
**Faculty of Engineering and Technology**

**Master of Software Engineering (SWEN)**

# Software Testing Techniques and Methods used by Outsourcing Companies: Palestine Case study

Master's Thesis in Software Engineering

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This Thesis was submitted in partial fulfillment of the
requirements for the Master's Degree in Software Engineering
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Technology at Birzeit University, Palestine

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# Declaration of Authorship

I am Mohammed Anan Hussein Ali, declare that this thesis titled," Software Testing Techniques and Methods used by Outsourcing Companies: Palestine Case study " and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given and with the exception of such quotations, this thesis is entirely our own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by ourselves jointly with others, I have made clear exactly what was done by others and what I have con- tributes ourselves.

Signed: Mohammed Anan Hussein ALi

Date: February 27 , 2021

# Abstract

**Recently, the IT sector in Palestine has been gaining much ground with many software development companies which specialized in software development outsourcing services. Maintaining high-quality and robust software products has always been a key success factor in the outsourcing sector. Also, Software testing is considered to be the main phase in which teams can assure high quality of software products without any defects. Therefore, we did an exploratory multiple-case study about software testing and this study involves four Palestinian software outsourcing companies of different domain. We provided insights about factors that affect the quality of software testing practice, and explore different applied testing techniques, methods and confronted challenges. The results reveal that there is more attention toward software testing as software development companies are investing more effort, time, and technical resources into their quality assurance teams. Additionally, among the applied software testing methods, more attention needs to be directed towards test automation. Finally, we proposed a new model that can help practitioners to enhance the quality of their outsourced software products.**

# Software Testing Techniques and Methods used by Outsourcing Companies: Palestine Case study

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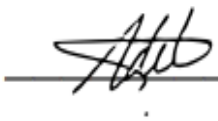

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# الملخص

فِي الآونة الْأَخِيرَة ، اكْتَسَب قُطَّاع تِكْنُولُوجِيا الْمَعْلُومَاتِ فِي فِلَسْطِينَ الْكَثِيرِ مِنْ التَّقَدُّمِ والتَّطَوُّرِ مَع العَدِيدِ مِنَ شَرِكات تَطوير البرمجيات المتخصصة فِي خَدَمَاتٌ التعهيد لتطوير البرمجيات . ولطالما كَان الْحُفَّاظُ عَلَى منتجات برمجية قَوِيَّةٌ وعالية الْجَوْدَة عَامِلٌ نَجَاح رَئِيسِيٌ فِي قُطَّاعِ الِاسْتِعَانَة بمصادر خَارِجِيَّة . عِلَاوَةً عَلَى ذَلِكَ , يُعْتَبَر اخْتِبَار البَرامِج الْمَرْحَلَة الرَّئِيسِيَّة الَّتِي يُمْكِنُ لِلْفَرْق مِنْ خِلَالِهَا ضَمَان الْجَوْدَة الْعَالِيَة للبرامج . وَلِهَذِه الْأَسْبَاب ، قُمْنَا بِدِرَاسَة اسْتِكْشَافِيَّة مُتَعَدِّدَة الْحَالَات حَوْل اخْتِبَار البَرامِج حَيْث تَشْمَلُ هَذِهِ الدِّرَاسَةَ أَرْبَع شَرِكات فلسطينية لتعهيد البرمجيات المتخصصة فِي مجالات مُخْتَلِفَةٌ. رُؤْيَتِنَا كَانَتْ فِي تَقْدِيمِ العَوَامِلُ الَّتِي تُؤَثِّرُ عَلَى جُودِه مُمَارَسَة اخْتِبَار البَرامِج ، واستكشاف تقنيات مُخْتَلِفَةٌ وَأَسَالِيب الِاخْتِبَار التَّطْبِيقِيَّة والتحديات الَّتِي مُمْكِنٌ أَنْ نواجهها . وَمَن خِلَال النَّتَائِج الَّتِي حَصَّلْنَا عَلَيْهَا اكتشفنا أَنَّ هُنَاكَ مزيدًا مِنْ الِاهْتِمَام بِاخْتِبَار البَرامِج حَيْث تستثمر شَرِكات تَطوير البرمجيات الْمَزِيدَ مِنْ الْجَهْدِ وَالْوَقْت وَالْمَوَارِد التقنية فِي فَرْقِ ضَمَان الْجَوْدَة الْخَاصَّة بِهِم . بِالْإِضَافَة التَّعَرُّف عَلَى الطُّرُقِ الْمُخْتَلِفَة الْمُطْبَقَة فِي اخْتِبَار البَرامِج فِي مُخْتَلَفِ الشَّرِكَات و تَوْجِيه الْمَزِيدَ مِنْ الِاهْتِمَام نَحْو أتمتة الِاخْتِبَار . وأخيرًا ، اقترحنا نموذجًا فَرْضِيًّا جديدًا يُمْكِنُ أَنْ يُسَاعِدَ الْعَامِلِينَ فِي هَذَا الْقُطَّاع والممارسين لَهُ عَلَى تَحْسِينِ جُودِه منتجات برامجهم الْخَارِجِيَّة.

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# Chapter 1

# Introduction

## 1.1 Background

Recently, businesses are more dependent on software products and the industry is paying more attention to automating their business processes. Many companies are looking to reduce the cost of software development as much as they can and increase system reliability. This can be achieved by exporting their software development to offshore vendors. Around 50% of the global IT market are using outsourcing [34]. Software development outsourcing is the activity of transferring functions and associated assets to an external supplier who provides agreed services for a specific time with qualified price [1].

The main purposes of outsourcing are to save cost, improved quality of services, and access to specialist expertise, free management time, and enhanced financial control [22]. There are many success factors which outsourcing activities focus on such as leadership activities, organizational learning, quality management, trust, customer satisfaction [24]. However,

outsourcing has many risks which can lead to lack of success and negative impact of customer satisfaction. For instance, bad quality, less knowledge transfer and lack of communication between client and vendor [24].

Outsourcing companies in Palestine care a lot about the quality of software to reduce the failures. Therefore, software testing is an important part of any software projects. It confirms that software projects meet requirements and conduct tasks effectively and efficiently. Furthermore, software testing has many testing phases and it can be one of the expensive tasks for any project due to poor analysis of software, more maintenance, and errors that lead to extra expenses [19].

There are few researchers who have researched the Palestinian development company's practices due to the fact that the Palestinian IT sector is still small compared to other countries IT sectors [37], [36], [2] [22]. Therefore, we were motivated to make an exploration study about software testing and how these companies adopted testing methodologies, tools and methods in their projects and how they confronted challenges. Our results revealed that there are many attention toward software testing by Palestinian outsourcing companies.

Additionally, companies apply a comprehensive set of testing methods, techniques, and testing tools. Further, this study shows that the percentage of automation is increasing but still relatively low due to many reasons such as time and cost constraints and this is lead that manual testing is still the dominant practice. What is more, we discovered that there is a gap between the industry and universities due to lack of testing courses in universities curriculum. Moreover, training and good management of technical teams are important factors, they play a role behind the quality of software. At the

end, we build a suggestion model which describes the needs and challenges of software testing outsourcing.

## 1.2 Research Problem

Nowadays, IT companies are facing different challenges and barriers to meet the quality standards of software projects especially in outsourcing companies. The main reasons behind these challenges are companies do not use the principle of testing correctly and the quality. All of companies look for the quality in their projects and this is achieved through software testing which become an essential for any projects.

In the last 10 years, the number of Outsourcing companies in Palestine has increased significantly, which has a positive impact on the Palestinian economy, especially the technology sector. [22]. However, very little is known about the testing practices and methods applied in these companies and how effective they are. Based on the literature, there are many studies in the world which care about software testing and software outsourcing [18] [4]. However, there are no studies focused on software testing in outsourcing companies in Palestine except two paper which focuses on mobile testing [37] and outsourcing in Palestinian companies [22].

Therefore, we used multiple case study to explore software testing and assess the current practice and levels of software testing that are used in Palestinian companies. We want to check the advantages of using testing practices and approaches to identify the most factors that affects software testing in any outsourcing projects. In the other words, to find the best

methods to reduce the percentage of failure and increase the percentage of success among software projects.

In this study, we revealed the reasons behind apparent lack of focus on testing and test automation, and how can the current situation be improved. Furthermore, to understand and get more knowledge about the factors that can increase percentage of automation across all testing activities and encourage to use many testing tools.

