



FACULTY OF ENGINEERING AND TECHNOLOGY
MASTER OF SOFTWARE ENGINEERING (SWEN)

**Software Development Estimation Techniques
in Industrial Contexts
An Exploratory Multiple Case-Study**

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January 26, 2019



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Declaration of Authorship

I, Ahmed Zarour , declare that this thesis titled, “Software Development Estimation Techniques in Industrial Contexts

An Exploratory Multiple 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 master degree at Birzeit 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. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
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Abstract

Software Effort Estimation is one of the most challenging aspects in the software development life cycle. Recent empirical studies in the area of software development estimation indicate the presence of two models for effort estimation: (i) Formal, and (ii) Expert Based (Informal).

IT sector in Palestine is one of the most promising and constantly growing sectors. Nonetheless, studies addressing effort estimation approaches and techniques within the Palestinian IT sector are still highly missing. Therefore, we were motivated to conduct a qualitative study to increase our understanding about how industrial teams approach software effort estimation and to explore the challenges they are facing.

Our investigation started with a survey that targeted software professionals, and then we conducted multiple-case study approach involving four different software development companies in Palestine. Results show that: (i) around 25% of cost overrun in software projects is due to inaccurate estimations; (ii) expert based estimation models are the mostly applied models especially within agile environments; (iii) a potential advantage can be achieved when formalizing the process of expert based models by having guidelines and checklists; (iv) accuracy of effort estimation is largely affected by team experience, domain knowledge, and requirements clarity; (v) companies working with outsourcing model do have better effort estimation accuracy than companies working in local market. Based on our findings, we highlight areas that require further investigation.

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Chapter 1

Introduction

Delivering software products within budget and time is not a trivial task. In almost all cases, software projects contain multiple resources that must be accurately estimated [21]. Software Effort Estimation is one of the major challenges in software development life cycle [18]. It has been found that inaccurate effort estimation can lead for project deviation and in some cases, a total project failure [15].

Not only Effort estimation is important, but also the quality produced by various models of effort estimation is also an integral part of a project success. Comparing estimated efforts with actual efforts can be used as an indication of the quality of the estimation model used.

It has been shown in earlier and recent studies [22] [4] [33] [41] [28] [5] [39] [38] that effort estimation can be approached in various ways. Different approaches over the past and till now are used to do effort estimation for software projects. Software development methodologies (Waterfall,

Agile...etc.) have different models of efforts estimations and each model has its strengths and weaknesses regarding the quality of estimation it produces.

Models of efforts estimation can be classified into two main categories, formal vs expert based [27]. Both models have many challenges and in some cases, they are combined to enhance estimation quality. For instance experts based models frequently have higher degree of inconsistency. Never the less, calibrated formal models are complex and require lots of parameter calibration to fit to the need of an organization [21].

Formal models like Parametric Based Models, Analogy Based Models, Size Based Estimation Models apply mathematical equations and algorithms and defined processes. Different factors are induced but a specific equation is used to calculate the efforts. Different factors can be removed or added to the formula of the model based approaches, further more calibration can be done on the parameters of the model to achieve better accuracy.

Expert based models like poker planning , top down or bottom up techniques relies on expert's judgments to produce estimations. Domain experts and historical data and team skills are the main factors affecting the output of estimation[12]. According to the studies by [39] [38], expert based models are the mostly used models in effort estimation. Although

parametric models are still used and have great value but the complexity of estimation comes to a point in which many factors should be considered. Determining the correct factors and their weight in many times is done by experts even in parametric models [12]. Collaborations of both approaches may lead to better estimations.

Even though there are lots of studies targeting software development and task prediction in general [18] [6], or in a specific software methodology like agile [10] [23] [24] [26] [15], no studies focus on understanding how Palestinian companies approach software prediction and the challenges they face. The Palestinian IT sector is a promising sector and has matured companies working in software development [44].

To our best knowledge, Only one study [44] has targeted Palestinian software development companies. In their study, the authors focus on exploring testing challenges and methods applied in the area of mobile app testing. Further, the authors show a diversity of software development companies that work in multiple areas and apply testing techniques used within mobile software development. However, in this research, the aim is to explore the challenges that Palestinian software development companies are facing in the specific area of effort estimation. More specifically, this research aims to understand the importance of estimation techniques in these companies in order to gain deeper knowledge about challenges they have and what estimation methods they apply. It

will try to map some of the problems to the general problems found in other studies and literature. Finally, this research will explore if there are issues or challenges tight to Palestinian market in specific or they are global issues shared with other markets and industries.

1.1 Problem Statement

Effort Estimation and Estimation Accuracy are one of the major challenges for software development projects [14] [7] [34]. The Palestinian IT sector is a promising sector and has matured companies working in software development [44]. Studies addressing effort estimation approaches and techniques within the Palestinian IT sector are still highly missing.

Understanding the current approaches taken by the Palestinian experts and IT professionals to conduct effort estimation is a key point in understanding the problems facing companies in the delivery of software projects. Factors affecting the estimation quality and accuracy is one of the main issues that determine the estimation techniques used and quality of effort estimation.

1.2 Research Aims and Objectives

The main objectives of this case study are to increase our knowledge about software estimation techniques used, and explore what challenges in real world companies have in their cost estimation. More specifically, the aim is to understand what factors affecting task overrun and eventually project cost estimation problems in the software development. Further, there is a need to understand the estimation process with respect to its accuracy in the context of agile software development and from the perspective of agile development teams. Additionally, this study will try to check whether the effects are only caused by technical limitations or estimation approaches or the culture and echo system in Palestine. Finally, this study aims to build a base for upcoming researches especially for Palestine IT sector based on our findings.

Thus the objectives of this research are:

- Understand how development teams approach effort estimation in general.
- Investigate the specific challenges faced by development teams and what factors that cause effort estimation.
- Investigate whether project type and business model type have influence on effort estimation.
- Compare results with state-of-the-art.

1.3 Research Questions

The Research questions we try to answer in this study are:

RQ1: How do industrial teams approach effort estimation? Moreover, what are the challenges they are facing?

RQ2: What are the factors that influence the accuracy of efforts estimation that are considered relevant and important? In addition, what are the real causes of these factors?

RQ3: Do project type and company business type influence the accuracy of efforts estimation?

1.4 Contributions

To our best knowledge this study is considered the first study exploring the current approaches taken by Palestinian companies in software effort estimation. It shows variety of approaches taken by the companies mainly using the informal models concentrated within expert-based judgment approach.

Our study shows a clear difference in the estimation of efforts between local companies working with local market and companies working as

outsourcing model with international companies. Additionally, the accuracy in software effort estimation within outsourcing companies is more than local companies which builds for more studies on how to improve local market software development companies to achieve better accuracy by studying the outsourcing company's models.

Furthermore, we have generated a set of recommendations to be used by software development firms in order to have better accuracy within their effort estimation techniques, including the formalization of expert judgment process using checklists and guidelines and possible enhancements on the expert judgment approach and estimation metrics.

Finally, our work has been accepted by the International Conference on Research in Engineering, Technology and Science ICRETS taking place in Lisbon, Portugal, and we are participating in the conference as oral presentation in Feb 2019.

Following Chapters are ordered as following: In Chapter Two details the related work and literature reviews. in Chapter Three the research methodology and protocol are discussed and detailed. Chapter Four describes and details the execution of the case studies and details the results found. Chapter five discusses the findings and recommendations chapter

six summarizes the findings and suggests possible future work .

Chapter 2

Related Work

2.1 Introduction

Understanding the current approaches to conduct effort estimation is a key point in understanding what challenges are facing companies in the delivery of software projects. This study follows a critical literature review approach to better understand the models of Effort Estimation. According to [11] a critical literature review helps to advance the understanding of what is already known. Further, a critical literature review is a kind of a story telling approach rather than just listing related work. Such review will lead to a stringing approach for the past work [11]. It starts by having a short summary and then listing authors and related work in a comparison style. Using this approach, the literature review will be containing an effective and original assessment of previously published information.

When determining related studies, this study followed the snowball

strategy [42] in selecting related work within the area of software effort estimation. Snowball strategy works in two directions, forward and backward. From its name, snowball method starts with a small set of related papers based on specific key words. Then, from the selected small set researcher starts by evaluating the references in the selected set which is called backward snowballing. Applying the search criteria produces another set of related work and so on. Another approach is called forward snowballing, in which the researcher searches for what other work has referenced the starting set of research. In this method the researcher can locate newer research and work done based on the selected set which produces a larger set of research work.

2.2 Literature Review Protocol

2.2.1 Targeted Databases

This research has targeted two main electronic databases IEEE and ACM, along with Google Scholar to find related work for software effort estimation.

2.2.2 Search Keywords

The search keywords used in the search are Estimation, Software, Data models, Computational modeling, Software engineering, Measurement, Planning, Agile with the use of logical operations like AND/OR.

2.2.3 Inclusion and Exclusion Criteria

Based on the search keywords a huge list of papers and articles were located. The first criteria used is to limit the resulting set using the publish year. The year 2013 was set to be the base reference year. From the output list after applying the year filter, 55 papers and articles were selected. The year 2013 have been selected in order to focus on newly effort estimation work. Although the effort estimation has been approached by research in earlier years, but a 5 years' interval has been selected to be up to date with research material.

Another exclusion criterion has been applied in which from the 55 papers and articles resulted from first exclusion criteria only the researches that targeted effort estimation in general has been selected. Lots of research on effort estimation was focused on a specific technique, or a specific methodology. Our research aims to increase the knowledge about software effort estimation in general not for a specific model or technique. Hence only researches focusing on the problem of effort estimation as a

problem in general have been selected, which results in a 25 papers and articles.

2.3 Related Work

2.3.1 Supporting Studies

This section describes the findings of supporting secondary and relevant studies that formulated the related work main themes and research questions.

The Main findings of the secondary studies shows a major focus on two main themes within Software Effort Estimation. The first theme focuses on Informal Models or what's so called Non-Parametric models such as Expert Based Judgment model, Planning Poker, Top Down and Bottom up approaches. The second theme focuses on Formal Models, or what's so called Parametric models such as COCOMO II, ESTIMACS or any functional point or use case point based model. The two types of models are used within Effort Estimation [12] and have pros and cons that can be used as a base to choose the best model for each situation [28].

Other studies have focused on a general approach within effort estimation, mainly focusing on exploratory research without focusing on a

specific theme. Studies like [14] [35] [20] [36] has focused on understanding the efforts estimation techniques being applied. Additionally, they have tried to find which factors affecting the accuracy of effort estimation. However, this thesis will focus on exploring the effort estimation techniques applied within the Palestinian IT sector. Further, this thesis will also explore what factors affect effort estimation accuracy.

Zein's Study [44] has been a unique study in the Palestinian market. It has been the only study trying to approach more knowledge about Software companies in Palestine and how they approach mobile development. In their study, the authors focused on exploring testing challenges and methods applied in the area of mobile app testing. Further, the authors show a diversity of software development companies that work in multiple areas and apply testing techniques used within mobile software development. However, in this research, the aim is to explore the challenges that Palestinian software development companies are facing in the specific area of effort estimation.

Nguyen-Cong, Danh and Tran-Cao in their SLR [22] reviewed the current research literature on effort estimation within agile environment. They have tried to show evidence about common trends and practices used with agile and iterative environments. Additionally, they have tried to spot research gaps and required future work regarding software effort estimation. The results of their study shows few empirical research in

the field of effort estimation and most of the research is focused on XP, general agile, iteration and increment development methods.

