systematic method, including a comparison and the identification of gaps, differences and overlaps. As further work, the authors are currently interested in the extension of the mapping presented here to test design techniques.

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