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A Proposed Estimation Method Framework in Scrum Development Methodology for Tech Startups

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Thesis Approval

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Declaration

I declare that the work provided in this thesis, unless otherwise referenced, is my own work, and has not been submitted elsewhere for any other degree or qualification.

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Date of Final Thesis Submission: 22/8/2023

Dedication

To My Amazing Parents

Who Have Been Always There for Me. It’s their unconditional Love that Motivates Me to Set Higher Targets.

To My Brother and Sisters

Who Have Provided Me with A Strong Love Shield That Always Surrounds Me and Never Lets Any Sadness Enter Inside.

I Present This Work

Acknowledgment

I would like to express my thanks to my supervisor. Dr. Amjad Rattrout for his guidance through this study. Also, I would like to express my thanks to Kathleen Chan, the founder and CEO of Calico who supported me during the study and shared the development company data for this study.

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Special thanks to the staff of Computer science for their collaboration and help. Thanks, are also expressed to my friends and family for their encouragement.

Finally, I take this opportunity to express my profound gratitude to my beloved mother. Thank you for being with me on each and every step of my life. I couldn't have done it without you. Your endless believe in me has made me work hard on this project and in the goal of becoming a great scientist.

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List of Abbreviations

XP: Extreme Programming

QA: Quality Assurance

AI: Artificial Intelligence

FDD: Feature-Driven Development

DSDM: Dynamic Systems Development Method

SM: Scrum Master

PO: Product Owner

ST: Scrum Team

BP: Product Backlog

DD: Done-Done

CR: Customer Request

PB: Product Backlog

SDO: Software Development Organization

UI: User Interface

GA: Genetic Algorithm

Abstract

Tech startups often face challenges in accurately estimating the number of backlog items that can be completed during a sprint, using the scrum agile development methodology. This can result in a negative impact on the relationship with customers, including costs and trust. One major factor that affects the delivery of features is the presence of defects or bugs, which can prevent backlog items from being marked as complete and shipped to the production environment. To address this problem, we propose a new estimation methodology that combines testing and development estimates to account for the impact of bugs on the completion of features.

Our approach is divided into two parts: a quantitative analysis to evaluate the model's effectiveness, and an applied implementation in a real startup development cycle. In the quantitative analysis, we assess the model's quality using various metrics. In the applied implementation, we test the model in the actual development process of a startup, using the results of the quantitative analysis to guide the approach.

The results of our study show that our method significantly improved the done percentage of sprints, going from 84.2% to 95.6%. This demonstrates a significant improvement compared to the previous results without using our approach. Our method offers a potential solution for tech startups facing difficulties with backlog item estimation and aims to improve the accuracy and efficiency of the development process. However, it is important to note that if the approach is not used correctly, it can result in a gap in development capacity and a deviation from agile best practice.

Chapter 1: Introduction

In this chapter, the focus is on tech startups and their use of software development methodologies. The first section provides an overview of scrum, a popular agile methodology used by many tech startups. The second section discusses Kanban, another agile methodology commonly utilized by tech startups. The third section delves into the specific context of tech startups and how they utilize these methodologies in their work. The purpose of this study is then presented as the fourth section, outlining the motivation behind examining the use of these methodologies in the tech startup industry.

Tech startup companies need to keep up the pace of the technology revolution and to satisfy their clients. To be able to do that, they make sure to cop up with the speed of technological inventions and new revolutions. Tech companies also try to globalize and reach up the industry competitors; specially software development companies which need to keep up with the customers' needs and make daily changes on the requirements. These companies try to make their offers to clients move fast. (Gonen & Sawant, 2020)

Since late 1990s, the most popular trend that was spread all over the world was named Agile or Agility (Boehm et al., 2010). Up until now this era is called "The Agile Method Era". It refers to the software systems as a set of technical and people-related practices. Many methods were added under the umbrella of Agile like, Extreme Programming (Beck & Andreas, 2004), Scrum (Beedle et al., 1999), FDD (Feature-Driven Development) (Palmer & Felsing, 2002), Crystal and DSDM (Dynamic Systems Development Method) (Palmer & Felsing, 2002). Through the years and the new leading way of product management,

especially in the agile software development. Many methods under the agile product management are now in practice (Palmer & Felsing, 2002). According to the 14th Annual State of Agile Report (Palmer & Felsing, 2002), Scrum methodology is widely used as an agile project management methodology. About 58% of the organizations are using the Scrum then followed by SCRUMBan with 10%, then the hybrid (multi-methodologies) with 9% and the rest is divided into smaller percentages of other methodologies like SCRUMBan, Hybrid, Kanban, Lean, XP and Iterative development.

1.1 Scrum

Scrum was first introduced in 1990s and it was referred to as a management and control process (Vlaanderen et al., 2009). Later on, it was defined as a framework that "employs an iterative, incremental approach to optimize predictability and control risk" (Vlaanderen et al., 2009).

Scrum has proved its great impact on the companies that implemented it. This is reflected on both team members and customers (Vlaanderen et al., 2009). Also, the strength of Scrum was presented to be helpful in the challenges that IT organizations might face in resource. The Scrum framework helps the organization to find its foundation and structure by providing unique set of values, practices, and principles to be implemented in the organization by its team. And while they create their own engineering practices to help the organization management of the Scrum, they will create a new version that is specially formed to their organization (Vlaanderen et al., 2009).

Many titles used to describe Scrum such as methodology, process (Vlaanderen et al., 2009), practices or a framework (Vlaanderen et al., 2009). The last update was to consider it as both an agile process and an iterative framework which is presented in Figure 1.

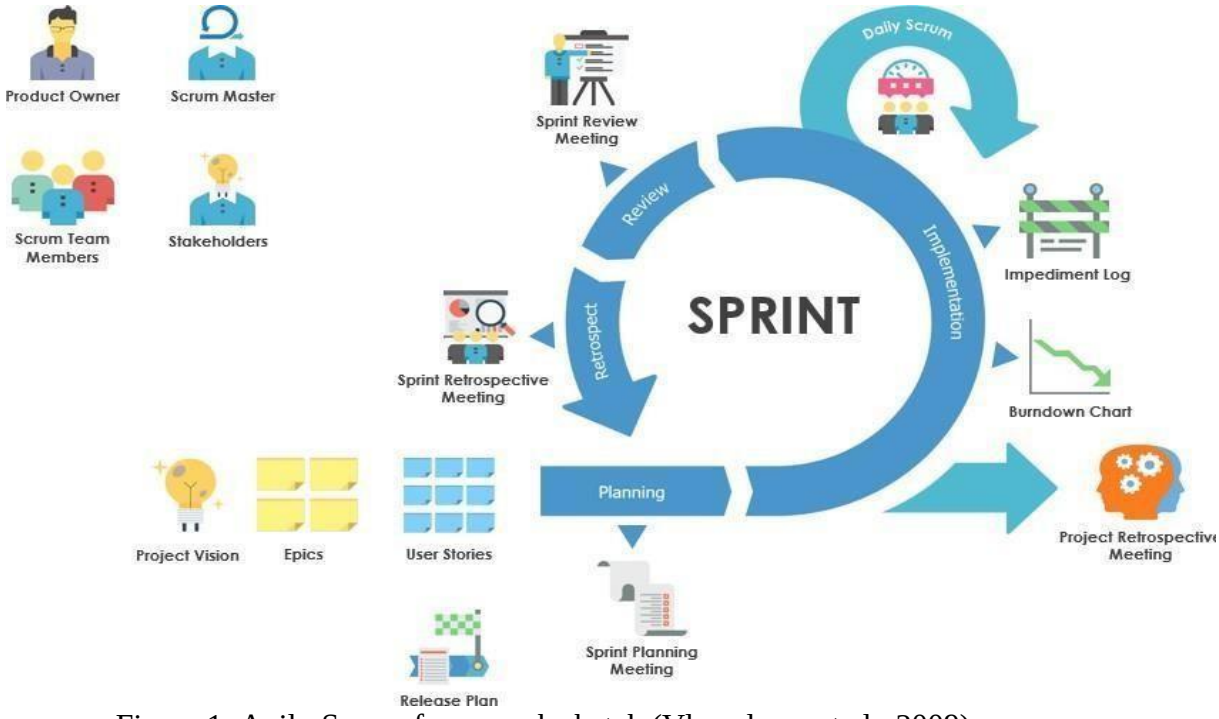


Figure 1: Agile-Scrum framework sketch (Vlaanderen et al., 2009).

Scrum is mainly followed to short iterations; it varies from one to four weeks. These iterations are called sprints, and during these sprints, the requests of the new developments or enhancements to the product are prioritized and divided into the sprints. After each sprint, a release is being launched with the new added developments without affecting the original functionality. The release could be at the end of each sprint.

1.2 Kanban

Kanban was first introduced in the early 1940s. The first Kanban system was developed for Toyota automotive in Japan (Vlaanderen et al., 2009). It was created as a simple planning system. The aim of Kanban was to control and manage work and inventory at every stage of production optimally.

The Kanban Method follows a set of principles and practices for managing and improving the flow of work. It is an evolutionary, non-disruptive method that promotes gradual improvements to an organization's processes. If you follow these principles and practices, you will successfully be able to use Kanban for maximizing the benefits to your business process – improve flow, reduce cycle time, increase value to the customer, with greater predictability – all of which are crucial to any business today (See figure 2).

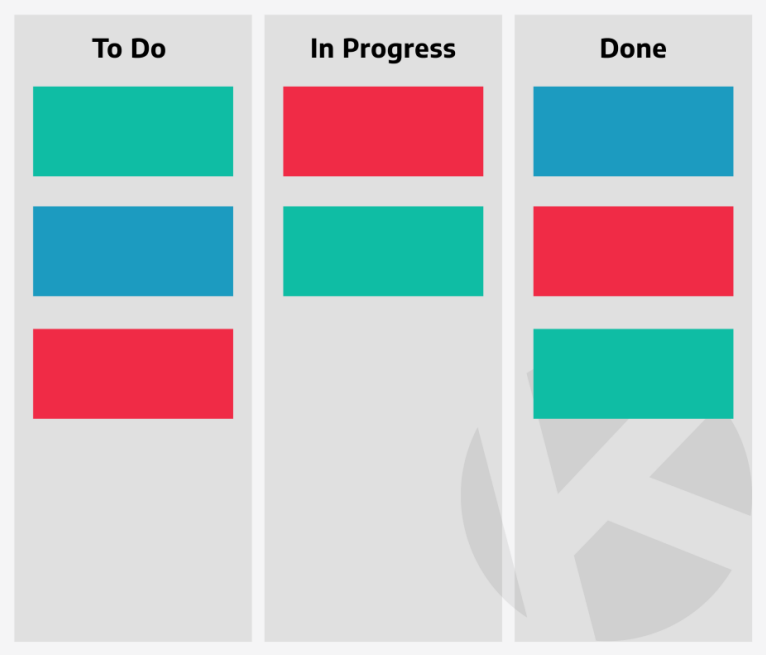


Figure 2: Agile-Kanban framework flow Kanban board. (Kanban and Agile, 2019)

1.3 Tech Startups

Software startups are newly created companies, with little or no operating history, producing cutting-edge products. The environment of software startups is extremely dynamic, unpredictable, and even chaotic. A systematic mapping study identifies the most frequently reported contextual features of a startup:

1. General lack of resources
2. High reactiveness and flexibility
3. Intense time-pressure
4. Uncertain conditions and tackling fast growing markets.

This thesis focused on tech startups since they started to be more common due to increasing demands of the current age to resolve pressing issues and challenges. Different developmental methodologies which are commonly used in tech startups were presented and a comparison was carried out between them.

Next, previous contributions in agile software development field will be presented. Even though these contributions are not dynamic to the agile characteristic's conditions, some of them are still used to build models to solve a complicated problem in the market.

1.4 Purpose of the Study

Tech startups are under pressure to keep up with the rapid pace of technological change and meet the needs of their customers. To do this, they often turn to agile software development methodologies, such as Scrum, which involve short iterations called sprints during which

new development or enhancement requests are prioritized and completed. However, tech startups often struggle with accurately estimating the number of backlog items that can be completed during a sprint, which can have a negative impact on their relationship with customers, including costs and trust.

One major factor that affects the delivery of features and the done percentage of sprints is the presence of defects or bugs, which can prevent backlog items from being marked as complete and shipped to the production environment. These bugs are typically identified and reported by quality assurance (QA) engineers, but they may not be taken into account in the original estimates made by developers. As a result, there is a gap between the effort estimated for sprint tickets and the actual effort required to complete them, which can lead to underestimated sprints and a lower done percentage.

To address this problem, we propose a new estimation methodology that combines testing and development estimates to account for the impact of bugs on the completion of features. Our approach is divided into two parts: a quantitative analysis to evaluate the model's effectiveness, and an applied implementation in a real startup development cycle. In the quantitative analysis, we will assess the model's quality using various metrics such as prediction accuracy and the done percentage of sprints. In the applied implementation, we will test the model in the actual development process of a startup, using the results of the quantitative analysis to guide the approach.

The purpose of this research is to provide a solution to the challenge of accurate estimation in tech startups using the Scrum development methodology. Our proposed estimation

methodology aims to improve the accuracy and efficiency of the development process by accounting for the impact of defects or bugs on the completion of features. By implementing this approach, tech startups will be able to deliver more accurate estimates to their customers, improving the relationship with customers and helping to build trust. Additionally, this methodology has the potential to improve the done percentage of sprints, reducing the risk of missed deadlines and overrunning budgets.