The SLR results shows that Expert based judgment is the most used approach in effort estimation. It also shows that effort estimation approaches can be classified into model based, monitoring based and expert judgment based. Their study shows lack of research on how much effect the use of historical data for the same project have on effort estimation output compared to the use of historical data from other projects. The results of the SLR shows also a lack of empirical research in validating suggested models for effort estimation. It shows that half of the suggested models have been applied with a backing empirical evidence.

Bilgaiyan in his SLR [4] explored the mechanisms used in effort estimation within agile development methods. Also he has explored the parameters affecting the estimation accuracy, comparing different estimation techniques based on the estimation accuracy. He has also investigated the possible circumstances affecting which estimation technique to use.

Bilgaiyan results show that 60% of projects have cost overrun and around 15% totally failed projects caused by wrong estimation. Such results show the importance of effort estimation within projects, and how much it is important for project managers to plan correctly. The results

show a set of estimation techniques used like Neural Networks, Exert Judgment, Planning Poker, Use case points and modified use case points, Linear regression wideband Delphi, Top down and bottom up approaches.

Along with estimation techniques a list of accuracy parameters is used to evaluate the resulted estimations. Metrics like magnitude of relative Error, Mean Magnitude of relative error, Median magnitude of relative error, mean absolute percentage error, mean squared error. . . etc.; are commonly used metrics to measure estimation accuracy.

Bilgaiyan results supported Nguyen-Cong results in which expert based judgment model is the most used model in effort estimation. Neural networks(NN) mechanism is also one of the most used models in agile software development according to Bilgaiyan, never the less the NN is not shown in Nguyen-Cong results as one of the most used approaches.

Bilgaiyan results show that choosing an estimation technique is related to some circumstances and factors. For example, neural network is a good choice when the relation between input data and output data is complex and when input data is distorted by the high noise level. On the other hand, when historical data is available Top Down(TD) and Bottom up (BU) approaches are a good choice. TD is more suitable for initial and early stage estimations while BU is suitable in case re-estimation is

required for the remaining phases. If historical data is available and expert's availability in the domain, then choosing expert based judgment mechanism can be a better choice. Planning poker come to be more suitable when the team are following scrum methodology with an agile environment, estimation within scrum is done using the group of developers participating in the project. Use case point is suitable when the company applied the UML (Unified modeling language) within their process. Linear regression is useful in situations where the number of cases in the estimation is more than the number of parameters required to be estimated.

Bilgaiyan study is more focused on agile methodologies and estimation techniques used. It provides analysis on the accuracy measures and what circumstances affect what mechanism to apply. On the other hand, Nguyen-Cong did not focus only on agile. Although agile is found to be the mostly used development methodology [19], still other methodologies are being applied in software development and require estimation. Bilgaiyan has focused more on factors affecting the estimation methodology to apply, providing high level guidelines when it is suitable to apply which mechanism.

Usman in his study [41] provides a detailed overview of the state of the art in the area of effort estimation within agile software development (ASD) context. The study explored the techniques used for effort estimation in an agile environment; along with the accuracy level that has

been achieved by those techniques. Furthermore, Usman has explored the metrics and cost drivers that have been used in effort estimation studies in agile environment. He has investigated the characteristics and the size of the dataset used by researchers studying effort estimation. Additionally, Usman investigated which agile methods has been focused by studies on effort estimation.

Usman study results shows that expert based judgment technique is the most frequently applied technique in effort estimation. Use case points and story points are the most used sized metrics and MMRE (Mean Magnitude of Relative Error) and MRE (Magnitude of Relative Error) are the most frequently used accuracy metrics. Team skills, experience and task size found to be the most important cost drivers affecting effort estimation output. Usman found that XP and scrum are the only two agile methods identified in primary studies. Usman stated that guidelines to choose which estimation technique for which agile methods are required for practitioners.

Similar to Bilgaiyan and Nguyen-Cong Usman results identify the expert based model as the mostly applied model in effort estimation. He has also identified same set of accuracy metrics as Bilgaiyan. Usman identified cost drivers affecting the effort estimation within an agile context and the need for guidelines for practitioners to follow in choosing the correct estimation techniques. On the other hand, Bilgaiyan identified

some areas and circumstances that helps identifying which technique to use. Usman had focused only on agile methodology and context, never the less other software methodologies do experience problems in project overrun and require analysis and research on possible improvements and guidelines for effort estimation.

Usman study has identified two main issues in earlier research, Although the data set used for identified researches are mostly industrial, which is a good indication for the acceptability of the results, still 72% of the data is within company not cross companies. Also Usman study identified that not all studies are covering all Software development lifecycle (SDLC) phases. Only 36% of studies took all activities into consideration. Such results influence this research to consider both industrial context and dataset along with all SLDC activities and phases.

Rijwani, Jain and Santani [28] provide findings of researches on parametric and non-parametric techniques Summarizing different literature findings in one place. Providing a one place containing discussions on the models found in effort estimation research. This helps researchers to get into the pros and cons of each model, similarities and differences between model can be easily spotted. Rijwani has found that There is no systematic way to choose the best estimation method, it always depends on the context and many other factors. Similar to Usman [41] the guidelines for choosing the appropriate estimation model is a need for

practitioners.

Rijwani has identified that project environment and the list of pros and cons of each model can help applying the best model for the project. For example, expert based or analogy methods are useful when the project or parts of the projects are known or historical data is available. This aligns well with Bilgaiyan study [4]. On the other hand, for larger and lesser known projects the use of algorithmic models like COCOMO 2 or ESTIMACS or any functional point based model are highly recommended especially in initial phases of the project. Rijwani also suggested the combining of both parametric and non-parametric models to generate more robust estimations. Empirical research is required to validate this combination.

The findings of Rijwani especially in relation of cost drivers and environment on effort estimation requires more empirical research. Although the findings of the research are close and aligned to previous mentioned researches findings, still It was not based on a Systematic literature review. The review has been done in the context of providing a one stop place for practitioners to find pros and cons about software effort estimation models to better decide when to use a specific technique.

2.3.2 Formal Models(Parametric Models)

Formal Models, or what's so called Parametric Models are famous Software Effort Estimation models applying mathematical, machine learning and defined formulas to quantify efforts. Formal models have been applied within software development for more than 40 years [12]. Thousands of researches and studies have approach formal models and several software engineering textbooks and guidelines described and promoted them [12].

The main difference between Formal Models and Informal Models is the quantification step. This step that transfer the input to an actual effort quantified and measured. Formal models such as COCOMO, function point based models use formulas to quantify input. This implies that repeating the same input multiple times into the same formula will always generate the same results. Such models are used by non-domain experts to quantify effort because they can be generated using formulas. This is a major advantage of a parametric model is that it doesn't modify its estimates when customers, managers, or marketers apply pressure [12].

Ramacharan in his Study [27] describes various Formal models within his research on identifying the problems that arise within offshore and distributed development teams. Ramacharan states that Formal models, within its current shape and without calibration, do not have the required competence to provide effort estimation for distributed software projects.

Ramacharan in his conclusion promotes to select COMOCO II and SLIM as effort estimation techniques. He has reasoned that by a set of findings like availability of literature, availability of tools, coverage parameters, using rate and if they support possible calibrations.

Ramacharan has focused his research on distributed teams within global software development environment (GSD). He tried to better estimate effort by identifying better estimation techniques. Nevertheless, other factors in GSD affects effort estimation. A study by Usman [38] shows that the most common used technique in effort estimation is the expert based models not the formal models. Furthermore, Team skills and experience has been found by Usman as main factors affecting effort estimation. Additionally, culture and language barriers are also considered as affecting estimation factors. Thus Formal models like COCOMO II or SLIM if to be used within GSD projects must consider such factors. More empirical evidence on the use of Formal Models is required especially if to include mentioned factors by Usman.

Popli in his study [24] suggests an algorithm to be used in effort estimation in case experts and historical data are not available. Popli has considered two main factors types within his algorithm, Project related Factors and People related factors. Results shows that even when the project related factors are of high level (High Impact), If people related factors like communication skill, managerial skill and familiarity in team

are good, the project takes relatively less time. Popli study has been done on three cases, the cases are not clear and has no information about each of them. Popli's algorithm has set hypothetical numbers to the factors, more empirical evidence is required to determine if such factors affect the estimation as implied by Popli. Additionally, the suggested people related factors have no reliable source, it is coming from the authors. For example, a need of exploratory studies to identify the factors is required.

In another study Popli [25] has proposed a method to do accurate cost and effort estimation. The method is based on mathematical estimation technique that supports the changing requirements and nature of agile methodology. The proposed mathematical approach focuses on multiple issues from other estimation models. For example, Popli is proposing to use different metrics than unit of time. Another issue has been considered by Popli is the risk. Risk tracking and Risk management is not considered within other approaches of estimation. Popli's Study builds up on the problems of current estimation methods and tries to enhance estimation by considering such factors. Mainly the unit of measurement to be story points rather than time and to take the uncertainty and changing requirements in mind, the factors are included within the suggested formulas.

The case studies used by Popli are not clear, it is just showing the results of the study. No sufficient information on the project being studied

and what is the company size, environment and other factors that might affect estimation. Additionally, the study builds on the estimation metric of fusing story points, although the literature survey shows the story point as one of the most used metrics but still not proven to be the solution for an accurate estimation. In Both Popli's studies, main issues are the insufficient information about the case studies and empirical research along with hypothetical parameters being proposed.

Porru in his study [26] proposed a machine learning approach to do estimate story points. The main data source was an industrial project along with 8 open source projects, Jira was the tool used for recording software issues. Porru's main aim was to provide a real time estimation support using a machine learning algorithm. Thus the performance of the suggested approach was required to be real time. Additionally, the approach should provide rationale about estimation output. The rationale comes from the classification of issues based on specific attributes. Clarification to which attributes are relevant to the classification and estimation has been determined within his study. Another important factor related to the approach suggested by Porru which is the training data. How much training data is required and how the behavior of the machine learning classifier changes based on the amount of learning data provided.

Porru's Result show a real time estimation happening by the classifier. In average 8 to 15 seconds was the time required by the classifier to generate output. The resulting performance figures make the use of such approach within a planning poker session for example a possible scenario. Further, the approach identified important issues fields and parameters to the estimation algorithm. Issue type, summary, description and the related components are main attributes affecting the quality of estimation by the machine. However, the importance of such attributes depends on the project. Results also show the training data required for such approach is around 200 issues. It is an achievable number of issues to be an input from historical data. Of course each project requires its own learning data to be provided.

Lenarduzzi in his study [15] tries to improve existing estimation models by monitoring and evaluating the project costs after each development phase. Using the effort of one phase to estimate the effort of the next phase comes to be beneficiary to the estimation of the project according to Lenarduzzi. Additionally, Lenarduzzi states that this type of estimation can help project managers react as soon as possible to estimation outputs per phase. The use of previously done phases in the project helps prediction the next phase along with prediction to the total remaining efforts of the project.

Lenarduzzi's study shows significant correlation between efforts spent

in one phase with effort spent in the following one. Additionally, a significant correlation between effort spent in a phase and the remaining efforts has been spotted. Along with significant correlation between the cumulative effort up to the current phase and the remaining effort. The data set used by Lenarduzzi is an industrial historical data set from the ISBSG database. However, the use of such approach within different organizations requires the consideration of organization related factors. Additional empirical evidence is required for this approach using data from multiple organizations.

Both Lenarduzzi and Porru has tried to use previous data to improve upcoming issues estimation. Both approaches require the presence of historical data to use for prediction of future tasks. The use of machine learning approach suggested by Porru within the proposed model of Lenarduzzi might be beneficiary. Using a machine learning approach based on early phases of the project to analyze the data and predict effort of future tasks in upcoming phases. However, the approach of Popli needs to be calibrated and modified to take into consideration subsequent phases in the project. This can be a potential future work for upcoming research.

