Framework for Mitigating Uncertainty for Story Points Estimation in Agile based Projects

Author

Samra Faisal Khan

Registration No: 00000401383

Supervisor:

Asst. Professor Dr. Muhammad Sohail

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Signature: _____

Name of Supervisor: Asst Prof Dr Muhammad Sohail

Date: 13/6/24

Signature (HoD): _____

Brig
Head of Dept of CSE
MI College of Sigs (NUST)

Date: 30/7/24

Signature (Dean/Principal): _____

Date: 1/8/24

Brig
Dean, MCS (NUST)
(Asif Masood, Phd)

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We hereby recommend that the dissertation prepared under our supervision by **NS Samra Faisal Khan,** Regn No **00000401383** Titled: **"Framework for Mitigating Uncertainty for Story Points Estimation in Agile Based Projects"** be accepted in partial fulfillment of the requirements for the award of **MS Software Engineering** degree.

Examination Committee Members

1. Name: **Assoc Prof Dr. Ihtesham Ul Islam** Signature: _____

2. Name: **Assoc Prof Dr Ayesha Maqbool** Signature: _____

Supervisor's Name: **Asst Prof Dr. Muhammad Sohail** Signature: _____

Date: 30/7/24

Brig
Head of Dept of CSE
MCS College of Sigs (NUST)
Head of Department

31/7/24
Date

COUNTERSIGNED

Brig
Dean, MCS (NUST)
(Asif Masood, Phd)
Dean

Date: 1/8/24

CERTIFICATE OF APPROVAL

This is to certify that the research work presented in this thesis, entitled "**Framework for Mitigating Uncertainty for Story Points Estimation in Agile Based Projects**." was conducted by Mr. **Samra Faisal Khan** under the supervision of **Asst Prof Dr. Muhammad Sohail.**

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Student Name: **Samra Faisal Khan,** Signature:_____

Examination Committee:

a) External Examiner 1: **Assoc Prof Dr. Ihtesham Ul Islam** Signature:_____
(Department of Computer Software Engineering)

b) External Examiner 2: **Assoc Prof Dr. Ayesha Maqbool** Signature:_____
(Department of Computer Software Engineering)

Name of Supervisor: **Asst Prof Dr. Muhammad Sohail** Signature:_____

Name of Dean/HOD: **Brig Adnan Ahmed Khan, PhD** Signature:_____

Brig
Head of Dept of CSE
College of Sigs (NUST)

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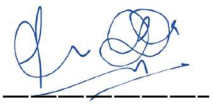
Student Signature: 

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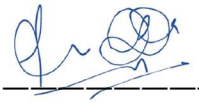
Student Signature: 

Name: **Samra Faisal Khan**

Date: 6th August 2024

DEDICATION

This thesis is dedicated to those who have been my pillars of strength and inspiration throughout my academic journey. To my parents, whose unwavering love, sacrifices, and encouragement have been the foundation of my achievements, your faith in me has been my driving force. To my siblings, thank you for your endless support and patience during the many hours I spent engrossed in study and research. To my professors and mentors, your guidance and wisdom have been instrumental in my academic and professional development, and I am deeply grateful for your support. To my friends, your camaraderie and understanding have been invaluable in providing balance and perspective during this journey. Finally, to all the unsung heroes whose silent contributions have profoundly influenced my work, your impact is deeply appreciated. Thank you all for your unwavering support and inspiration.

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Abstract

In Agile techniques, the inherent uncertainty in estimating story points presents a challenge due to the dynamic nature of the project aspects, such as the ever-changing needs and the ever-evolving dynamics of the team. Because of this uncertainty, the planning and execution of the project are less accurate. This research endeavors to develop a comprehensive "Framework for Mitigating Uncertainty in Story Points Estimation in Agile-based Projects." Agile methodologies, characterized by their adaptability to changing project requirements and dynamic team structures, face a significant challenge in accurately estimating story points due to inherent uncertainty. The dynamic nature of Agile projects introduces complexities that can impact project planning and execution accuracy. This study contributes towards a robust framework specifically designed to address the complexities of uncertainty in story point's estimation. By providing practical solutions, the framework aims to elevate the accuracy of story point's estimation in Agile projects. This research has significant potential to enhance the success rate of Agile projects by improving critical aspects such as project planning, resource allocation, and timely project delivery. The central challenge addressed in this research is the uncertainty associated with estimating story points in Agile projects. Agile methodologies thrive on adaptability, but this very dynamism introduces uncertainty in story point's estimation. Factors such as evolving project requirements and dynamic team dynamics contribute tothis uncertainty, impacting the reliability of story point's estimation. The repercussions of inaccurate story point's estimation are substantial, leading to challenges in project planning and execution. Potential consequences include project delays, misallocation of resources, and compromised project success. Recognizing the critical need for a dedicated framework, the study asserts that existing methodologies fall short in addressing the specific challenges posed by uncertainty in story point's estimation. Hence, there is acompelling need for a comprehensive framework that proactively tackles uncertainty, ultimately enhancing the precision and reliability of story point's estimation in Agile-basedprojects.

Keywords: Uncertainty, Story point estimation, Agile based project, Comprehensive Framework, Mitigating Uncertainty, Adaptability, Resource Allocation, Project Success, Estimation Reliability

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LIST OF SYMBOLS, ABBREVIATIONS AND ACRONYMS

GSD: Global Software Development

ASD: Agile Software Development

SP: Story Point

SDLC: Software Development Life Cycle

TTF: Total Technical Factors

TUCP: Total number of Use Case points

TEF: Total Environmental Factors

TEC: Total Estimated Cost

AUP: Agile Unified Process

ASD: Adaptive Software Development

FDD: Feature-Driven Development

SAF: Scaled Agile Framework

ATDD: Approval Test-Driven Development (ATDD)

BDD: Behavior-Driven Development (BDD)

CI: Continuous Integration

ID: Incremental Development

TDD: Test-Driven Development

PBI: Product Backlog Item

WBS: Work Breakdown Structure

HEF: Holistic Estimation Framework

PERT: Program Evaluation and Review Technique

Chapter 1

Introduction

1.1 Overview

Agile software development is founded upon four core values and twelve guiding principles as outlined in the Agile Manifesto [1]. A group of 17 practitioners wrote it in 2001 to improve the process of creating software responsive to fast changes and centered on the individual user's needs. Agile software development is a less burdensome methodology compared to the more complex conventional processes of software engineering. The Agile Manifesto highlights that the best way for a development team to communicate is through face-to-face conversations. However, this becomes difficult in a Global Software Development (GSD) setup, where team members are scattered across different locations. Due to the growing popularity of agile approaches in the software industry, numerous researches has been undertaken to examine effort estimation in Agile Software Development (ASD). Most of this research focuses on using story points as the main way to measure the amount of work needed to complete software tasks. They also suggest creative SEE models to provide estimates for this endeavor [2]. These models are designed to replace the expert estimator or, in a consensus-based approach like planning poker, provide estimation as an additional member of the estimation team. Constructing a tool to precisely calculate the Story Point (SP) value for a task will empower the project manager and development team to allocate resources and strategize the development process with in-

creased certainty, resulting in timely software delivery.[3]

In agile software development, story points serve as a metric to gauge the relative effort or complexity of particular user stories or activities within a project. Agile teams utilize them as a means to strategize and rank tasks, distribute resources, and monitor advancement. Nevertheless, software development inherently involves uncertainty, which can have a substantial effect on the precision and dependability of narrative point estimates [4]. The concept of uncertainty revolves around the absence of information. Researcher observes that there are nearly an equal number of definitions of uncertainty as there are discussions on the topic [5]. Their shared characteristic is the presence of partial knowledge or a state of uncertainty. However, uncertainty can be categorized into several components such as risk, ambiguity, and equivocality. Therefore, it is essential to establish added properties of these notions to understand uncertainty by empirical means.

Modern users have a strong need for a superior level of contentment when engaging with a product. Users anticipate being able to utilize the product effortlessly to swiftly and effectively complete their jobs. Furthermore, for a product to be successful, it is crucial to take into account hedonic interaction qualities, which refer to aspects that are not directly focused on the product's intended purpose [6]. Software development organizations employ agile methodologies to enhance the efficiency of product or service development. Agile methodologies for instance Kanban, Extreme Programming (XP), and Scrum decrease the development time necessary to place the product in the market [1]. The iterative aspect of software development reduces the likelihood of producing software that do not qualify the market constraints. The implementation of retrospectives after each iteration has the capability to boost the characteristic of both the agile process and the delivered product.

Agile approaches serve as a substitute for conventional project management practices. Originally conceived for software development, these tools have since expanded their utility to encompass a wide range of projects across several industries. Agile approaches have proven effective in helping teams manage uncertainty in projects by using incremental

delivery and iterative cycles. The primary advantage of Agile Software Development is its capacity to facilitate the progressive growth of teams in a flexible manner, all the while maintaining a strong emphasis on delivering substantial product value[23]. Furthermore, for the success of teams collaboration plays a vital part, as it necessitates working together and comprehending individual responsibilities within the process. Another crucial aspect is the maintenance of high-quality, which is ensured through continuous testing during the development process. This allows for sufficient time to identify and address any defects in the code, ensuring that they are reported to the development team for timely resolution [7].

Organizations have been utilizing Agile over the past two decades, and several trends and evolution have emerged. The Scrum framework is widely regarded as one of the most effective approaches used in Agile methodologies. The problems faced in agile development and maintenance projects include iterative development, clear work objectives, effective cooperation, customer engagement, direct communication, minimal documentation, frequent testing, shared responsibility, and knowledge sharing [8]. The risk associated with Agile methodology can be assessed based on factors such as inadequate comprehension of requirements, ineffective team meetings, insufficient site visits, inadequate training, poor communication, and the number of project personnel involved [9]. The key features of development methods that are compared with the proposed hybrid approach to achieve greater realization at a lower cost are as follows: Large Scale, High Reliability, High Productivity, High Accuracy of Estimations, Early Realization, and Changeability [10].

A total of five estimating algorithms for Multiagent core components were developed. The incorporation of facility factors, ontology knowledge bases, knowledge creation processes, and knowledge tree maintenance substantially enhances the accuracy of effort estimations in Agile development. The accuracy of work estimates in Agile projects is enhanced by utilizing expert-based estimations [11]. By analyzing the life cycle of story points, a reference model was developed to facilitate estimations. This model incorporates the most frequently utilized tale points [5]. Explored various Software Development Life Cycle (SDLC) methodologies ranging from Waterfall to Agile and presented the benefits

and drawbacks of each technique [12]. The suggested algorithm aims to attain accuracy by taking into account both environmental and technical parameters. The Algorithm comprises the Total number of Use Case points (TUCP), Total Technical Factors (TTF), and Total Environmental Factors (TEF) weights for determining the Total Estimated Cost (TEC) [13]. Determine the Functional Point value for a specified requirement using Weighted and Complexity Factors. Incorporate the influential aspects into the FP estimates. The proposed algorithm aims to convert functional point estimates into story point estimates [14]..

Agile projects tend to be more successful than those using the Waterfall method, with Agile initiatives being roughly twice as successful. Specifically, 42% of Agile projects succeed, 50% face challenges, and 8% fail. According to the Standish Group's 2018 Chaos Report, Agile projects have a success rate that is 60% higher than non-Agile projects [15]. In discussing different estimation methods, the user highlighted various approaches including Analogy-Based Effort Estimation, Regression-Based Estimation Model, Software Size-based Estimation Model, Functional Estimation Model, Work Breakdown Structure, and Story Point Estimation. They recommended using a Work Breakdown Structure with Story Points as the most suitable method for Agile projects [16]. When comparing the average size of suggested User Stories with the Consensus size, it was found that using the average size is less accurate than using the Consensus size. A survey on Agile mobile application development showed that 63% of projects use the Poker technique, 47% use the Analogy approach, and 38% rely on expert judgment [17].