## 1.3 Research Questions

Our main research questions are as follows:

- **RQ1:** What is the state of practice of software testing in outsourcing companies in Palestine ?
- **RQ2:** What are the currently applied testing methods and techniques?

These questions assisted us to elicit data and collect them from interview questions that we used in our case studies.

## 1.4 Contributions

The main contribution of this thesis are as follows :

- This is the first study which cover software testing in outsourcing companies in Palestine. It focused on testing approaches and present testing practices. Furthermore, to understand the types, processes and challenges involved in software testing outsourcing companies.

- We identify the most frequently used software testing methods and techniques in these companies. We also present different tools that are used by outsourcing projects and to see how much automation are applied and its impact on these projects.

- This research presents an exploratory study that aim to identify the factors that affect quality of software testing outsourcing. We build a model that show all of these factors and can be used to enhance the current practices and theory of software testing. This model can be beneficial for both practitioners and researchers.

- We published paper about software testing outsourcing in Palestine and we got acceptance by scientific journal Vol 10 Feb 2021, Journal name is **IJATCSE** – "International Journal of Advanced Trends in Computer Science and Engineering".

## 1.5 Thesis Structure

The structure of this thesis contains many chapters including this chapter:

This research contains many chapters including this chapter :

- **Chapter One**: Introduction chapter has has an introduction about the topic and includes the problem of the study, research questions, contribution and the structure of the thesis.

- **Chapter two**: literature Review chapter includes the definition, related studies to software outsourcing, software testing within outsourcing teams, automation testing.

- **Chapter Three**: Research Methodology presents the methodology that we used. It show multiple case study approach and cover all of the methods that are used in data collection. Further, it shows the method that we used to analyze this study.

  Covers all of the methods that are used in data collection and methodology, data collection procedure.

- **Chapter Four**: This chapter presents the results of the data collected using observation, interview and focus groups methods.

- **Chapter Five**: Research Discussion provides detailed analysis of this study finding by discussing the results into different parts, provide proposed Conceptual Model and discuss the main threats of validity in this study.

- **Chapter Six**: The final chapter contains the summary of this research report, recommendation to improve software testing process and future work.

# Chapter 2

# Literature Review

## 2.1 Chapter Overview

In the last decade, researchers have turn to interest of Software development outsourcing and software testing because of their importance. They play major role behind the quality of the projects and reduce the number of defects that face teams.

This Chapter presents a literature on the Software Testing and Outsourcing field. It shows in depth the last research study about these topics and divided into groups. It begins with the first group which includes the definition of Global outsourcing software development, challenges and benefits. The second group presents software testing practices in outsourcing Development projects. The third group discussed automation and how teams applied automation during these teams. Finally, we summarize literature review.

## 2.2 Literature Review Protocol

### 2.2.1 Targeted Databases

This study has focus about two electronic databases ACM and IEEE, along with Google Scholar to find related work for software testing.

### 2.2.2 Search Keywords

There are many keywords used in the research such as Software Testing, Automation Testing, Software outsourcing, Case Study.

### 2.2.3 Inclusion and Exclusion Criteria

In our research, We followed inclusion criteria as follow:

- The target is to determine all of the papers that related to IT outsourcing and Software Testing, these paper are used to extract information and describe software testing outsourcing.
- All papers are written in English language.
- We have used papers for the last 5 years.
- All paper are extracted from online databases ACM, IEEE and Google Scholar.

The critical literature review is based on the methodology provided by Jesson et al. [20]. It was conducted on the final results set that contained 20 papers, the papers discuss three categories: Software Development Outsourcing, Testing Methods in Outsourced Projects, Automation testing.

## 2.3 Software Development Outsourcing

Outsourcing has become a major trend in human resources over the past decade. It's the practice of transferring functions and any associated assets to an external supplier or service provider for a specified period of time with probably qualified price. It also means a significant amount of work will be implemented outside the original company abroad [18].

Rawan et al [22] in their research explore and understand the challenges and factors that affect outsourcing in Palestine. They revealed that Palestinian IT sector are growing and found that outsourcing quality is affected by some factors such as client satisfaction, cost and geographical distances location. Therefore, they proposed model about outsourcing in Palestinian IT sector to expand their work. Moreover, Zarour et al [36] increase awareness of how software companies deal with software effort estimation and confronted challenges. They show that effort estimation accuracy increases with companies which adopt outsourcing models compared with companies that work in the local area.

The success of software development outsourcing depends on many factors such as good leadership capabilities, quality management practices, successful training arrangements, and knowledge transfer activities. However, one of the biggest challenges that outsourcing companies face is customer satisfaction followed by domain unfamiliarity and project schedule [24], [34].

There are many technical processes for any team which want to outsource: Define the set of activities for managing teams, identify opportunities for technology outsourcing, select partner and establish

contract, control and monitor contract and assure requirements were achieved, close contract and evaluate partners. Outsourcing companies have different levels of skill and maturity when considering software development processes [7]. Any organization needs to understand the nature of projects and importance, also they should comprehend the project purpose clearly [16].

Moreover, Outsourcing development should follow agile and incremental development approaches. Outsourcing activities also need to focus on leadership, organizational learning, and quality management practices, trust and customer satisfaction. Additionally, the success of outsourcing depends on Personal working at the operational level and sharing knowledge between outsourcing parties which are so important [18].

Outsourcing has many advantages for any organization, cost saving as a core objective. It is considered as a solution, since it is usually easier and faster to establish cooperation with another partner. Any IT departments face increasing pressure to achieve and accomplish more with less money and resources [18]. However, despite the amount of outsourcing experience and knowledge, the outcomes can surprise and not always positively and have many risks. It can bring a negative impact of customer satisfaction, kinds of failure in work and the typical challenges that face teams unsuccessful leadership and communication. Additionally, some challenges such as Geographical barriers, Intercultural differences, Confidentiality risk, Loss of control and language, these challenges are the main challenges which are found in any software outsourcing [22].

Based on the lesson learned from the last practices in the outsourcing situation. Development and interaction were needed in communication

and interaction practices and more focus on training arrangements. The IT trainers should have training competencies and preferably pedagogical knowledge and need to have hands-on experience. Successful training management with good practices and contents can bring cost savings and decrease the need to retrain [18].

Majnoja et al [24] show that main managerial implications can be conclude as a need to focus on quality management practices, leadership capabilities, knowledge transfer and trainers' competencies and successful training arrangements. They advise that outsourcing development should follow agile and incremental development approaches, and to focus on efficient and timely knowledge-transfer activities.

## 2.4 Testing Methods in Outsourced Projects

In recent years, software testing is becoming more important and popular in the software development industry. Testing is the critical element of software quality assurance and represents the ultimate review of design, specification, and coding. Software can be tested either manually or automatically.

There are many previous surveys and studies which have revolved around various practices and issues about software testing outsourcing , their findings show that software testing is a very important phase in software validation and verification [9]. Testing phase is important due to many reasons: reduced cost and time, building software with high quality, ensuring that projects tasks work properly and being able to do all of the functions correctly [17]. Therefore, the management of software

testing outsourcing projects need some guidance [16]. However, there are many challenges and barriers such as money, cost and lack of resources and expertise, available time for projects. Cost items can be divided into direct cost and indirect cost, which represent projects expenses [4], [30]]. Moreover, universities do not consider software testing as part of their educational curriculum and there are many barriers behind the weakness of giving education and training such as budget and schedule constraints [21].

However, all of studies care and give attention to software testing in different countries [14] [4] [3], but there are no studies in Palestinian outsourcing companies except the study by Samer et al [37] who identified the current testing techniques and challenges that they face in mobile applications in Palestinian companies. They revealed that testers and developers have low experience and skills on how to test and develop mobile applications and present some issues such as communications issues.

Additionally, there are many testing methods and types and many studies show that black box is slightly more dominantly used than white box testing method in software organization [32]. Also, manual testing is still the dominant and automated testing is limited. Further, unit testing is still little used while system and functional testing are used a lot [34]. Some studies show that system and acceptance testing are useful and important while usability, and security and Performance are the top three non-functional testing activities [19], [27].

After making the decision to conduct testing outsourcing, there are many important processes, strategies must be planned and goals and

objectives must be defined. The schedule should be estimated and specify infrastructure and human resources needed. The work space is important and cost estimation too. The determination of test work priorities and appropriate test parts to outsource should be set in advance [29].
Vukovic et al. [4] present software testing techniques and methodologies like this:

(i) Static vs. dynamic testing

(ii) Box (testing) approaches

(iii) Testing at different levels (integration testing, unit testing, and system testing)

(iv) Testing types (installation testing, compatibility testing, smoke testing, regression testing, and acceptance testing)

(v) Alpha testing

(vi) Beta testing.