2.3.3 Informal Models (Non-Parametric Models)

Informal models and Experts based judgment model in specific is becoming the most used model within Software Effort Estimation [41] [4].

Studies show that the use of expert based models achieves more accuracy than the use of formal models [12].

The dependency of Expert Based Models on the availability of experts and historical data; led to the need for enhancements. Providing guidelines, checklists and structured group processes can help in achieving even more accurate estimates[12]. However, the amount of research to improve Expert based models is much less than the amount of research done on formal models[13].

Most of the primary and secondary studies approaching Experts based judgment models are considering it within an agile environment. The fact that agile context is based on multiple iterations and change is frequent introduces the need for more simple and lean estimation models. Expert based judgment model is in fact the mostly used model within agile environments [41] [4].

Lenarduzzi in his Study [16] questioned about the effectiveness of using Function point size measure within a scrum environment. Function point is an estimation measurement unit that depends on the number of functions being developed based on the requirement and it is normally used within formal models.

Results of Lenarduzzi's study show that the estimations made by developers produced more accuracy than estimations done based on functional measurement. The functional size measurement did not help to get more accuracy.

Lenarduzzi results shows that the use of experts based judgment still the better approach in scrum than FPs, However Lenarduzzi considered SCRUM in his study, more specifically moonlight scrum which is a scrum framework used within teams with less overlapping working hours. SCRUM has a strict defined process and may not be a good option to use FPs within. However, SCRUM and XP are the mostly used methods within agile framework [19].

In Expert based models the existence of experts is a must, in an agile environment experts may not available all the time and in most cases the estimation is done in groups. Lack of documentation in early stages of the project affects the quality of estimation produced by developers. Usman [40] suggested an improvement to expert based judgment model. According to Usman the expert based judgment model is the mostly used model. However, Experts Based Models lacks formalism of the process. Experts are humans and can miss some important factors like testing effort, non-functional requirements . . . etc.

According to Usman, another Important factor that leads to inaccurate estimation within agile context is the lack of documentation. The concentration of producing other artifacts in every iteration causes loss in documentation and estimation historical data that is needed for Expert Based Models.

In Usman's study A multi cases approach has been taken studying three companies from different countries. All of selected cases used expert judgment as a main estimation method. All companies follow agile methodology with time boxed sprints and release planning and in all company's efforts is always underestimated and projects mostly overrun.

Usman's proposal was to develop an estimation checklist for agile teams to use within their estimation process. Introducing checklists helps in documenting activities and factors considered by experts and the team while estimation. It helped junior developers to do estimations based on the expert's activities and process steps considering the factors affecting estimation.

Usman's result shows that the use of check lists indeed helped in achieving better estimations. Introducing the formalism helped the organization to have consistency in effort estimation processes in other projects. Having a defined process also helped in identification of factors affecting estimations. Subsequent enhancement on the process achieves

more and more accuracy by considering further factors along the organization project delivery process.

Formalization of the Expert Based Judgment process has been also approached by Hamouda in his study [8]. Hamouda proposes a methodology to formalize the project sizing process while using agile story points within a CMMI organization. According to Hamouda agile story point size can vary depending to project and the development team. In CMMI organizations to achieve a symmetric and unified process across organization; a formal process should be approached to determine agile story point size.

A company of CMMI level 3 has been selected as a case study, a unified process for measuring story point size has been proposed and implemented in the company. Results show significant improvement in the accuracy of estimation across the company projects.

The methodology proposed by Hamouda establish a reference library for requirement. This library is used across all organization projects and collect information from different projects. Additionally, the proposed methodology focuses on considering the environmental factors affecting

the estimation across projects and not only for specific projects. Furthermore, the proposed methodology establishes a unified productivity measurement to be used across all projects. The productivity factor is calculated to be the average velocity of all teams across the organization.

Dagnino in his study [7] is trying to improve effort estimation in case historical data is not available. Dagnino study has been done on a real-world case study in a Business Unit (BU) of a multi-national power and automation technologies research and development organization. The focus of the study was to outline a portion of the organization estimation process used to do initial estimation for software development projects. The project under study was to enhance a user interface of an existing system that controls power grid system.

Expert Based models rely mainly on the presence of experts and the presence of historical data. The absence of historical data can be a challenge for developers to apply estimation specially for initial project estimations. Dagnino proposes a toolkit that is called "ONESET" that combines multiple concepts and practices described separately in the literature. The toolkit contains guidelines for organizations who have no historical data to start collecting it. Additionally, it contains guidelines on how to combine both expert judgment and model based methods in the estimation process to derive an initial estimation.

Results of Dagnino show an improvement in initial effort estimation if multiple models have been used. If historical data is not available a combination of both Expert Based Models and Formal Models can be utilized to derive the estimates. However, the combination of Formal and Informal models requires more empirical evidence.

Absence of historical data is a challenge in agile environment, Initial project estimation is a challenge in such situations. This has been the focus of the study done by Ali [1]. Ali's study focuses on the challenges of discovering the metrics and techniques which determine project size in an agile context. Identifying the factors and metrics used in estimating user stories points size in agile environment, helps identifying the size and accuracy of estimation.

Ali's proposes a technique to estimate user stories, it starts by classifying user stories (clear and understandable pieces of requirements) depending on complexity and effort required for implementation. Such categorization is important not only for estimating the project size; it is also important set the priority of user stories. The categorization should be revisited after each iteration to achieve more accurate estimations.

After setting user stories, sub user stories may be created for each story. After that each story is assigned a size based on points. Each team will determine his point size. To determine a story points two factors

should be considered (complexity and man hours). To determine the complexity a detailed activity of each story will help. Details of how many database transactions this story will require, how many screens or User interfaces are required, how many classes required to implement this story and how many test cases to achieve the success criteria ... etc. Detailing such activities per user story can help estimate the complexity of a story. Then the velocity of resources assigned to the story is calculated. Finally, the velocity is multiplied by the complexity to achieve the story point size. Eventually the total project cost can be estimated by summing the size of its stories.

Not only to the absence of historical data is affecting the accuracy of Experts Based Estimation. The impact of change is also a main factor affecting experts based estimation output [34]. According to Tanveer the main methods of experts based judgment like Planning Poker, Analogy and disaggregation do not consider the use of tools and techniques to determine the impact of change during estimation. Impact of changes on the underlying system is one of the factors that affect the magnitude as well as the accuracy of estimation.

In his study Tanveer is building on a previous study [35] in which an improvement framework had been suggested to integrate the impact of change to the effort estimation methods. Tanveer is setting guidelines to

be followed on how to integrate the impact analysis while estimating effort while using the proposed framework.

Tanveer study had been done using Systematic literature review to find which change impact analysis techniques are found in literature and which effort estimation techniques are commonly used in agile effort estimation. Results show that expert based judgment is the most used estimation technique and planning poker is the mostly used method. Additionally, Tanveer conducted brain storming sessions with an estimation expert from Fraunhofer IESE. Results of the brain storming sessions suggests the quantification of change impact information in at least two dimensions (complexity and size). Then present this information to experts to do estimation.

In another study [37], Tanveer is trying to evaluate the concept of Integrating Change Impact Analysis (IA) into EE (Expert Based Estimation) methods. IA is a technique that identifies the effects of a change or estimates the tasks required to implement a change [17]. According to Tanveer EE for effort estimation do not consume the use of tools and techniques to integrate and perform IA in their processes and methods to its best advantage. Introducing a framework to integrate EE with IA through mockups and visualization of change impact, will enhance the EE methods estimation accuracy.

Results of Tanveers proposed framework show that utilizing Change Impact Analysis techniques is extremely valuable in supporting EE methods that can perform change impact. Moreover, Practitioners recognized that the effect representation gives greater objectivity to estimation compared to the subjective nature of expert judgment. Besides, considering test coverage and developer knowledge as impact indicators can additionally enhance the viability of effect impact analysis for effort estimation. However, Tanveer work is a concept and requires more empirical studies to validate the output of such concept and framework on real data and real projects. Further, the main concept of the mockup is to formulate the query that extracts the affected methods, this requires special knowledge in the code and architecture of the system.

Chapter 3

Research Methodology

3.1 Research Overview

In this study, we followed a mixed research methodology that consisted of two phases. In the first phase, we conducted a survey to investigate how professionals at Palestinian software development companies approach effort estimation in general. While on the second phase, we conducted a qualitative research to gain deeper understanding about applied effort estimation techniques and challenges faced. The outcome of the first phase helped us better design the protocol questions of the second phase.

3.2 Survey Design

The survey was built initially for collecting general information about how Palestinian software development companies approach effort estimation. The survey was distributed for one month over forums and groups of software and IT practitioners, using Facebook groups PalGeeks and Peeks as well as linkedIn platform.

Survey questions were designed to be closed and open-ended, in which, respondent can add more information to the answers. Later on, these answers were used in building and designing more targeted interview questions for the second pahse. Table 7.1 below shows the list of survey questions and explain the objective of each question and its relation and effect on interview questions and hypothesis generation.

TABLE 3.1: Survey questions and objectives.

Id	Question	Objective
1	What is your current job title	To have a general look on the software development jobs titles to which we can know if there are any effort estimation related titles.
2	How much experience you have in software development field	To know how is the software development experience is distributed and how much experienced developers exist

3	How to evaluate your knowledge in the software effort estimation field?	To understand and know if the responded have previous knowledge in software effort estimation and how much is that knowledge to better phrase our interview questions and to make sure we do need a pre-interview meeting to explain the subject.
4	What is the average accuracy for estimation provided in initial phases of the project (based on your experience)	To know if there is any difference in initial project estimation than estimation within planning phases of a project and if there is an accuracy in provided estimations or not.
5	What are the techniques you or your company use in software effort estimation	To have an overall overview on which techniques used and to better design our interview questions
6	What metrics you use in measuring effort estimation	To have an overall overview on which metrics used and to better design our interview questions

7	If you rely on your experience while providing effort estimation for a software project, do you depend on historical data	To get more information if there is any use of historical data and consider this within our interviews.
8	Do you use tools to support you in effort estimation	To have an overall overview on which tools used and to better design our interview questions.
9	How is effort estimation is done in your company	This is an open-ended question that we set to better know how effort estimation is done (team based, user based, managers based) in order to design our interview questions. some predefined choices were provided to the responded with ability to enter more.
10	In your Opinion, what are the main reasons causing projects estimation to NOT be accurate	A list of responses was set with ability to add more, this question was very important to know what cases we should focus on within our interview questions.

11	In your opinion, does the methodology you use in project development (Agile, Waterfall, Prototype. etc.) affect effort estimation accuracy and techniques	To understand and collect information about any possible relation between methodology and estimation techniques so that we do design our interview questions accordingly.
12	In your opinion, does the location of developers (on premise or work from home) affect effort estimation	To understand and collect information about any possible relation between location of developers and estimation techniques so that we do design our interview questions accordingly.
13	In your opinion, does project size (small, medium large) affect efforts estimation	To understand and collect information about any possible relation between project size and estimation techniques so that we do design our interview questions accordingly.

3.3 Cast Study Design

A case study can have multiple shapes, a multi-case-study approach is somehow another expanded implementation of a single case study in which a study can have multiple cases to study. A case can be a team

of developers, or a company, in multiple case studies. Researchers can study multiple teams or multiple companies. A case may have multiple units of tests, for example multiple teams under one company, multi-case study provides more robust findings and evidence and is often considered more robust [31]. Thus this case study will contain four cases; each case represents a development team working in a software development company.