1.2 Importance of accurate story points estimation in Agile projects

When it comes to Agile projects, accurate assessment of story points continues to be extremely important for several reasons. Accurate estimation helps in anticipating project schedules and resource requirements, which in turn makes successful planning far easier

to accomplish. According to the findings of a research [18], accurate estimating enhances project planning, which in turn leads to enhancements in resource allocation and scheduling. Through the process of estimating, teams can more effectively manage resources by determining the workload for each sprint. Research conducted in recent times has brought to light the significance of precise estimating in the management of resources, which has vital role in ensuring the success of projects and the productivity of teams.[19]

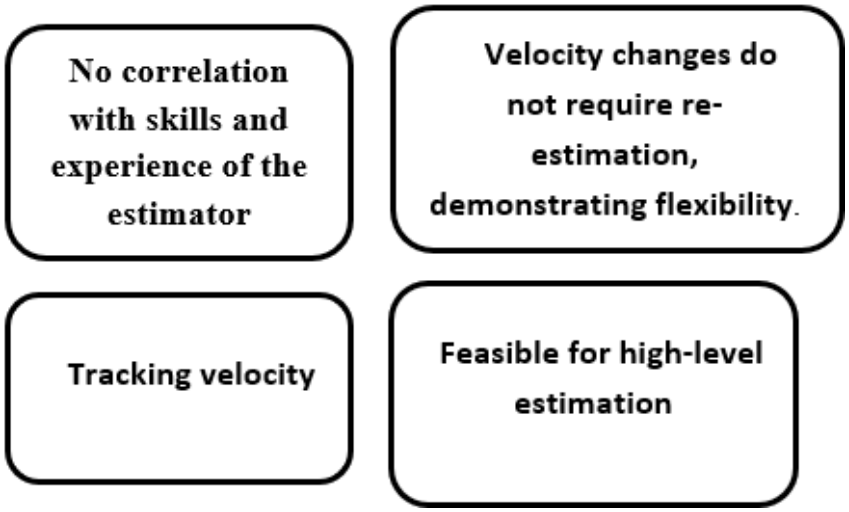

Figure 1.1: Major benefits of story points

When teams have accurate estimating, they can detect possible risks and dependencies at an earlier stage in the lifespan of the project. According to the findings of research [20], accurate estimating plays a significant role in limiting project risks by offering valuable insights into the complexity of tasks and potential obstacles. For the purpose of ensuring that commitments are made in a manner that is both reasonable and timely, reliable estimating helps to customer satisfaction. The results of a poll conducted [21] revealed that 85% of respondents believed that correct estimating had a positive influence on customer satisfaction by ensuring that expectations and outcomes are aligned. Through the provision of feedback on previous performance and the direction of future iterations, estimation contributes to the process of continuous improvement. Agile teams can better prepare for workload and grasp dependencies when they do accurate estimations. It is a tool that may be utilized by teams to assess progress, ensure that everyone

is held accountable, include discipline in the process of development, and define a release timetable. Engineers can acquire greater insights into their processes by comparing the expected amount of effort with the actual amount of time spent. This allows them to inform retrospectives and make adjustments [22].

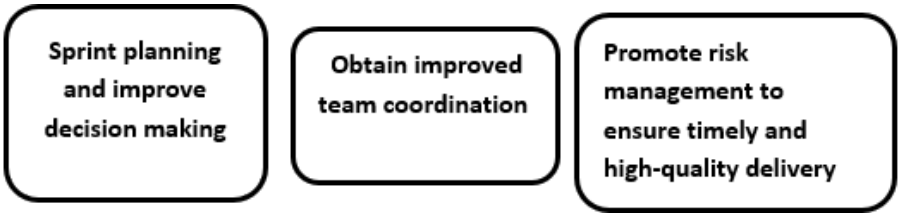

Figure 1.2: Benefits of Agile Estimation

1.3 Motivation

The selection of this study is driven by several compelling reasons. Firstly, existing research on Agile project management acknowledges the challenges of uncertainty in story points estimation, but a dedicated framework specifically designed for mitigating this uncertainty is notably lacking. This study addresses this gap by introducing a novel framework that not only recognizes the complexities of Agile projects but also provides practical solutions to enhance the accuracy of story points estimation. Secondly, as Agile methodologies continue to gain prominence in software development, the need for precise story points estimation becomes critical for effective project planning and execution. A dedicated framework for uncertainty mitigation aligns with the evolving demands of Agile practices, ensuring adaptability and responsiveness in the face of dynamic project elements.

Furthermore, the justification extends to the practical implications of the research. Inaccurate story points estimation can lead to project delays, resource misallocation, and compromised success. By focusing on uncertainty mitigation, the research seeks to contribute a framework that not only fills a critical gap in existing knowledge but also offers tangible applications for Agile practitioners. Additionally, the interdisciplinary nature

of the topic that encompassing elements of project management, risk assessment, and Agile methodologies, positions it at the forefront of cutting-edge research in the software engineering and AI domain. The selection of this topic, therefore, is not only driven by the evident research gap but also by its potential to make an impact on overall success rate of Agile-based projects.

1.4 Problem statement

The primary concern being discussed is the ambiguity associated with calculating story points in Agile projects. Uncertainty in estimating narrative points is influenced by dynamic elements such as evolving needs and team dynamics, which affect the estimation's dependability. Inaccurate estimating results in difficulties in project planning and implementation, potentially resulting in delays, misallocation of resources, and compromised project success. Furthermore, the presence of ambiguity regarding project needs, dependencies, and technological restrictions adds complexity to the estimating process.

Teams may have difficulties in accurately estimating the amount of labor needed to fulfill user stories, particularly for activities that are intricate or new. The presence of this ambiguity can lead to either an overestimation or an underestimation of the amount of work required, which in turn can result in imprecise project planning and possible delays in its execution. A lack of familiarity with Agile estimate approaches might worsen these difficulties. Teams without knowledge of estimate processes may have difficulties in decomposing user stories into smaller, estimable tasks or in efficiently using estimation methodologies. This can lead to incongruous or untrustworthy approximations, compromising the team's capacity to strategize and execute sprints efficiently.

The need for a specialized framework to reduce ambiguity in estimating story points is clear. Current techniques frequently lack effectiveness, requiring a complete framework that actively deals with uncertainty, improving the accuracy and dependability of story points estimate in Agile-based projects.

1.5 Objectives

Following are some research goals that are intended to be accomplished by the proposed research

- Develop a Comprehensive Framework: Create a detailed and comprehensive framework specifically designed to mitigate uncertainty in story points estimation within Agile-based projects.
- Evaluate the Framework's Effectiveness: Assess the effectiveness of the developed framework through empirical studies and real-world case studies, evaluating its impact on the accuracy of story points estimation.
- Identify Key Factors Contributing to Uncertainty: Investigate and identify the factors participating to enhance uncertainty in story points estimation within Agile projects, providing a nuanced understanding of the challenges involved.
- Explore Emerging Trends and Innovations: Investigate emerging trends and innovations in Agile project management and uncertainty mitigation, ensuring that the developed framework remains adaptable to evolving industry practices.
- Contribute to Theoretical Understanding: Contribute to the theoretical understanding of uncertainty in Agile project management by synthesizing existing knowledge, identifying gaps, and proposing a novel framework that adds depth to the academic discourse.
- Provide Guidelines for Framework Implementation: Develop clear and practical guidelines for implementing the framework, offering a roadmap for Agile practitioners to seamlessly integrate uncertainty mitigation into their story points estimation processes.

The overall purpose of these research goals is to address the gaps that have been identified, make a contribution to both the theoretical and practical aspects of Agile project management, and offer valuable insights to researchers, practitioners, and organizations that are looking to improve the accuracy of story point estimation in Agile-based projects.

Chapter 2

Literature Review

Agile software development encourages the implementation of flexible planning, gradual development, timely delivery, continuous improvement, and the ability to accommodate changes in requirements during the development process [22]. In 2011, the Agile Alliance created the Guide to Agile Practices, a compilation of knowledge that is freely available for use. The book offers accurate definitions of agile methodologies, terminology, and elements, along with assessments and practical recommendations from diverse global communities. The Manifesto of Agile Development comprises a set of 12 principles. The principles include Continuous Delivery, Agile Requirement Adaptation, Daily Collaboration between Programmers and Business, Individual Work Encouragement, Personal Meetings, Functional Software, Sustainable Development Teams, Continuous Design, Optimization of Work Not Complete, Optimal Architectures, and Enhanced Team Effectiveness [6].

Agile estimating occurs at several stages of the project's life cycle [23]. Estimations are conducted at the Proposal or project Level, Release Level, and Sprint Level as shown in figure 3. Accurate Sprint Level predictions are crucial for the Scrum Master to ensure timely delivery of the project with optimal quality. Management teams monitor the progress of planning and overseeing teams to carry out project implementation (development), testing, and delivering the project to the end-user within the designated time-frame. In an Agile project, erroneous estimates by the managers or scrum master

may necessitate concessions on planning and management activities, ultimately resulting in the delivery to the customer of a substandard product or project [24].

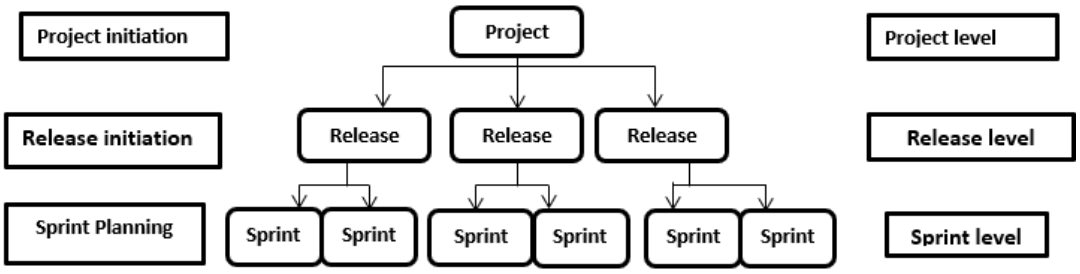

Figure 2.1: Level of Agile Estimation

Agile includes many software development approaches that cover a wide range of stages in the life cycle of software development (SDLC). The list includes the following approaches: Agile Unified Process (AUP), Extreme Programming (XP), Adaptive Software Development (ASD), Feature-Driven Development (FDD), Kanban, Scrum, and Scaled Agile Framework (SAFe). Agile utilizes many software development methodologies to streamline specifications, approach programming, evaluations, scheduling, handling risks, operations, and defect control. Below are some notable practices in Agile Software Development: Approval Test-Driven Development (ATDD), Backlogs, Behavior-Driven Development (BDD), Pair Programming, Continuous Integration (CI), Incremental Development (ID), Test-Driven Development (TDD), User Story, Planning Poker, and Velocity Tracking are all terms associated with software development methodologies and practices.

Scrum has emerged as a prominent framework within the realm of Agile projects in recent years. Scrum is a methodology utilized for the development, delivery, and long-term maintenance of intricate goods. Sprint, in the context of Scrum methodology, involves dividing the work into objectives that can be accomplished within a period of 2 to 3 weeks [26]. Scrum is an expression used in software development under the Agile paradigm. It refers to an iterative and incremental technique for managing complex tasks. As part of the Scrum process, the Scrum master facilitates the Spring Planning session, during which the development team selects tasks based on priority and estimates them using

various methodologies agreed upon by the team. The magnitude of the Product Backlog Item (PBI) is determined by using Story Points. Teams in different setups employ diverse Agile estimate methodologies based on their project scope and expertise. The primary responsibility of the Scrum Master is to select the most appropriate estimating standard for task estimation. Scrum enhances the team's ability to make more precise estimations of Story points. Relative size is a crucial factor in the process of estimating Story Points by team members. Each member of the team, including the Scrum Developer, Scrum Master Scrum, Product Owner, Stakeholders, and Tester, has the responsibility of estimating the level of work required [27].

2.1 Agile Estimation Techniques

2.1.1 Planning Poker:

Planning Poker is a commonly employed estimate tool in Agile for estimating Story Points. Planning Poker is an agile estimating approach that uses narrative points and playing cards with notations of 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, and so on to determine relative size. The playing card values assigned at the scrum meeting reflect story points, which are used to quantify the complexity or effort required for a specific item or story by the team. The number sequences often refer to the Fibonacci series. The use of the Fibonacci sequence has the advantage of facilitating a more effective comparing reasoning process, rather than allowing for subjective correctness. This kind is commonly employed for estimating the Product Backlog and serves as the basis for establishing the narrative points assigned to each user story.

When using a sequence of successive integers, the team may consistently associate it with days or hours in an attempt to ensure accuracy in the estimating process. The product owner or scrum master reviews the user narrative and provides a detailed explanation of all the features and requirements. The team then engages in discussions on both technical and non-technical aspects in order to make estimations. The primary role of the product

owner is to address all inquiries or requests for clarification posed by the team. Following a thorough examination and conversation of the story, all team members are required to choose a single card to estimate a user narrative. Each estimator or team selects a corresponding value from the poker cards, which then becomes the final estimate. If the figures are not the same, the moderators will request an elaboration about the estimators and why they have chosen the values, taking into consideration both high and low values [28].