Moreover, some test processes are:

(i) Agile or extreme testing

(ii) Top-down or bottom-up testing

(iii) Testing in the traditional water fall model

(iv) Automated testing by using tools.

Hrabovská et al [13] provide an overview of existing software models which can be applied to improve testing process. They represent 17 testing models which identified to show the advantage and procedure of each one.

To improve the testing process and make it more beneficial, the appropriate test tools and systematic procedure are necessary. The testing process must be continuously controlled and testers should monitor their progress. Moreover, Reporting testing status is so important. However, Some testing outsourcing projects have failed outright. These projects either exceed the specified time or the allocated budget or failed to deliver the anticipated quality [16].

Although, Software testing outsourcing is becoming a trend in many organisations nowadays. There are many advantages that are believed to be obtained through software testing outsourcing such as cost savings, access to experts and better technology as well as higher quality software products. provides some understanding of the current practice [16].

On the other hand, there are many testing tools which widely adopted for different purpose such as test execution, test management, performance testing, defect tracking, test automation and test design [27]. Further, like Ibrahim et al [15] paper show comparison with different testing tools and automated testing methodologies which is helpful in selection testing tool and methodology which is helpful in terms of cost and time.

## 2.5 Automation Testing

These days, automation testing has become a solution for many companies due to many benefits such as reducing cycle time, decreasing testing costs in software development. It shows the positive effects on budgets and quality and carries out the testing tasks in effective ways. It is also considered a core component in agile development [11]. Furthermore, automation

testing helps large organizations to expand their projects such as Google and Microsoft [10].

However, automation testing has maintenance costs and high implementation, sometimes is difficult to maintain and has significant failure and risk [23], [9]. Also, lack of testing management makes the automation process more complex and leads to failure. Furthermore, automation for small projects is too expensive due to setting up automation and make configuration can be too costly compared to the rest of the testing effort. Sometimes automation leads to extra effort and cost and could be even less effective than manual in detecting errors [10].

Furthermore, software testing tools can be divided into different categories as follows: testing management tools which are used for storing information, load testing tools that are used to determine the behavior under different loads and testing functional tools [4]. Testing tools are useful to record and play and re-executed test cases repeatedly. There are many powerful tools which are used for automated test execution —for example, Selenium and Testdroid [15] [10]. Selenium is the most common tool and used for mobile applications and web development in Pakistan IT industry [19].

However, automation cannot replace manual testing completely or eliminate personnel costs. It became more mainstream in the software industry. The decision on when and what to automate becomes very important since wrong decisions in this context can lead to disappointments and major wrong expenditures (resources and efforts) [11]. Many organization see automation's testing as a solution to reduce cycle time and decrease testing costs in software development [11].

Test automation has a history of over two and half decades, it is the solution of time problems in software testing. Automation doesn't come for free and thus must be carefully implemented to ensure success [10]. Automation can lead to many benefits such as higher software quality and cost savings. Also, it can manage time and cost and improve the process effectiveness by reducing risk of human error and make tests more repeatable and improve the process efficiency. It depends on stability and structure in the testing and successful processes. The replacement of manual work by automation will cause major change in the tester daily work. So changes to the work require major training and training require both a budget and time and priority in the work schedule [33].

Test automation is a core component in agile development. Moreover, automation suggests quality improvement by providing formal test coverage, avoiding human error and speeding up the test execution process [23]. Test automation has positive effects on software quality developed which saves time and resources [23] [10].

Additionally, automation of test cases has a high implementation and maintenance costs, sometimes is difficult to maintain and has significant risk and failure. Lack of management makes the process of automation more complex and leads to failure. Through testing life cycle, Small and medium sized companies are often unaware so much into automation due to automation is too expensive for small projects, Setting up automation can be too costly compared to the rest of the development effort [25]. Further, test automation is often a complex activity that requires specialist skills.

While test automation mostly started with the automation of test

execution, it has expanded to other areas of testing too, e.g., automated test-case design, automated test scripting, and automated defect reporting [11]. Papers present six testing activities where a large potential for automation could be seen [11] [16] :

(i) Test scripting

(ii) Test-case design

(iii) Test evaluation

(iv) Test-result reporting

(v) Test execution

(vi) Test management and other test engineering activities

## 2.6 Summary

The aim of this chapter is to make a comprehensive picture of the Software outsourcing and software testing and relationship between each other and discuss these topics through the literature review in order to provide better understanding of the concepts and current practices.

Software testing outsourcing brought the attention to researchers across the world, many research papers have been published. These papers present a lot of knowledge about the last testing practices and which factors affects testing process. These paper also show the advantages and disadvantages of applying all of testing approaches and methods. Further, they show many factors that play a role behind applying automation methods in outsourcing teams.

Despite the increase in the number of achievements related to software testing and outsourcing in different countries during the past years, and the increase in the number of research related to it, there is still a lack of research focusing on exploring the outsourcing testing in the Palestinian technology sector[37][22]. In this study, we aim to further explore the impact of factors on the Palestinian technology sector, as this study will be beneficial to all practitioners and researchers.

# Chapter 3

# Research Methodology

We did an exploration research to gain in-depth understanding about software testing practices in outsourcing companies in Palestine and explored how they applied testing methods and techniques.

## 3.1 Qualitative Research

Qualitative research is considered as one of the research related to social sciences that aims to collect data, explain its meanings and help in understanding social life by studying populations or targeted places. One of the most important aspects of qualitative research is gathering, organizing, analyzing and activating information [26].

On the other hand, qualitative research seeks to understand the social reality of cultures, groups and individuals and to identify their characteristics, and their natural environment. This type of data is descriptive, not numeric. Further, qualitative research aims to explore and explain phenomena and behavior through "how" and "why" [35].

In this study, we conducted a qualitative research to understand the software testing within software outsourcing teams in the Palestinian IT sector and explore the main methods and techniques that are applied.

## 3.2 Case Study Design

The main goal of our research is to collect data and make an exploration study about software testing in outsourcing vendors and understand the factors that affect software testing. Therefore, we used case study which is the most suitable for this type of research. Case study depends on industry and plays a good role in defining theory and theme. It divided into single case and multiple case study and we applied multiple case studies due to it being considered more trustworthy and active than single case. It also gathered more data from cases and gave good descriptions about the characteristics of each case. However, it needs time and resources compared to the single case research, and case study shouldn't merge with statistical sampling and replications.

Additionally, theoretical propositions approach assist us to know which data can be ignored and which data should be focused on [35]. Our research depend on multiple-case study design which can be shown in Figure 3.1 and inspired by Yin [35].

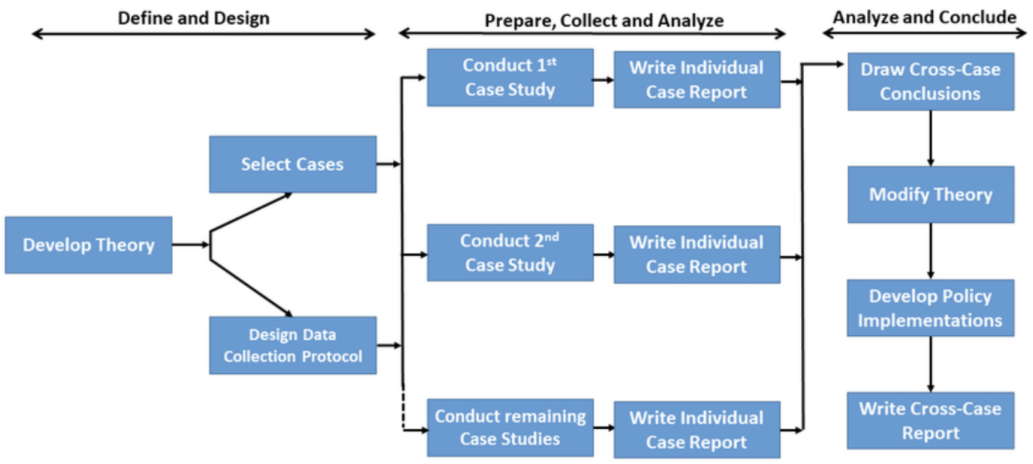


FIGURE 3.1: Multiple-case study Design [35]

## 3.3 Data Collection Procedure

In this study, our approach to do case study was based on collecting data through observations, interviews and focus groups. These methods are the source of our data that were collected to ensure case study construct validity through data triangulation [12] [31]. Since we collect data from different sources and have qualitative research, data triangulation is the most suitable and helpful. It helps us to more quality data and also save them in places that would easily be reached by another researcher such as a document and spreadsheet. Data triangulation can be shown in figure 3.2.