It is important to note that if the proposed approach is not used correctly, it could result in a gap in development capacity and a deviation from agile best practices. Therefore, it is crucial to carefully consider and follow the values, practices, and principles of Scrum in order to effectively implement our proposed estimation methodology.

Overall, this research aims to address a significant challenge faced by tech startups using the Scrum development methodology: the difficulty of accurately estimating the number of backlog items that can be completed during a sprint. By combining testing and development estimates to account for the impact of defects or bugs, we hope to provide a solution that can improve the accuracy and efficiency of the development process, leading to better outcomes for tech startups and their customers.

Chapter 2: Literature Review

Tech startups often face challenges in accurately estimating the number of backlog items that can be completed during a sprint using the Scrum agile development methodology. This can result in a negative impact on the relationship with customers, including costs and trust. One major factor that affects the delivery of features is the presence of defects or bugs, which can prevent backlog items from being marked as complete and shipped to the production environment. To address this problem, we propose a new estimation methodology that combines testing and development estimates to account for the impact of bugs on the completion of features.

There is limited research on this problem in the context of tech startups, but several studies have identified challenges with estimation in agile software development more broadly. For example, Jalali and Gholami (2017) conducted a systematic review of agile estimation techniques and found that practitioners face a number of challenges when making estimations in agile projects, including:

- A lack of shared understanding of the requirements: Estimations are often based on incomplete or ambiguous requirements, which can lead to inaccurate estimates.
- Insufficient data and information: Estimations may be based on insufficient data or information about the project, leading to inaccurate estimates.
- Changing project conditions: Agile projects are characterized by rapid iteration and continuous delivery, which can lead to changes in the project conditions and requirements.

This can make it difficult to accurately estimate the time and effort required to complete backlog items.

To address these challenges, various techniques have been proposed, including planning poker, functional measures, and AI-based models. However, these techniques have had mixed results and may not be sufficient to fully address the issues with estimation in agile projects.

Niemann and Mock (2013) also conducted a systematic review of estimation in agile software development, focusing on the Scrum methodology. They found that Scrum practitioners face several challenges when making estimations, including:

- A lack of shared understanding of the requirements: As with agile projects more generally, Scrum projects may suffer from a lack of shared understanding of the requirements, leading to inaccurate estimates.
- Insufficient data and information: Scrum projects may also be impacted by a lack of data and information, which can make it difficult to accurately estimate the time and effort required to complete backlog items.
- Changing project conditions: The rapid iteration and continuous delivery of Scrum projects can also lead to changes in the project conditions and requirements, which can impact estimation accuracy.

In addition to these challenges, Niemann and Mock (2013) noted that traditional estimation techniques, such as expert judgment and functional measures, may not be sufficient to

address the problems with estimation in Scrum projects. They suggested that more research is needed to identify effective approaches to estimation in this context.

"A comparison of agile estimation techniques" by A. Arora, S. Verma, and K. Kavita (2018): This study compares the effectiveness of expert estimates, planning poker, and functional measures in agile software development. The authors find that planning poker can improve the focus on code quality and may be more accurate than expert estimates in some cases, but caution that it should not be used in isolation as it only considers the developers' estimates and not other factors that may impact estimation accuracy.

"Estimation in agile software development: A systematic review of the state of the art" by J. Niemann and S. Mock (2014): This systematic review updates the literature on estimation in agile software development, with a focus on the Scrum methodology. The authors identify several challenges and problems with estimation in Scrum and discuss the various techniques and approaches that have been proposed to address these issues. They also suggest areas for future research, including the development of new estimation techniques and the investigation of factors that impact estimation accuracy.

"A study of agile estimation techniques" by M. Beedle et al. (1999): This study investigates the use of planning poker and other techniques for tracking time/cost and burn down chart visualization of progress in agile software development. The authors find that a combination of planning poker and expert estimates can be useful for estimation, but caution that it may not result in good prediction accuracy on its own. They suggest that functional measures may be a more effective approach to estimation in agile projects.

"Agile estimation techniques: An empirical study" by V. Lenarduzzi et al. (2015): This study investigates the factors that impact estimation accuracy in agile software development, including capacity, developer knowledge, developer implementation experience, complexity, impact on existing system, priority, and clarity of requirements. The authors propose the development of a tool to consider all of these factors in order to help developers provide more accurate estimates in agile methodologies.

Other approaches that have been proposed to address the challenges with estimation in agile software development include AI-based models that learn from previous estimations in order to optimize estimation accuracy (Lenarduzzi et al., 2015) and the use of scrum patterns, such as stable teams, yesterday's weather, swarming, interrupt pattern, daily clean code, emergency procedure, scrumming the scrum, happiness metric, and teams that finish early (Lenarduzzi et al., 2015). However, these approaches may not fully address the issues with estimation in agile projects and may not be suitable for tech startups, which face unique challenges in this regard.

Overall, it is clear that estimation in agile software development, and particularly in the Scrum methodology, is a complex and challenging problem. A number of techniques and approaches have been proposed to address the issues with estimation, but there is a need for further research to understand how to effectively apply these techniques and to identify additional approaches that may be more effective. In particular, there is a need to consider the specific context of tech startups and the unique challenges they face in accurately estimating backlog items. Our proposed estimation methodology seeks to address these

challenges by combining testing and development estimates to account for the impact of bugs on the completion of features.

Chapter 3: Methodology

In this study, a thorough analysis of the data was conducted, followed by the implementation of a methodology that included the use of various formulas to structure our model. Our methodology was divided into two parts: a quantitative approach, which was used to evaluate the effectiveness of the model, and an applied approach, which involved the implementation of the model in the real development cycle of a tech startup. The results of the quantitative approach were then used to inform the applied approach, allowing us to assess the model's performance in a real-world setting.

In this chapter, we will first provide an overview of the tech startup Calico that has been used in this study, including its application requirements, scenarios and functions, and technologies utilized. We will then describe the two models used in this study: the quantitative model and the applied model.

3.1 Startup Info

Over the past two years, I have been a founding team member and Vice President of Engineering at Calico, a tech startup based in Canada. As a product development operating system, Calico serves the $1.4 trillion eCommerce production market from concept to delivery. In 2022, Calico received funding of 2.1 million dollars from Sereena Williams Ventures.

The Calico engineering team consists of two developers and one quality assurance engineer, and follows the agile scrum software development methodology with two-week sprints and a total capacity of 200 hours. Each developer has a capacity of 70 hours, while the quality

assurance engineer has a capacity of 60 hours. These capacities take into account the time allocated for scrum meetings.

3.1.1 Application Requirements

Calico is a product development platform that provides a range of tools and resources for eCommerce brands to manage their supply chain and bring their products to market. It is designed to help brands manage the design and production process, from concept to final delivery, and offers a variety of features to support this process.

Some of the key requirements for the Calico platform include:

- Collaborative workspace: Calico AI provides a dedicated workspace for brands and suppliers to work together on product development. This includes tools for design and communication, as well as the ability to share documents and other resources.
- Global network of factories: Calico AI has a network of factories around the world that are available for use by brands. These factories are selected based on a variety of criteria, including region, sustainability, and other factors.
- Factory bidding and quotes: Brands can request bids and quotes from multiple factories, allowing them to find the best price and production options.
- Production management: Once production is underway, brands can use Calico AI to manage the process and track progress. This includes tools for communication, quality control, and other aspects of production.

- AI workflows: Calico AI includes a range of AI-powered workflows and tools to help streamline and optimize the product development process. This includes features such as automatic scheduling and resource allocation, as well as predictive analytics and other capabilities.

3.1.2 Scenarios and Functions

In this thesis, we conducted experiments during the development of the Techpacks and RFQ modules for the Calico product development platform. These modules serve important functions within the platform, facilitating effective communication and organization during the product development process.

The Techpacks module allows designers to compile all necessary information for the manufacturing of a product into a single document. This includes technical details such as colorways, size gradations, measurements, and labels, as well as materials breakdowns and component listings. The Techpacks module also includes a feedback section for comments and revisions during the sample stage, and order details for delivery dates and bulk production addresses.

The RFQ (Request for Quote) module allows brands to connect with and request quotes from a network of global factories, filtered by region, sustainability, and other criteria. Brands can manage the entire production process within the Calico platform, from design to manufacturing.

Overall, the Techpacks and RFQ modules serve to streamline the product development process and reduce the risk of errors and miscommunications. By providing a comprehensive

and organized system for communication and organization, these modules help to increase efficiency and speed up the time to market for new products.

3.1.3 Technologies

Calico utilizes a range of technologies to power its product development platform. The backend is built using .NET 6 and C#, while the frontend is powered by Angular 14. To store and manage data, Calico employs both a SQL database deployed on Amazon Web Services (AWS) Relational Database Service (RDS) and a NoSQL database deployed on AWS DocumentDB. File storage is handled through the use of AWS Simple Storage Service (S3). The cloud infrastructure for Calico is provided by AWS, including load balancers, CloudFront distributions, and Elastic Compute Cloud (EC2) instances. These technologies work together to provide a reliable and scalable foundation for the Calico platform, enabling it to support the needs of eCommerce brands as they bring their products to market.

3.2 Quantitative Model

In this study, we propose a new model for developer estimation that builds upon the planning poker estimation method in order to increase the percentage of completed product backlog items in sprints. The Scrum software development methodology typically includes QA engineers in the estimation process for backlog items alongside software developers. However, in our model, we exclude QA engineers from estimating developers' work and instead provide them with separate capacity and estimation for testing in order to prevent their estimation from impacting the developers' estimates. Figure 3.0 illustrates the traditional

planning poker estimation approach that has been commonly used to estimate product backlog items.

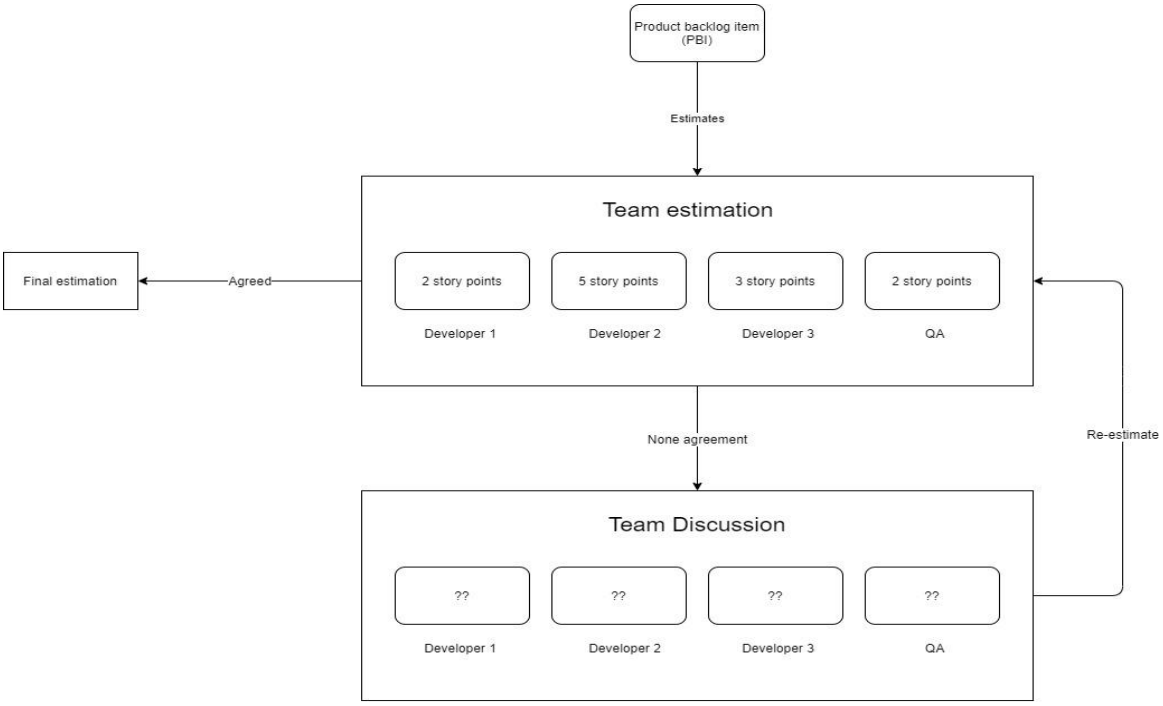


Figure 3.0: Normal planning poker estimation approach

To address the issue of accurately estimating product backlog items in the Scrum software development methodology, we propose a new model based on the planning poker method. In this model, the QA engineer's estimation of the backlog item is taken into account and combined with the estimation made by the developers. This is done in order to ensure that the testing effort required for the item is accurately reflected in the overall estimation and to minimize the potential for discrepancies. The percentage of the QA engineer's estimation that is added to the developer's estimation should be determined based on the effort, potential for bugs, and other relevant factors. In Figure 4.0, we demonstrate how the QA engineer's

estimation is integrated with the developer's planning poker estimation to provide a more accurate overall estimate.