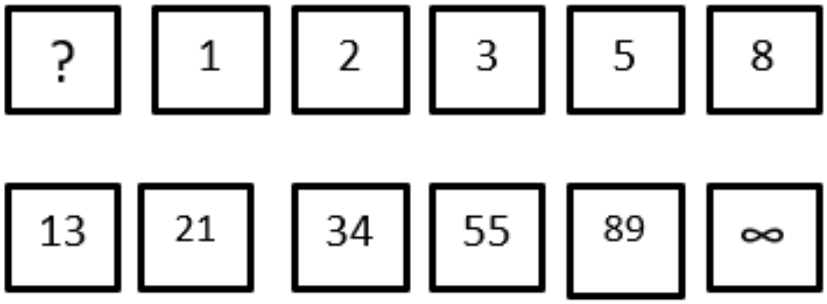

Figure 2.2: Planning Poker – an exciting estimation technique

2.1.2 Wideband Delphi:

The Wideband Delphi estimation method is a consensus-based strategy used mostly in the management of software development projects to estimate project workload. The Delphi technique, which was famously established by the RAND Corporation in the 1950s-1960s, is the basis for this forecasting tool. [28]. During the 1970s, Barry Boehm and John A. Farquhar introduced a broad-spectrum version of the Delphi approach. The word "wideband" is employed to describe the wideband Delphi approach due to its increased level of contact and communication among participants compared to the Delphi method (29). It has since been applied in several sectors to calculate a diverse variety of activities, ranging from statistical data gathering outcomes to sales and marketing predictions. The primary benefits of Wideband Delphi include its straightforward deployment, affordability, and lack of reliance on past data.

The overall procedure involves gathering, condensing, and analyzing data on the issues to be forecasted, based on input from experts. Subsequently, the findings are shared with the experts in an anonymous manner. Opinions are requested repeatedly, consolidated repeatedly, and input is sought repeatedly until a consensus is formed. Wideband Delphi is a modified version of the Delphi estimating method. In this approach, specialists in a particular field provide estimates separately in numerous rounds. After each round, the project team engages in a debate until they reach a consensus. In the Wideband Delphi method, the individuals responsible for the highest and lowest estimations provide a detailed explanation of their reasoning, after which other participants revise their estimates. The procedure continues until convergence is attained [30].

The figure illustrates that Wideband Delphi necessitates the implementation of the subsequent steps. The preparation phase is unidirectional, involving the gathering of topics, materials, and suggestions by the meeting stakeholders, followed by the conference-review segment, which establishes the final workload through numerous iterations [29].

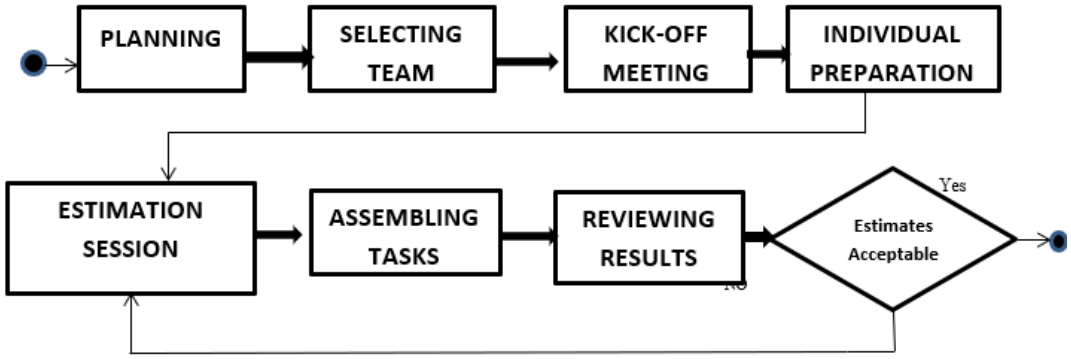

Figure 2.3: Steps of Wideband Delphi

Planning & Selection

Choosing eligible teams is a very crucial part of making precise predictions. Individuals on the team must be ready to evaluate each job objectively and work well with others around them. Know what the company needs and what engineering projects have been done in the past. Know enough about engineering jobs to make accurate estimates. From managers to designers, programmers, developers, experts, specialist writers, contributors, and more, the team should have people from every part of the development team. Facilitators, who are also called managers, should know how the Delphi method works, but they should not be involved with the results of the Delphi [30].

Kickoff Meeting Explain to members the goal, the objectives, and any other important information. Before the estimating meeting, the project manager and facilitator should mutually agree upon the statement of objectives and ensure its distribution to the team. The description of the scope of work to be estimated should be concise and limited to a few phrases. As an illustration: Produce projections for the duration and cost of the initial phase of coding and testing for Project X. The summit encompasses the following activities:

- The moderator provides a comprehensive explanation of the wideband Delphi approach to every new evaluator.
- If any member of the team has not familiarized themselves with the vision, scope, and accompanying documents, the facilitator will provide a comprehensive overview to the team.scope, and accompanying documents, the facilitator will provide a

comprehensive overview to the team.

- The presenter examines it together with the crew.
- The reviewer assesses the objectives of the evaluation meeting with the team and verifies if a team member have the expertise to make a valuable contribution.
- The team engages in discussions on goods currently in development and collaboratively generates hypotheses.
- Create a task list consisting of 10 to 20 primary tasks. These jobs correspond to the furthest level of the work breakdown system.
- Consensus on the units used for estimating (e.g., days, weeks, pages).

Individual Preparation

As soon as the meeting starts, the facilitator writes down and gives out the ideas and tasks that the team comes up with. The team member independently creates a set of prepared results that include:

Assessments for each task

- All other tasks that have to be incorporated into the WBS (Work Breakdown Structure) [31]. Work Breakdown Structure (WBS) is a way to organize all the tasks that the project team needs to do in order to reach their goals and turn in all the required outputs. As you go down the WBS, you can see more detailed descriptions of the jobs that need to be done on the project.
- Tasks that were overlooked by the team during the launch meeting.
- Any presuppositions formed by team members throughout the estimation process.

Exclude any work about project costs (such as status meetings, reports, vacations, etc.) from consideration. It should be included in the "Project Overhead Task" section. It is important to disregard any possible delays that may arise, such as jobs that are unable to commence until a specific date. The word "Than" should be included in the

"Calendar Wait time" column. Each estimation should be grounded in the amount of work required, rather than the duration of time. During the evaluation process, team members might utilize triple estimators, namely Max, Min, and ML, to ascertain values. The team has the option to allocate distinct weights to the three numbers, or alternatively, they can opt to utilize the mean as the ultimate outcome of the estimating round.

Estimation Session

The moderator gathers all the estimations. Sketch the approximate sum on the whiteboard and record it in a table. The estimator, who is neither the moderator nor any team member, verbally communicates explanations and updates to the list of tasks documented on the estimator. Suggest novel or modified assignments, identified conjectures, or inquiries. No exact timeframe is mentioned. The team successfully addressed issues or conflicts. Arguments typically arise on the activity itself rather than exact anticipated timings. These arguments may frequently be resolved by introducing assumptions. Estimators adjust their estimations by completing the "Delta" field.

Assemble Tasks

In collaboration with the facilitator, the project manager compiles the outcomes of each individual preparation and estimation meeting. The project manager eliminates superfluous information and resolves any remaining discrepancies in estimates to generate a definitive to-do list, along with work estimations. All of the presumptions are summed up clearly and appended to the list. Revise the suppositions in other files and Visio file. The project manager should generate spreadsheets documenting the definitive estimates provided by all team members. A spreadsheet should clearly display the optimal and worst-case scenarios. Any jobs that deviate considerably from the norm should be highlighted for additional examination and discussion. The ultimate job list should adhere to the identical format as the individual preparatory outcomes.

Review Results

After the completion of the findings, the project manager convenes a concluding meeting

to assess the estimates with the team. The purpose of the meeting was to assess the adequacy of the conference's outcomes for future planning. The team should assess the reasonableness of the estimate and evaluate the acceptability of the range. It is advisable for them to additionally examine the completeness of the final to-do list. There is a potential area that needs improvement. For instance, a work may require being divided into smaller tasks. In this scenario, the team may decide to conduct an additional estimates session to analyze the tasks and estimate each sub-task individually. This approach is also effective for managing tasks that have significant variations between the most favorable and least favorable outcomes.

2.1.3 T shirt Size

The T-shirt model incorporates the sizes XS (Extra Small), S (Small), M (Medium), L (Large), and XL (Extra Large). Agile estimating use T-shirt sizes to make approximate estimations for a large backlog of things. The approach facilitates rapid and approximate calculations for project scope. The team members should engage in mutual debate to choose a relative size, namely Medium, and then collectively agree on one estimation for the need based on the assigned relative size of Medium. The main benefit of using t-shirt sizes is the ability to make rapid estimates and initiate projects, while also facilitating the team's understanding of relative estimation through a range-based approach, as opposed to relying on specific numerical values. The team can swiftly reach a consensus on approximate calculations [28].

2.1.4 Dot Voting

The Dot Voting approach involves rating the tasks/stories in the Product Backlog based on their importance, with the highest priority story being ranked first and the lowest priority tales being ranked last. This helps determine which tasks/stories should be started first. A Scrum wallboard is employed to affix all user stories using yellow stickers along with their corresponding descriptions. Stakeholders at the Scrum Meeting participate in

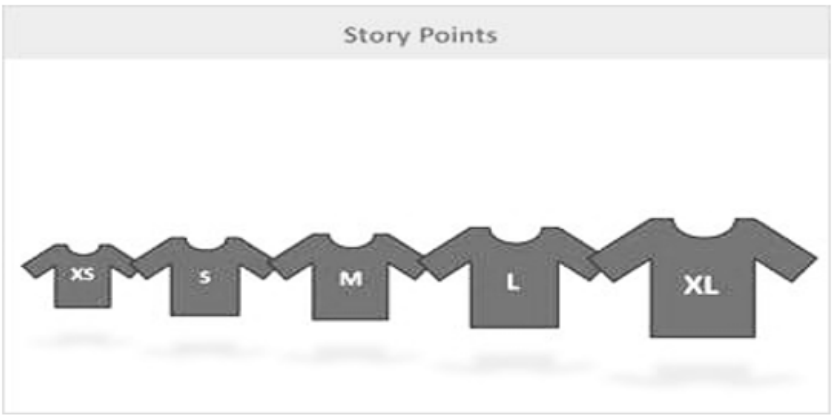

Figure 2.4: T shirt Size

voting to determine the priority needs for each of the criteria. Each stakeholder submits their vote for the requirement using a single dot, indicating whether it is affirmative or negative. The Product Owner reorders the product backlog items based on the amount of dots received by each Story, from highest to lowest. Once the priority tasks are finished, the product backlog is separated into three distinct categories based on their level of importance: high, medium, and low priority groups. Take a single set of backlog items and repeat the same process inside that set to get the prioritization order of the product backlog group. The process is iteratively executed until the ultimate order is attained by consensus among all stakeholders. According to this directive, the tasks with the highest priority would be initiated by the team and finished within the agreed-upon time frame. This approach is efficient and rapid, yielding good results when evaluating a limited number of narratives (up to 8-10) [31].

2.1.5 Bucket System

Using Planning Poker becomes more challenging when dealing with a greater quantity of things and a higher number of team estimations. The bucket system is employed to estimate a greater quantity of objects by a bigger number of teams. A range of relative size categories is established and labeled with numbers, including 0, 1, 2, 3, 4, 5, 8, 13, 20, 30, 50, 100, and 200. The estimator picks a task or story from the backlog and places it into the right bucket as stated above. The estimator gives a full explanation

of how it fits into that group. Use the dividing-and-conquering approach to address the remaining backlog items and allocate an appropriate estimation category for each task or story. The activity was iterated until all the tasks/stories in the backlog were done. The role of the Scrum Master is to ensure that no task or story is moved forward without first doing sanity checks. The Bucket System is a rapid and collaborative estimating tool. Estimating the product backlogs into appropriate buckets necessitates a team with expertise [27].

2.1.6 Large/uncertain/small

The Large/Uncertain/Small method is an important way to make estimates. This method is easier to use than the bucket system because it only needs three standard sizes instead of many buckets. The group of estimators divides the item or story into three separate groups: Large, Uncertain, and Small. When there are similar things or stories in the Product Backlog, this method of estimating is used. The Simple, Medium, and Complex estimating model is similar to this method [28].