In this study, we mainly relied on selecting cases based on the availability of team members, companies 'acceptance and readiness, personal relationships and past experience. We selected four Palestinian software companies which give outsourcing services and we called them C1, C2, C3 and C4. We made two focus groups and four single interviews with these cases. The first company C1 had one focus group and two single

interviews. The other cases were also a single interview except C4 which was a focus group.

Before data analysis, we recorded all of the notes and data which discussed during the interviews and transcribed them in spreadsheets and documents using an identification code [8]. During the analysis, we used thematic coding approach to make analysis and it depends on giving each sentence special code and linking them to the original spreadsheet and document. Also, we spent three month during collecting all of the data from cases. Furthermore, our data was stored in documents which allow the other researcher to trace and retrieve [35], [28].

All of the data in this study are available in GitHub repository as PDF and spreadsheet. The link has all of results of all interviews: [1].


FIGURE 3.2: Data triangulation

[1]https://github.com/MohammedHussein15/ThesisData

### 3.3.1 Focus Groups

Focus group is one of market research methods that are popular because it is lower cost than other methods, results can be generated very quickly and it's easy to conduct and accurate. This technique is flexible and can be adjusted based on group behavior. It is designed to identify the feelings, perceptions, and thoughts of consumers about a particular product, service, or solution. This method will be used with a small group of participants at the same time in a conversation designed to generate data relevant to the research question [35].

Focus groups are group interview techniques for data collection. It is employed for their effectiveness in exploring and identifying relevant questions in a research area. focus groups helps interviewees to support each other in their answer and helps the researcher to understand outsourcing teams in general and when Software testing methods specifically. Moreover, to collect views and opinions from participants, it follows the same interview questions style semi-structured and open-ended questions [35].

We conducted two focus groups with cases C1 and C4, the focus group was with a group of participants due to the individuals gathered having common experience or sharing common views. Our role during the session was a moderator and collecting data and notes. The number of participant for each focus interview were three and it conducted in their company.

### 3.3.2 Interviews

In this method, face-to-face interviews are conducted with software outsourcing team members. Interviews were semi structured and open-ended since they are well suited for this kind of research. Interview saves time and increases the knowledge of both the interviewer and the interviewee, also it can help to collect fresh, new and primary information as needed. Further, this approach helps interviewees to express themselves freely and openly to learn more about issues related to research topics from their own perspective by answering different questions [35].

Regarding interviews, some of the interviews were held online and the other were face-to-face. We applied semi-structured open ended design in our interviews and this approach was discussed by Hancock Algozzine [12].

We conducted two single interview with case C1 and both of them were online. We also conduct online interview with C3 but C2's interview was held in their company. Each interview consists of three parts. Firstly, we gave all of the participants an introduction about our research and why we selected them. Secondly, we asked them to introduce themselves and told us about their experience. Finally, all participants answered all of the interview questions and we collected all of the data. At the end of interviews, we thanked all interviewees about their participation.

### 3.3.3 Observation

Observation will be through by taking notes on the behaviors and activities of software team members. It can provide an understanding on how

things work in clinical practice. Observation Good for explaining meaning ,context and Access to people in real-life situations [35]. It is known as a frequent source of information in qualitative research and it provides more objective information.

Outsourcing teams who adopt software testing methods have many activities which can be observed and investigated. This will help to reveal more information about different activities such as factors and challenges that faced all of the team and company and process to implement testing methods correctly, present factors that affect testing and how teams find defects and solve them. The data is collected through recording field notes by the researcher in unstructured or semi-structured activities in the research site about the behaviors and activities of the Software testing team.

The first company was the only company which allowed us to collect information through observation. So, the process of observation was by taking notes on the behaviors and activities of participants of C1. All activity related to type of testing, testing tools, framework, methods that are used for recording and identifying bugs and challenges that they faced.

## 3.4 Data Analysis

Since our research is qualitative research, we used thematic analysis due to it being a popular method and can be used to analyze research questions and datasets with different ways. It depends on finding the theme for data, label themes, organize them, analyze them, and report research papers. Thematic coding is a good method to analyze data in case study research methodology [35].

In our research, we applied thematic coding and followed steps which were suggested by Clarke and Braun [6]. After we conducted all of the interviews, we familiarized all the data which was recorded, we created labels for the important features. Then we identified and searched suitable themes for our data. We review these themes and ensure that each theme has names. All of these processes were documented and saved them in spreadsheets. Figure 3.3 shows the steps of process that we have followed.

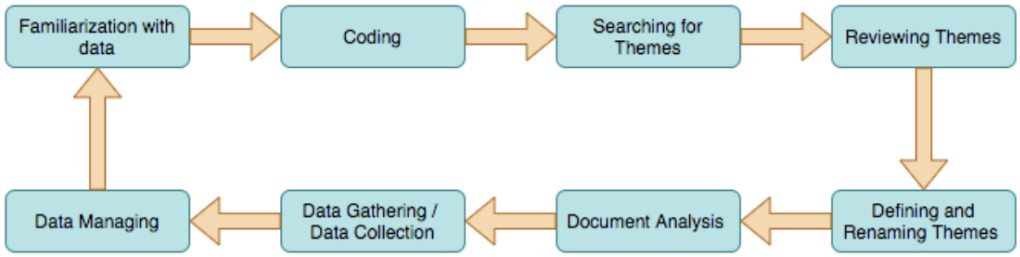


FIGURE 3.3: Data analysis steps [22]

# Chapter 4

# Research Result

## 4.1 Demographics information

In our study, we include four different cases and we refer to them as C1, C2, C3 and C4. Each company has a different number of employees and we considered a company as a large company if they have more than 200 employees. Further, if the companies have 70 to 200 employees, we call them as medium companies. However, companies which were less than 70 were considered small companies [22].

The first Case study (C1) which is a large company with multiple teams, it provides different software and hardware services. Teams there are specialized in developing web, mobile applications, network services and cloud systems. The second case study (C2) is considered as a medium sized company, it provides multiple solutions which relate to Hardware.

The third company (C3) offers digital marketing and sales solutions for the restaurant section and it is a medium size company. The last company C4 specializes in providing financial services to businesses customers. It's

a small company that provides software services for United State and European companies. Table 4.1 shows all of the demographic data.

TABLE 4.1: Cases Demographics Data

| Case study ID | Specialization - Provided Services | Company Size | International Client Locations | Number of Interviewees | Number of Company Employee |
|---|---|---|---|---|---|
| C1 | Hardware , Software | Large | United States, France, Israel, Taiwan, Ukraine | 5 | 330 |
| C2 | Hardware , Software | Medium | Israel, United States, Europe | 1 | 120 |
| C3 | Software | Medium | United States | 1 | 75 |
| C4 | Software | Small | United States, Europe | 3 | 35 |

Moreover, Table 4.2 presents the demographic data of each participant in the focus group and interview. It shows the role of each participant in their teams and how many years of experience do they have in the general and testing field. Moreover, the table shows the highest academic degree and number of team members for each one. At last, it includes the gender of each one.

The following sections present findings of cross-case analysis that identifies similarities and differences in the description of testing approaches, methods, tools, methodologies. It summarizes common observed testing practices in each case.