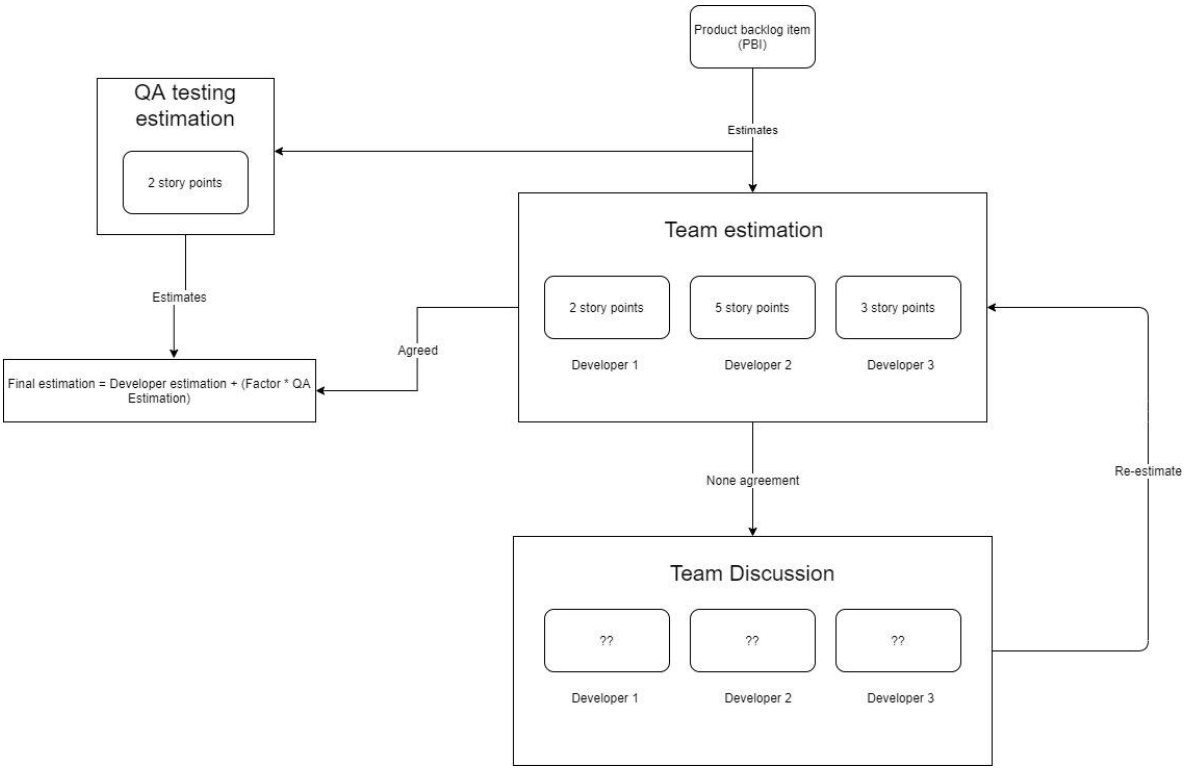


Figure 4.0: Developers planning poker estimations combined with QA estimation

To further refine our model, we propose the addition of a percentage of QA estimation for a given PB item to the developer's estimation. This percentage is intended to compensate for any gaps in effort, bugs, and estimation. Our model is represented by the formula:

$Estimation = DE + (\alpha \times QE)$, where DE is the developer estimation, alpha is a percentage factor based on historical bugs percentage data for the startup, and QE is the quality assurance testing estimation.

To implement this model in practice, we map quality assurance estimations to their respective sprints and add the calculated percentage to the developer backlog items' estimations. However, as this may result in an excess of tickets with updated estimations, we also propose a selection process to remove tickets in order to fit within the capacity of the sprint for the developer.

3.2.1 Selection Process

The selection process in our model is designed to ensure that the capacity of each sprint is met while also considering the potential risks to delivering items to end users. This process involves identifying the tickets with the closest estimations to the remaining capacity of the sprint and removing them as necessary. In cases where the remaining capacity is not more than three hours, the estimations of some tickets may be rounded up to meet the capacity. If the remaining capacity is greater than three hours, a small ticket from the product backlog may be selected and added to the sprint using the same approach. It is important to note that the selection process is utilized in the quantitative phase to optimize the utilization of the sprint capacity and prioritize the inclusion of product backlog items as the sprint planning and estimation have already been completed prior to the execution of the sprint. However, this process is not implemented in the applied phase. By applying this process in the quantitative phase, we are able to effectively simulate the impact of various selection strategies on the efficiency of the sprint.

3.2.2 Collecting Data and Analysis

In this study, we utilized data from Calico, a tech startup that utilizes the scrum software development methodology. Specifically, we analyzed data from three different sprints at Calico. Calico provided us with data on ticket numbers and their corresponding estimations but did not provide any information on the content or description of these tickets.

Our research, depicted in Figure 5.0, aimed to understand the capacity of each sprint and the capacities of the developers and quality assurance team at Calico. By examining this data, we aimed to calculate the percentage of work completed at the end of each sprint.

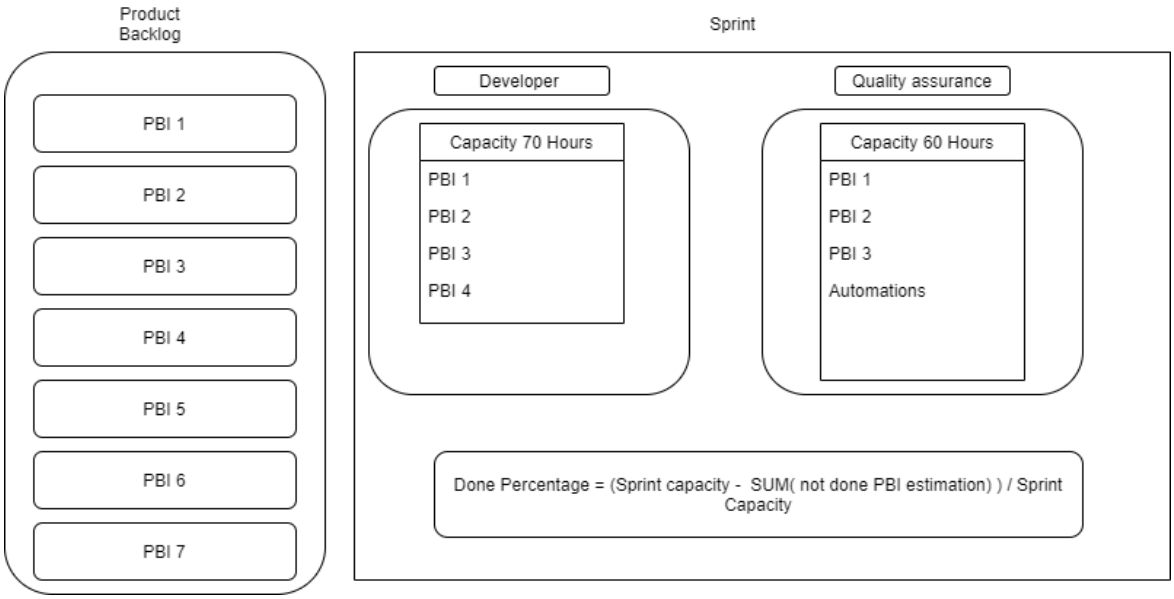


Figure 5.0: Sprint backlog planning

We can see in Figure 5.0, done percentage formula which is to calculate the done percentage for each sprint, we used the formula shown in Figure 5.0. This formula

$Done\ percentage = \frac{C - \sum NDP}{C}$, considers the sprint capacity (C) and the percentage of not done product backlog items (NDP) to determine the overall done percentage.

3.3 Applied Model

In order to compare the effectiveness of the proposed model, we will be conducting a case study on Calico.

The startup has agreed to provide us with data from ten sprints in which the proposed model will be applied to their RFQ module. This will be compared to data from ten previous sprints in which the startup utilized their traditional estimation method for their Techpack module.

To conduct the case study, we will first analyze the data from the ten sprints in which the proposed model was applied to the RFQ module. This will include examining the capacity of the sprints, the estimation values of the developers and QA engineers, and the final done percentage at the end of each sprint. We will then compare this data to the data from the ten previous sprints in which the traditional estimation method was used for the Techpack module. This comparison will allow us to determine the effectiveness of the proposed model in improving the done percentage and delivering product backlog items within the sprint.

Chapter 4: Design Investigation and Implementation

In this chapter, the data collection process used to gather data from Calico was described, followed by the implementation approach that was implemented in order to obtain the results. The startup consists of two developers and one quality assurance engineer, with a sprint duration of two weeks and a capacity of 200 hours for both developers and the quality assurance engineer. The model was implemented on three different sprints, each with a different percentage of the quality assurance engineer's capacity included in the developers' estimations (10%, 15%, and 20%). The 15% condition was used in the applied model. The chapter begins with the implementation of the quantitative model and then proceeds to the applied model implementation.

4.1 Quantitative implementation

In this sub-section, we describe the process of implementing the proposed model for developer estimation in the quantitative phase of the study. The data for this phase was collected from Calico, a startup using the Scrum software development methodology. The company agreed to provide us with data from three different sprints, including the number of tickets and their respective data.

To evaluate the effectiveness of the proposed model, we calculated the done percentage using the following formula:

$$Done\ Percentage = \frac{\sum DTE}{C}$$

Where DTE represents the estimated number of completed tasks and C is the total capacity of the sprint, including the estimations for quality assurance tasks. In this study, we experimented with three different percentages (10%, 15%, and 20%) for the contribution of quality assurance estimation to developer estimation. The results showed that a done percentage of 100% was achieved when the percentage was set to 20%. However, this resulted in a significant reduction in the overall workload, leading us to conclude that a balance must be struck between the done percentage and the amount of work.

In the following sections, we will discuss the details of the sprints and the proposed calculations for the different percentages. Prior to this, we will provide an explanation of the columns in Table 1.0.

Table 1.0 Sprint data parameters

Table Columns
Ticket Number
Developer Estimation
Developer Effort
Done Percentage
New Estimation of (n) percentage
New Estimation Capacity after removing ticket
New Estimation of (n) - Developer Effort
Done Percentage on proposed model
New Model Effort Capacity After Removing A Ticket Contains Bug
QA Estimation
Bugs opened
Bugs Effort

As we can see in Table 1.0, the first column is ticket number, which is the number of the ticket inside project management software, usually the ticket starts with 2 or 3 letters of the project name then the number of the ticket inside the system.

The developer estimation is the estimation done by the developers using planning poker technique in the planning meeting and before the sprint starts. The developer effort is the real effort has been done on each ticket and it should be close to the developer estimations in the ideal case scenario.

The done percentage is the percentage of the solved tickets based on its estimation combined together divided into the total sprint hours, we've did that for each developer separately and on the whole sprint, noting that product backlog cannot be marked as done if it has a blocker (bug).

The new estimation is the developer estimation multiplied by a percentage of quality assurance estimation on the tickets and the (n) is the percentage amount.

The new estimation capacity after removing tickets is the final developer sprint capacity after removing the overhead tickets, because the developer sprint should only contain tickets with the available capacity and our proposing method will add more estimation on every ticket so we had to remove a ticket/s from the sprint.

The new estimation – developer effort, is what the sprint capacity left would look like if they made the estimation using our technique of (n) percentage if the ticket is done if it's not completed, we'll minus the estimation assuming it will be done on the estimation time.

Done percentage on proposed model is what the new done percentage will be if the percentage of (n) added to the developer estimation and we remove tickets to match the sprint capacity.

New Model Effort Capacity in the end of sprint, which is the left capacity when we apply the new model of (n) percentage at the end of the sprint after removing a ticket that a quality assurance didn't open a bug on it.

New Model Effort Capacity After Removing A Ticket Contains Bug, which is the left capacity when we apply the new model of (n) percentage at the end of the sprint after removing a ticket that a QA opened a bug on it.

Bugs Opened, are the tickets number of the main tickets that quality assurance issued a bug on them during sprint.

Bugs Effort are the real developer effort time spent on the bugs on the next sprint or same sprint if the developer had a time to work on them.

4.2 Quantitative Data Analysis

We have combined multiple percentages to see what's the best accurate results related to done percentage and its relationship with left capacity inside the sprint.

Sprint A

Sprint A contained the following tasks, developers' estimations, and effort as it shown in the Table 2.0.

Table 2.0: Sprint A data

Sprint A

	Ticket Number	Developer Estimation	Developer Effort	QA Estimation
Developer 1	CV-741	4	3	2
	CV-742	5	5	2
	CV-743	6	6	3
	CV-744	5	5	2
	CV-745	12	12	2
	CV-746	5	3	2
	CV-747	10	13	2
	CV-748	5	5	2
	CV-749	6	7	2
	CV-750	5	3	1
	CV-751	7	6	4
	Bug - 751		3	
	Bug - 748		2	
	Bug - 744		2	
	SUM	70	75	24

	Ticket Number	Developer Estimation	Developer Effort	QA Estimation
Developer 2	CV-752	7	7	4
	CV-753	3	4	3
	CV-754	8	9	3
	CV-755	13	11	4
	CV-756	10	12	5
	CV-757	6	4	3
	CV-758	5	4	5
	CV-759	6	4	3
	CV-760	12	15	6
	Bug - 756		6	
	Bug - 752		2	
	Bug - 760		3	
	SUM	70	81	36

We can see that the first developer estimations on the tickets are 70 hours but when it came to the actual effort, there is 5 hours more which cause of not closing two tickets bugs and marked them as un-done.

We can see that the second developer tickets mainly have higher estimations, which indicates a problem in separating tickets into multiple tickets so he can spread a better estimation. Thus, 11 hours of bugs opened on 3 tickets which caused three tickets of total 29 hours

estimations to be marked as not-done, also he had 1 un-completed ticket which added 6 hours more to un-done percentage.