2.1.7 Ordering Method

This estimating approach is suitable when there is a high volume of backlog items and a limited number of resources. This approach offers accurate measurements for the relative sizes of the product backlog items. The Low to High scale ranges are specified and randomly positioned among the order of importance. Every team member is required to transfer the item from one scale to another. The process involves adjusting the order of items/stories in the product backlog, moving them up or down by one position at a time, until all team members are satisfied with the prioritization, from highest to lowest. This action establishes the prioritized order of items in the product backlog [30].

Agile estimate approaches are important for reducing uncertainty by equipping teams with tools and processes to make well-informed judgments even when they don't have all the necessary information [34].

Iterative Approach:

Agile estimating tools, such as Planning Poker and Wideband Delphi, promote the process of continuously improving estimates through iterative refinement. By consistently reviewing and modifying estimates for the entire duration of the project, teams may easily respond to evolving needs, dependencies, and uncertainties. By adopting an iterative strategy, teams may effectively integrate new information and insights, therefore minimizing the influence of uncertainty as the project advances.

Collaborative Decision-Making:

Agile estimating methodologies facilitate cooperation among team members, stakeholders, and subject matter experts. By including a range of viewpoints and expertise, teams may more effectively recognize and tackle uncertainty linked to tasks and user stories. The team's combined intelligence facilitates the early identification of possible risks and uncertainties, enabling the implementation of proactive mitigation methods.

Relative Sizing:

Methods such as Planning Poker and relative estimation emphasize the comparison of tasks or user stories in relation to one another, rather than providing estimates in absolute terms. This technique minimizes the requirement for accurate estimations and assists in managing the uncertainty linked to unknown factors. By placing emphasis on relative size, teams may determine the priority of tasks based on their perceived level of complexity and uncertainty, thereby optimizing the allocation of resources.

Feedback Loops:

Between the estimating and execution stages, agile estimation methodologies provide regular feedback loops. As teams engage in task completion, their comprehension of the true level of exertion and the related ambiguities improves. The feedback loop allows teams to constantly improve their estimations, so lowering uncertainty gradually. Furthermore, receiving input from stakeholders and consumers aids in confirming assumptions and clar-

ifying requirements, hence reducing ambiguity.

Transparency and Visibility:

By making the estimating procedures and results available to all parties involved, agile estimation methodologies encourage transparency. Through transparently discussing and recording estimates, teams establish a collective comprehension of project scale, timescales, and uncertainties. Adopting transparent estimate procedures promotes trust and collaboration among team members and stakeholders, facilitating more efficient risk management and tactics to reduce uncertainty.

Adaptive Planning:

Agile techniques readily accept and incorporate changes and uncertainties as essential elements of software development. Agile estimate approaches facilitate adaptive planning by allowing teams to modify priorities, resources, and deadlines in response to changing uncertainty. Agile teams priorities prompt and efficient responses to changing conditions instead of aiming for flawless predictions. This approach helps minimize the negative effects of uncertainty on project outcomes [34].

Table 2.1. Addressing Agile Estimation Techniques in Tabular Form

Estimation Technique	Technique Type	Description	Type of scales	Suited for	Benefits
Planning Poker	Formal	Here the estimators are provided with deck of planning poker cards with values like 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, and so on The values represent number of story points	Fibonacci sequence	Small groups(5-8) members	Give an equal voice to everyone on the team
T-shirt sizes	Informal	In this simple technique, user stories or tasks are sized based on T-shirt sizes like XS, S, M, L, XL, etc., representing the relative effort required. The team discusses and assigns a size to each task based on its complexity, effort, and risk.	T shirt size	Medium group(10-25 members)	This method provides a quick and intuitive estimation without diving into specific time units.
The bucket system	Informal	Similar to T-Shirt Sizing, the Bucket System categorizes tasks into predefined buckets or groups established on their difficulty or effort. E.g., tasks might be categorized as "small," "medium," or "large." This approach simplifies estimation by reducing the number of options and focusing on relative sizes.	Numeric sizing	Medium or large group (more than 20)	much quicker for estimation than poker planning
Wideband Delphi	Formal	Structured communication process to achieve consensus	Anonymous input, iterative feedback, expert involvement	Suitable for both(small and large groups	Incorporates diverse perspectives, mitigates groupthink
Affinity Mapping	Informal	Organizes tasks into groups based on similarities	Grouping, visual representation	Small groups	Identifies patterns, encourages discussion, clarifies scope

2.1.8 Types of uncertainty and their impact on project outcomes

Software development teams are identified by an overwhelming sense of uncertainty. It has a significant impact on several decisions and is of utmost importance for the success of a project. Software development teams must acknowledge and address uncertainty, as it can result in higher development expenses, compromised product quality, delayed product release, and customer dissatisfaction [35]. The complexity of software development projects is heightened by the presence of uncertainty arising from several sources, which in turn impacts all facets of the development process, rendering it challenging to effectively manage. It is impossible to efficiently handle uncertainty in a manner that attains complete control over it. We consider uncertainty management to be the strategy used to address and handle uncertainty. In the context of a particular scenario, while dealing with ambiguity, teams have the option to select from many strategies. These strategies include investigating unclear matters to decrease uncertainty or transfer it to another issue, intentionally disregarding confusion, or even intentionally increasing uncertainty [36]. The project uncertainty type refers to the uncertainties related to the aims of the project [37]. It arises from the lack of precision in estimating and is commonly associated with project performance indicators such as time, money, and effectiveness. The uncertainty may arise due to a lack of clarity in the description or requirements, which can be attributed to an inexperienced project team, intricate project procedures, unforeseen actions, or biased predictors and decision-making. The system complexity of a project may be increased by the number, variety, and connectivity of project stakeholders, which in turn can result in project uncertainty. Projections on project objectives may prove to be inaccurate, leading to unforeseen adjustments to the project's scope or timeline [38]. The project uncertainty in software development projects may be categorized into two types: requirement uncertainty and technical uncertainty.

- Requirement uncertainty The challenge of requirement uncertainty has been extensively examined in Information System Research, mostly owing to the challenges associated with eliciting needs from users. The IT industry is now grappling with the formidable challenge of requirements ambiguity. The phase of requirement analysis is often regarded as the most crucial step in the development of software projects since it has a profound influence on subsequent phases. During the first stages of several projects, there is often a lack of clarity among users and analysts on the necessary specifications, resulting in a vague and inadequate set of requirements. Requirement uncertainty pertains to the ambiguity surrounding the specific needs and desires of the user [39]. Regular modifications to these constraints necessitated a thorough examination of agreement and deliberation on the responsibility for subpar project results.

- Technological uncertainty The level and quantity of technology employed in software projects are connected to technical uncertainty. Consequently, it is a comparison between the number of technical advancements that exist and the specific technology that may be utilized in IT projects [40]. Despite the inherent risks, modern technology is often sought after for the creation of new products or features that need its use. Customers anticipate enhanced performance and results when using contemporary technology, yet these endeavors include substantially higher levels of danger compared to familiar technologies. It is the primary source of uncertainty that is referenced most frequently in research articles. The amount of technical uncertainty is determined by the utilization of sophisticated or well-established technology. The degree of technological uncertainty in a software project varies depending on subjective factors such as the level of technical knowledge about its applications and availability among different firms. These uncertainties might potentially affect the analytical capabilities of a project leader and their team [41].

- Environment Uncertainty Based on the literature review, the environment is identified as the primary factor contributing to uncertainty in software projects [42]. Environmental uncertainty measures the level of uncertainty within an organiza-

tion's external and internal environment. Management principles highlight the significance of organizations adjusting to their environment to ensure their continued viability. These uncertainties can be reduced by comprehending the environmental characteristics of the project. This study facilitates decision-making about processes and also aids in identifying different sorts of environments that give rise to diverse uncertainty. The organization's environment may give rise to ambiguity, leading to a situation of individuals who see themselves as lacking essential information regarding environmental matters. The text encompasses the ambiguity associated with both genuine and commercial advancements that may influence the product. Additionally, it addresses matters pertaining to the choice of technology and the suitability of the necessary infrastructure. Impacts may arise from technological advancements in the market, leading to project or component failure and therefore the incapacity to supply services to the organization [44]. Similarly, the quantity or punctuality of the provision of items, components, and equipment necessary to complete service duties may be uncertain. Environmental uncertainty can arise from various factors, including potential changes in the environment and challenges related to the prospects and characteristics of events that affect firms and specific groups within firms, such as vendors, buyers, customers, the government sector, shareholders, real planning size, and funding sources.

- Organizational uncertainty Uncertainty within the organization develops beyond the project's scope but remains within its boundaries. This uncertainty is closely associated with policy goals such as the prospects of enterprises, as well as problems with the governance plan, duties of different units, industry standards, and monitoring. Organizational uncertainty sometimes arises from alterations in the organizational structure or the introduction of new ideas, leading to ambiguity and doubt about job stability. The firm may lack the necessary information on how to carry out a task, leading to ambiguity. Organizational uncertainty arises from a deficiency in skills and the inability to recognize it from the beginning. Throughout the progress of the project, the alterations made to the project resulted in a state

of ambiguity for the project itself, which in turn led to doubt in the relationships involved. Prior research indicates that external factors had a role in initiating, facilitating, and impeding the evolution process at precise intervals, outside the direct influence of management. Therefore, it is imperative for managers to effectively manage environmental unpredictability [42].

2.1.9 Agile Software Development Approaches to Uncertainty

When it comes to software development, requirements ambiguity is the main source of uncertainty [45, 50]. Various methods have been suggested to address the uncertainty of requirements to minimize the potential risks to the performance of the product. For instance, enhancing communication and planning procedures are key recommendations for enhancing the resilience of needs. Nevertheless, the failure to effectively safeguard requirements from alterations has led to the emergence of alternative methodologies that organize development into iterative stages of gradual improvement [43]. These methodologies enable development teams to adapt and respond flexibly to unexpected circumstances and changes. This trend signifies the criticism of premeditated organization in intricate tasks. Consequently, efforts to satisfy the triple constraint (money, time, quality) are being substituted more and more by cycles of re-planning. In the past ten years, a significant number of software development teams have embraced various agile approaches [47, 49].

By implementing adaptable strategies to respond to modifications, they provide an approach that contrasts significantly with conventional plan-driven project management. Specifically, they provide teams with methodologies that aid in managing uncertainty by providing developers with a significant degree of adaptability [50]. It is important to note that uncertainty management does not mean reducing or getting rid of uncertainty completely. Instead, it is a technique to examine and adjust to unforeseen situations. Although the potential of agile software development methods to actively observe and potentially even encourage uncertainty for the purpose of managing it is not explicitly discussed, it is necessary to combine different agile methods to address various types of

uncertainty. Agile methods recommend specific practices for team coordination, such as frequent planning and empowering developers to self-organize, to help deal with uncertainty.

Among these methodologies, Extreme Programming (XP) and Scrum are particularly popular among agile software engineers and have been the subject of much research [51]. Scrum, for instance, proposes a managerial approach to development projects by prioritizing cooperation structures and team autonomy, rather than focusing on engineering processes. Maruping and colleagues conducted a study to examine the connections between project control, team autonomy, and project performance. They discovered that the utilization of agile methodologies is particularly advantageous in situations characterized by significant levels of uncertainty [52]. Scrum lacks concrete recommendations for managing uncertainty. However, it specifically deals with the notion, particularly by reducing confusion around needs.

Development teams frequently enhance their processes by incorporating elements from XP, which provides additional computer programming techniques that help teams deal with uncertainty. Prototyping and incremental task planning significantly influence and have a strong impact on a team's ability to handle various forms of uncertainty without relying on their complete eradication. XP techniques, however, do not address the comprehensive requirements of the entire project. Consequently, teams must cultivate adaptability by integrating several agile methodologies. Agile practitioners employ brief development iterations lasting two to four weeks, which are regularly interrupted by customer feedback loops. The main purpose of this approach is to assist teams in mitigating risks arising from unpredictable or unclear requirements. This is achieved by frequently and consistently validating their work with input from stakeholders.[12, 53] Scrum also promotes team retrospective meetings to evaluate work processes after each iteration and recommends a series of meetings to plan iterations and conduct daily meetings to keep team members informed. These sessions, aided by visualization technologies, enable the monitoring of projects in several areas such as changes in needs and the prediction of short-term productivity. The focus is on experimentally evaluating ideas, such

as through fast prototyping and gradual improvement [50]. These activities promote the gradual accumulation of knowledge, which in turn enhances the quality of decision-making [49]. Various agile methodologies provide a range of practices that go beyond the mere use of iterations. Nevertheless, practitioners face a dearth of guidance when it comes to effectively managing uncertainty, rather than only focusing on reducing it. The lack of uncertainty management in agile software development, despite its well-recognized importance in the literature, is both regrettable and perplexing [51].