TABLE 4.2: Interviews and Focus Groups Participants Demographics

| Case study ID | Type of Research Method | Role in the Team | Experience | Testing Experience | Highest Academic Degree | Number of Team Member | Gender |
|---|---|---|---|---|---|---|---|
| C1 | Focus Group | Senior QA Team Leader<br>Senior QA Team Leader<br>QA Manual Test Engineer | 11 years<br>12 years<br>2.5 years | 11 years<br>10 years<br>2.5 years | Bachelor<br>Bachelor<br>Bachelor | 5 members<br>3 members<br>4 members | Female<br>Female<br>Female |
| C1 | Single Interview | Project Manager | 10 years | 10 years | Bachelor | 6 Team Leaders, Each Team 5-6 | Male |
| C1 | Single Interview | QA Team Leader | 10.5 years | 5.5 year | Bachelor | 4 members | Male |
| C2 | Single Interview | Technical Team Leader | 10 years | 10 years | Master | 7 members | Male |
| C3 | Single Interview | QA Manager | 4 years | 3 years | Bachelor | 14 members | Male |
| C4 | Focus Group | Senior QA<br>Senior QA<br>Senior QA | 8 years<br>8 years<br>8 years | 5 years<br>5 years<br>4 years | Bachelor<br>Master<br>Bachelor | 6 members<br>6 members<br>5 members | Male<br>Male<br>Female |

## 4.2 Applied Testing Approaches

All of the cases have different types of outsourced projects which part of them related to software and the other related to Hardware and network. For example, C4 provides Financial systems where users can use money investments, financial analysis and comparing data. C3 offers solutions for restaurants which have different operations such as reporting, scheduling, organizing, controlling, monitoring employees and accounting. Moreover, the second case C2 has a Software that helps for designing chips, semiconductor and make validation and improvement for the results. The last case C1 has different teams and types of projects such as Network

management system which provide controlling, monitoring network's packets, servers. In addition, the other teams of C1 care about Hotels and Communication apps. Furthermore, all of cases use web platform in their projects, beside web platform C1 and C3 use mobile platform and this is can be shown in Figure 4.1.

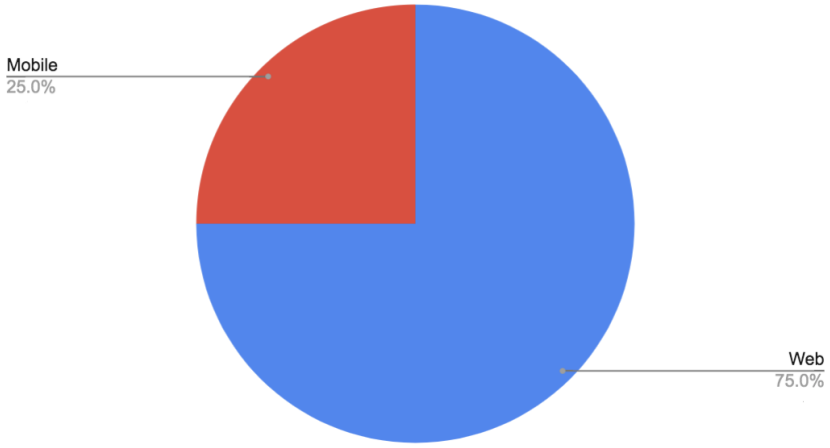


FIGURE 4.1: Platform that are used

In general, Quality assurance is important the same as development. Companies investigate different types and levels of testing to meet requirements, increase quality and reduce the errors that happened with different teams. There are many different types and levels of testing and each one has its objectives. In our study, all of the cases deal with many levels and apply many methods and try to apply as much as they can to make software without any bugs. Functional and non-functional testing are so important and include different types and all cases deal with them.

Additionally, software testing has many phases and all of the phases are important such as requirements, design and execution. Requirements

come from different sources such as customers through sales and marketing teams and project managers, sometimes it comes from testing teams. Without analyzing and understanding the requirements correctly, there will be problems in the other phases. Testing teams have standards for testing and automation. New ideas come from product owners who suggest features, discover and buy new products. This is mentioned by C3: "We have a huge number of clients, each team of our company has a product owner who speaks with these clients. Product owners explain ideas for the teams about what are the new features and give suggestions. Sometimes clients ask for special features and QA teams approve features by asking clients if they care or not. " – QA Manager, C3.

There are many factors that stand behind the success of software testing outsourcing in any project such as time, good requirements, clear process, and factors related to team management, human resources and personality. This is highlighted by one of QA team leader in C1:"After good experience in software testing, there are many factors that depend on the success of projects such as if the team is qualified or not, bad time allocation, critical bug after production or from the customer, poor testing and weak process. Moreover, check the test plan if it is good or weak and if there are missing cases." – Senior QA Team Leader, C1.

On the other hand, students who come from universities care more about development and give more attention to development jobs. They said that these jobs gain more experience and salaries. This is confirmed by C1 who said: "Students are weak and they have misunderstandings about

testing approaches and principles. They care more about development than testing and said that testing is not important and this is wrong. "– QA Team Leader, C1.

In general, students who come from local universities don't have any experience, so training is so important to solve this issue. All of the cases give training for their fresh students and novice testers, except C4 who do not give any training and let the others depend on themselves. Furthermore, time is an important factor for training and topics of training too. So, some cases such as C3 give training for two month for the automation course and two weeks for a manual course. C2 gives two month training about software testing both automation and manual. Regarding C1, they have good programs which cover problems of testing, goals, approaches and methods. Some teams inside C1 give training practical tasks 1-2 month and others suggest good material for any fresh testers ten days for manual and one month for automation, UI and API testing. They train to hire and make them junior to be ready to join. Moreover, C4 recommended about ISTQB certification [1], they said that this certification is so useful.

[1] International Software Testing Qualifications Board

### 4.2.1 Testing Methods and Applied Tools

The findings from our interviews revealed that all of the cases applied agile methods in their projects except C2. Agile methodology is so important and beneficial for software testing and many companies applied it in their teams.

Each project consists of many features and has many sprints and each sprint has different needed time. Some cases like C3 need for a sprint two week and others more than three weeks to finish any sprint. Time depends on feature size. According to C1 who explain the process in their work , he said: *"The scenario of our testing is: features come from the customers then we understand these features clearly then our test engineers write test cases such as sanity, performance tests then we review these tests and filter them. After that, we decide which tests are manual or automation. Finally, when the QA team has approval to execute, the sprint begins and we try to finish it on time. Moreover, We care about agile methods such as scrum and give attention to documentation "* – Project Manager, C1.

Figure 4.2 shows the summary of testing techniques that are applied in all cases. This diagram show how many case use different testing methods. We revealed that all of cases apply Manual, Automation and Black box testing. Also, functional and nonfunctional testing are important and used with different percentage.

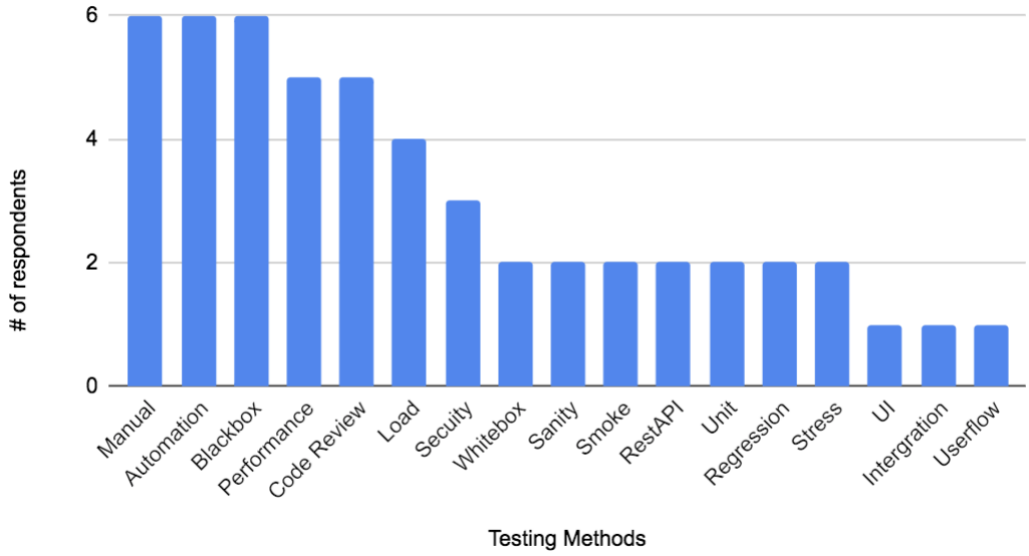


FIGURE 4.2: Frequency of Testing Methods that used by Cases

Additionally, there are many tools that are used by all of cases and help teams in their works. These tools divided into:

- **Communication** tools, cases use different tool for communication and the most used one is Microsoft Teams. These tools can be shown in Figure 4.3
- **TestPlan** tools which used for storing and managing test cases, these tools can be shown in Figure 4.4
- **Different** tools used for different purposes. These tools can be shown in Figure 4.5