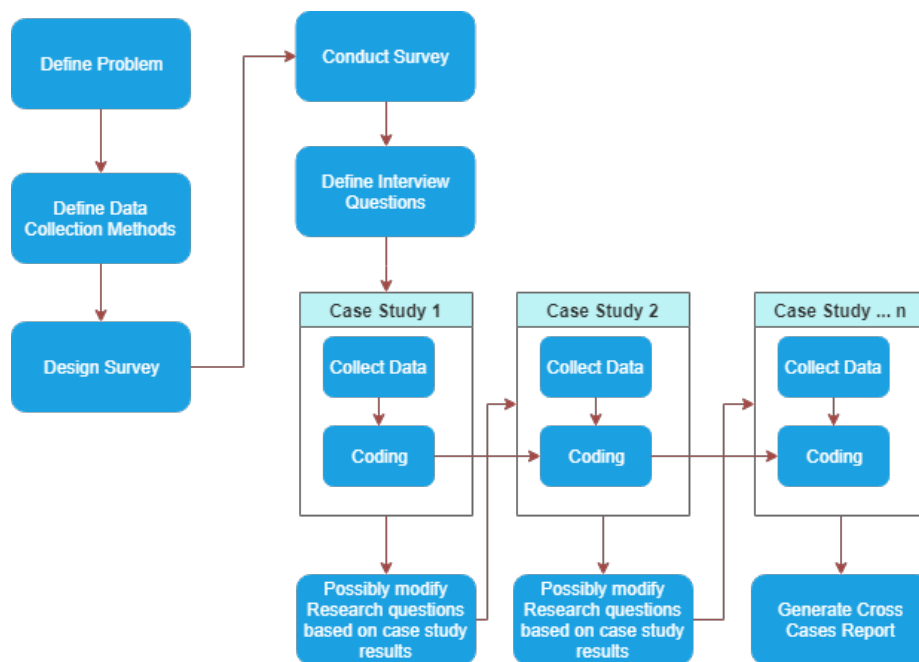
Another approach to increase the precision and strengthen the validity of empirical research is Methodological Triangulation. Triangulation can be done by having the data collection from different sources. Three sources for example provides a data triangulation, such sources can be Interviews, Observations, and Focus groups. This research tries to have data triangulation based on the previously mentioned sources, more data sources can be a better approach of course but in qualitative research and flexible design research in general, cost and time limit the data collection somehow. Never the less such techniques in data collection provides a flexible approach to gather more data in case needed for the research while it is ongoing [31].

Analysis of data will be carried out in parallel with data collection. That is because in flexible research strategies, during data analysis it may appear that more data is needed to better analyze the outcome. Using this iterative approach it allows going back and enrich the data collection

phase by adding more sources or by changing some interview questions to better analyze data.

Figure 3.1 describes the research methodology which is based on multiple case-study design along with iterative approach in which data can be enriched and research questions and interview questions may change according to the outcome of each case study.

FIGURE 3.1: Research Methodology.



3.4 Theoretical Proposition

Theoretical propositions, as discussed by Yin [43], will form the main pillar for the case study design strategy. Theoretical propositions, is the most preferred strategy and is based on following the theoretical propositions (see table 3.2) that led to the case study design. The propositions will shape the data collection plan and give priorities to the relevant analytic strategy. Additionally, propositions help to focus and put more emphasize on certain data and to ignore another data. For instance, in this case study, the focus will be on how the developers and team leaders are using specific effort estimation techniques such as formal models or informal models.

TABLE 3.2: Theoretical propositions.

Hypothesis (theoretical propositions):	<ul style="list-style-type: none">• Accurate effort estimations require clear and detailed processes and guidelines to be considered by estimation team.• Expert based models are the most used models in estimation within Palestinian companies.• Missing Guidelines and missing use of historical data when applying experts based models.• The use of formal models is either missing or is used without calibration.
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3.5 Selection of Cases

In Cases selection the potential companies in Palestine are a lot, however choosing between them can be a challenge since lots of companies do professional software development. The main criteria suggested for choosing companies is the availability and acceptance of the company to participate in the case study. Another criteria is the size of the development team. The potentially required team size is between 5 to 9 developers in an agile team , therefor the selection of teams was based on this number in which the team under study have this number of developers. The size of the team was based on the high probability of Palestinian companies using agile as a main development methodology for software delivery [44]. It is expected that the selected companies do use agile hence agile development is the most used software development methodology [2].

3.6 General Procedures

Each subject (software developer, team leader and manager) will be asked the same set of questions in the same order. Subjects should have experience in estimating software products features by having a previous experience and involvement in a software feature or a project. Interviews will be done at targeted companies during normal working periods. The interviews and observations will be done by the researcher as part of his MSc master thesis. As part of validity control and study reliability, PhD supervisor will review study protocol, and collected data.

3.7 Data Collection

In This Research and to achieve data triangulation we have used below three data collection techniques.

- Interviews
- Focus groups
- Observation

Data has been collected through interviews, focus groups and observations. In the three cases C1, C2 and C3 both interviews and Focus groups have been conducted, However C4 was the only company that allowed data collection through observations. The data collection strategy for the cases C1, C2 and C3 consisted of two parts. The first part was one to one interview with development manager and senior resources. the second part was a focus group with part of the development team members. However not all team members in the three companies were available for the interview. Selection of members was done by the development manager in each company.

Collection of data through observations was done in C4 premises. The author had been working with C4 as a part time consultant and had access to the development team within their planning sessions. Notes and activities for the teams in C4 were taken during observation sessions (observant without participation). Observation sessions had been done on

two sprint planning for two different projects with two different teams.

3.7.1 Interviews

In this approach, a face-to-face along with email interviews were conducted with engineers and other software development team members or managers. Interviews are designed to be semi-structured since they are well suited for this kind of research [9]. Interview questions will be predetermined and flexibly worded to collect tentative answers. In addition, follow-up questions may be asked to measure and focus on more issues of interest deeply. This approach allows the interviewee to express his opinion freely and discuss problems and issues without being pushed or in some odd cases non-realistic because of for example management or company pressure.

Interview questions were designed as per the survey conducted prior to conducting the data collection for the case study. Questions were open ended and interviewees had the flexibility to express their thoughts and opinion along with their experience freely and from their own perspective. Each interview lasted for around 45 minutes and due to the unavailability of all team members, only selected team members by the development manager in each company have been interviewed.

Data collection approaches:

- Conduct a semi-structured open-ended interview and take interview notes.
- Conduct online and email interviews when cannot meet participant in person.

Focus groups interviews.

These interviews are semi-structured and generally open-ended questions to gather views and opinions from participants.

Table 3.3 describes the Interview Questions and relation of each question to the original research question.

Interview Questions Rationale :

Regarding research question 1, interview questions were designed to help better understand the effort estimation in companies, we have started by high level questions to drive the interview and focus group discussions to a more detailed questions that will follow , the need for such approach is to understand and better know the interviewee and his knowledge about this subject. However all questions did have the opportunity for each interviewee to talk about his own opinion freely and to provide more information , this is very useful for the researcher to collect as many information and he can for the coding of themes in next

phases.

Regarding the research question 2 the interview questions were designed to focus on specific topics which are the factors and challenges an in some cases in specific areas of software development like requirements elicitation.

Regarding the research question 3 the interview questions were designed to collect information about the business type and cultural issues which we believe was very specific to the Palestinian market and no previous researches were done for this part. However, the questions were designed to focus on the interviewees opinion and their own thoughts and the cultural factors they see in their environments.

TABLE 3.3: Interview Questions.

Research Questions	Interview Questions
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<p>RQ1: How do industrial teams approach effort estimation? Moreover, what are the challenges they are facing?</p>	<ul style="list-style-type: none">• How effort is estimated in your company?• What metrics you are using to Estimate ? for example Hours, Story Points ..etc• Which steps do you follow during an effort estimation process?• How much historical data is useful in the effort estimation approach taken by your company?• What tools supports you in the effort estimation and planning ?• Who participates in effort estimation in your company?• In your opinion , how initial project estimations techniques differs from other effort estimation techniques for a full project in planning phase?
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<p>RQ2: What are the factors that influence the accuracy of efforts estimation that are considered relevant and important? In addition, what are the real causes of these factors?</p>	<ul style="list-style-type: none">• In your Opinion, what are the main reasons causing projects estimation to be not accurate?• What are the main challenges in estimating development effort?• What are the factors that are considered by you when estimating a story or a feature?• During requirements elicitation, do you consider constraints/risks that can affect effort estimation?• Are there any factors regarding people participating in the project? what are these factors?• In your opinion, how can effort estimation be improved ? what changes should be made to current approach ?
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<p>RQ3: Do project type and company business type influence the accuracy of efforts estimation?</p>	<ul style="list-style-type: none">• Are there any factors related to the client that can affect the effort estimation? what are these factors?• Are there any set of factors related to your company or business that can affect an effort estimate? Which are these factors?• In your opinion, does the methodology you use in project development affect effort estimation? explain the effect of methodology.• How do you categorize projects based on size?• In your Opinion , how does project size (small , medium large) affects efforts estimation?• In your opinion , How much the location of developers (on premise or work from home) affects effort estimation?• In your Opinion , How much your company business type affects the accuracy of effort estimation?
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3.7.2 Focus Groups

Interviews can have a shape like focus groups, having team members in one place and conduct an interview with all team members. Such data collection technique is useful especially when members share their ideas and opinions all together, providing a space of discussion that enrich data collection information. It is also helpful in decreasing the time and effort in interviews in case a multi case study is consuming time rather than having single interviews with individual team members.

We have conducted the focus groups in each company with team members to better collect data with more insight on the process of effort estimation in a way a discussion between team members provided more information about different approaches taken even within same team in effort estimation. Additionally, during group discussion our role was to moderate the discussion giving each team member the chance to express his thoughts and giving his opinion, after that a discussion between team members was done and recorded.

3.7.3 Observations

Observations are known as frequent source of information in qualitative research. Unlike interviews, observations often provide more objective

information related to the research topic as suggested by Hancock and Algozzine [9].

Collection of data through observations was done in C4 premises. The author had been working with C4 as a part time consultant and had access to the development team within their planning sessions. Notes and activities for the teams in C4 were taken during observation sessions (observer without participation). Observation sessions had been done on two sprint planning for two different projects with two different teams.

Data collection Approaches:

- Gather observational notes by conducting on observation as an observer (without participation).

What will be observed?

All activities involved in the software effort estimation will be investigated.

- This includes all effort estimation activities and steps taken, recording any use of special tools and focusing on the practice and techniques used within effort estimation.
- How requirements are being handled and how effort estimation is being done on requirements stories, features or bugs.

- How effort estimation is validated and if a team or specific persons are validating estimations output.
- What challenges and factors affecting the estimation output, what considerations and constraints are being considered.

We have recorded and stored data collected from interviews, focus groups and observations using audio recorded voice that has been transcript into documents. The data within documents had been coded and each sentence was given a code and then we did group of codes with a link of each code to original document.

3.8 Data Analysis

As case study research is a flexible research method, qualitative data analysis methods are commonly used [32]. The main objective of data analysis is to derive conclusions from the data, keeping a clear chain of evidence, which allow derivation of results and conclusions from the collected data [43].