Based on the previous data we have 150 done tasks hours including quality assurance testing tasks of 200 total estimations which shows an 76.5% done ratio on the Sprint A as total.

IF we calculated every developer sprint as separated, we can see that the done ratio of the first developer is 83% and the second developer sprint done ratio is 50%.

In the same sprint we have applied new model of estimation with 3 different percentages 10%, 15% and 20%, and we'll discuss every percentage with its pros and cons down below.

10% Percent

We've added 10% of the quality assurance estimation on the tickets on the developers' main estimations which shows a result as shown in Table 3.0

Table 3.0: Sprint A with a variable of 10% QA estimation

Done Percentage	New Estimation 10%	New Estimation Capacity After Removing Ticket
Done	4.2	
Done	5.2	6
Done	6.3	6.5
Done	5.2	5.2
Done	12.2	12.2
Done	5.2	6
Done	10.2	10.2
Not Done	5.2	5.2
Done	6.2	6.2
Done	5.1	5.1
Not Done	7.4	7.4
83%	72.4	70

Done Percentage	New Estimation 10%	New Estimation Capacity After Removing Ticket
Not Done	7.4	7.4
Done	3.3	3.3
Done	8.3	8.3
Done	13.4	13.4
Not Done	10.5	10.5
Not Completed	6.3	6.3
Done	5.5	
Done	6.3	8.2
Not Done	12.6	12.6
50%	73.6	70

In this case, we observed that the capacity of the first developer was exceeded by 2.4 hours, requiring us to remove a ticket and round the estimates of other tickets in order to balance the capacity. We used our selection process to determine which ticket to remove, ultimately selecting ticket CV-741 due to its 4.2 hour estimation. The remaining tickets, CV-742, CV-743, and CV-746, were rounded to match the 70 hour capacity for the first developer. Similarly, the capacity of the second developer was exceeded by 3.6 hours, requiring us to

remove ticket CV-758 using the selection process and round the estimation of ticket CV-759 to meet the 70 hour capacity. The results of this process, using a percentage of 10% for the combination of developer and quality assurance estimations, demonstrated a higher and better percentage of tasks completed, as shown in Table 4.0.

Table 4.0: Sprint A with variable of 10% QA estimation with the selectin process

New Estimation 10% - Developer Effort	Done Percentage On Proposed Model
	will not enter sprint
1	Done
0.5	Done
0.2	Done
0.2	Done
3	Done
-2.8	Done
0.2	Done
-0.8	Done
2.1	Done
1.4	Not Done
-3	
-2	
-2	
-2	92.5% or 89.4%

New Estimation 10% - Developer Effort	Done Percentage On Proposed Model
0.4	Not Done
-0.7	Done
-0.7	Done
2.4	Done
-1.5	Not Done
0	Done
	Didn't enter sprint
4.2	Done
-2.4	Not Done
-6	
-2	
-3	
-9.3	56.4% done percentage

We can see in Table 4.0 that the first developer could close 2 more tickets which marked un-done before due to bugs, also it raised the done ratio to 92.5% or 89.4% depends on which bug the developer decided to solve.

The second developer was able to finish 1 more ticket too, and it raised the done ratio to 56.4% but couldn’t complete any bug. However, the percentage shows a jump from 50% done percentage to 56.4% done percentage.

However, we’ve tried to simulate the same approach on different tickets, because it’s not always easy to get rid of tickets which has the closest estimation as shown in Table 5.0

Table 5.0: Sprint A with variable of 10% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
1.2
0.2
0.3
0.2
0.2
2.2
-2.8
will not enter sprint
2
2.1
2
-3
-2
New Capacity: 70
4.6
4.6 free hours and 100% done percentage
New Model Effort Capacity After Removing A Ticket Contains Bug
0.4
-0.7
-0.7
2.4
-1.5
0
4.2
-2.4
-6
-2
-3
New Capacity: 70
-9.3
0 free hours and 56.4% done percentage

The results of removing other tickets that contained a bug showed 100% done percentage for the first developer with 4.6 free hours, and the second developer couldn't remove any other ticket contained a bug because it won't match the capacity.

As a result of sprint A with adding 10% quality assurance estimations on the developer estimation, the method goes to a 82.15% done percentages when we removed the closest

tickets estimation and when we removed tickets that has bugs it caused a 84.75% done percentage.

15% Percent

We've added 15% of the quality assurance estimation of the tickets on the developers' main estimations which shows a result as shown in Table 6.0

Table 6.0: Sprint A with variable of 15% QA estimation

New Estimation 15%	New Estimation Capacity After Removing Ticket
4.3	
5.3	6
6.45	6.45
5.3	5.3
12.3	12.3
5.3	5.3
10.3	10.3
5.3	5.3
6.3	6.3
5.15	5.15
7.6	7.6
73.6	70

New Estimation 15%	New Estimation Capacity After Removing Ticket
7.6	7.6
3.45	3.45
8.45	8.45
13.6	13.6
10.75	10.75
6.45	6.45
5.75	6.8
6.45	
12.9	12.9
75.4	70

The results showed 3.6 more hours for the first developer so we removed 1 ticket which is CV-741 and rounded up ticket CV-742 to match 70hours capacity.

The second developer had 5.4 more hours, so we've removed ticket CV-759 and rounded up CV-758 to match 70hours capacity.

The results of 15% we're the same as 10% for both developers as shown in Table 7.0

Table 7.0: Sprint A with variable of 15% QA estimation with the selectin process

New Estimation 15% - Developer Effort	Done Percentage On Proposed Model
	will not enter sprint
1	Done
0.45	Done
0.3	Done
0.3	Done
2.3	Done
-2.7	Done
0.3	Done
-0.7	Done
2.15	Done
1.6	Not Done
-3	
-2	
-2	
-2	92.4% or 89.1%

New Estimation 15% - Developer Effort	Done Percentage On Proposed Model
0.6	Not Done
-0.55	Done
-0.55	Done
2.6	Done
-1.25	Not Done
0	Done
2.8	Done
	Done
-2.1	Not Done
-6	
-2	
-3	
-9.45	55.3 %

We can see that the results showed 92.4% or 89.1% done ratio for the first developer, and the second developer a 55.3% done ratio.

After applying the same method tickets that contain bugs as shown in Table 8.0

Table 8.0: Sprint A with variable of 15% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
1.3
0.3
0.45
0.3
0.3
2.3
-2.7
will not enter sprint
1
2.15
2
-3
-2
New Capacity: 70
2.4
2.4 free hours and 100% done percentage
New Model Effort Capacity After Removing A Ticket Contains Bug
0.6
-0.55
-0.55
2.6
-1.25
didn't enter sprint
2.8
2.45
-2.1
-6
-2
-3
New Capacity: 70
-7
0 free hours and 81.5% or 89.1% done percentage

We can see that the first developer closed the sprint with its 2 bugs and had 2.4 free hours, the second developer had -7 hours so he could close two more tickets.

The results show a 100% done ratio for the first developer and 81.5% or 89.1% done percentage depending on which bug they will not complete and its task estimations.

As a result of sprint A after adding 15% percentage of the quality assurance estimation, we can see that 81.7% or 80.5% done percentage with the most fit removable tasks and 94.6% done percentage when we remove other tasks contain bug to fit the developers capacity.

20% Percent

We've added 20% of the quality assurance estimation on the tickets on the developers' main estimations which shows a result as shown in Table 9.0

Table 9.0: Sprint A with variable of 20% QA estimation

New Estimation 20%	New Estimation Capacity After Removing Ticket
4.4	5
5.4	
6.6	6.6
5.4	5.4
12.4	12.4
5.4	5.4
10.4	10.4
5.4	5.4
6.4	6.4
5.2	5.2
7.8	7.8
74.8	70

New Estimation 20%	New Estimation Capacity After Removing Ticket
7.8	7.8
3.6	5
8.6	
13.8	13.8
11	11
6.6	6.6
6	6
6.6	6.6
13.2	13.2
77.2	70

The results showed 4.8 hours more for the first developer, so we have to get rid of a ticket to balance the capacity for the developer, we've randomly chooses the closest ones which isn't more than 70 hours. So, we've removed ticket CV-742 which has 5.4 hours estimations and rounding the closest ticket to match 70hours capacity which we did on ticket CV-741. The second developer had 7.2 more hours, so we got rid of ticket CV-754 that has 8.6 estimation and we rounded up ticket CV-753 to match 70 hours capacity.

The results of using 20% were impressive as table 10.0 shows.

Table 10.0: Sprint A with variable of 20% QA estimation with the selectin process

New Estimation 20% - Developer Effort	Done Percentage On Proposed Model
2	Done
	will not enter sprint
0.6	Done
0.4	Done
0.4	Done
2.4	Done
-2.6	Done
0.4	Done
-0.6	Done
2.2	Done
1.8	Done
-3	
-2	
-2	
0	100%

New Estimation 20% - Developer Effort	Done Percentage On Proposed Model
0.8	Done
1	Done
	Done
2.8	Done
-1	Not Done
0	Done
2	Done
2.6	Done
-1.8	Done
-6	
-2	
-3	
-4.6	84.2% or 70%

We can see in the above table that after applying the new estimation of 20% it shows a 100% done percentage for the first developer sprint and 0 more available hours which is the ideal case for any sprint. The second developer we had to remove a ticket CV-754 and round up ticket CV-753 to match the sprint capacity, the results showed 84.2% or 70% done percentage depends on the chosen bugs to work at.

We've re-applied the same methodology and removed a ticket contains a bug to see how would this affect the done ratio and capacity by the end of the sprint as you can see in table 11.0

Table 11.0: Sprint A with variable of 20% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
2
0.4
0.6
0.4
0.4
2.4
-2.6
Didn't enter sprint
-0.6
2.2
1.8
-3
-2
New Capacity: 70
2
2 free hours and 100% done percentage
New Model Effort Capacity After Removing A Ticket Contains Bug
Didn't enter sprint
0.2
0.4
2.8
-1
0
2
2.6
-1.8
-6
-3
New Capacity: 70
-4.6
0 free hours and 81% done percentage

An analysis of the data in the table revealed that eliminating tickets that quality assurance identified as containing bugs also resulted in the removal of the bugs themselves. Upon implementing this approach and adding a 20% estimation for the impact of quality assurance on the overall sprint, we found that the first developer achieved a 100% completion rate for

their sprint tasks within the allotted two hours, while the second developer completed 81% of their tasks without any remaining capacity. The overall sprint completion rate increased to either 94.5% or 89.5% depending on the inclusion or exclusion of certain tickets. Specifically, removing tickets with identified bugs resulted in a completion rate of 94.5%.

Sprint B

Sprint B contained the following tasks, developers' estimations and effort as it shown in the Table 12.0

Table 12.0: Sprint B data

Sprint B	Ticket Number	Developer Estimation	Developer Effort	QA Estimation
Developer 1	CV-371	3	3	2
	CV-372	2	1	1
	CV-373	3	2	1
	CV-374	5	6	3
	CV-375	8	9	3
	CV-376	7	8	3
	CV-378	5	7	2
	CV-379	6	5	3
	CV-380	6	5	2
	CV-381	6	5	2
	CV-382	5	4	2
	CV-383	3	4	2
	CV-384	5	4	2
	CV-385	4	4	1
	CV-386	2	3	1
	Bug - 375		3	
	Bug - 378		1	
	Bug - 382		2	
	Bug - 385		1	
	SUM	70	77	30
Developer 2	Ticket Number	Developer Estimation	Developer Effort	QA Estimation
	CV-387	6	7	4
	CV-388	10	11	5
	CV-389	11	10	4
	CV 390	7	8	3
	CV-391	8	9	3
	CV-392	9	8	2
	CV-393	5	5	3
	CV-394	5	4	3
	CV-395	9	8	3
	Bug - 389		6	
	Bug - 390		3	
	SUM	70	79	30

We can see in Table 12.0 that the developer estimation on the tickets are 70 but, when it came to actual effort it took from him 77 hours which caused 68.5% done percentage due not finishing the bugs which are opened and blocking the main tickets to be done. The second developer had 70 hours estimation too and the actual effort was 9 hours more which caused 74% done percentage.

Based on the previous data we have 160 hours done tickets including quality assurance testing tasks of total 200 estimations hours, which shows 80% done percentage as a whole sprint including both developers and quality assurance.

We'll be applying the proposed estimation model in three different percentages which are 10%,15%,20% down below.

10% Percent

After applying 10% of the quality assurance estimation of the QA tickets on the developer's main estimations, it showed a result as shown in table 13.0

Table 13.0: Sprint B with variable of 10% QA estimation

Done Percentage	New Estimation 10%	New Estimation Capacity After Removing Ticket
Done	3.2	3.2
Done	2.1	2.1
Done	3.1	3.1
Done	5.3	5.3
Not Done	8.3	8.3
Done	7.3	7.3
Not Done	5.2	5.2
Done	6.3	6.3
Done	6.2	6.2
Done	6.2	6.2
Not Done	5.2	5.2
Done	3.2	
Done	5.2	5.4
Not Done	4.1	4.1
Done	2.1	2.1
68.5%	73	70

Done Percentage	New Estimation 10%	New Estimation Capacity After Removing Ticket
Done	6.4	6.4
Done	10.5	10.5
Not Done	11.4	11.4
Not Done	7.3	7.3
Done	8.3	8.3
Done	9.2	9.2
Done	5.3	
Done	5.3	7.6
Done	9.3	9.3
74%	73	70

The results showed for the first developer 3 more hours of estimation, so we had to get rid of a ticket to match the capacity, we've removed ticket CV-383 and rounded estimation of ticket CV-384 to match 70 hours capacity.