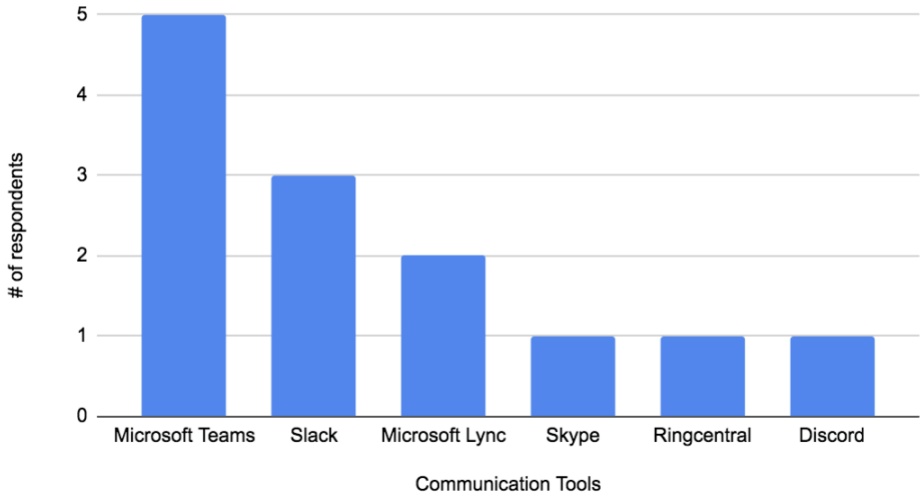


FIGURE 4.3: Frequency of Communication tools that used by Cases

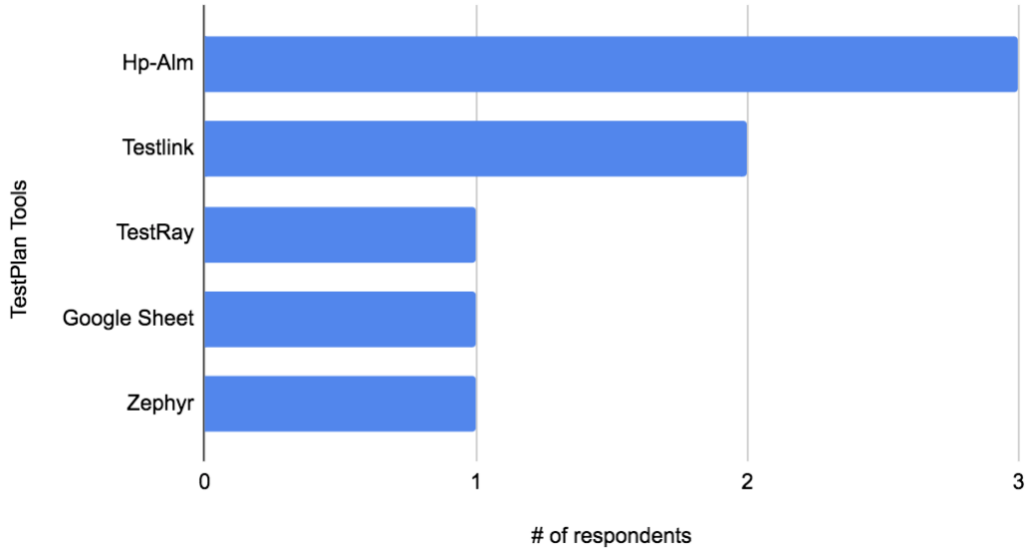


FIGURE 4.4: Frequency of Test Plan tools that used by Cases

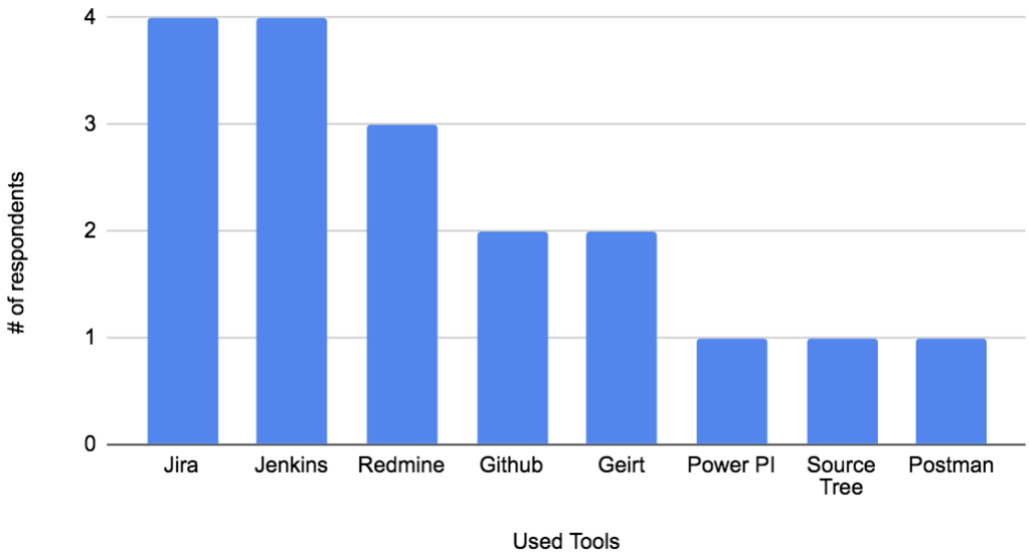


FIGURE 4.5: Frequency of different tools that used by Cases

On the other hand, there are many prevention techniques that are used by cases to increase the quality of testing. All cases have common techniques such as increasing communication between teams and increasing the number of meetings between them. Also, make good documentation for the process of software testing and transfer knowledge. Moreover, C4 mentions that there is a gap between IT and business, this creates misunderstanding and lack of knowledge. He said: "*After my experience, there are many techniques to enhance such as code review for API automation, good knowledge transfer. Therefore ,QA engineers should have business wise and make more communication between IT and business. Furthermore, sometimes there is a gap between junior and senior testers*" – Senior QA, C4.

### 4.2.2 Automation Testing

Based on the data that we collected, all cases use automation testing in their projects. Figure 4.5 shows the automation percentages for each cases which depends on the number of test cases that be executed by automation testing. For example, C4 said that they have 11,000 test cases, 25% of these tests are executed by automation while the rest executed by Manual testing. Furthermore, C1 divided into three column due to case 1 has one focus group and two interviews.

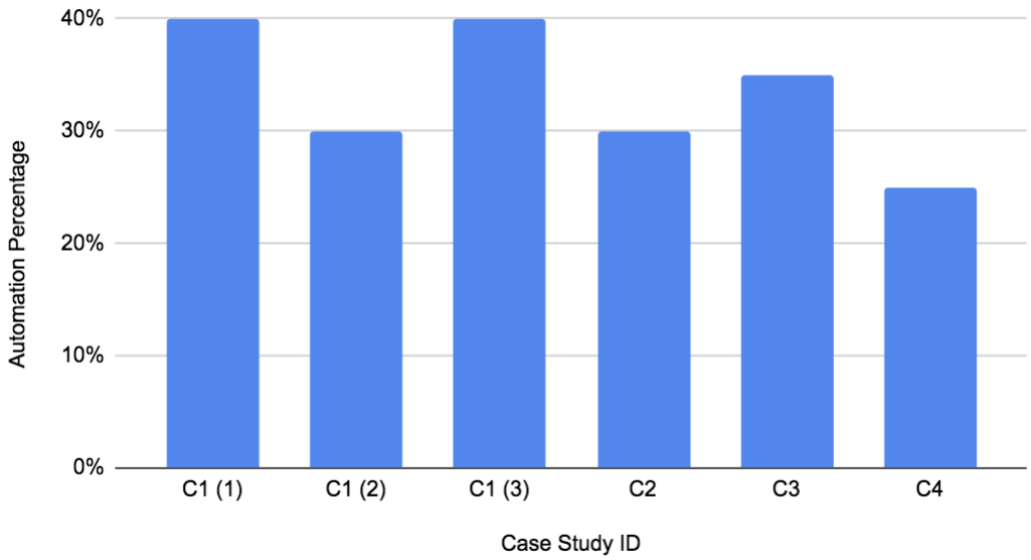


FIGURE 4.6: Automation Percentage for each cases

Additionally, automation testing need many tools which are important to execute test cases and give report about all of the results. Selenium tool is one of the famous tool that are used by different cases due to its free and open source. Figure 4.7 show different automation tools used by cases. Moreover, the most used programming language is Java and this can be

shown in Figure 4.8, all of cases use Java except C4 that use C#, some cases use different language for different purposes.