Analysis of data had been carried out in parallel with data collection. That is because in flexible research strategies, during data analysis it may appear that more data is needed to better analyze the outcome. Using this iterative approach it allows going back and enrich the data collection phase by adding more sources or by changing some interview questions

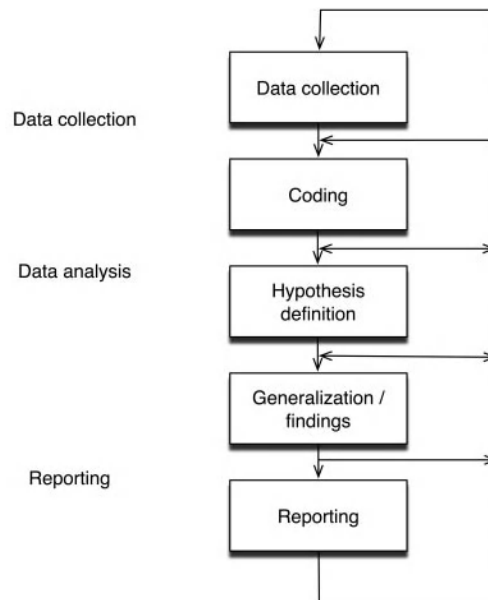
to better analyze data.

The analysis has been conducted in a series of steps, based on Robson's guidelines [29], First the data is coded, one code is usually assigned to many pieces of text, and one piece of text can be assigned more than one code. Codes can form a hierarchy of codes and sub codes. Then The coded material can be combined with comments and reflections (i.e., memos). When this is done, start identifying the hypotheses.

The identified hypotheses can then be used when further data collection is conducted in the field, that is, resulting in an iterative approach where data collection and analysis is conducted in parallel. During the iterative process a small set of generalizations can be formulated, eventually resulting in a formalized body of knowledge, which is the final result of the research.

Figure 3.2 shows the data analysis process, in which how multi-case studies can help achieving the required results with multiple approaches of data collection. The approach allows an iterative methodology in which the outputs of one case study can help refactoring the interview questions and possible some research questions. Findings from cases studies can lead to more questions or to focus on areas not considered thoroughly in earlier stages.

FIGURE 3.2: Main steps of data analysis.



3.9 Activity Plan

To conduct the planned activities list of tasks and items needs to be taken within the planned time line. Following the actions and activities in Figure 3.1 , a high level plan is shown in Figure 3.3. The plan contains the high level activities with sub tasks detailing how main activities will be taken .

Below The Main Plan Activities

- **Select Cases :**

Because of legal purposes and confidentiality the selected companies and their area of work will be kept confidential, however for

the rest of the study we will call them C1,C2 and C3 . Another possible approach that depends on the availability of experts is to have face to face interview with two experts in the area of software development and in estimation in specific. The experts are chosen based on their proven and historical experience in the area of software development and effort estimation.

- **Conduct Case Studies :**

Based on the research overview section, the data collection for the case study will have a triangulation approach. In Such Approach interviews (face to face and possibly online) are conducted with the development teams and their managers and team leaders, the case studies had been done sequentially within a time frame of one week for each case.

- **Generating a Report for each Case Study :**

For each case a report is generated to include the outcome of the case study. Interview questions and their answers were documented and recorded for further analysis. In many cases the outcome of one case study can potentially affect the research questions by adjusting them or adding to them , for this minor changes within interview questions had been done with following cases.

- **Generate Cross Case Study Report :** After finalizing all four case studies a cross case report is generated containing the summary of

3.10 Plan For Validity

According to Yin [43], four tests have been commonly used to strengthen the quality of any empirical social research and these tests are also relevant to case studies. Table 3.4 shows the four tests along with recommended tactics to ensure these tests.

Tests	Case Study Tactic	Phase of research in which tactic occurs
Construct validity	<ul style="list-style-type: none"> • Use multiple source of evidence • Establish chain of evidence • Have key informants review draft case study report 	<ul style="list-style-type: none"> • Data Collection • Data Collection • Composition

Internal validity	<ul style="list-style-type: none"> • Do patterns matching • Address rival explanations 	<ul style="list-style-type: none"> • Data analysis • Data analysis
External validity	<ul style="list-style-type: none"> • Use of theory 	<ul style="list-style-type: none"> • Research design
Reliability	<ul style="list-style-type: none"> • Use case protocol • Develop case study database 	<ul style="list-style-type: none"> • Data Collection • Data Collection

TABLE 3.4: Case Study Tactics for Four Design Tests (Yin [43])

Chapter 4

Results and Analysis

This section presents the results from four case studies which represents our multiple case study. The cases represent 4 companies operating in Palestine specialized in software development, three of the companies have been selected for interviews and focus groups and the fourth company has been selected for observations. For confidentiality issues we will refer to the companies with C1, C2, C3 and C4 representing the four cases. Table 4.1 describes the demographics of the selected cases. Additionally, a survey was done for collecting information about effort estimation within the Palestinian market. The survey was built using Google forms and distributed for 2 weeks using Facebook groups related to Palestinian IT Facebook groups, the researcher owns linked in profile and emails to known participants upon the researcher relations.

TABLE 4.1: Demographics of the studied cases

Case Code	Domain	Methodology	Technology	Size
C1	Web Tools for Managing Infrastructure Network devices (Outsourcing)	Scrum	Java Based	Large
C2	Custom software development	Scrum, Waterfall, and Prototyping	.NET, Oracle	Medium
C3	Web Tools for Managing Infrastructure Network devices (Outsourcing)	Scrum	Python	Large
C4	Custom Web and Mobile Apps for AID sector	Kanban, Scrum and Iterative Waterfall	PHP	Medium

4.1 Survey Results

A total of 101 respondents to the survey distributed were 33% senior developers, 21% developers and 35% managers and team leaders, the rest are divided between students and non-IT members. Respondents experience is divided as 40% with 5-10 years of experience within software development 36% less than 5 years and the rest are over 10 years experience. These results determined the selection of team members for focus groups and interviews with 5 and more years of experience.

Results of show that no actual specialized software estimation jobs are in Palestine. Additionally, experience and knowledge of effort estimation is distributed between 44.6% saying they have moderate knowledge in

software effort estimation, 32.7% saying they have strong knowledge and a 22.8% saying they have basic knowledge. further, more than 78% of IT practitioners and software developers agree that projects finish late with 25% more or less of effort estimation accuracy error. Additionally, results show that Expert based estimation is the dominant estimation techniques used in the Palestinian IT companies with more than 84%. However, the results also show that around 19% of practitioners do use parametric or formal models. Figures 4.1 4.2

An interesting result from the survey is that more than 75% agree that poor requirements are the main reason for poor estimation. While 50% also chose to have management pressure as a main reason for that. Moreover 19% selected Cultural issues as a reason for poor estimation. Additionally, more than 65% percent of respondents believe that the software development methodology affects the accuracy of estimation. However, only 10% does not agree on that and the rest are not sure.

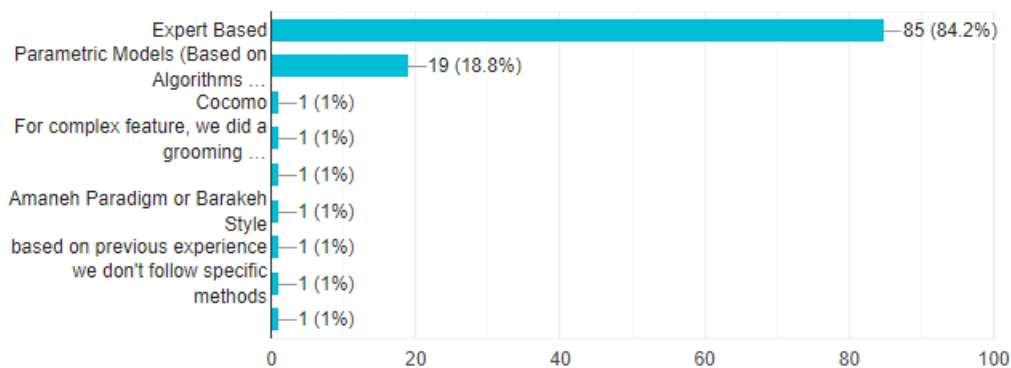


FIGURE 4.1: Techniques used in software effort estimation

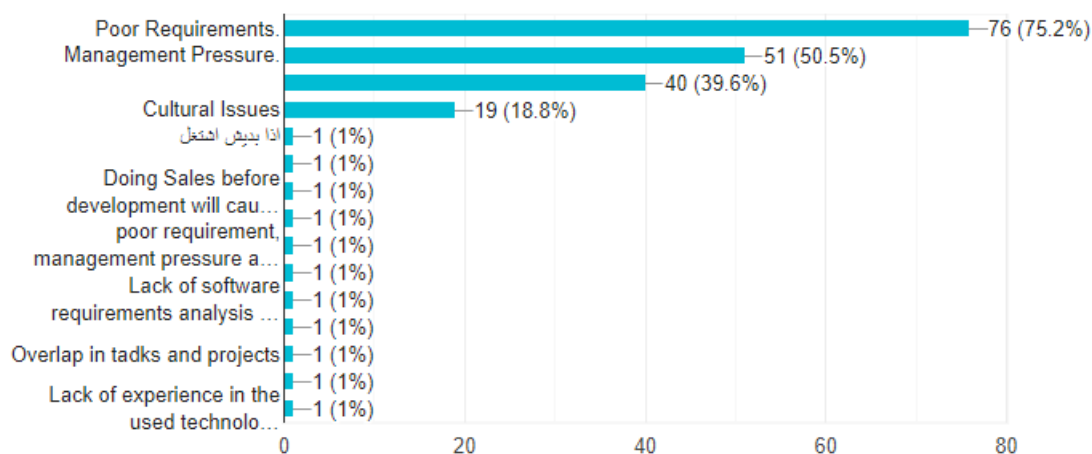


FIGURE 4.2: Factors affecting accuracy of effort estimation

Furthermore, survey results show that almost all developers use time-based metrics in their effort estimation, with some intersection between time based and story points. Figure 4.3

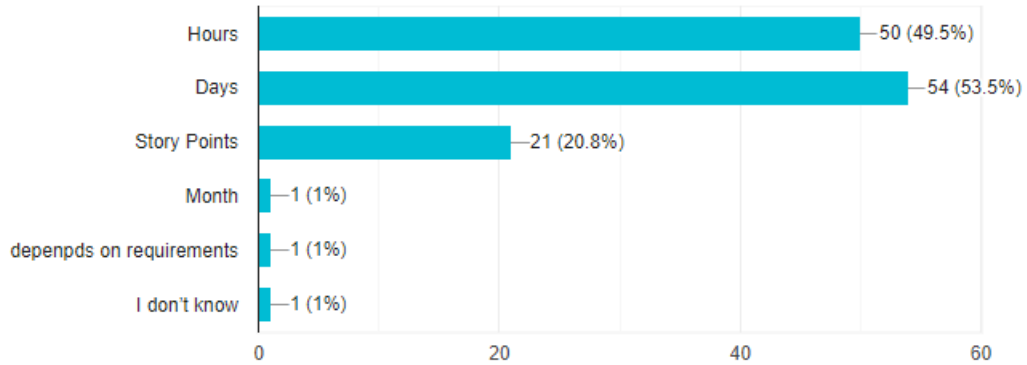


FIGURE 4.3: Metrics used in effort estimation

Additionally, results show that more than 46% do not use any tools within their effort estimation, while around 52% do use tools. Figure 4.4. This result from the survey shows a major issue in the Palestinian software development market in which almost half of the respondents did not use any type of tools within their software estimation which indicates a major issue in this field.