Table 2.2. ASD Frameworks and key features

Framework	Key Features
Scrum	The complete extent of the project is divided into brief development periods known as Sprints. The duration of the Sprint ranges from one to four weeks. The team must adhere rigorously to a predetermined work plan for each Sprint. Individuals participating in a project have predetermined responsibilities.
Kanban	Workflow visualization is a fundamental aspect of development. The ongoing task is given priority. Development cycles are not limited by a specific time frame. The team has the flexibility to modify the work plan at any given moment.
Hybrid	Agile and Waterfall are mutually beneficial. Agile software development operates within the constraints of a Waterfall approach, which includes a fixed timeline, a budgeted budget, and a comprehensive risk assessment.
Bimodal	There are two distinct modes of work available: conventional (Mode 1) and Agile (Mode 2). Two distinct teams are engaged in projects with divergent objectives. The Mode 1 team is responsible for the maintenance of the IT system infrastructure. The Mode 2 team provides innovative apps. Interdisciplinary cooperation is crucial.
Lean Software Development	The framework facilitates speedier software development with reduced effort, duration, and expenditure. The development cycle is minimized. The early-delivered product is undergoing ongoing improvement. The team operates autonomously and assumes a broader scope of duties compared to teams in Scrum, Bimodal, and Hybrid methodologies. Developers can conceptualize the product's idea.
XP	The concentration is on software development technology. Engineering principles in XP help developers write concise code. Writing, testing, analyzing, designing, and integrating code are constants in product development. Direct team communication and client involvement in development are essential.
Feature-Driven Development (FDD)	Breaks down development into small, client-valued features, facilitating early feedback and reducing uncertainties by focusing on incremental delivery.
Dynamic Systems Development Method (DSDM)	Provides a framework for iterative and incremental project delivery, emphasizing collaboration, flexibility, and prioritization to address uncertainties effectively.
Crystal Methods	Offers a family of methodologies tailored to different project contexts, emphasizing communication, simplicity, and reflection to manage uncertainties while promoting team collaboration.
Agile Risk Management	Integrates risk management practices into Agile processes, including identifying, assessing, and mitigating risks iteratively throughout the project lifecycle to reduce uncertainties.
Adaptive Project Framework (APF)	Combines Agile and traditional project management principles to manage uncertainties by adapting to changing requirements, stakeholders, and project environments.
Cynefin Framework	Provides a sense-making framework for understanding the complexity of a problem domain and selecting appropriate Agile approaches to manage uncertainties based on the nature of the domain (simple, complicated, complex, and chaotic).
Real Options Thinking	Applies the principles of real options theory to Agile decision-making, providing flexibility and adaptability to manage uncertainties by deferring irreversible decisions until more information is available.
Continuous Delivery (CD)	Automates the deployment pipeline and enables frequent releases to production, reducing uncertainties associated with manual processes, integration issues, and deployment failures.
Behavior-Driven Development (BDD)	Promotes collaboration among business stakeholders, developers, and testers to establish acceptance criteria in advance and address uncertainties by ensuring that requirements and implementation are aligned.
Agile Leadership and Culture	Fosters a culture of trust, transparency, and empowerment within organizations, enabling teams to adapt to uncertainties proactively and make decisions collaboratively to achieve shared goals.
Monte Carlo Simulation	Utilizes probabilistic modeling to analyze the impact of uncertainty on project outcomes, allowing teams to simulate various scenarios and make informed decisions based on statistical data.
Real Options Analysis	Applies financial option theory to Agile decision-making, enabling teams to evaluate the value of different choices and maintain flexibility in responding to uncertainties as the project evolves.
Complex Adaptive Systems Theory	Draws on concepts from systems thinking and complexity science to understand and manage uncertainties in complex software development environments, emphasizing emergence, self-organization, and adaptation.
Agile Risk Burn-Down Charts	Visualizes the progress of risk mitigation activities over time, providing stakeholders with insights into the effectiveness of risk management efforts and enabling proactive responses to emerging uncertainties.
Dependency Management Strategies	Implements techniques such as Dependency Structure Matrix (DSM) analysis, interface control documents (ICDs), and service-oriented architecture (SOA) to identify and manage dependencies between components and mitigate uncertainties related to integration and interoperability.
Continuous Experimentation and A/B Testing	Embeds experimentation and validation into the development process, allowing teams to gather empirical data, test hypotheses, and validate assumptions iteratively to reduce uncertainties and improve decision-making.
Agile Portfolio Management	Applies Agile principles and practices at the portfolio level to manage uncertainties across multiple projects, including prioritization, resource allocation, and strategic alignment, while fostering transparency, adaptability, and value delivery.
Decomposition and Convergence Strategies	Breaks down large, complex features or epics into smaller, manageable units that can be developed and validated incrementally, enabling teams to reduce uncertainties by focusing on specific aspects of the problem domain and converging towards a viable solution iteratively.
Cybernetic Control Theory	Utilizes feedback loops and control mechanisms to maintain stability and adaptability in dynamic, uncertain environments, enabling teams to monitor, regulate, and adjust their processes and behaviors to achieve desired outcomes effectively.
Empirical Process Control	Embraces empiricism as the foundation for decision-making, emphasizing transparency, inspection, and adaptation to manage uncertainties based on observable outcomes and feedback from stakeholders and the environment.

Agile software development techniques priorities managing uncertainty more than conventional approaches to software development. However, as Moran [54] states, they do so in a passive and implicit manner, which can result in activities being misdirected and misconstrued. Significantly, the extent to which they can effectively tackle opportunities that result from uncertainty has received less attention in research. To harness this potential, it is necessary to enhance decision makers' ability to differentiate between threats and opportunities. However, it is crucial to examine if and how threat and opportunity can be effectively controlled using the same methods for dealing with uncertainty. These questions are crucial since they impact the fundamental operations of development programs. Hence, our objective is to investigate the techniques, which are regularly utilized by agile software developers, as well as the overall guiding principles that go beyond the recommendations of agile approaches in order to reduce uncertainty.

Table 2.3. A Tabular summarization of literature review

Paper Title	Authors	Publication	Focus	Research Gap
Issues, challenges, and a proposed theoretical core of agile software development research [39]	Corey Baham, Rudy Hirschheim	Information systems (Journal)	Explores the theoretical underpinning for ASD, which may inform professional and educational ASD method customization. The four fundamental concepts can be contrasted with firm agility and IS recovery agility to show how software development differs.	Needs further analysis of benefits, costs, and complexity of overlapping agile software development methods.
Measuring and Improving Agile Processes in a Small-Size Software Development Company [6]	Micha Choras, Tomasz Springer, Rafa Kozik, Lidia López, Silverio Martínez-Fernández, Prabhat Ram,Pilar Rodríguez and Xavier Franch	IEEE Access(Journal)	This paper presents a real experience of using metrics in the software development process to assist small and medium-sized enterprises (SMEs) in developing software using an Agile approach.	Although the findings are derived from a specific SME company and its product, additional research is needed to explore using the agile approach in a broader setting.
Selection of software agile practices using Analytic hierarchy process [36]	Royer David Estrada-Esponda,, Mauricio Lopez-Benítez, Gerardo Matturro	Heliyon (Journal)	This study investigates the ranking of agile methods and improvement goals in software development, utilizing the Analytic Hierarchy Process (AHP) methodology.	Highlights the necessity of examining other agile methodologies using multi-criteria evaluation methods to determine suitability.
A teamwork effectiveness model for agile software development [41]	Diane Strode1 Torgeir Dingsøyr, Yngve Lindsjorn	Empirical Software Engineering (An International Journal)	Explores the efficacy of the agile teamwork effectiveness model (ATEM) in the context of collocated agile development teams. The model is derived from empirical data collected through focus groups, case studies, and a comprehensive review of diverse literature. It is an updated version of a broad team effectiveness model.	This research lacks comprehensive analysis of emerging study areas in empirical software engineering, which hinders researchers from examining the reasons and mechanisms behind the impact of agile practices and methodologies on agile team effectiveness.
An empirical study to design an effective agile project management framework [26]	Nitin Uikey, Ugrasen Suman	In Proceedings of the CUBE International Information Technology Conference	Including multiple elements of both agile and traditional project management methodologies for software development. The project management framework proposed prioritizes methodology, requirements management, teams, clients, testing, and documentation.	Identifies a need for more efficient use of agile methods to mitigate the uncertainties
Study on Agile Story Point Estimation Techniques and Challenges [4]	Ravi Kiran Mallidi, Manmohan Sharma	International Journal of Computer Applications	The main goal is to showcase different Agile Story Point estimate approaches employed in development settings and the difficulties they entail. Assists development teams in implementing appropriate estimate methodologies in their projects.	Additional research is required to develop more effective methods for estimating effort in Agile Scrum projects, including addressing the problems associated with Story Point estimations.
Tackling Requirements Uncertainty in Software Projects: A Cognitive Approach [35]	Mohd. Haleem, Md. Faizan Farooqui, Md. Faisal	International Journal of Cognitive Computing in Engineering	Examine the several categories of uncertainty, their origins, connections, and consequences, and ultimately go into the details by proposing a hypothetical framework for handling uncertainty in requirements.	There is a need for a more precise or clearly defined method to handle uncertainties in software project management.
Two Sides of The Same Coin – How Agile Software Development Teams Approach Uncertainty as Threats and Opportunities [38]	Denniz Donmez, Gudela Grote	International Journal of Information and Software Technology	Analyze uncertainty management methods. Recognize both the detrimental and good effects of uncertainty, and prefer to extend knowledge and improve software development techniques for uncertainty.	can enhance the creation of more resilient and dependable estimation methods, thereby enhancing project planning, execution, and delivery in Agile contexts
Ontology Based Multiagent Effort Estimation System for Scrum Agile Method [14]	Muhammad Adnan Muhammad Afzal	9th International Conference on Dependable Systems and Their Applications (DSA)	This study focuses on the tough issues of software effort estimation and knowledge management in the context of adopting the Scrum approach in agile software development.	To improve the technique, consider incorporating additional variations of agile approaches to accurately predict the necessary efforts for future projects.
The Impact of Agile Methodologies and Cost Management Success Factors: An Empirical Study [29]	Javed Iqbal, Mazni Omar, Azman Yasin	Baghdad Science Journal	This study examines the relationship between cost management victory criteria, project management factors, and three agile techniques (Kanban, XP, and Scrum) in the Pakistani software sector.	Lack some other aspects of agile methodologies and projects management factors
The Effects of Agile Methodologies on Software Project Management in Pakistani Software Companies [42]	Javed Iqbal, Mazni Omar Azman Yasin	Turkish Journal of Computer and Mathematics Education	The proposed study aims to conduct a comprehensive statistical analysis to assess the efficacy of agile approaches in relation to their impact on project management factors.	A limitation of this study is the lack of comprehensive framework specifically tailored to mitigate uncertainty in story points estimation
Issues and Challenges of Cost Management in Agile Software Development Projects [43]	Mansor, Zulkefli Razali, Rozilawati Yahaya, Jamaiah Yahya, Saadiah Arshad, Noor Habibah	American Scientific Publishers	This article examines the concerns and challenges encountered by Project Managers when managing costs in agile software development projects.	Additional research is required to develop more effective methods for estimating effort in Agile Scrum projects, including addressing the problems associated with Story Point estimations.

In examining the current research landscape for the proposed topic, "Framework for Mitigating Uncertainty for Story Points Estimation in Agile-based Projects," it becomes apparent that while there exists literature on Agile project management and story point's estimation, there is a noticeable gap in dedicated frameworks aimed at addressing the inherent uncertainties in this process. Prior studies may touch upon the challenges posed by uncertainties in Agile projects, but the presence of a comprehensive framework specifically tailored to mitigate uncertainty in story points estimation seems to be a less-explored area. The existing literature showcases varied methodologies and techniques related to story points estimation but lacks a dominant theme concerning a holistic framework for uncertainty mitigation.