The second developer had 3 more hours so we removed ticket CV-393 and rounded up ticket CV-394 to match 70hours capacity. The results of adding 10% showed a higher done percentage as shown down below in table 14.0

Table 14.0: Sprint B with variable of 10% QA estimation with the selectin process

New Estimation 10% - Developer Effort	Done Percentage On Proposed Model
0.2	Done
1.1	Done
1.1	Done
-0.7	Done
-0.7	Not Done
-0.7	Done
-1.8	Done
1.3	Done
1.2	Done
1.2	Done
1.2	Done
	will not enter sprint
1.4	Done
0.1	Done
-0.9	Done
-3	
-1	
-2	
-1	
-3	88.1% or 85.1% or 86.7%

New Estimation 10% - Developer Effort	Done Percentage On Proposed Model
-0.6	Done
-0.5	Done
1.4	Not Done
-0.7	Done
-0.7	Done
1.2	Done
	Done
3.6	Done
1.3	Done
-6	
-3	
-4	83.7% done percentage

We can see in table 14.0 that the first developer closed 3 more tickets which will cause one of 88.1%, 85.1%, 86.7% done percentages based on what developer will pick bugs to work at during the rest of the time in the sprint. But in both ways, it's higher than 68.5% done percentage. Also, we can notice that the over capacity is 3hours instead of 7 hours.

The second developer showed a 83.7% done percentage and 0 free hours which is more than 74% done percentage. However, we've removed other tickets contain a bug after adding a percentage of quality assurance estimations to see how it will affect the done percentage as shown in table 15.0

Table 15.0: Sprint B with variable of 10% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
0.2
1.1
1.1
-0.7
-0.7
-0.7
-1.8
1.3
1.2
1.2
1.2
-0.8
1.2
will not enter sprint
0.2
-3
-1
-2
New Capacity: 70
-2
0 free hours and 92.5% or 88.1% done percentage
New Model Effort Capacity After Removing A Ticket Contains Bug
-0.6
-0.5
1.4
-0.7
-0.7
1.2
2.6
1.3
-6
-3
New Capacity: 70
-5
0 free hours and 83.7% done percentage

The results of removing other tickets for developer 1 showed a better-done percentage which is one of 92.5%, 88.1%, 85.1% based on what bugs the developer will be working at.

The second developer we couldn’t remove a ticket contains a bug because of the selection process, so we’ve removed another ticket to calculate new done percentage which showed a 83.7% done percentage.

As a result of sprint B with adding 10% quality assurance estimations on the developer estimation, the method goes to a 90.15% done percentages and when we remove tickets contain bugs in the selection process the results go to 91.7% done percentage.

15% Percent

After applying 15% of QA tasks estimations on developers tickets it showed the results as shown in table 16.0

Table 16.0: Sprint B with variable of 15% QA estimation

Done Percentage	New Estimation 15%	New Estimation Capacity After Removing Ticket
Done	3.3	4.1
Done	2.15	
Done	3.15	
Done	5.45	5.45
Not Done	8.45	8.45
Done	7.45	7.45
Not Done	5.3	5.3
Done	6.45	6.45
Done	6.3	6.3
Done	6.3	6.3
Not Done	5.3	5.3
Done	3.3	3.3
Done	5.3	5.3
Not Done	4.15	4.15
Done	2.15	2.15
68.5%	74.5	70

Done Percentage	New Estimation 15%	New Estimation Capacity After Removing Ticket
Done	6.6	6.6
Done	10.75	10.75
Not Done	11.6	11.6
Not Done	7.45	7.45
Done	8.45	8.45
Done	9.3	10.25
Done	5.45	
Done	5.45	5.45
Done	9.45	9.45
74%	74.5	70

The first developer has 4.5 more hours over capacity, so we removed Two tickets to match the 70 hours capacity which are CV-372 and CV-373 and rounded up ticket CV-371 to match the 70hours capacity.

The second developer had 4.5 over hours so we ticket CV-393 and rounded up ticket CV-392 to match 70hours capacity.

In table 17.0 we can see the done percentage results of adding 15% of QA estimation percentage.

Table 17.0: Sprint B with variable of 15% QA estimation with the selectin process

New Estimation 15% - Developer Effort	Done Percentage On Proposed Model
1.1	Done
	Done
	Done
-0.55	Done
0.55	Not Done
-0.55	Done
1.7	Not Done
1.45	Done
1.3	Done
1.3	Done
1.3	Done
-0.7	will not enter sprint
1.3	Done
0.15	Done
-0.85	Done
-3	
-1	
-2	
-1	
-4	80.3% or 82% or 78.9%

New Estimation 15% - Developer Effort	Done Percentage On Proposed Model
-0.4	Done
-0.25	Done
1.6	Not Done
0.55	Done
-0.55	Done
2.25	Done
	didn't enter sprint
1.45	Done
1.45	Done
-6	
-3	
-4	83.4% done percentage

We can see that the first developer had 2 more done tickets and one of the following done percentages 80.3%, 82%, 78.9% based on which bugs will be working on. The second developer showed a 83.4% done percentage.

We've removed other tickets contains bugs in the selection process to see other results and how it will affect the sprint done percentage and results show in table 18.0.

Table 18.0: Sprint B with variable of 15% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
1.1
1.15
1.15
-0.55
-0.55
-0.55
-1.7
1.45
1.3
1.3
didn't enter sprint
-0.7
1.3
0.15
-0.85
-3
-1
-1
New Capacity: 70
-1
0 free hours and 94% or 92.4% done percentage
New Model Effort Capacity After Removing A Ticket Contains Bug
0.9
-0.25
1.6
didn't enter sprint
-0.55
1.3
3.4
1.45
1.45
-6
New Capacity: 70
3.3
3.3 free hours and 100% done percentage

The first developer showed a better-done percentage which is either 94% or 92.4% based on which bug the developer will be working on thus. The second developer showed a 100% done percentage with 3.3 available hours when we removed a ticket contains a bug with its bug. As a result of sprint B with adding 15% quality assurance estimations on the developer estimation, the method goes to 87.3% done percentages in the proposed selection process and 92.1% done percentage when we remove ticket contains bug in the selection process.

20% Percent

The results of adding 20% of QA estimations is shown in table 19.0

Table 19.0: Sprint B with variable of 20% QA estimation

Done Percentage	New Estimation 20%	New Estimation Capacity After Removing Ticket	
Done	3.4	3.4	
Done	2.2	2.8	
Done	3.2		
Done	5.6	5.6	
Not Done	8.6	8.6	
Done	7.6	7.6	
Not Done	5.4	5.4	
Done	6.6	6.6	
Done	6.4	6.4	
Done	6.4	6.4	
Not Done	5.4	5.4	
Done	3.4		
Done	5.4	5.4	
Not Done	4.2	4.2	
Done	2.2	2.2	
68.5%	76	70	

Done Percentage	New Estimation 20%	New Estimation Capacity After Removing Ticket	
Done	6.8		
Done	11	11.8	
Not Done	11.8	11.8	
Not Done	7.6	7.6	
Done	8.6	8.6	
Done	9.4	9.4	
Done	5.6	5.6	
Done	5.6	5.6	
Done	9.6	9.6	
74%	76	70	

We can see that the first developer had 6 more hours so we removed two tickets which are CV-373 and CV-383 and round up two tickets which are CV-371 and CV-372 to match 70 hours capacity. The second developer had 6 more hours so we removed ticket CV-387 and rounded up ticket CV-388 to match 70 hours capacity. The done percentage of adding 20% shown in table 20.0

Table 20.0: Sprint B with variable of 20% QA estimation with the selectin process

New Estimation 20% - Developer Effort	Done Percentage On Proposed Model
0.4	Done
1.8	Done
	will not enter sprint
-0.4	Done
-0.4	done
-0.4	Done
-1.6	done
1.6	Done
1.4	Done
1.4	Done
-1.4	Done
	will not enter sprint
1.4	Done
-0.2	Not Done
-0.8	Done
-3	
-1	
-2	
-1	
-1	94% or 92.2% or 87.7%

New Estimation 20% - Developer Effort	Done Percentage On Proposed Model
	didn't enter sprint
0.8	Done
-1.8	Not Done
-0.4	Done
-0.4	Done
1.4	Done
0.6	Done
1.6	Done
1.6	Done
-6	
-3	
-2	83.1% or 89.1% done percentage

The first developer showed 94%, 92.2%, 87.7% done percentage on the sprint based on which bug tickets will be working at. The second developer showed 83.1% or 89.1% done percentage depends on what bugs will work at. After removing other tickets in the selection process that contains bugs the result of done percentage is shown in table 21.0

Table 21.0: Sprint B with variable of 20% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
0.8
1.2
1.2
-0.4
didn't enter sprint
2.2
-1.6
1.6
1.4
1.4
1.4
-0.6
1.4
0.2
-0.8
-1
-2
-1
New Capacity: 70
5.4
5.4 free hours and 100% done percentage

New Model Effort Capacity After Removing A Ticket Contains Bug
1.4
0
1.8
didn't enter sprint
-0.4
1.4
0.6
3.6
1.6
-6
New Capacity: 70
4
4 free hours and 100% done percentage

The results in table 21.0 showed for the first developer a 100% done percentage and 5.4 free hours. The second developer showed a 100% done percentage and 4 free hours.

As a result of sprint B with adding 20% quality assurance estimations on the developer estimation, the method goes to a 92% done percentage and 100% done percentage when we removed tickets contains bugs.

Sprint C

Sprint C contained the following tasks, developers' estimations and effort as it shown in the Table 22.0

Table 22.0: Sprint C data

Sprint C	Ticket Number	Developer Estimation	Developer Effort	QA Estimation
Developer 1	CV-511	5	4	2
	CV-512	8	9	3
	CV-513	6	6	4
	CV-514	7	7	2
	CV-515	4	5	2
	CV-516	6	7	2
	CV-517	2	2	2
	CV-518	3	3	2
	CV-519	2	1	1
	CV-520	2	1	1
	CV-521	4	5	2
	CV-522	4	5	2
	CV-523	5	4	2
	CV-524	6	5	2
	CV-525	6	5	1
	Bug - 513		3	
	SUM	70	72	30
	Ticket Number	Developer Estimation	Developer Effort	QA Estimation
Developer 2	CV-526	4	4	2
	CV-527	5	4	2
	CV-528	8	9	2
	CV-529	6	5	2
	CV-530	5	7	2
	CV-531	7	5	2
	CV-532	4	5	3
	CV-533	4	4	3
	CV-534	8	7	3
	CV-535	7	5	4
	CV-536	3	5	1
	CV-537	4	4	2
	CV-538	5	6	2
	SUM	70	70	30

We can see in Table 22.0 that the developer estimation on the tickets is 70 but, when it came to actual effort it took from them 72 more hours because of a bug that opened to a done ticket which caused 91.4% done percentage.

The second developer had 70 hours of capacity and it's been done in the time without any bugs or blockers. Based on the previous data we have 194 hours done out of 200 total estimation hours which caused 97% done percentage.

We'll be applying the proposed estimation model in three different percentages which are 10%,15%,20% down below.

10% Percent

We've added 10% of the quality assurance estimation on the tickets on the developers' main estimations which shows a result as shown in Table 23.0

Table 23.0: Sprint C with variable of 10% QA estimation

Done Percentage	New Estimation 10%	New Estimation Capacity After Removing Ticket
Done	5.2	5.2
Done	8.3	8.3
Not Done	6.4	6.4
Done	7.2	7.2
Done	4.2	4.2
Done	6.2	6.2
Done	2.2	2.2
Done	3.2	
Done	2.1	2.1
Done	2.1	2.1
Done	4.2	4.2
Done	4.2	4.2
Done	5.2	5.4
Done	6.2	6.2
Done	6.1	6.1
91.4%	73	70

Done Percentage	New Estimation 10%	New Estimation Capacity After Removing Ticket
Done	4.2	4.2
Done	5.2	5.2
Done	8.2	8.2
Done	6.2	6.2
Done	5.2	5.2
Done	7.2	7.2
Done	4.3	4.3
Done	4.3	4.3
Done	8.3	8.3
Done	7.4	7.4
Done	3.1	
Done	4.2	4.3
Done	5.2	5.2
100%	73	70

The results showed 3 hours more for the first developer, so we have to get rid of a ticket to balance the capacity for the developer, we've couldn't choose an exact number to match the developer's capacity. So, we've removed ticket CV-518 based on our selection process which has 3.2 hours estimations and rounding the closest ticket to match 70hours capacity which we did on ticket CV-523.

The second developer had 3 more hours, so we got rid of ticket CV-536 based on our selection process and rounded up ticket number CV-537 to match 70hours capacity.