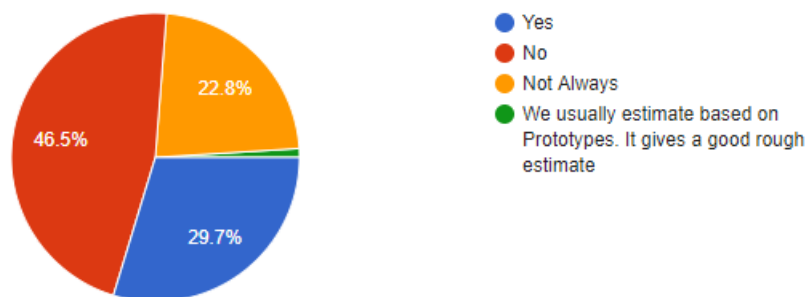


FIGURE 4.4: Tools support in effort estimation

Further, it has been shown that more than 73% of effort estimation is being done by all team members, this comes along with the more use of agile methodologies in software development in Palestine [3] [45] . Figure 4.5

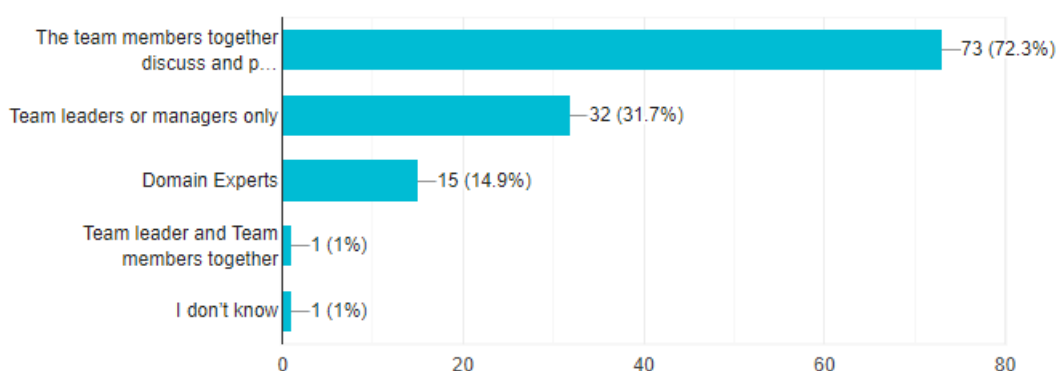


FIGURE 4.5: How effort estimation is being done

Additionally, results show that software developers do believe that the use of a specific methodology in software development and the size of the project have a great effect on effort estimation. On the other hand the developers did not agree that much that the location of developers do have an effect on effort estimation as around 44% agree that the location of developer (working off shore or from home or within the company premises) do have an effect of effort estimation while around 34% did not agree on that. Figures 4.6 4.7

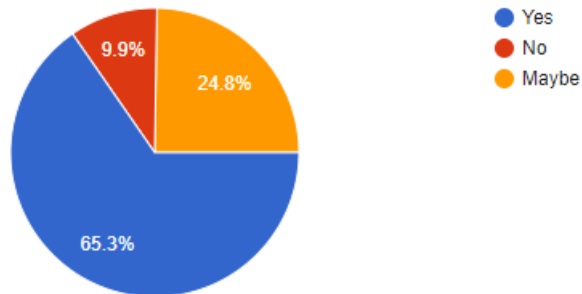


FIGURE 4.6: Does the used methodology in software development have an effect on effort estimation accuracy

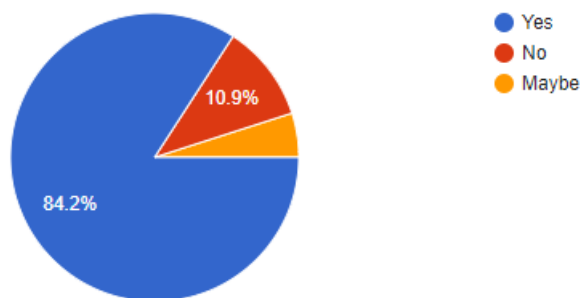


FIGURE 4.7: Does project size (small, medium, large) affect efforts estimation

4.2 Case study results

In this section we provide the results from our qualitative cases studies (interviews, focus groups and observations) in relation to our research questions. The research questions are revolving on three main points to which we address our interview questions and discussed and observed

within the selected cases teams.

The results of the case studies were based on the interviews and focus groups with C1,C2 and C3 . while C4 had a two sprints observation sessions.

Interviews were done with development managers in the three companies with an time of 30 minutes to 45 minutes for each interview, after that the manager was asked to suggested a group of 2 or 3 resources to participate in a focus group, the 3 companies have provided 2 resources in each focus group due to the availability of resources. The focus group time was also between 30 to 45 minutes and in one case C2 it expanded to one hour.

All interviews and focus groups discussions, questions and answers were recorded using a smart phone recorder after informing and taking approval from the the attendees that the sessions will be recorded.

4.2.1 Techniques used in effort estimation

In general, it was noticed that expert-based judgment is the dominant technique used in effort estimation. All cases have approached this technique with differences in the approach. Although this comes aligned with our survey results, but we did not notice any of the cases use any

formal or parametric models within their estimations. C1 and C3 approach expert-based estimation within their scrum methodologies. In which team members provide estimation as a team depending on their experience. Shared experience within team members and mutual discussions within the planning phase provide a base for a shared experience to be used in providing as much accurate estimations as possible.

C2 and C4 on the other hand provide expert based estimation in another approach. Although both C2 and C4 do try to use scrum but in the planning phase the estimation is provided by the team leader or development manager alone without consulting with team members. On the other hand, teams within C2 and C4 do share their opinion for the provided estimations but initial estimations are only provided by managers or team leaders. This indicates somehow a lack of knowledge in applying scrum or agile in general.

The results show the absence of any tools in providing effort estimations and all cases do use time-based metrics in their estimations, hours or days are the mostly used time-based metrics. Additionally, results show that C1 and C3 use a technique to estimate features complexity based on number of interfaces and interactions with other modules. However, C2 uses number of screens and number of inputs or operations for each module. Furthermore, C4 do use a combination of both.

We also noticed that the use of historical data to help in expert-based judgment is not used within estimation process. Nevertheless, all cases do store their estimations using tools like JIRA but data is not reached by teams to help in their estimations. However, C1 Development manager mentioned that in rare cases they might go back to previous estimations to help in decisions. Moreover, C3 team leader mentioned that he might go back to earlier estimations as a way of knowledge transfer in cases the resources provided estimations for some modules are not available any more within the team members or they have resigned.

In Addition to the above, results show that all cases did not state any special way to handle initial project estimations that differ from their way in providing estimation in planning phase. They are following same approach whether the estimation is required for an initial requirement or for a full detailed requirement. However, C2 development manager stated that in cases where initial estimation is required on a very high-level, they use surveys or meetings to collect further requirements to provide more accurate estimations.

4.2.2 Factors and challenges influencing the accuracy of effort estimation

Most of the cases have highlighted that unclear requirements is the main factor affecting the accuracy of estimation. C1 development manager stated *“The most important reason is unclear requirements; Product manager is not understanding what he wants and of course the requirements come unclear so we start even trying to tell him what he should have or the customer may need.”* Furthermore, Team members and leaders within four cases has agreed that poor requirements affect the accuracy of estimation because developers tend to assume things. assumptions vary from easy and strait forward features to more complex features. Additionally, C2 Development managers said that he uses direct meetings and sometimes surveys with stakeholders to understand requirement better in order to provide more accurate estimations.

Additionally, results show that there are major challenges developers face while estimating a software project. For example, C1 has stated that one of the main challenges that affected their estimation was to manage the agile (scrum) process in away that team members follow strictly as per the scrum model. Although scrum is considered very useful for us, Said C1 development manager, still the time we took to achieve a standard scrum process was more than 1 year of efforts. *“Doing scrum in a standard way do produce more accurate estimations.”* C1 Development

manager.

The C1 case in using scrum is an interesting case as it somehow shows that using an agile technique like scrum was considered a challenge for the teams to estimate. However, C1 development manager stated and clarified that the use of agile by team members without sufficient knowledge in agile was a challenge since the transition to agile and the teaching and training of team members to be an agile team costs time and effort in which they did not consider in their estimations which became a main factor in their estimations accuracy.

Moreover, C2 stated that the main challenge they have in estimation is the time, *"we always have a strict time to deliver our projects in"* C2 development manager. However, business domain that the developer must understand was main challenge for developers in C2. *"Developers must understand the domain in order to estimate well"*, C2 developer. Additionally, C3 Team member stated that one of the major challenges is the ability to break down requirements into smaller pieces in order for developer to estimate well. Estimating a large feature consists of huge uncertainty.

Software development methodology is a main factor affecting estimation. All cases agree on that. *"The use of agile for example, helped us a lot in providing more robust estimations than what we had in earlier"*

waterfall methodology". C1 development manager. Additionally, C2 Developers started that proving mock-ups and prototypes also helps a lot in providing more robust estimations. Further more C3 and C4 agree on that area in which agile is the best model for getting better estimations. *"because of the fact that requirements are divided into smaller features that will help estimating easier and more accurate"* , C2 Developer.

Although results from C1 and C2 for example in using agile looks contradicting but as explained by the managers in both cases, the use of agile helps but after being agile professional which takes time and effort to become one.

4.2.3 Effect of the company business type and business model on the effort estimation techniques

According to Zein [44] Palestinian Eco system shows a diversity of software development companies that work in multiple areas. Further more the survey results show an effect of the business type and cultural issues on software effort estimation. The effect has been found in this study results.

C1 and C3 work within an outsourcing model for bigger international

companies while C2 and C4 deal with local markets, or in case C4, markets very similar to local markets. Furthermore, both C1 and C3 work within the process of the client they do outsourcing for. Requirements normally comes ready and well established. Additionally, they both work in almost one technology and with no restriction on time to deliver all requirements in one release. However, the delivery of features is determined after the planning phase in which each release (pre-determined in time) has a set of features that can be delivered . Nevertheless, C2 and C4 work for different clients and provide custom software for different needs every time. *“we do develop systems in various technologies which introduce a huge challenge on the team”* . C2 Software Developer.

Additionally, cultural issues within the company itself do affect the estimation. For example, C1 and C3 has their teams working directly with the international companies and local management do not interfere with their decisions. *“The culture of international company is reflected on the culture of the developers within the Palestinian company”* , C1 Developer said.

Developers location effect on software estimation was splited opinion between cases. C2 development manager did not like the work from home and offshore teams. He stated that the *“communication overhead is not considered while estimating. although it should be”* . C2 Development Manager. Furthermore, C1 and C3 did not consider the location of

developers causing a difference or an effect on software effort estimation accuracy.

Although C1 and C3 results is different in opinion with C2 but we have noticed that outsourcing companies like C1 and C3 do have more robust communication plans especially with their product owners which reduces the communication overhead the team leader is required to increase when developers are working in different geographical locations, However C3 did mention that the quality of work especially for unexperienced developers or fresh graduates working in a project is much more controlled when they work within the company's premises under his supervision.

Chapter 5

Discussion

In this section, we provide our discussion based on our key findings and observations on effort estimation within the industrial context of software development in Palestine. More specifically, we map the findings to the study hypothesis and we provide some recommendations to enhance the software effort estimation approach and accuracy; as several issues can be concluded from the observations and results of our case studies.

5.1 Techniques used within software effort estimation

In relation to Research question RQ1, it was found that Expert-Based technique is the mostly used technique in software estimation within the Palestinian software development companies. This corresponds to our

hypothesis that “Expert-based models are the most used models in estimation within Palestinian companies”. However, we have noticed that expert-based techniques were not conducted in a systematic way. In fact, it has no defined process nor checklists to understand how it should be done.

The use of expert-based judgment as the mostly used software estimation technique complies with the findings from the literature and many other researches [22] [39] [4] that expert based techniques and informal models in general are the most used techniques within effort estimation.