In this context, there is a potential opportunity for the proposed research to contribute significantly by bridging this gap. The review suggests a need for a more focused exploration of frameworks that not only theorize about uncertainty but also provide practical applications for Agile-based projects. By synthesizing existing knowledge and identifying emerging trends, the study aims to deliver a novel framework that not only addresses the uncertainties associated with story points estimation but also offers tangible solutions for enhancing accuracy and reliability in the dynamic environment of Agile projects.

Chapter 3

THEORETICAL FRAMEWORK

3.1 Holistic Estimation Framework (HEF)

The Holistic Estimation Framework (HEF) is designed with a primary objective: to offer a robust and flexible methodology that effectively tackles the complexities of story point's estimation within Agile projects. Rooted in the principles of accuracy, collaboration, and risk mitigation, HEF aims to streamline the estimation process while minimizing the dependency on specialized technical expertise. At its core, HEF seeks to provide a comprehensive approach that considers various dimensions of each user story, ensuring a more nuanced and accurate estimation. By integrating diverse perspectives such as technical complexity, business value, and potential risks, HEF fosters a holistic understanding of the tasks at hand, enabling teams to make informed decisions during the estimation process. One of the key strengths of HEF lies in its emphasis on collaboration. By promoting structured workshops and facilitated discussions, HEF encourages active participation from all team members, ensuring that a wide range of insights and viewpoints are taken into account. This collaborative approach not only enhances the accuracy of estimations but also fosters a sense of ownership and alignment within the team.

Moreover, HEF incorporates dynamic risk assessment as an integral component of the estimation process. By proactively identifying and addressing potential risks associated

with each user story, teams can develop mitigation strategies early on, minimizing the likelihood of project disruptions and delays. This risk-informed approach not only enhances the reliability of estimations but also contributes to overall project resilience. Importantly, HEF is designed to be adaptable to various project contexts and team dynamics. Whether dealing with evolving requirements, changing priorities, or diverse stakeholder expectations, HEF provides a flexible framework that can be tailored to suit the unique needs of each project. This adaptability ensures that teams can effectively navigate the uncertainties inherent in Agile development without being constrained by rigid methodologies.

3.1.1 Components

3.1.1.1 Multi-Perspective Estimation

- Approach: Instead of relying solely on individual estimates, HEF encourages team members to consider various perspectives, including technical complexity, business value, and potential risks. This multi-dimensional approach ensures a more holistic view of each user story.
- Technical Consideration and implementation
  - Structured Template or Checklist:
    - Develop a digital template that guides team members through the estimation process.
    - Implement the template in a format compatible with collaborative tools (e.g., Google Docs, Microsoft Teams).
  - Collaborative Tools:
    - Choose a platform that supports real-time collaboration and editing.
    - Utilize agile project management tools with collaborative features or integrate with virtual whiteboards

3.1.1.2 Facilitated Workshops

- Approach: Facilitated Workshops in HEF provide a structured platform for team members to collectively engage in the estimation process. By bringing together diverse perspectives and facilitating open discussions, these workshops ensure that estimations are based on a comprehensive understanding of the user stories. For example, in a facilitated workshop for estimating the complexity of a software development task, team members from different functional areas such as development, testing, and product management collaborate to share their insights and discuss the various factors influencing the estimation. The presence of a facilitator helps steer the conversation, ensuring that all relevant viewpoints are considered, and biases are mitigated. This collaborative approach fosters team alignment and ownership of the estimation process, ultimately leading to more accurate estimations.

- Technical Consideration and implementation

  - Video Conferencing or Collaborative Tools:

    * Select a video conferencing tool (e.g., Zoom, Microsoft Teams) that supports breakout rooms and screen sharing.

    * Explore collaborative tools with virtual whiteboard capabilities for interactive workshops.

  - Facilitator Guidance Features:

    * Implement features that allow the facilitator to guide discussions and capture key points.

    * Use agile project management tools with workshop facilitation capabilities or supplement with additional facilitation tools.

3.1.1.3 Dynamic Risk Assessment

- Approach: Dynamic Risk Assessment within HEF integrates risk management into the estimation process, enabling teams to proactively identify and address potential risks associated with each user story. For instance, when estimating the story

points for a new feature development, team members may identify risks such as dependencies on external APIs, resource constraints, or changes in project scope. By acknowledging these risks upfront and developing mitigation strategies, teams can better anticipate and respond to challenges during project execution. This proactive approach not only enhances the accuracy of estimations but also contributes to overall project resilience and risk mitigation.

- Technical Consideration and implementation
  - Risk Assessment Template:
    - Develop a digital risk assessment template integrated into the estimation process.
    - Use form-building tools (e.g., Google Forms, Microsoft Forms) or integrate risk management modules in agile project management tools.
  - Repository for Risk Information:
    - Create a centralized database or repository to catalog identified risks and mitigation strategies.
    - Utilize cloud-based storage or database solutions accessible to the team.

3.1.1.4 Reference Task Library

- Approach: The Reference Task Library component of HEF serves as a repository of well-defined tasks with known story points. This library provides teams with a benchmark for estimation, allowing them to align their estimations with previously completed tasks of similar complexity. For example, when estimating the story points for a new development task, team members may refer to similar tasks completed in previous iterations or projects to gauge the level of effort required. By leveraging historical data and past experiences, teams can make more informed estimations, reducing the variability and uncertainty associated with new tasks. This reliance on empirical data enhances the accuracy and consistency of estimations across different projects and teams.

- Technical Consideration and implementation
  - Centralized Repository:
    * Develop a centralized repository or knowledge base for storing reference tasks.
    * Implement version control systems (e.g., Git) or use knowledge management platforms with search functionalities.
  - Accessibility Features:
    * Ensure easy accessibility to the reference task library during estimation sessions.
    * Integrate the library with agile project management tools or provide direct links for quick access.

3.1.1.5 Continuous Feedback Loop

- Approach: The Continuous Feedback Loop in HEF establishes a mechanism for revisiting past estimations during retrospective sessions. By reflecting on previous experiences and soliciting feedback from team members, teams can identify patterns, trends, and areas for improvement in their estimation approach. For instance, during a retrospective session following the completion of a project iteration, team members may review the accuracy of their initial estimations and identify any discrepancies between estimated and actual effort expended. This retrospective analysis enables teams to learn from past experiences, refine their estimation techniques, and continuously improve their estimation accuracy over time.

- Technical Consideration and implementation
  - Feedback Mechanism:
    * Implement a digital feedback mechanism within the agile project management tool or a dedicated feedback tool.

    - Use feedback features within the chosen tool or integrate with third-party survey tools.
  - Categorization and Analytics:
    - Categorize and store feedback in a structured format for future analysis.
    - Utilize analytics modules within agile project management tools or external analytics platforms.

3.1.1.6 Expert Consultation Sessions

- Approach: Expert Consultation Sessions in HEF provide teams with access to experienced individuals who can offer insights and guidance on estimation challenges. Either internal subject matter experts or external consultants, these sessions enable teams to tap into diverse expertise for more accurate estimations. For example, when facing uncertainty about the technical feasibility of a proposed feature, team members may consult with experienced developers or architects to gain insights into potential implementation challenges and associated effort estimates. By leveraging external expertise and domain knowledge, teams can make more informed decisions and improve the accuracy of their estimations.

- Technical Consideration and implementation
  - Virtual Consultation Spaces:
    - Set up virtual spaces for expert consultation, using video conferencing tools or dedicated consultation platforms.
    - Integrate scheduling tools to facilitate appointment bookings.
  - Expert Directory System:
    - Implement an expert directory system for tracking expert availability and expertise areas.
    - Develop a digital directory accessible to team members.

3.1.1.7 Use of Estimation Ranges

- Approach: The Use of Estimation Ranges component of HEF advocates for a departure from traditional single-point estimates and encourages the use of estimation ranges (e.g., low, medium, high) to acknowledge and communicate the inherent uncertainty in the estimation process. For example, instead of providing a precise estimate of five story points for a development task, team members may provide a range of three to eight story points to reflect the variability and uncertainty associated with the task. This approach not only provides stakeholders with a more realistic assessment of project complexity but also facilitates more effective resource planning and decision-making. By embracing estimation ranges, teams can better manage uncertainty and adapt to changing project requirements, ultimately improving the overall accuracy and reliability of estimations.

- Technical Consideration and implementation

  - Customized Estimation Input Fields:

    * Modify the estimation input fields in the agile project management tool to accommodate ranges or discrete levels.

    * Use customization features within the chosen tool or develop custom fields using scripting capabilities.

  - Validation Checks:

    * Implement validation checks to ensure consistency in range selections.

    * Use built-in validation features or incorporate additional scripting to enforce range constraints.

3.1.2 Benefits

- Collaborative Decision-Making: HEF fosters collaboration, ensuring that the collective intelligence of the team is utilized for more accurate estimations.

- Risk-Informed Estimations: By integrating risk assessment, HEF allows teams to proactively address potential challenges, reducing the impact of uncertainty on project execution.

- Learning and Improvement: The continuous feedback loop and reference task library enable the team to learn from past experiences, refining their estimation skills over time.

- Adaptability: HEF is designed to be adaptable to different project contexts, accommodating changes in requirements, team dynamics, and project priorities.

The Holistic Estimation Framework (HEF) provides a balanced and effective approach to story point's estimation in Agile projects. By emphasizing collaboration, risk management, and continuous improvement, HEF aims to enhance the accuracy and reliability of estimations, contributing to the success of Agile projects without the need for specialized technical knowledge.

The technical implementation of each component in the Holistic Estimation Framework (HEF) revolves around selecting suitable tools, integrating digital templates, ensuring collaboration features, and leveraging data analytics for continuous improvement. The choice of specific tools may vary based on the team's preferences and the organization's existing tech stack. The objective is to create a seamless and user-friendly technical environment that aligns with HEF's goal of enhancing accuracy and collaboration in Agile story points estimation.

Table 3.1. Components of the Holistic Estimation Framework (HEF)

Component	Approach	Technical Consideration and Implementation
Multi-Perspective Estimation	Encourages team members to consider various perspectives including technical complexity, business value, and potential risks.	- Develop a digital template that guides team members through the estimation process. - Implement the template in a format compatible with collaborative tools (e.g., Google Docs, Microsoft Teams).
Facilitated Workshops	Provides a structured platform for team members to collectively engage in the estimation process.	- Select a video conferencing tool (e.g., Zoom, Microsoft Teams) that supports breakout rooms and screen sharing. - Implement features that allow the facilitator to guide discussions and capture key points.
Dynamic Risk Assessment	Integrates risk management into the estimation process enabling teams to proactively identify and address potential risks associated with each user story.	- Use risk management tools to document and monitor risks. - Integrate risk assessment into the estimation template.
Virtual Consultation Spaces	Set up virtual spaces for expert consultation using video conferencing tools or dedicated consultation platforms.	- Implement an expert directory system for tracking expert availability and expertise areas. - Develop a digital directory accessible to team members.
Use of Estimation Ranges	Encourages the use of estimation ranges (e.g., low, medium, high) to acknowledge and communicate the inherent uncertainty in the estimation process.	- Modify the estimation input fields in the agile project management tool to accommodate ranges or discrete levels. - Implement validation checks to ensure consistency in range selections.