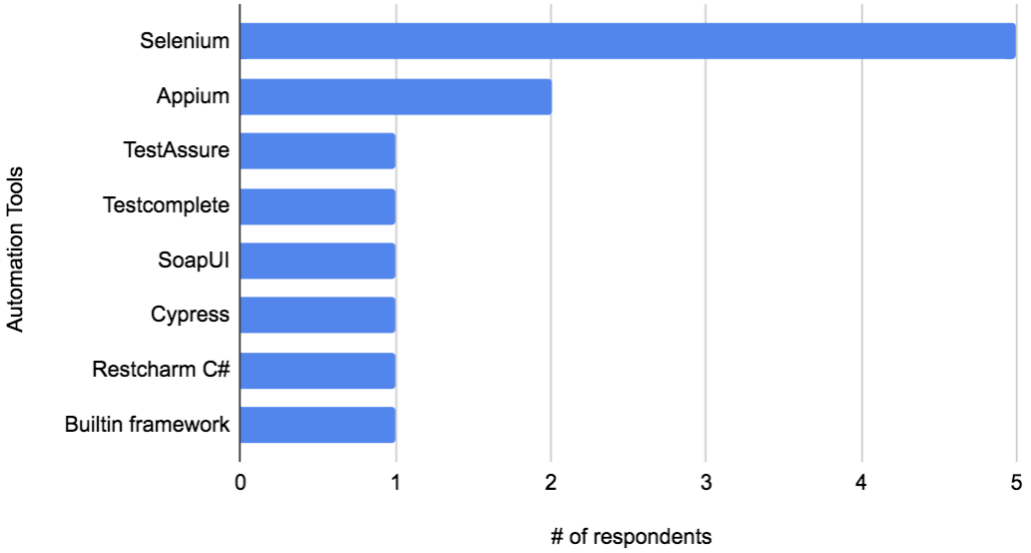


FIGURE 4.7: Automation tools that are used by cases

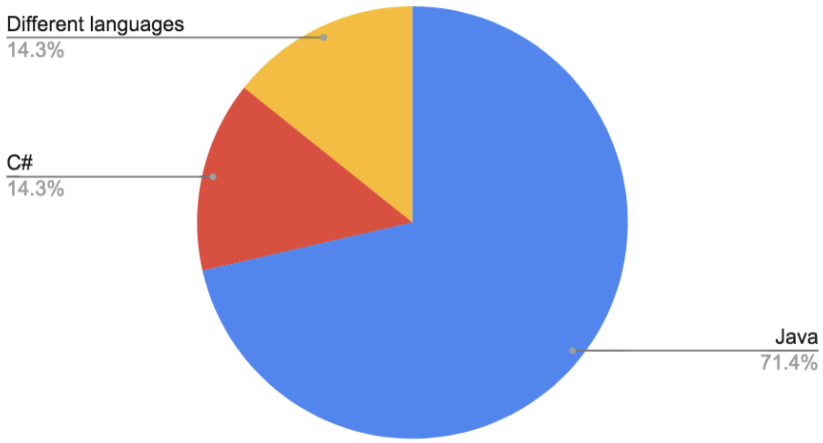


FIGURE 4.8: Programming languages that are used by automation

### 4.2.3 Results of Interest

All of cases advise and give an good results, in-general all cases try to do a full quality assurance process and full coverage percentage for test plans.This can be confirmed by C1 who said: "*at least 90% percent of test cases should be covered*". So, there should be approval from QA teams and without approval releases will not be launched. Moreover, Time management is so important for the testing process, at least 2 weeks to 3 weeks for doing all of the testing process C3 & C4 need two weeks for their sprint while C1 need for their sprint 3 week. Furthermore, C1 advises us that the tester and developer ratio should be 1:2.

# Chapter 5

# Research Discussion

## 5.1 Introduction

In this chapter, we discussed all of the results that we gain through data collection methods. The targets are to explore and increase our understanding of testing methods that are applied by outsourcing teams in the Palestinian IT sector and the challenges that they are facing and give good recommendations to these teams especially latest testing practices. Moreover, we discuss the factors that help industry to increase quality of testing. Therefore, We build a conceptual model that show different factors with their components and relationship with each other.

## 5.2 Testing Approaches and Challenges

Several insights can be concluded from the results related to software outsourcing testing and many factors play a good role behind the quality of software testing. In general, it was observed that the Palestinian industry

is paying more attention to the needs of software testing. This can be shown by the number of testing projects being increased in the current period. Outsourcing companies care more about testing and give good budgets and resources unlike local, government and startups projects which don't care so much, this is can be confirmed by C4. Therefore, there are many factors for good software testing such as communication internally or externally. We observed from the result that all cases suffer from bad communication between teams and they said that they are suffering, this bad communication leads to misunderstanding and gaps between team members and increased coordination costs. Furthermore, sometimes there are issues that come from the development side such as misunderstanding of the requirements clearly, less communication, low developer's experience and skills. Moreover, three cases C1, C2 and C3 confirm that bad English language decreases the quality of the testing process since team members are communicated with each other especially from different cultures and countries. Therefore, to solve these issues, teams should make good analysis for requirements and hold more meetings and increase collaboration between teams and select students who have good English language skills. On the other hand, tester skills are so important and all of the cases advise that testers should have development skills and think like developers, object oriented and programming language's basics help to increase the quality. Further, C1 suggest the number of testers regarding to developers ratio should be 1:2 and this came across with paper [3].

The results show good testing management and good requirement

analysis will lead to successful projects. There are many testing phases and each phase has many processes and should be clear. Regarding cases, testing requirements and features come from customers through the marketing team and product managers, and sometimes the testing teams suggest some requirements. Requirements divide into features and stories, and each feature has a different number of positive and negative test cases. All of these things should be documented clearly with good details. Despite all of these processes, testing teams should execute at least 90% as coverage of any testing cycle.

Any testing team should consider many aspects and key challenges: time, resources, cost, and size of the projects, quality of tools, skills, salaries, high academic degree, environment, staffing and training (material and time). The result shows that time is a barrier and it plays a good role behind the quality of software testing. Moreover, a good environment reduces technical issues that outsourcing companies face. However, number of participants in our cases who have high degree are low and the salaries of testers in Palestinian companies are less than developer. Therefore, students prefer any development jobs more than testing.

One of the important factors to increase and enhance quality of testing is increasing the percentage of training and all of the cases recommended this. Before the beginning of any software testing job, there should be good training for that job. It's essential for young testers to get their hands dirty with real testing work. There should be a map for the road of testing and a balance between theory and practice. Moreover, there should be training

about the business environment, what the current projects are and what are the constraints and company culture and give good induction about making the person feel welcome. The results show that companies should prepare good training's material about software testing and give more exercises with many test cases and continuous feedback. Unfortunately, universities' curriculum often neglect software testing courses, they prefer to focus on building software.

## 5.3 Lack of Automation Testing

Based on the response of all interviewees and the results, manual testing is still in the dominant position versus automated testing. Percentage of Automation in outsourcing companies is less than manual due to many reasons such as time, cost and resources. All of the cases applied automation testing with low percentage and prefer manual due to manual testing is a good fit for smaller projects but if the number of team's increases and companies become bigger, manual testing will be hard. In addition, all of the cases deal with manual testing due to many reasons such as it is more flexible than automation testing and short-term cost is much lower with manual testing. With manual testing, results can be shown quickly and configuration for automation takes more time especially when changes come.

However, it was observed that teams face challenges when they apply manual testing due to test cases sometimes are difficult especially if they have some conditions and these conditions need time. Further, manual

testing can be repetitive and boring and this lets testers leave their work if they don't change their position. The result shows that automation has many advantages and all of the cases prefer it due to running tests quickly and effectively. Companies prefer automation for long run projects, is more effective and saves money and time but is not good for short term run projects. It keeps technical minds involved and committed to the process. When the team is doing automation testing, the rest of the team can see results of testing easily, and allows more collaboration and a better final product. In General, it is more suitable for large projects. Moreover, all of the cases are using automation for web platforms which is common and some cases like C1 and C3 use mobile platforms. The results show that cases prefer to use the web platform selenium tool because it's free and open source and for mobile platforms is Appium. Additionally, Figure 4.8 shows that the most programming language are used in Palestinian IT companies for automation is Java at variance C4 who use C# language instead of Java. Further, some cases sometimes build their own framework such as C1

## 5.4 Software Testing Methods and Techniques

Based on the results of all interviewees and diagrams, most teams applied black-box testing more than white-box testing and this can be shown in Figure 4.2. Low percentage of the outsourcing companies which apply white-box methods such as C1 and C4 . In general, Black-box testing approaches are more popular than white-box testing due to testers don't need to know about the internal working of the software system and they

focuses more on behavior. We noticed that not all of the cases apply unit testing and it is applied for automation code. Moreover, Non-functional testing is so important and it is applied such as Performance, load and security testing. We also noticed that integration testing is not applied so much and has difficulties sometimes. Therefore, it is done manually through debugging with a very basic scenario. Additionally, Figure 4.2 shows that 5/6 of respondent are doing code review for automation code and it is an important technique for. However, some testing techniques are not used so much such as Smoke, stress and API testing. Furthermore, we can also notice that cases prefer to apply agile in their teams especially scrum framework.