Additionally, it was found that some companies do rely on their team experience to provide estimation and, in rare cases, a domain expert is available. However, it was clear that the Expert-based estimations are tight to the resources experience in development. This affects the actual estimation for the task if another resource is assigned to it, in which the real effort estimation is not recorded in isolation of the resources who will do the task. This will cause of inaccurate recorded effort estimation for the use of historical data.

Furthermore, companies do store their estimations and planning output using tools like JIRA and Redmine. Nevertheless, the use of those tools by team members or managers to help them in effort estimation using the historical data recorded is very rare. This is because they rely on

team experience for estimation which can vary from one resource to another.

Resources related factors in specific has been examined by Tanveer [36] and Popli [24] in which they both found that those kind of factors are the main factors affecting effort estimation like the resources experience and developers knowledge. The findings from our study shows a clear and tight relationship between resources and accuracy of estimation in which more experienced resources do have more accurate estimations.

These findings correspond to our next hypothesis in which “Accurate effort estimations require clear and detailed processes and guidelines to be considered by estimation team” And “ Missing Guidelines and missing use of historical data when applying experts-based models.”. Results of the cases studies shows that few companies do use a set of guidelines or process to do effort estimation. However, it was found that the cases that used guidelines and process did have more accurate estimations than companies did not.

Finally, the need of such process is an actual need for the developers in these companies as stated in their focus groups and interviews. However, companies that do not apply such guidelines are mainly companies working in the local market with diversity of technologies and business domains. Which makes it very hard for them to build up a process for

each product, domain or technology. Jorgensen in his study [12] states that Providing guidelines, checklists and structured group processes can help in achieving even more accurate estimates.

5.2 Challenges and factors affecting software effort estimation

In relation to research question RQ2, it has been observed that unclear requirements and inexperienced team members are the main factors affecting the quality and accuracy of effort estimation. Further, it has been observed that estimations were not done by the team as a whole in all development phases. Initial estimations are mostly done by managers or team leaders which introduces a constraint for the rest of the team in the actual planning phase. The team members do estimate features with a constraint in mind that the required feature had already been estimated by the manager or the team leader which causes estimation outputs to be less accurate.

Another factor affecting the accuracy of effort estimation is the guidelines that are set by the company for the teams to consider while developing estimations. The more guidelines and clear steps defined the more accurate estimation is provided. Companies for example that only consider number of screens or number of inputs and outputs of a module do have less accurate estimations than companies follow strict guidelines to

consider while estimation like number of interfaces, deployments, testing and research tasks.

Finally, it has been observed that adopting agile development methods is also a main challenge facing Palestinian companies. Such transition can affect software effort estimating. This is because team members first need to master the new agile principles and practices.

5.3 Effect of outsourcing as a business type on effort estimation.

In relation to RQ3 it has been found that business type does affect the effort estimation technique used and the accuracy of that estimation. In this study we had observed and interviewed different types of cases that work in different types of software development business. Part of the cases focus on outsourcing model and the other part focus on local software development.

The main difference between both types is that the outsourcing-based companies do follow a process defined by the company they do outsourcing for. Teams do follow a strict process which is in most cases an agile process which allow the requirements to come clearer because of the presence of the domain expert and the product owner. Additionally, the

estimation is being done by the whole team members which makes it more accurate as more experienced resources share ideas and experience with less experienced resources. However, in companies developing for local market it was totally different. First there was no defined process for software development Life cycle, Furthermore, companies develop projects in several domains and using several technologies which makes it a challenge to put a standard process for the team to follow.

Regarding the location of developers and the distributed development in which teams may not be within the same premises, the result from the survey shows more than half of the developers did not see an effect of that factor on software estimation. Although this looks contradicting with Usman's findings [38] that geographical distance between teams is considered a main cost driver, The results from the case studies clarifies this contradiction.

The results show that although developers themselves see no effect of their location while doing development, still the managers and team leaders consider the more the distance between developers the more communication overhead is needed to keep the context as if they are working within the same premises. These findings shows that the location of developers do affect effort estimation but not directly on the task itself but on the managers and team leaders tasks with more communication overhead they have to consider.

Another factor we have noticed specially for local market is the use of agile as a development methodology within their projects. Although agile is considered the most used development methodology in software development, we had an interesting result from local market companies and specially their developers that agile is actually causing their estimations or projects to fail instead of success. However, this same methodology seems to help outsourcing companies in Palestine to have much more accurate estimations and more successful projects.

The main reason for local market companies to consider agile as an obstacle although they use it is - from their point of view - the fact that they do use agile within a very limited time-boxed projects that already have their budget, delivery time and requirements set. However, from the results of the study we have noticed that the local market teams and the types of clients they work for do not understand the agile process as the outsourcing companies and their teams do. We have noticed that local companies do need more robust agile training and to have additional knowledge on how agile is implemented and the most needed knowledge is that agile has more than one practice to apply for different contexts since scrum is not the only technique to use.

5.4 Formal models in effort estimation

Finally, and corresponding to the last hypothesis we stated about formal models; we have found that the use of formal models is either missing or is used without calibration. It has been found that companies do not follow any of the formal models defined neither specific tools for estimations. The multiple case study tried to cover multiple sectors within the Palestinian software development industry but still more research is required to understand how formal models are being approached by companies.

Our understanding for not using such models is that the effort estimation experience in the Palestinian market is not mature enough. the information about formal models is very rare and the expert based model are dominating this field. Furthermore, the use of formal models requires information about resources, requirements and other factors in the project which we did not see companies do collect and register in a formal way. expert based models comes to be easier to implement because of the presence of experts which do not require any effort of registering information and parameters for the project.

5.5 Recommendations

In this study we do recommend some enhancements to several approaches in software effort estimations. It has been found that following a process and a specific guidelines in software effort estimation do provide more robust and accurate estimations and this has been also approached by Jorgensen [12] who found that providing guidelines, checklists and structured group processes can help in achieving even more accurate estimates.

The guidelines can state how to do expert based estimations and what factors to consider while doing estimations. the steps to follow when estimating a feature and a process for validation of such estimations can be very helpful. For example defining which steps to take when estimating a feature like counting number of interfaces required for integrations, considering the deployment effort , considering the testing efforts can help even less experienced resources to better estimate and not to forget any important piece or factor.

For larger companies having multiple teams, providing a kind of formalization for the teams estimation process can help in providing more standard estimations across the company teams. for example each team can determine the size of the story point base don his experience while the company it self should have a standard story point size across all

teams to have more accurate estimations for all its projects.

The dependency on resources experience while doing estimation is not a good idea since this will affect the actual estimation of the task. However, a better approach is to try estimating the task before assigning to any of the resources and add more tasks for knowledge transfer and research or proof of concept when the task is assigned to less experienced resource. This will help teams in future querying historical data to better know how much such task was estimated with no relation to the resources that has been assigned the task.

Another recommendation is to include nonfunctional requirements while doing effort estimations. This can be approached by guidelines in which deployments, testing and further nonfunctional efforts can be considered for each task.

In general formalizing a non-formal model like expert-based judgment is a good idea and will help developers and team leaders better estimate and provide more accurate estimations (Jorgensen et al, 2009). However, as it has not been found in any the cases any use of formal models, we do believe that combining both formal and non-formal models can be of a better advantage for effort estimation in software development industry [28].

The use of agile should be practiced well by local market companies and their teams. One good example is what have been done in C1 in which they have stated that they provided an agile coach for their teams within their work premises to teach them the correct agile process while working on projects, this kind of training can help local market companies to do better in their estimations and do more successful projects if they have learned better how to use agile and in specific to learn what agile technique to use for which context. However, more research for this field might be required.

The use of historical data has not been noticed by any of the cases. Although the data is recored using tools like JIRA and Redmine but the teams do not use this historical data at all. We do recommend that the mining of this historical data and/or to be used within some kind of Neural networks or machine learning algorithms can help in achieving better accuracy in software estimation, researches has been done on such approaches [26] and results show major benefits for estimation accuracy.

Chapter 6

Conclusion and Future Work

6.1 Summary and Conclusion

6.1.1 Thesis Distinction from Other Studies

Even though there are lots of studies targeting software development and task prediction in general [18] [6], or in a specific software methodology like agile [10] [23] [24] [26] [15], no studies focus on understanding how Palestinian companies approach software prediction and the challenges they face.

To our best knowledge, only one study by Zain et al. [44] has targeted Palestinian software development companies. In their study, the authors focused on exploring testing challenges and methods applied in the area of mobile app testing. However, in this research, the aim is to explore the challenges that Palestinian software development companies are facing in the specific area of effort estimation.

A few secondary studies have approached software effort estimation; Systematic literature review studies [22] [4] [41] and surveys investigating the state of the art practices within effort estimation [39] [38]. This study will try to investigate and increase the knowledge of software effort estimation in Palestine since the availability of research on Palestinian market within Software Effort Estimation context is none.

Tanveer exploratory case study at a German multinational software corporation, SAP SE [36], is very similar to this study. Tanveers' aims were to Understand and investigate the accuracy of efforts estimation within an agile environment. His goals were to improve the effectiveness of effort estimation within an agile context. Furthermore, He has focused on understanding the estimation process with respect to which methods are being applied. Who participates in the estimation and what are the decisions being taken with estimation process. Tanveer also tried to understand which factors are affecting the estimation process. Additionally, if there are any tools support required in the estimation process by practitioners.

Tanveer results show that the impact of change in an agile environment is affecting the estimation accuracy. Change impact effect comes

from the fact that agile context itself is embracing change. Further, Factors such as developer's experience and knowledge are main factors affecting the estimation accuracy.

Although Tanveer's study share similar aims and objectives to this study, nevertheless this Study is focusing on Palestinian market. Furthermore, this study is not targeting a special development methodology like agile. It is trying to explore and advance the understanding of Effort Estimation in Palestine regardless of development and delivery methodology. The expected results of This study will help understand the challenges and factors affecting the accuracy and quality of Software Effort Estimation in Palestine. Additionally, it may help Palestinian companies to approach better estimation models and guidelines based on its results.

6.1.2 Conclusion

Expert Based Estimation (EE) models are the most used models especially within agile environment. Multiple improvement has been done on EE models to formalize the process. Proposing guidelines and checklists to the EE process improves the quality and accuracy of estimation.

Lots of Research has been done on formal models. However, fewer research is available on the Expert based models ad Informal models in

general. More research is required in this area and it appears to be a potential advantage to better organize and formalize the process of expert based models to achieve better accuracy.

Expert Based models can easily loose the focus on other cycles of development like testing and non-functional requirements. Additionally, the basic EE model is non structured and is affected by the human decision which leads to inaccurate estimation output depending on the resources and experience. However, improvements on the EE process can be done by checklists and guidelines to better include missing cycles and enhance the accuracy.

A potential advantage can be achieved by combining different parametric models to do Effort Estimation. Models such as Neural Network based, Machine Learning based and traditional function size and use case point models can be used to have better parametric models. However, the project factors, the environment and the development context affects what to choose as a technique within estimation [4]. Furthermore, some parametric models can be calibrated to meet the organization specific needs and circumstances. Adding more parameters to a model can also be an enhancement as another model version to be used within current software engineering and development practices.

Another potential advantage is to combine both Formal and Informal

models. Including the machine learning for example as part of Planning Poker team. Use the Neural Networks to predict initial effort estimation in absence of historical data. Such combination can be a potential improvement to effort estimation. However, empirical evidence is still required in this area as potential future work.