The results of 10% we're good as a done percentage, as it gave a better and higher percentages for done ratio as shown in Table 24.0

Table 24.0: Sprint C with variable of 10% QA estimation with the selectin process

New Estimation 10% - Developer Effort	Done Percentage On Proposed Model
1.2	Done
-0.7	Done
0.4	Done
0.2	Done
-0.8	Done
-0.8	Done
0.2	Done
	will not enter sprint
1.1	Done
1.1	Done
-0.8	Done
-0.8	Done
1.4	Done
1.2	Done
1.1	Done
-3	
1	100% done percentage

New Estimation 10% - Developer Effort	Done Percentage On Proposed Model
0.2	Done
1.2	Done
-0.8	Done
1.2	Done
-1.8	Done
2.2	Done
-0.7	Done
0.3	Done
1.3	Done
2.4	Done
	will not enter sprint
0.3	Done
-0.8	Done
5	100% done percentage

We can see in table 24.0 that the first developer closed the last ticket with 100% done percentage but it caused 1 free hour. The second developer already closed the sprint by default so it caused 5 free hours with 100% done percentage.

We've tried to remove the ticket that contained the bug in the selection process and the results shown in table 25.0

Table 25.0: Sprint C with variable of 10% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
1.2
-0.7
0.4
0.2
-0.8
-0.8
0.2
0.2
1.1
2.3
will not enter sprint
-0.8
1.2
1.2
1.1
-3
New Capacity: 70
3
3 free hours and 100% done percentage
New Model Effort Capacity After Removing A Ticket Contains Bug
0.2
1.2
-0.8
1.2
-1.8
2.2
-0.7
0.3
1.3
2.4
will not enter sprint
0.3
-0.8
New Capacity: 70
5
5 free hours and 100% done percentage

We couldn’t remove the ticket that contains the bug due to the huge gap for the first developer so we removed ticket CV-521 and the results is 100% done percentage and 3 free hours for the first developer. The second developer hadn’t any bugs so we removed the same ticket with 100% done percentage and 5 free hours of capacity by the end of the sprint.

As a result of sprint C with adding 10% quality assurance estimations on the developer estimation, the method goes to a 100% done percentage for both developers and total sprint with 1 free hour for the first developer and 5 free hours for the second developer.

15% Percent

We’ve added 15% of the quality assurance estimation on the tickets on the developers’ main estimations which shows a result as shown in Table 26.0

Table 26.0: Sprint C with variable of 15% QA estimation

Done Percentage	New Estimation 15%	New Estimation Capacity After Removing Ticket
Done	5.3	5.3
Done	8.45	8.45
Not Done	6.6	6.6
Done	7.3	7.3
Done	4.3	4.3
Done	6.3	6.3
Done	2.3	2.3
Done	3.3	3.3
Done	2.15	2.15
Done	2.15	2.15
Done	4.3	4.3
Done	4.3	5.1
Done	5.3	
Done	6.3	6.3
Done	6.15	6.15
91.4%	74.5	70

Done Percentage	New Estimation 15%	New Estimation Capacity After Removing Ticket
Done	4.3	4.3
Done	5.3	5.3
Done	8.3	8.3
Done	6.3	6.3
Done	5.3	5.3
Done	7.3	7.3
Done	4.45	4.45
Done	4.45	4.45
Done	8.45	8.45
Done	7.6	7.6
Done	3.15	3.15
Done	4.3	5.1
Done	5.3	
100%	74.5	70

The first developer had 4.5 more hours so we removed ticket CV-523 to match the sprint capacity and rounded up ticket CV-522. The second developer had 4.5 more free hours so we removed ticket CV-538 and rounded up ticket CV-537 to match the sprint capacity.

The results of adding 15% percentage showed the same results of 10% due to not having a lot of bugs but it added more free hours as we can see in table 27.0

Table 27.0: Sprint C with variable of 15% QA estimation with the selectin process

New Estimation 15% - Developer Effort	Done Percentage On Proposed Model
1.3	Done
-0.55	Done
0.6	Done
0.3	Done
-0.7	Done
-0.7	Done
0.3	Done
0.3	Done
1.15	Done
1.15	Done
-0.7	Done
0.1	Done
	will not enter sprint
1.3	Done
1.15	Done
-3	
2	100% done percentage

New Estimation 15% - Developer Effort	Done Percentage On Proposed Model
0.3	Done
1.3	Done
-0.7	Done
1.3	Done
-1.7	Done
2.3	Done
-0.55	Done
0.45	Done
1.45	Done
2.6	Done
-1.85	Done
1.1	Done
	will not enter sprint
6	100% done percentage

We can see the first developer had 100% done percentage with 2 free hours by the end of the sprint and the second developer 100% done percentage with 6 free hours. We've removed other tickets and it cause the same results as it shown in table 28.0

Table 28.0: Sprint C with variable of 15% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
-0.55
0.6
1.1
-0.7
-0.7
0.3
0.3
1.15
1.15
-0.7
-0.7
1.3
1.3
1.15
-3
New Capacity: 70
2
2 free hours and 100% done percentage
New Model Effort Capacity After Removing A Ticket Contains Bug
0.3
1.3
-0.7
1.3
-1.7
2.3
-0.55
0.45
1.45
2.6
-1.85
1.1
will not enter sprint
New Capacity: 70
6
6 free hours and 100% done percentage

As a result of sprint C with adding 15% of quality assurance estimation, it caused 100% done percentage for both developers and a sprint as total with more free hours than 10% percent.

20% Percent

We've added 20% of quality assurance estimation to the developers' tasks as shown down below in table 29.0

Table 29.0: Sprint C with variable of 20% QA estimation

Done Percentage	New Estimation 20%	New Estimation Capacity After Removing Ticket
Done	5.4	5.4
Done	8.6	8.6
Not Done	6.8	6.8
Done	7.4	7.4
Done	4.4	4.4
Done	6.4	6.4
Done	2.4	2.4
Done	3.4	3.4
Done	2.2	2.2
Done	2.2	2.2
Done	4.4	4.4
Done	4.4	4.4
Done	5.4	5.4
Done	6.4	6.6
Done	6.2	
91.4%	76	70

Done Percentage	New Estimation 20%	New Estimation Capacity After Removing Ticket
Done	4.4	4.4
Done	5.4	5.4
Done	8.4	8.4
Done	6.4	
Done	5.4	5.8
Done	7.4	7.4
Done	4.6	4.6
Done	4.6	4.6
Done	8.6	8.6
Done	7.8	7.8
Done	3.2	3.2
Done	4.4	4.4
Done	5.4	5.4
100%	76	70

We can see in table 29.0 that the first developer had 6 more free hours and we removed ticket CV-525 and rounded up ticket CV-524 to match sprint capacity. The second developer had 6 more free hours and we removed ticket CV-529 and rounded up ticket CV-530 to match sprint capacity. As a results of adding 20% of QA estimations it shows a done percentage as shown in table 30.0

Table 30.0: Sprint C with variable of 20% QA estimation with the selectin process

New Estimation 20% - Developer Effort	Done Percentage On Proposed Model
1.4	Done
-0.4	Done
0.8	Done
0.4	Done
-0.6	Done
-0.6	Done
0.4	Done
0.4	Done
1.2	Done
1.2	Done
-0.6	Done
-0.6	Done
1.4	Done
1.6	Done
	will not enter sprint
-3	
3	100% done percentage

New Estimation 20% - Developer Effort	Done Percentage On Proposed Model
0.4	Done
1.4	Done
-0.6	Done
	will not enter sprint
-1.2	Done
2.4	Done
-0.4	Done
0.6	Done
1.6	Done
2.8	Done
-1.8	Done
0.4	Done
-0.6	Done
5	100% done percentage

We can see in table 30.0 that the first developer had 100% done percentage with 3 more free hours. The second developer had 5 more free hours with 100% done percentage.

We've removed other tickets in selection process but none of them that has a bug could match using the selection process so we've removed other tickets as shown in table 31.0

Table 31.0: Sprint C with variable of 20% QA estimation with bug removal

New Model Effort Capacity After Removing A Ticket Contains Bug
1.4
-0.4
0.8
0.4
-0.6
-0.6
0.4
0.4
1.2
1.2
-0.6
-0.6
1.8
1.8
-3
New Capacity: 70
3.6
3.6 free hours and 100% done percentage
New Model Effort Capacity After Removing A Ticket Contains Bug
0.4
1.4
-0.6
will not enter sprint
-1.2
2.4
-0.4
0.6
1.6
2.8
-1.8
0.4
-0.6
New Capacity: 70
5
5 free hours and 100% done percentage

We can see that the first developer had 3.6 free hours with 100% done percentage and the second developer had 5 free hours and 100% done percentage.

As a total sprint after adding 20% of QA estimations it caused a total 100% done percentage with 3 free hours for the first developer and 5 free hours for the second developer.

4.3 Applied Implementation

Based on the results of the Quantitative approach and the previous ten sprints history, which were specialized in building the Techpack module, I decided to implement the 15% implementation model in the RFQ module in order to increase the done percentage with the minimum amount of free working hours for developers. In table 32.0, you can see the previous 10 sprints done percentage using the agile Scrum development methodology without implementing the new estimation model. In this applied implementation, the percentage model will be applied to 10 sprints.

Table 32.0: Ten sprints without the new estimation model.

	0%		
	Done Percentage	Bugs Percentage	Available capacity
Sprint A	76.5%	9.00%	0 hours
Sprint B	80%	8%	0 hours
Sprint C	97%	1.50%	0 hours
Sprint D	82%	10.30%	0 hours
Sprint E	87%	7%	0 hours
Sprint F	83%	8.3%	0 hours
Sprint G	89%	7.7%	0 hours
Sprint H	80%	13.2%	0 hours
Sprint I	81%	9.7%	0 hours
Sprint J	87%	8.2%	0 hours

The result shows a done percentage with an average of 84.2% and 8.3% bug percentage.

We can see from the previous table that the average done percentage is 84.25% and the average bug percentage is 8.29%. These sprints specialized in the development of Tech-pack module in Calico software with results as seen in Figure 6.0

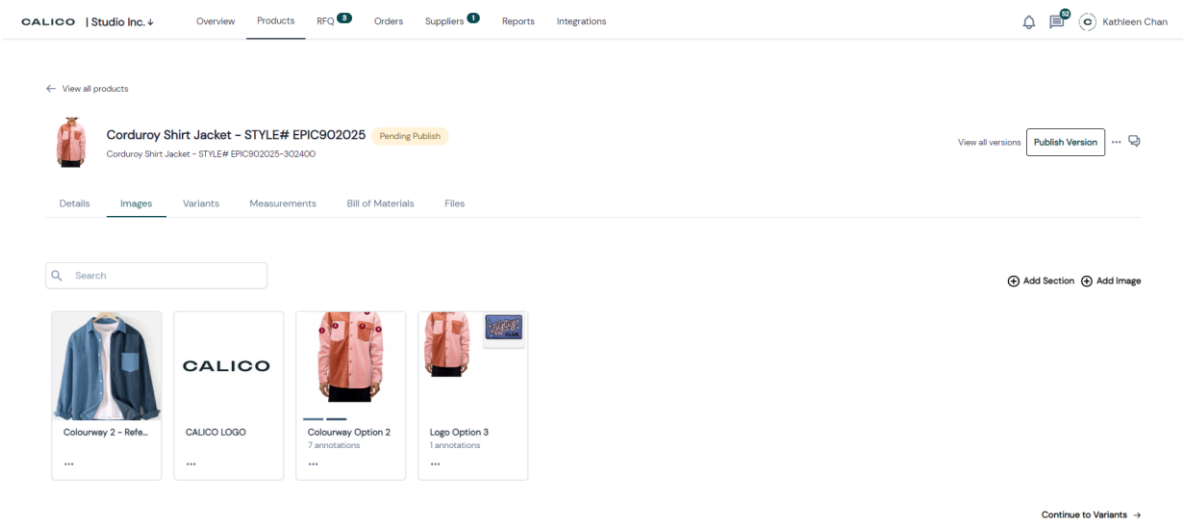


Figure 6: Calico tech-pack module.

After building up the estimation model and test it in quantitative approach, we apply it on the next ten sprints using 15% estimation model while working on request for quotation module in six months as seen in Figure 7.0.

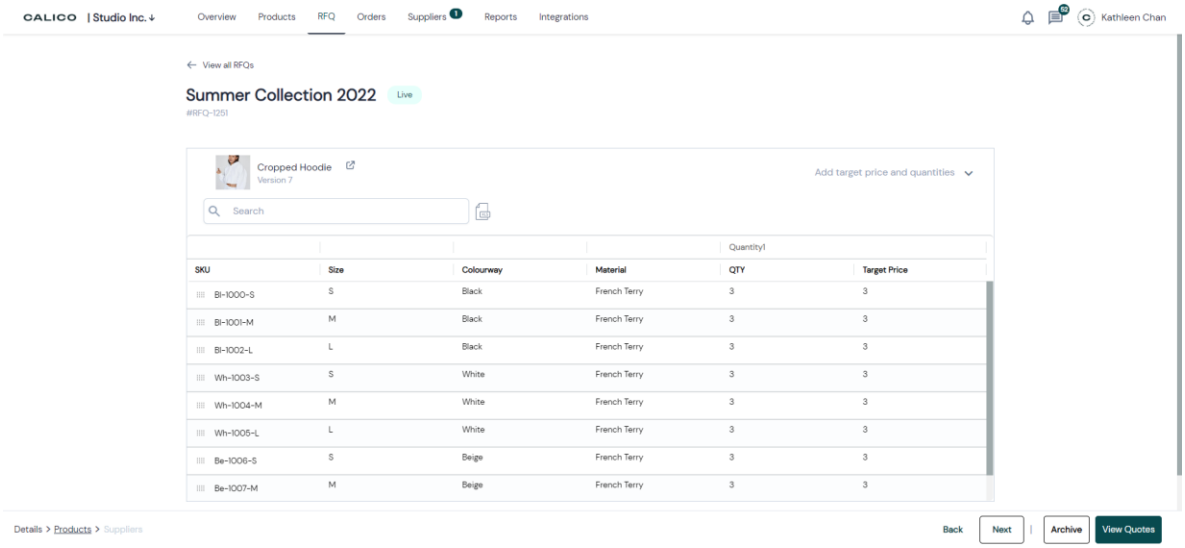


Figure 7: Calico request for quotation module.