## 5.5 The Proposed Model (Quadruple Testing Model)

In this section, after obtaining many results from various cases, making a good analysis of the existing data, and studying many previous studies related to the subject of software testing, we came to many observations and factors that play an important role in maintaining the quality of software and show relationships between each other. Therefore, we suggest a conceptual model for building and enhancing software testing outsourcing in Palestine IT sector. The proposed model can help to increase the quality of software testing in outsourcing vendors and assist them in applying methods successfully.

There are many previous studies about testing but a few of them have models about software testing outsourcing such as “Conceptual Process

Model" [17] [5] [13]. This model aims to increase awareness about the factors that influence the success of software testing outsourcing and understand the current practices of testing [17]. Figure 5.1 shows the suggested conceptual model which can help the outsourcing vendors to do better and increase quality of software testing through software development life cycle. This model can be helpful for both researchers and testers who work in companies.

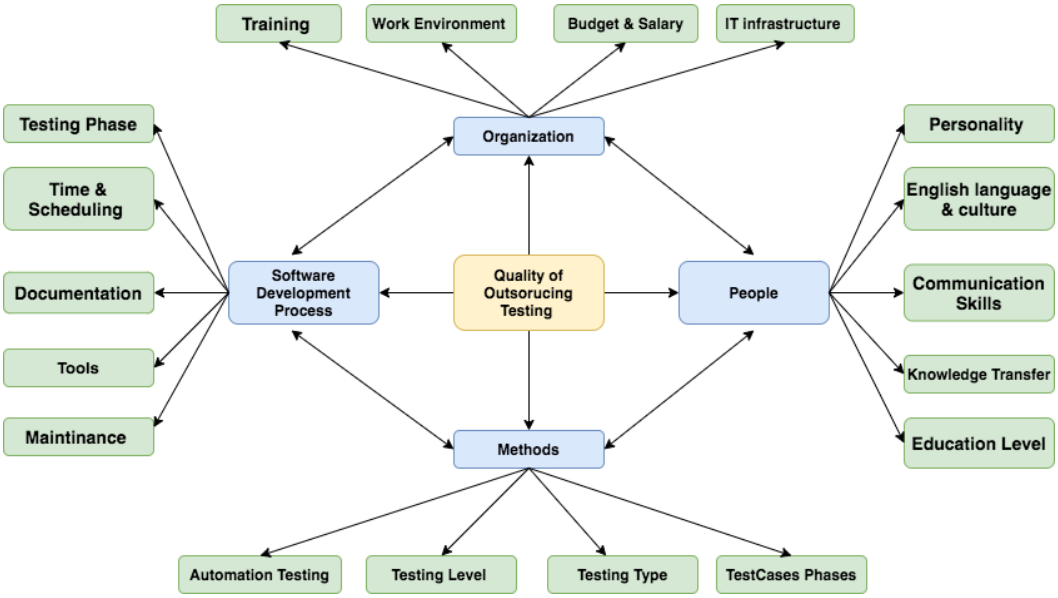


FIGURE 5.1: Quadruple Testing Model

Quadruple Testing model consists of four factors: People, Organization, Software Development Process and Methods. These Factors have a relationship and depend on each other. The first factor is People factor, which consists of five elements: Personality of the testers and their relationship with the other teams. Good English language helps testers and teams to understand and make knowledge transfer especially if the other testers and teams come from different cultures. Moreover, communication internally and externally with different teams especially different culture.

Finally, education level encourages testers to make more research about software testing and follow the latest testing practices that are applied in different outsourcing companies in other countries.

The second factor is Organization, which contains four elements: Good training helps novice testers to get involved in work fast. Work environment is important that lets the other employees feel safe and not feel bored. If a company hasn't good IT infrastructure, it will face problems during the testing process, especially contact with teams from different countries. Budget and salary are so important, it encourages fresh students to choose software testing and do their best during work.

The third factor is the Software Development Process which contains four elements: Testing phases are so important and should be clear, these phases should be executed in specific time. Time is an important factor for software testing too. Moreover, all of the process should be documented from requirement, design into execution and everything should be reported between all of the team members. These processes will be executed using special tools and each phase has its special tools.

The last factor is Methods, this factor depends on good analysis and understanding requirements to help teams to do their work clearly and without any maintenance. It consists of four elements: Automation testing, Testing level (such as unit, integration, system and acceptance testing), testing type such as functional, non-functional, Black box testing, etc. Test Cases phases (design, management, risk, tools and reporting test cases).

## 5.6 Threats of validity

The main goal of using reliability and validity is to gain more confidence and robustness results. In our paper, we applied three criteria and some tactics for these criteria [35]. The first one was construct validity which we used multiple sources of evidence and we established a chain of evidence. The second was external validity which we used theory based on literature research. Furthermore, for reliability we used case study protocol and developed a case study database. Despite all that, we believe that if more industrial cases were included in this study, more accurate findings could have been reached. Further, some bias may have been introduced during data collection by the first author.

# Chapter 6

# Conclusions and Future Work

The current paper provides a study of software testing outsourcing in four different IT software companies in Palestine. The goal is to explore and understand the software testing process and the main factors and challenges that face these companies. This paper have observed that the numbers of projects that are related to software testing are increasing and Palestinian industry is paying more attention toward applying software testing methods in their teams. Software testing outsourcing provides more opportunities to both vendors donors from cost, time, mutual partnerships, future bonding, etc.

There are many testing methods and techniques that are applied. Manual testing is still in the dominant position versus automated testing. We revealed that the percentage of automation is increasing but is still low due to many reasons such as time and cost. We also found that there is a gap between universities and industry and education curriculum neglect software testing courses. Therefore, good training and good material are an important factor to increase the quality of software testing outsourcing.

Additionally, we proposed conceptual model for the quality of software testing outsourcing, this model can assist Palestinian outsourcing vendors to open new testing teams and enhance process of testing. We called it "Quadruple Testing Model".

In future work, after reading many papers and exploring software testing, we wish to conduct research studies on the topic of the relationship between DevOps and software testing and go deep in the automation process and latest trends in software testing practices. Furthermore, to look for new methods in test case generation.

In our thesis, we had limitations in the focus group with the number of participants. The number of participants should be six to eight participants in any focus group session, in our focus group we only had 3 participants[8].

# Chapter 7

# Appendices

All of the data in this study are available in GitHub repository as PDF and spreadsheet. The link has all of results of all interviews:
**https://github.com/MohammedHussein15/ThesisData**

The next table show all of the questions that are used in interviews and focus groups.

**General Demographics Information**

1. What is (are) your current position(s)?
2. How many years of work experience do you have in IT and software development industries?
3. How many years of work experience do you have in software testing, in specific?
4. What type of business is it ?
5. What is your highest academic degree?
6. What is the size of your company (number of employees)?
7. How many team members are working on a single project?

**RQ1: To what extent do testing approaches influence the success rates of outsourced projects?**

1. What is the nature of outsourced software projects in this company ?
2. What are the testing requirements/expectations by the customer/ client ?
3. Is there any standard/formal testing requirements asked by the customer ?
4. Can poor/inadequate testing processes jeopardize project success ?

**RQ2: What are the currently applied testing methods and how effective they are?**

1. What are the processes in the software testing phase ?
2. What are the methods that are applied in the Software testing phase in your teams ?
3. Which test frameworks/tools do you use in your company ? (explain)
4. Which test automated frameworks/tools do you use in your company? (explain)
5. What are the prevention techniques you use to enhance team quality ?
6. Does your organization have a training program ? Are there any challenges for providing software testing training ?
7. Do you have any recommendations for the future testers?

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