Findings of our case study showed that The Palestinian IT sector and especially the software development sector is a young and new sector. Future research on software development lifecycle, estimation using formal models and studies on improving estimations using a combination of both formal and informal models is required to build a better software development industry.

Studies on how to benefit from outsourcing models to enrich the local market software development and enrich the local development companies with experience from outsourcing models are also required. Furthermore, our study shows that the use of agile methodologies is increasing within the Palestinian software development sector. However, there is a need for a comparison research and studies on how local market is approaching agile with companies working with outsourcing business.

6.2 Threats to validity

To ensure validity and reliability to our study several actions have been taken and several reliability and validity strategies have been applied while conducting this study.

To ensure we are collecting the right information and we do had a set of hypothesis based on the literature review, regarding the construct validity we have used multiple sources of data. A chain of evidence has been established by reviewing the results from observations, interviews and focus groups and comparing them with survey results. Additionally, Thematic coding was used to analyze the qualitative data collected, sentences were numbered and linked to their data sources.

As we did not have previous information nor previous research in the field of effort estimation for Palestine the External validity was done by developing set of theories based on the literature review. Theories were built upon latest research in the topic. The findings of the case studies did correspond to the theories.

The Palestinian software development market is diverse and has lots of cases to cover in order to understand the current situation, The reliability of this study has been empowered by having a case study protocol with a selection of cases that tried to cover multiple industrial cases that

we believe provide a good sample of the Palestinian IT sector. the samples covered 4 companies working for both outsourcing and local market.

6.3 Acknowledgements

We would like to thank the managers, team leaders and developers in the four companies who have participated in our case study.

Chapter 7

Appendices

7.1 Appendix A - Survey Questions and Answers

TABLE 7.1: Survey questions and objectives.

Id	Question	Objective
1	What is your current job title	To have a general look on the software development jobs titles to which we can know if there are any effort estimation related titles.
2	How much experience you have in software development field	To know how is the software development experience is distributed and how much experienced developers exist

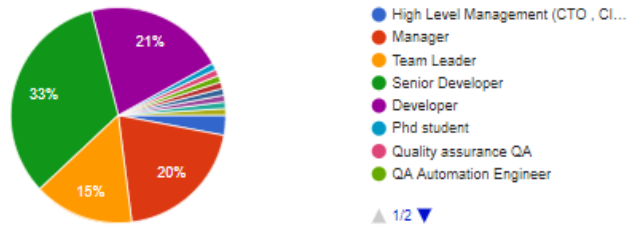
3	How to evaluate your knowledge in the software effort estimation field?	To understand and know if the responded have previous knowledge in software effort estimation and how much is that knowledge to better phrase our interview questions and to make sure we do need a pre-interview meeting to explain the subject.
4	What is the average accuracy for estimation provided in initial phases of the project (based on your experience)	To know if there is any difference in initial project estimation than estimation within planning phases of a project and if there is an accuracy in provided estimations or not.
5	What are the techniques you or your company use in software effort estimation	To have an overall overview on which techniques used and to better design our interview questions
6	What metrics you use in measuring effort estimation	To have an overall overview on which metrics used and to better design our interview questions

7	If you rely on your experience while providing effort estimation for a software project, do you depend on historical data	To get more information if there is any use of historical data and consider this within our interviews.
8	Do you use tools to support you in effort estimation	To have an overall overview on which tools used and to better design our interview questions.
9	How is effort estimation is done in your company	This is an open-ended question that we set to better know how effort estimation is done (team based, user based, managers based) in order to design our interview questions. some predefined choices were provided to the responded with ability to enter more.
10	In your Opinion, what are the main reasons causing projects estimation to NOT be accurate	A list of responses was set with ability to add more, this question was very important to know what cases we should focus on within our interview questions.

11	In your opinion, does the methodology you use in project development (Agile, Waterfall, Prototype. etc.) affect effort estimation accuracy and techniques	To understand and collect information about any possible relation between methodology and estimation techniques so that we do design our interview questions accordingly.
12	In your opinion, does the location of developers (on premise or work from home) affect effort estimation	To understand and collect information about any possible relation between location of developers and estimation techniques so that we do design our interview questions accordingly.
13	In your opinion, does project size (small, medium large) affect efforts estimation	To understand and collect information about any possible relation between project size and estimation techniques so that we do design our interview questions accordingly.

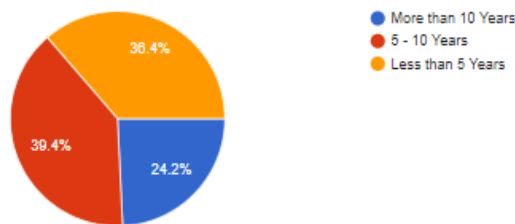
What is your current job title ?

100 responses



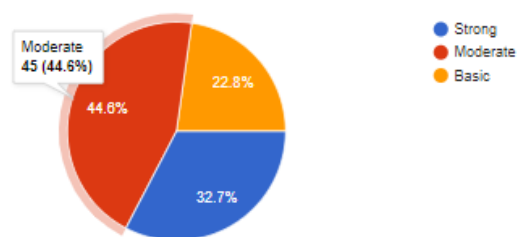
How much experience you have in software development field ?

99 responses



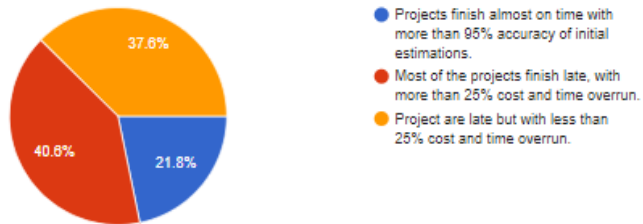
How to evaluate your knowledge in the software effort estimation field?

101 responses



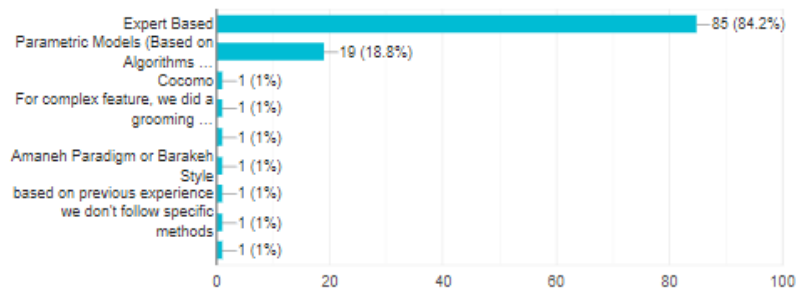
What is the average accuracy for estimation provided in initial phases of the project (based on your experience) ?

101 responses



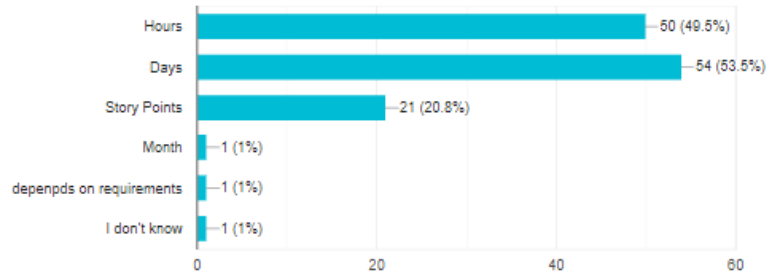
What are the techniques you or your company use in software effort estimation ?

101 responses



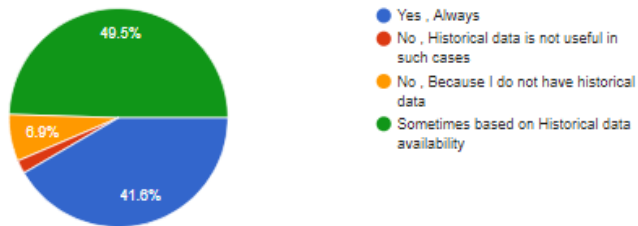
What are the metrics you use in measuring effort estimation?

101 responses



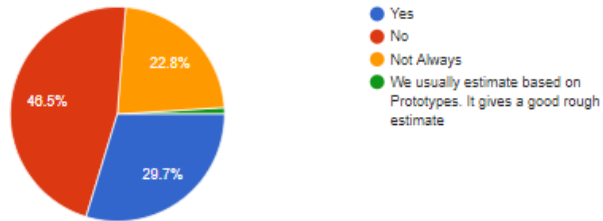
If you rely on your experience while providing effort estimation for a software project, do you depend on historical data?

101 responses



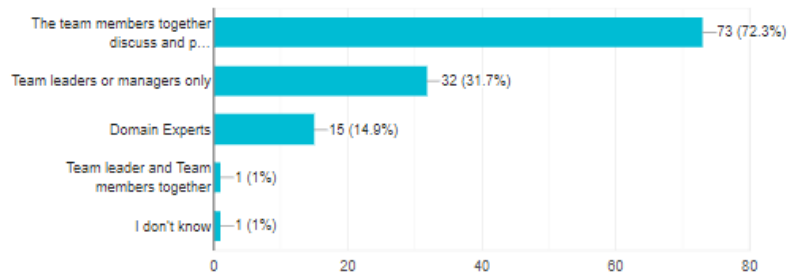
Do you use tools to support you in effort estimation?

101 responses



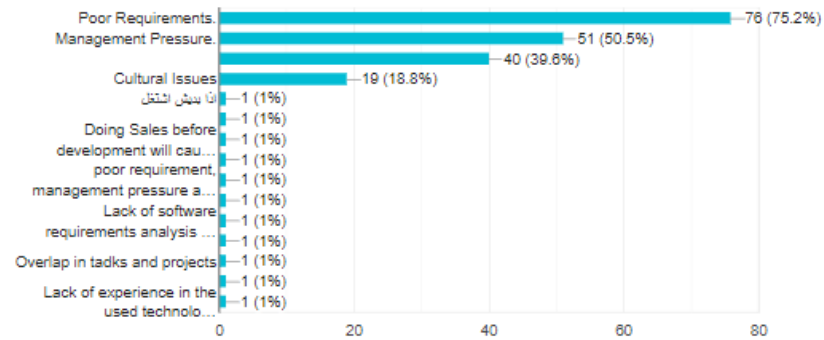
How is effort estimation is done in your company ?

101 responses



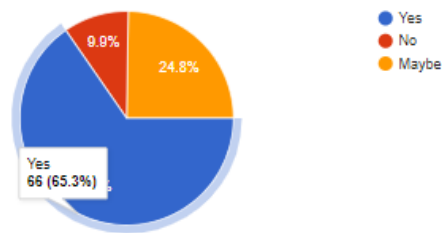
In your Opinion, what are the main reasons causing projects estimation to NOT be accurate?

101 responses



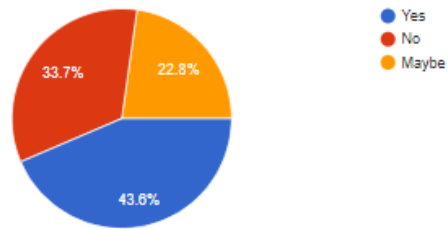
In your opinion, does the methodology you use in project development (Agile , Waterfall , Prototype ..etc) affect effort estimation accuracy and techniques?

101 responses



In your opinion , does the location of developers (on premise or work from home) affect effort estimation?

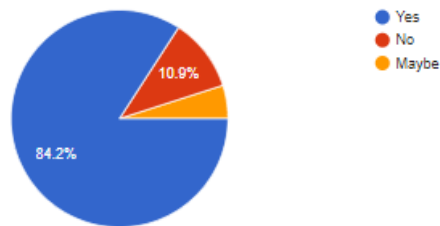
101 responses



In your Opinion , does project size (small , medium large) affect efforts estimation?



101 responses



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