Table 33.0 presents the initial sprint (k) and its accompanying ticket descriptions. This table provides an overview of the first sprint and the corresponding tasks that were assigned to it. The ticket descriptions are an important aspect of the sprint, as they provide a clear understanding of the objectives and goals for each task. The information contained in Table 33.0 will be valuable for anyone looking to gain insight into the initial sprint and its objectives.

Table 33.0: Sprint K tickets description

Ticket Number	Ticket Title
CV-821	Add RFQ Menu item in Brands application
CV-822	Add RFQ Menu item in Suppliers application
CV-823	Add Workspace for RFQ Module in brands
CV-824	Add Workspace for RFQ Module in suppliers
CV-825	Add searchable list in the workspace in brands
CV-826	Add searchable list in the workspace in suppliers
CV-827	Add 5 list filterations in RFQ workspace in brands
CV-828	Add 3 list filterations in RFQ workspace in suppliers
CV-829	Add create RFQ button that creates a draft RFQ in brands
CV-830	Add export to excel functionality for items in workspace in brands
CV-831	Add export to excel functionality for items in workspace in suppliers
CV-832	Create navigation functionality from items in list to RFQ edit/view page in brands
CV-833	Create navigation functionality from items in list to RFQ view page in brands
CV-834	Add actions in RFQ workspace grid to allow users to archive RFQs in brands
CV-835	Add actions in RFQ workspace grid to allow users to archive RFQs in suppliers

In the development of the Brands and Suppliers applications, a series of functions have been identified as part of Sprint K to enhance the user experience for RFQ management.

The following use cases and functions can be considered for research purposes in the development of the Brands and Suppliers applications:

- Functionality to Add RFQ Menu item: This function allows users to access the RFQ module in the Brands and Suppliers applications.
- Functionality to Add Workspace for RFQ Module: This function creates a dedicated workspace for the RFQ module in both the Brands and Suppliers applications.
- Functionality to Add Searchable List in Workspace: This function provides a searchable list of RFQs in the RFQ workspace for both the Brands and Suppliers applications.

- Functionality to Add List Filtrations in RFQ Workspace: This function provides the ability to filter RFQs in the RFQ workspace based on specific criteria. 5 filtrations are added in the RFQ workspace in the Brands application, while 3 filtrations are added in the Suppliers application.

- Functionality to Add Create RFQ Button: This function provides a button that creates a draft RFQ in the Brands application.

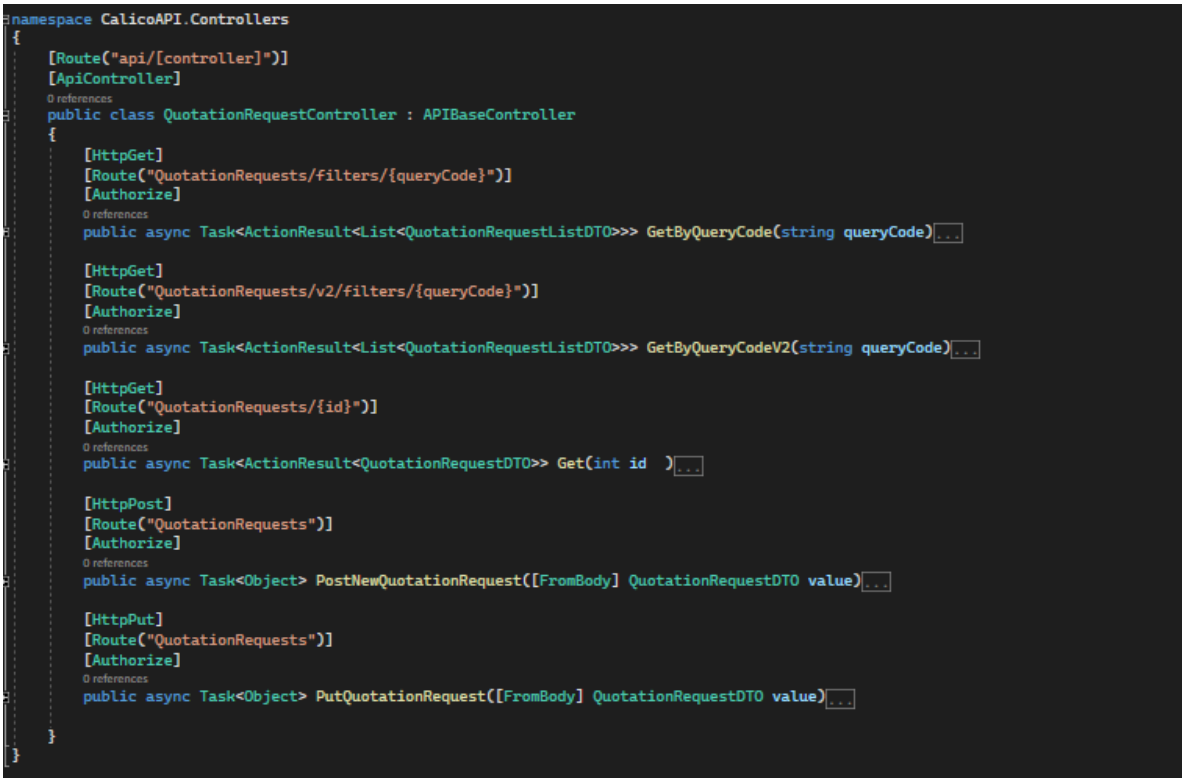
- Functionality to Add Export to Excel: This function allows users to export RFQ information to an Excel file in both the Brands and Suppliers applications.

- Functionality to Create Navigation: This function provides navigation functionality from items in the RFQ list to the RFQ edit/view page in the Brands application, and to the RFQ view page in the Suppliers application.

- Functionality to Add Actions in RFQ Workspace Grid: This function provides the ability to archive RFQs in both the Brands and Suppliers applications through actions in the RFQ workspace grid.

The accompanying snapshot illustrates the endpoints that have been developed in the Calico application as part of Sprint K. This representation provides a visual representation of the endpoints and serves as a useful tool for comprehending the breadth of functionality that has been integrated into the Calico application during Sprint K. These endpoints represent the culmination of the efforts and the hard work of the development team in ensuring that the Calico application is equipped with the necessary features to meet the needs of its users. The

snapshot serves as an important reference for anyone seeking to understand the capabilities of the Calico application, and highlights the significance of the efforts made during Sprint K.



```
namespace CalicoAPI.Controllers
{
    [Route("api/[controller]")]
    [ApiController]
    0 references
    public class QuotationRequestController : APIBaseController
    {
        [HttpGet]
        [Route("QuotationRequests/filters/{queryCode}")]
        [Authorize]
        0 references
        public async Task<ActionResult<List<QuotationRequestListDTO>>> GetByQueryCode(string queryCode)...

        [HttpGet]
        [Route("QuotationRequests/v2/filters/{queryCode}")]
        [Authorize]
        0 references
        public async Task<ActionResult<List<QuotationRequestListDTO>>> GetByQueryCodeV2(string queryCode)...

        [HttpGet]
        [Route("QuotationRequests/{id}")]
        [Authorize]
        0 references
        public async Task<ActionResult<QuotationRequestDTO>> Get(int id  )...

        [HttpPost]
        [Route("QuotationRequests")]
        [Authorize]
        0 references
        public async Task<Object> PostNewQuotationRequest([FromBody] QuotationRequestDTO value)...

        [HttpPut]
        [Route("QuotationRequests")]
        [Authorize]
        0 references
        public async Task<Object> PutQuotationRequest([FromBody] QuotationRequestDTO value)...

    }
}
```

Figure 8: Sprint (K) RFQ backend End points

The accompanying figure presents a snapshot of the frontend RFQ module and its file structure, along with the output that has been achieved during Sprint K. This representation provides a comprehensive view of the frontend RFQ module and its underlying file structure, and serves as an effective tool for understanding the architecture and design of the module. The output produced during Sprint K represents a significant milestone in the development of the frontend RFQ module, and showcases the progress that has been made towards delivering a functional and user-friendly module. The figure is an essential resource for

anyone seeking to understand the frontend RFQ module and the efforts that have been made to develop it. The snapshot provides valuable insights into the structure of the frontend RFQ module, and highlights the significance of the achievements made during Sprint K.

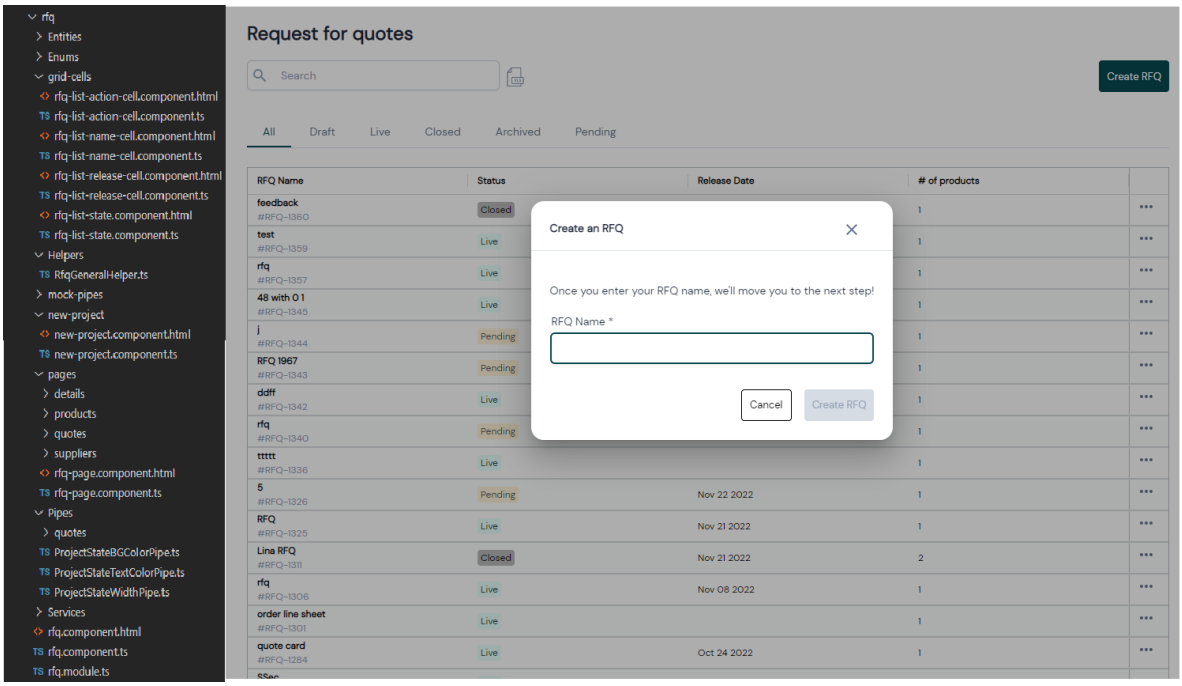


Figure 9: Sprint (K) RFQ Frontend files and results

In table 33.0 you can see the first sprint(K) after applying the new estimation model.

Table 34.0: Sprint K with 15% estimation model

	Ticket Number	Developer Estimation	Developer Effort	Done Percentage	QA Estimation
Developer 1	CV-821	8	7	Done	2
	CV-822	10	11	Done	3
	CV-823	5	5	Done	2
	CV-824	10	9	Done	3
	CV-825	6	7	Not Done	2
	CV-826	14	14	Done	4
	CV-828	5	6	Not Done	2
	CV-827	12	15	Done	4
	Bug - 825		3		
	Bug - 828		2		
	SUM	70	74	84.3%	22

	Ticket Number	Developer Estimation	Developer Effort	Done Percentage	QA Estimation
Developer 2	CV-829	7	7	Not Done	2
	CV-830	11	10	Done	3
	CV-831	9	9	Done	3
	CV-832	12	13	Done	4
	CV-833	10	10	Done	3
	CV-834	8	7	Done	2
	CV-835	13	14	Done	4
	Bug - 829		3		
	SUM	70	73	90%	21

The results showed for the first developer 84.3% done percentage and 90% done percentage for the second developer while having 91% done percentage as total and 4% bugs percentage.

The application of a 15% estimation model to Sprint K resulted in the completion of a higher percentage of tasks, as the developer was able to utilize the extra time to address bugs reported by the QA engineer. This methodology provided a more accurate estimate of the time required to complete the tasks within the sprint, allowing the developer to allocate the necessary resources to address bugs and improve the overall quality of the deliverables. The result was an increase in the done percentage for Sprint K, as the developer was able to effectively balance the competing demands of bug resolution and task completion. This

outcome highlights the importance of using accurate estimation models in the planning and execution of software development projects, as it enables the development team to allocate resources more effectively and achieve higher levels of productivity.