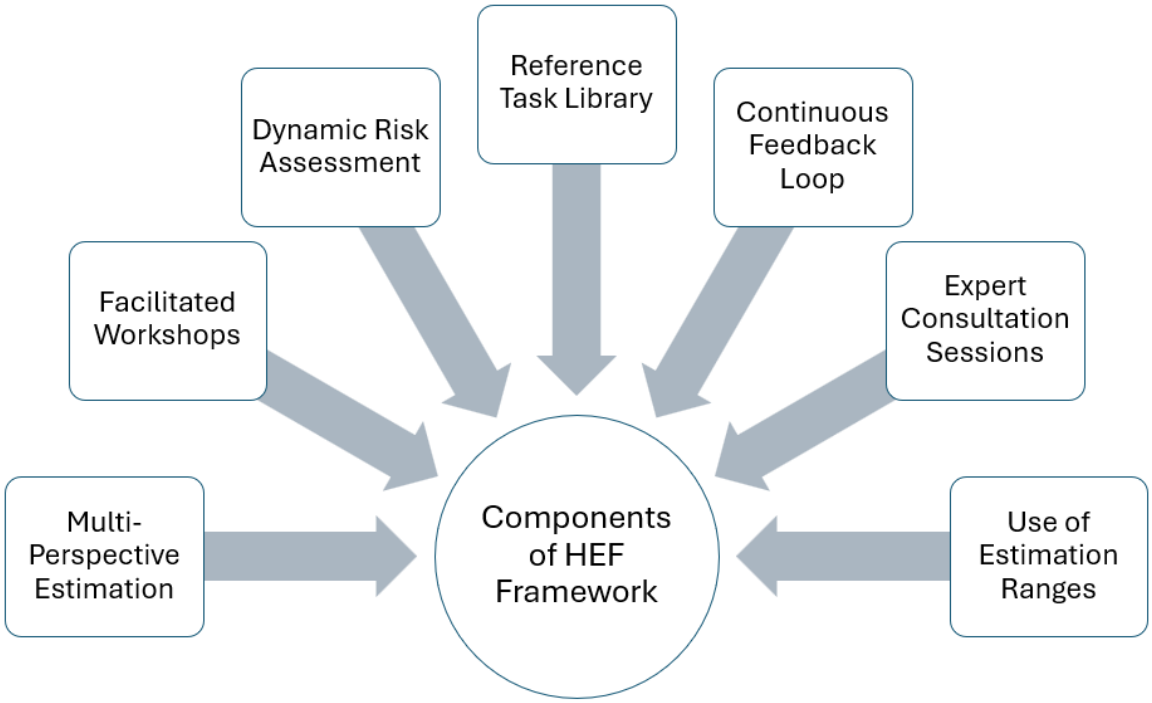

Figure 3.1: Components of HEF Framework

3.2 Detailed Explanation of the Multi-Perspective Estimation

The Multi-Perspective Estimation component of HEF advocates for a departure from traditional, single-dimensional estimation approaches. By encouraging team members to consider various perspectives such as technical complexity, business value, and potential risks, HEF ensures a more comprehensive evaluation of each user story. For instance, when estimating the story points for a feature enhancement in a software application, team members may consider not only the technical intricacies involved in the implementation but also the anticipated impact on user experience and the potential risks associated with introducing new functionalities. This multi-dimensional approach fosters a more holistic understanding of the tasks at hand, leading to more accurate and informed estimations.

3.2.1 Technical Implementation:

3.2.1.1 Structured Template or Checklist

- Digital Template: Develop a digital template that team members can use during the estimation process. This template should include sections for technical complexity, business value, and risks.

- Collaborative Tools: Implement the template using collaborative tools like Google Docs, Microsoft Teams, or other shared document platforms. Choose a collaborative platform that supports real-time collaboration, allowing team members to contribute to the estimation process simultaneously. Ensure the collaborative tools are compatible with various devices and operating systems for seamless accessibility.

3.2.2 Dimensional Perspectives

3.2.2.1 Technical Complexity

- Definitions: Clearly define technical complexity criteria, such as the level of expertise required, integration challenges, or technological novelty.

- Quantifiable Metrics: Integrate quantifiable metrics where applicable to make technical complexity more objective.

3.2.2.2 Business Value:

- Value Criteria: Define criteria for assessing the business value, considering factors like user impact, strategic alignment, or market demand.

- Scoring System: Implement a scoring system to quantify the perceived business value.

3.2.2.3 Risks

- Identification: Include a section for identifying potential risks associated with the user story.
- Mitigation Strategies: Encourage the team to propose mitigation strategies for identified risks.

3.2.3 Template Accessibility

- User-Friendly Interface: Design the template with a user-friendly interface, ensuring that team members can easily navigate and input their estimations.
- Versioning: Implement version control mechanisms for the template to track changes and improvements over time.

3.2.4 Feedback Mechanism:

- Real-Time Feedback: Enable real-time feedback within the collaborative tool, allowing team members to comment or provide suggestions during the estimation process.
- Iterative Refinement: Use feedback to iteratively refine the template, making it more effective and aligned with the team's needs.

3.2.5 Benefits:

- Comprehensive Estimations: Incorporating multiple perspectives ensures a more thorough and well-rounded estimation process, leading to accurate story point assignments.
- Objective Criteria: By defining criteria for technical complexity, business value, and risks, the estimation process becomes more objective and less susceptible to individual biases.

- Enhanced Collaboration: The use of collaborative tools fosters team collaboration and communication, encouraging open discussions about various perspectives during estimation sessions.
- Continuous Improvement: The feedback mechanism allows for continuous improvement of the estimation template, adapting it to the evolving needs and challenges faced by the team.

The Multi-Perspective Estimation of the Holistic Estimation Framework component adopts a comprehensive mode of story points estimation. It includes multiple dimensions and benefits from community-based tools to allow teams to obtain a more accurate estimation that would cover their technical specifications, business nuances, and potential risks. The technical solution will be a user-friendly and flexible template, stimulating collaboration and guaranteeing a comprehensive overview.

3.3 Detailed Guide and Requirements for Implementing the Holistic Estimation Framework (HEF)

3.3.1 Implementation of Holistic Estimation Framework (HEF)

To successfully implement the Holistic Estimation Framework (HEF), it is essential to follow a structured methodology. Below is a detailed guide on the steps, requirements, and criteria for progressing through the framework:

Steps to Implement HEF:

3.3.1.1 Initiate Estimation Process

- Objective: Establish the necessary tools and environment for the estimation process.
- Activities:
  - Select and configure collaborative tools (e.g., Google Docs, Microsoft Teams).

  - Prepare structured templates or checklists for estimations.
  - Identify and gather the team members involved in the estimation process.
- Criteria to Move Forward:
  - All tools are configured, and templates are ready.
  - Team members are informed and available for the process.

3.3.1.2 Conduct Multi-Perspective Estimation

- Objective: Evaluate each user story from different perspectives to ensure comprehensive estimation.
- Activities:
  - Use the structured template to assess technical complexity, business value, and potential risks.
  - Encourage input from all team members, ensuring diverse perspectives.
- Criteria to Move Forward:
  - All perspectives (technical, business, risk) are documented for each user story.
  - Consensus on the estimations from the team.

3.3.1.3 Facilitate Workshops

- Objective: Conduct workshops to collaboratively refine and validate estimations.
- Activities:
  - Schedule and conduct video conferencing sessions with breakout rooms if necessary.
  - Use facilitator guidance to ensure structured discussions.
  - Document the outcomes of the workshops.

- Criteria to Move Forward:
  - Workshops are conducted, and outcomes are documented.
  - Team agreement on the refined estimations.

3.3.1.4 Perform Dynamic Risk Assessment

- Objective: Identify and mitigate potential risks associated with each user story.
- Activities:
  - Use the template to document identified risks and mitigation strategies.
  - Prioritize risks and develop plans to address them.
- Criteria to Move Forward:
  - Risks are identified, documented, and mitigation strategies are in place.
  - Team agrees on the risk management plan.

3.3.1.5 Apply Estimation Ranges

- Objective: Communicate the uncertainty in estimations by using estimation ranges.
- Activities:
  - Modify estimation input fields to accommodate ranges.
  - Validate the consistency of the estimation ranges.
- Criteria to Move Forward:
  - Estimation ranges are applied consistently across user stories.
  - Team understands and agrees on the ranges.

3.3.1.6 Incorporate Continuous Improvement

- Objective: Continuously refine the estimation process based on feedback and lessons learned.
- Activities:
  - Analyze historical data to inform future estimations.
  - Conduct retrospectives to review estimation accuracy and identify improvements.
- Criteria to Move Forward:
  - Historical data is analyzed, and insights are documented.
  - Retrospective actions are agreed upon and implemented.

3.3.1.7 Ensure Stakeholder Involvement

- Objective: Engage stakeholders to integrate diverse perspectives and domain knowledge.
- Activities:
  - Organize consultation sessions with stakeholders.
  - Maintain a directory for scheduling and tracking consultations.
- Criteria to Move Forward:
  - Stakeholder consultations are conducted, and feedback is integrated.
  - Agreement on the final estimations with stakeholders.

Figure 3.2: HEF Framework Flowchart

3.3.2 Requirements and Criteria for Each Step in HEF

Below are the detailed requirements and criteria for each step in the implementation of the Holistic Estimation Framework (HEF):

3.3.2.1 Initiate Estimation Process

- Requirements:
  - Collaborative tools (e.g., Google Docs, Microsoft Teams).
  - Structured estimation templates or checklists.
  - Availability of team members.
- Criteria:
  - All tools configured.
  - Templates prepared.
  - Team briefed and available.

3.3.2.2 Conduct Multi-Perspective Estimation

- Requirements:
  - Completed structured templates.
  - Diverse team input.
- Criteria:
  - Documented perspectives.
  - Team consensus on estimations.

3.3.2.3 Facilitate Workshops

- Requirements:
  - Scheduled video conferencing sessions.
  - Facilitator guidance features.
- Criteria:
  - Workshop outcomes documented.
  - Team agreement on estimations.

3.3.2.4 Perform Dynamic Risk Assessment

- Requirements:
  - Risk identification sections in templates.
  - Risk mitigation strategy documentation.
- Criteria:
  - Risks documented.
  - Mitigation strategies in place.
  - Team agreement on risk management plan.

3.3.2.5 Apply Estimation Ranges

- Requirements:
  - Modified estimation input fields.
  - Validation checks for ranges.
- Criteria:
  - Consistent estimation ranges.
  - Team understanding and agreement.

3.3.2.6 Incorporate Continuous Improvement

- Requirements:
  - Historical project data.
  - Regular retrospective sessions.
- Criteria:
  - Analyzed historical data.
  - Documented insights.
  - Implemented retrospective actions.

3.3.2.7 Ensure Stakeholder Involvement

- Requirements:
  - Consultation session schedule.
  - Expert directory system.
- Criteria:
  - Stakeholder feedback integrated.
  - Final estimations agreed upon.

Table 3.2. Requirements Criteria in Holistic Estimation Framework (HEF)

Step	Requirements	Criteria
1. Initiate Estimation Process	- Collaborative tools (e.g., Google Docs, Microsoft Teams) - Structured estimation templates or checklists - Availability of team members	- All tools configured - Templates prepared - Team briefed and available
2. Conduct Multi-Perspective Estimation	- Completed structured templates - Diverse team input	- Documented perspectives - Team consensus on estimations
3. Facilitate Workshops	- Scheduled video conferencing sessions - Facilitator guidance features	- Workshop outcomes documented - Team agreement on estimations
4. Perform Dynamic Risk Assessment	- Risk identification sections in templates - Risk mitigation strategy documentation	- Documented risks - Mitigation strategies in place - Team agreement on risk management plan
5. Apply Estimation Ranges	- Modified estimation input fields - Validation checks for ranges	- Consistent estimation ranges - Team understanding and agreement
6. Incorporate Continuous Improvement	- Historical project data - Regular retrospective sessions	- Analyzed historical data - Documented insights - Implemented retrospective actions
7. Ensure Stakeholder Involvement	- Consultation session schedule - Expert directory system	- Stakeholder feedback integrated - Final estimations agreed upon

The Holistic Estimation Framework (HEF) is a comprehensive approach designed to enhance the accuracy and reliability of project estimations. Implementing HEF involves a structured series of steps, each with specific objectives, activities, and criteria to ensure thorough execution.

The process begins with setting up the necessary tools and gathering the team, followed by evaluating user stories from multiple perspectives. Collaborative workshops are then conducted to refine estimations, and dynamic risk assessments are performed to identify and mitigate potential risks. The framework incorporates estimation ranges to communicate uncertainties and emphasizes continuous improvement through the analysis of historical data and regular retrospectives.

Furthermore, the active involvement of stakeholders ensures that diverse perspectives and

domain knowledge are integrated into the estimation process. Each step is supported by clear requirements and criteria, ensuring a methodical and effective approach to project estimation. This structured methodology not only enhances the accuracy of estimations but also fosters team collaboration and continuous improvement.

3.4 Multi-Perspective Estimation Digital Template:

Objective: To facilitate a comprehensive estimation process by considering technical complexity, business value, and potential risks for each user story.