After applying the model in ten sprints, we get the following results as seen in table 34.0

Table 35.0: Ten sprints with the new estimation model

	15%		
	Done Percentage	Bugs Percentage	Available capacity
Sprint K	91%	4.00%	0 hours
Sprint L	93%	3.8%	0 hours
Sprint M	95%	3.2%	0 hours
Sprint N	97%	5.1%	0 hours
Sprint O	96%	3.7%	0 hours
Sprint P	98%	3.5%	0 hours
Sprint Q	100%	0%	1 hours
Sprint R	90%	4.5%	0 hours
Sprint S	100%	0%	2 hours
Sprint T	96%	1.5%	0 hours

The result shows a done percentage with an average of 95.6% and 2.9% bug percentage.

4.4 Summary

In the Design Investigation and Implementation chapter, the proposed estimation model was implemented and tested through a quantitative approach using data from previous sprints. The model was applied in three different percentages (10%, 15%, 20%) and the results were compared to the traditional agile scrum development methodology.

The results of the quantitative data analysis showed that the proposed estimation model significantly increased the done percentage while also reducing the percentage of bugs. The model achieved the highest average done percentage when implemented at a 15% estimation.

Based on these findings, the 15% estimation model was chosen for implementation in the next ten sprints. The results of the applied implementation showed a significant improvement in the average done percentage, with an average of 95.6% compared to the 84.2% done percentage achieved through the traditional agile scrum development methodology. The bug percentage was also greatly reduced, with an average of 2.9% compared to the 8.29% bug percentage in the previous ten sprints.

Overall, the implementation of the proposed estimation model proved to be a successful approach for improving the efficiency and effectiveness of the development process.

Chapter 5: Results and Discussions

Scrum is the most popular software development methodology used by software engineers worldwide. Researchers showed the power of using scrum as software development methodology because of its criteria which starts of planning and the phase (sprint) is kept short since many of the requirements might change thus, it's approach with the interaction of scope, technology and feedback loops which keeps the performance high. (Sutherland et al., 2014)

A study showed how scrum can deal with a different time zones with the maximum amount of time difference, it's proved by a real case that it's possible to create a distributed software scrum team without time-zones problem. Also, it showed that the talents can be hired with less cost than finding them in the same place and can open a new market for the companies world-wide. (Sutherland et al., 2014)

Still, there isn't a lot of articles and research work related to scrum. A researcher reported that even though that SCRUM method is popular in companies it's not a simple task to find a lot of materials and articles related on the internet. The collected articles showed that 92% of them are qualitative approaches and 67% of them done by companies. (Sutherland et al., 2014)

Sprints is a time-iterations contains of several product backlog items that has to be done with in a time-collapse. After applying quantitative approach on three different percentages on three sprints, we could get a better-done percentage than the normal sprint which indicates us to apply it practically in ten sprints during six months to get more accurate data. Thus, the

applied approach shows a significant improvement comparing with the last ten sprints in both done percentage and bugs percentage in the sprints.

5.1 Quantitative Approach Results Discussion

Here in this part, quantitative model data of the three different sprints was mapped and compared using three different variable percentages and estimation factors.

10% Percentage

We can see in sprint A with 9% bugs percentage, we've raised the done percentage to 82.15% with 0 available capacity by the end of the sprint. Sprint B with 8% of bugs percentage we raised the done percentage from 80% to 90.15% - 91.7% done percentage based on which bugs the developers will choose to work at. In sprint C which contains a small bugs percentage we raised the done percentage from 97% to 100% with 6 hours available capacities by the end of the sprint as shown in table 35.0

Table 36.0: Comparison of Sprints A, B, C data before and after applied model with 10%.

			10%	
	Done Percentage	Bugs Percentage	Done Percentage	Available capacity
Sprint A	76.5%	9.00%	82.15%	0 hours
Sprint B	80%	8%	90.15% - 91.7%	0 hours
Sprint C	97%	1.50%	100%	6 hours

15% Percentage

Adding 15% done percentage showed a better result in sprint A and sprint B but a bad results when it came to sprint C due to more available capacities. In sprint A we could raise the done percentage from 76.5% to 80.5% - 94.6% based on the bugs tickets the developer will work on and with 0 available capacities. In sprint B we've raised the done percentage from 80% to

87.3% - 92.1% with 0 available capacities and in sprint C we've raised the done percentage to 100% but with 8 hours of free capacity in the end of the sprint as shown in table 36.0

Table 37.0: Comparison of Sprints A, B, C data before and after applied model with 15%.

			15%	
	Done Percentage	Bugs Percentage	Done Percentage	Available Capacity
Sprint A	76.5%	9.00%	80.5% - 94.6%	0 hours
Sprint B	80%	8%	87.3% - 92.1%	0 hours
Sprint C	97%	1.50%	100%	8 hours

20% Percentage

Adding 20% done percentage showed a better result in sprint A and Better results in some cases of sprint B because it affected the available capacity by the end of the sprint. However, sprint C become worst as it affected the available capacity too.

In sprint A we could raise the done percentage from 76.5% to 89.5% - 94.5% based on the bugs ticket that the developer will be working at. In sprint B we've raised the done percentage from 80% to 92% - 100% based on the bugs ticket will be working at and up to 3 free hours by the end of the sprint. In sprint C with a low bug percentage, we've raised it to 100% done percentage with 8 free hours by the end of the sprints as shown in table 37.0

Table 38.0: Comparison of Sprints A, B, C data before and after applied model with 20%.

			20%	
	Done Percentage	Bugs Percentage	Done Percentage	Available Capacity
Sprint A	76.5%	9.00%	89.5% - 94.5%	0 hours
Sprint B	80%	8%	92% - 100%	0-3 hours
Sprint C	97%	1.50%	100%	8 hours

5.2 Applied approach results discussion

After applying the new estimation model of 15% on ten sprints during six months we can see a significant improvement in the done percentage and a reduce in bugs percentage overall as show in table 37.0 down below.

Table 39.0: Comparison of ten sprints using proposed estimation model

	0%				15%		
	Done Percentage	Bugs Percentage	Available capacity		Done Percentage	Bugs Percentage	Available capacity
Sprint A	76.5%	9.00%	0 hours	**Sprint K**	91%	4.00%	0 hours
Sprint B	0.8	8%	0 hours	**Sprint L**	93%	3.8%	0 hours
Sprint C	0.97	1.50%	0 hours	**Sprint M**	95%	3.2%	0 hours
Sprint D	0.82	10.30%	0 hours	**Sprint N**	97%	5.1%	0 hours
Sprint E	0.87	7%	0 hours	**Sprint O**	96%	3.7%	0 hours
Sprint F	0.83	8.3%	0 hours	**Sprint P**	98%	3.5%	0 hours
Sprint G	0.89	7.7%	0 hours	**Sprint Q**	100%	0%	1 hours
Sprint H	0.8	13.2%	0 hours	**Sprint R**	90%	4.5%	0 hours
Sprint I	0.81	9.7%	0 hours	**Sprint S**	100%	0%	2 hours
Sprint J	0.87	8.2%	0 hours	**Sprint T**	96%	1.5%	0 hours

As seen in the previous table the average done percentage for normal sprints is 84.2% and the bugs percentage is 8.3%. On the other hand, the average done percentage using the new model in the sprints is 95.6% and the bugs percentage is 2.9%. In figure 8.0 we can see the twenty sprints and its improvement in done and bugs percentage during the sprints once we start implementing the new estimation model.

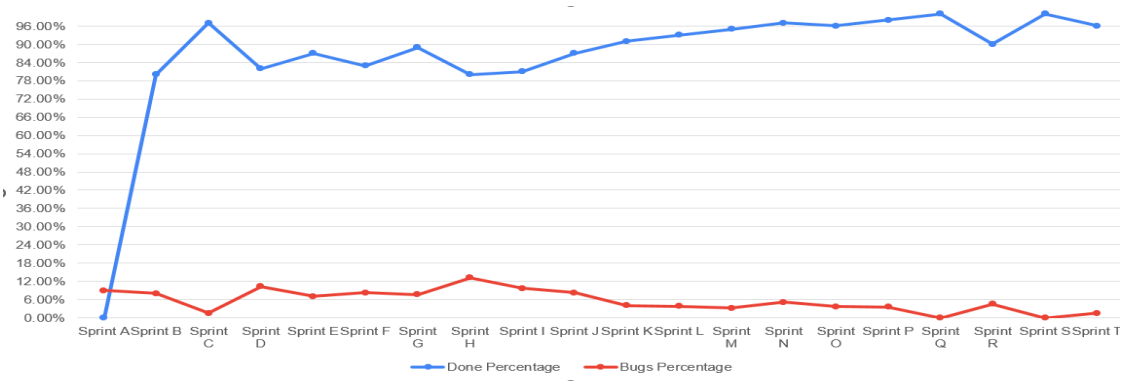


Figure 10: Twenty sprints before and after using proposed estimation model.

The result shows a 13% improvement in done percentage after using new estimation model and 186% reduction of the bugs percentage.

Chapter 6: Conclusion and Future Work

In this study, we aimed to investigate the effectiveness of incorporating quality assurance (QA) estimation into the task estimation process of software development teams using the Scrum framework. We specifically focused on Scrum-based tech startups in order to understand the potential benefits and challenges of implementing this approach in a startup context.

To conduct our research, we first performed a quantitative analysis of three sprints, each with varying percentages of QA estimation included in the task estimation process. Our results showed that the incorporation of QA estimation significantly improved the done percentage of tasks and reduced the number of bugs in the sprints. Specifically, we observed the highest improvement when QA estimation made up 15% of the total task estimation.

Based on these findings, we applied the 15% QA estimation model to ten sprints over a period of six months. The results of this applied implementation showed a significant improvement in the done percentage and a reduction in the number of bugs compared to the previous ten sprints without the QA estimation model. The average done percentage increased from 84.25% to 95.6%, and the average bug percentage decreased from 8.29% to 2.9%.

In summary, our research suggests that the incorporation of QA estimation into the task estimation process can lead to significant improvements in the performance of Scrum-based tech startups. However, it is important to note that these findings are specific to the context of our study and may not generalize to other types of Scrum teams or organizations. Further

research is needed to fully understand the potential benefits and challenges of implementing this approach in different contexts.

The results of this study demonstrate that implementing a quality assurance estimation model can significantly improve the done percentage and reduce the bug percentage in scrum tech startups. However, there are several directions for future work that could further improve the effectiveness of this model.

One possibility is to extend the model to other agile methodologies, such as Kanban or Lean. While this study focused specifically on scrum, it is likely that the principles of the model could be applied to other agile approaches with similar benefits. Further research could be conducted to compare the performance of the model across different agile methodologies.

Another avenue for future work is to investigate the potential impact of different estimation percentages on the model's effectiveness. In this study, we examined three different percentages (10%, 15%, and 20%) and found that the 15% percentage resulted in the best performance. However, it is possible that different percentages may be more effective in different contexts, or for different types of projects. Further research could explore the optimal estimation percentage for different scenarios.

Additionally, this study only examined the impact of the model on two-developer teams. It would be interesting to investigate the effectiveness of the model on teams of different sizes and compositions. This could help to identify any potential scaling issues and allow for the development of strategies to address them.

Finally, future research could explore the potential for integrating the model into an automated tool or platform. This could make it easier for teams to implement the model and track its performance, potentially leading to wider adoption and further improvements in project management.

Overall, there are many opportunities for future work to build upon the findings of this study and further refine the quality assurance estimation model for use in scrum tech startups. By continuing to investigate and improve upon this model, we can help teams to better manage their projects and deliver higher-quality software to their users.

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ملخص الرسالة

تعاني الشركات الناشئة في مجال التكنولوجيا من عدم القدرة الصحيحة على تقدير الوقت اللازم للعمل اثناء تطوير التطبيقات باستخدام منهجية التطوير المرن، مما يتسبب في علاقة سيئة مع عملائها وقد يتسبب في عواقب وخيمة تؤدي الى خسائر فادحة وبالتالي الى دمار الشركة.

إحدى العوامل الرئيسية التي تؤثر على ميزات شحن جزئيات المنتج هي العيوب (الأخطاء) التي يقوم مهندس ضمان الجودة باصدارها و التي تمنع مهام الموظفين من جعلها تامة على اكمل وجه و بالتالي التأخر في اطلاق الخدمات الجديدة الى بيئة الانتاج. في هذه الرسالة ، نقترح منهجية تقدير تستند إلى تقديرات ضمان الجودة لضمان تغطية الفجوة بين الأخطاء وتذاكر المطورين التي تحدث داخل فترة العمل اللازمة لانتاج المهام ، مما سيساعد الشركات الناشئة على أن تكون أكثر دقة والحصول على نسب إنجاز أعلى في فترة العمل بناءً على نسب الأخطاء التاريخية في الشركة. ومع ذلك ، إذا لم يتم استخدام النهج بشكل جيد ، فسيؤدي ذلك إلى حدوث فجوة و زيادة في ساعات العمل للمطورين و هذا يعد ممارسة سلبية في منهجية التطوير المرن.

أظهرت نتائج النموذج المقترح تحسنًا نوعيًا في النسبة المئوية المنجزة لثلاث فترات عمل والتي استخدمناها لإجراء تجارب البيانات عن طريق اضافة نسب مختلفة بنائا على نسب الاخطاء السابقة في فترات العمل للشركة, و بنائا على النتائج قمنا بتطبيق النموذج المقترح عمليا على 10 فترات عمل خلال ستة اشهر و قمنا بمقارنتها ب 10 فترات عمل سابقة, و اظهرت النتائج تحسناً نوعيا أيضاً