3.4.1 Step-by-Step Guide:

1. Overview Section:
    (a) User Story ID: [Auto-generated ID]
    (b) User Story Description: [Brief description of the user story]
2. Technical Complexity:
    (a) Criteria: Expertise Required:
        i. Low
        ii. Moderate
        iii. High
    (b) Integration Challenges:
        i. Low
        ii. Moderate
        iii. High
    (c) Technological Novelty:
        i. Low
        ii. Moderate

iii. High

(d) Quantifiable Metrics:

(e) Lines of Code: [Input field]

(f) Number of Integrations: [Input field]

(g) New Technologies Used: [Input field]

3. Business Value:

(a) Criteria:

(b) User Impact:

i. Low

ii. Moderate

iii. High

(c) Strategic Alignment:

i. Low

ii. Moderate

iii. High

(d) Market Demand:

i. Low

ii. Moderate

iii. High

(e) Scoring System:

(f) Numeric Score: [Input field, 1 to 10]

4. Risks:

(a) Identification:

(b) Potential Risks: [Input field, bullet points]

(c) Mitigation Strategies:

(d) Mitigation Plan: [Input field, detailed explanation]

5. Collaboration and Comments:

   (a) Real-time Collaboration:

   (b) Use the collaborative tool's comment section for team members to discuss and share insights during the estimation process.

6. Feedback Mechanism:

   (a) Feedback Section: Encourage team members to provide feedback on the template's effectiveness and suggest improvements.

7. Accessibility and Versioning:

   (a) Accessibility: Ensure that team members can easily access and fill in the template through the chosen collaborative tool.

   (b) Version Control: Implement version control to track changes and updates to the template over time.

3.4.2 How to Use the Template:

1. User Story Identification: Assign a unique User Story ID for each story and provide a brief description in the Overview section.

2. Technical Complexity:

   (a) Assess the required expertise, integration challenges, and technological novelty.

   (b) Input quantifiable metrics like lines of code, number of integrations, and new technologies used.

3. Business Value:

   (a) Evaluate user impact, strategic alignment, and market demand.

   (b) Assign a numeric score based on the provided criteria.

4. Risks:

    (a) Identify potential risks associated with the user story.

    (b) Propose mitigation strategies to address each identified risk.

5. Collaboration and Comments: Engage in real-time collaboration by using the comment section to discuss and share insights.

6. Feedback Mechanism: Provide feedback on the template's usability and suggest improvements for continuous refinement.

7. Accessibility and Versioning:

    (a) Ensure easy accessibility to the template within the chosen collaborative tool.

    (b) Track changes using version control to maintain a record of template revisions.

This Digital Template fosters a structured and collaborative approach to multi-perspective estimation. Team members can collaborate in real-time, consider various perspectives, and contribute to a more accurate and holistic estimation process. The template is adaptable to different tools, providing flexibility for teams to choose the collaborative platform that best suits their needs.

Table 3.3. Comparison table including the Holistic Estimation Framework (HEF) alongside several other popular estimation frameworks

Aspect	Holistic Estimation Framework (HEF)	Wideband Delphi	Planning Poker	Parametric Estimation	PERT (Program Evaluation and Review Technique)	Story Points Estimation
Approach	Comprehensive, holistic view	Expert judgment, iterative consensus	Collaborative, consensus-based	Mathematical modeling based on historical data	Probabilistic estimation based on three estimates (optimistic, pessimistic, and most likely)	Relies on relative size estimation and consensus
Dimensions Considered	Multiple dimensions of uncertainty	Expert opinions, historical data	Relative size, expert judgment	Size, complexity, effort, and other project parameters	Time, effort, and resource estimates	Complexity, effort, and risk factors
Stakeholder Involvement	High involvement throughout process	Limited involvement, expert panel	High involvement, team consensus	Limited involvement, expert judgment	Minimal involvement, estimation team	High involvement, team consensus
Risk Management	Integrated into estimation process	Considered separately, risk analysis	Minimal consideration	Incorporated into parametric models	Considered through optimistic, pessimistic, and most likely estimates	Implicitly managed through story point estimation process
Agile Alignment	Aligned with Agile principles	Flexible, adaptable approach	Compatible with Agile practices	Not inherently aligned with Agile methodologies	Can be adapted to Agile iterative cycles	Intrinsic to Agile methodology
Data-Driven	Relies on historical data and evidence	Limited reliance on data	Minimal reliance on data	Relies heavily on historical data	Partial reliance on historical data	Limited reliance on historical data
Continuous Refinement	Emphasizes ongoing refinement	Limited refinement after consensus	Continuous refinement	Refinement based on new data and feedback	Can be refined iteratively	Iterative refinement process
Flexibility	Flexible and adaptable	Moderately flexible	Flexible and iterative	Moderate flexibility depending on model	Moderate flexibility based on input parameters	Flexible and adaptable
Complexity Handling	Addresses technical and non-technical complexities	Focuses on technical aspects	Focuses on relative complexity	Handles various dimensions of project complexity	Considers complexity and uncertainty	Incorporates complexity assessment
Estimation Technique	Multidimensional analysis	Expert consensus, averaging	Relative sizing, consensus	Regression analysis, algorithms	Statistical analysis of estimates	Expert judgment and consensus

3.5 Advantages of Holistic Estimation Framework (HEF)

The Holistic Estimation Framework (HEF) offers several advantages over other estimation frameworks: Comprehensive Approach: HEF takes a holistic view of project esti-

mation by considering multiple dimensions of uncertainty, such as technical complexity, requirements volatility, team dynamics, and external dependencies. This comprehensive approach allows for a more nuanced understanding of estimation challenges compared to frameworks that focus solely on numerical values or specific aspects of the project. Stakeholder Involvement: HEF emphasizes the involvement of stakeholders throughout the estimation process. By integrating diverse perspectives and domain knowledge into the estimation, HEF ensures that estimates are more accurate and reflective of the project's context and objectives. This contrasts with frameworks that may rely solely on expert judgment or historical data without considering the insights of key stakeholders. Risk Management Integration: HEF integrates risk management practices into the estimation process. By identifying and mitigating risks early on, HEF helps to minimize uncertainty and improve the reliability of estimates. This proactive approach to risk management sets HEF apart from frameworks that treat risk assessment as a separate or secondary consideration. Agile Alignment: HEF aligns with Agile principles and practices, such as iterative development, continuous feedback, and adaptation. This allows for flexibility in estimation, enabling adjustments as new information becomes available throughout the project lifecycle. HEF's compatibility with Agile methodologies makes it particularly well-suited for dynamic and evolving project environments compared to frameworks that may be more rigid or prescriptive in nature. Data-Driven Decision Making: HEF leverages historical data and empirical evidence to inform estimation decisions. By analyzing past project performance and outcomes, HEF enhances the accuracy of estimates and provides a basis for continuous improvement. This data-driven approach to estimation sets HEF apart from frameworks that rely solely on expert judgment or subjective assessments. Continuous Refinement: HEF recognizes that estimation is an ongoing process that requires continuous refinement and adjustment. By regularly reassessing estimates based on evolving project dynamics, HEF ensures that estimates remain relevant and reliable over time. This focus on continuous refinement distinguishes HEF from frameworks that may provide static or one-time estimates without accounting for changing project conditions. Overall, the Holistic Estimation Framework offers a more compre-

hensive, stakeholder-oriented, risk-aware, Agile-aligned, data-driven, and continuously refined approach to project estimation compared to other frameworks. By addressing the complexities and uncertainties inherent in project environments, HEF provides a robust foundation for generating more accurate and reliable estimates, ultimately leading to improved project outcomes.

Chapter 4

Case Study Implementation of Proposed Framework

4.1 Project Background

The project at hand is the development of a web-based e-commerce platform for a medium-sized retail company aiming to expand its online presence and enhance customer engagement. The primary objective of the project is to create a user-friendly and robust online shopping experience that drives sales, improves customer satisfaction, and increases brand loyalty. The platform will allow customers to browse products, make purchases, track orders, and interact with customer support services seamlessly.

1. Scope: The scope of the project includes the design, development, testing, and deployment of the e-commerce platform. This encompasses various features such as product catalog management, user account management, shopping cart functionality, payment processing integration, order management, and customer support features like live chat and email support. Additionally, the platform will be optimized for both desktop and mobile devices to cater to a wide range of users.

2. Stakeholders:

   (a) Project Sponsor: Executive leadership team of the retail company

(b) Project Manager: Overseeing the project execution, resource allocation, and timeline management

(c) Development Team: Cross-functional team of developers, designers, and testers responsible for building and testing the platform

(d) Marketing Team: Providing input on user experience design, branding, and promotional strategies

(e) Customer Support Team: Offering insights on customer needs and preferences for integrating support features into the platform

(f) End Users: Customers who will use the e-commerce platform for browsing and purchasing products

3. Characteristics:

(a) Size: The project is of medium size, requiring the collaboration of a dedicated development team over several months.

(b) Complexity: The project complexity is moderate, given the integration of multiple features and functionalities into the e-commerce platform. Additionally, ensuring security, scalability, and performance optimization adds to the project's complexity.

(c) Duration: The project is estimated to span approximately six months from initiation to deployment, with multiple iterations and milestones along the way.

(d) Importance of Accurate Story Points Estimation: Accurate story points estimation is crucial for project planning and delivery for several reasons:

(e) Resource Allocation: Estimation helps in allocating the right resources (developers, designers, testers) to each user story or task, ensuring efficient utilization of team capacity.

(f) Timeline Management: Estimation informs project timelines and helps in setting realistic deadlines for delivering features and milestones, thereby manag-

ing stakeholder expectations.

(g) Prioritization: Estimation allows for the prioritization of user stories based on their complexity and estimated effort, enabling the team to focus on high-value features first.

(h) Budget Management: Accurate estimation aids in budget forecasting and management by providing insights into resource requirements and associated costs.

(i) Risk Mitigation: Estimation helps in identifying potential risks and uncertainties early in the project lifecycle, enabling proactive risk management strategies to be implemented.

(j) Given the dynamic nature of Agile development, where requirements evolve iteratively, accurate story point's estimation is essential for maintaining project agility, adaptability, and ultimately, delivering a successful e-commerce platform that meets the needs and expectations of the retail company and its customers.

4.1.1 UML Diagrams for the use case

Each type of diagram provides a different perspective of the system, contributing to a comprehensive understanding of both the static and dynamic aspects. They play crucial roles in various stages of software development, from requirement analysis to design, implementation, and documentation. By using these diagrams, teams can improve communication, ensure clarity, and create more robust and well-understood systems.

4.1.1.1 Use Case Diagram

- Description: A use case diagram captures the functional requirements of a system. It shows the interactions between actors (users or other systems) and the system itself through various use cases.

- Importance:

- Requirement Analysis: Helps in identifying the functional requirements of the system.
- User Perspective: Provides a user-centric view of the system, illustrating how users will interact with the system.
- Communication Tool: Serves as a communication tool between stakeholders, helping to ensure that all requirements are understood and agreed upon.
- Foundation for Other Diagrams: Acts as a foundation for creating other diagrams like sequence diagrams, activity diagrams, and class diagrams.

- The use case diagram outlines the interactions between users (actors) and the system.
  - User: Interacts with the system to:
    * Browse Products
    * Add to Cart
    * Checkout
  - Admin: Manages products in the system.
  - Development Team: Deploys updates to the system.
  - QA Team: Tests features in the system.

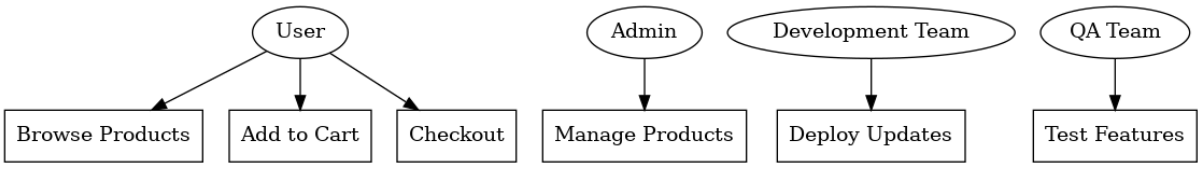

Figure 4.1: E-commerce Use-Case Diagram

4.1.1.2 Activity Diagram

- Description:An activity diagram represents the workflow of a system, showing the sequence of activities and the flow from one activity to another. It visually captures the dynamic aspects of the system.

- Importance:
  - Visualizing Workflows: Helps in understanding the sequence of steps involved in a process.
  - Identifying Bottlenecks: Helps in spotting inefficiencies or potential problem areas.
  - Communication: Provides a clear and visual way to communicate the process to stakeholders.
  - Documentation: Serves as a part of the system documentation, useful for both developers and users.
- The activity diagram shows the flow of activities involved in an e-commerce process from start to end.
  - Start: The process begins.
  - Browse Products: The user browses the available products.
  - Add to Cart: The user adds the desired products to their cart.
  - Checkout: The user proceeds to the checkout process.
  - Enter Payment Details: The user inputs payment details.
  - Confirm Order: The user confirms the order.
  - End: The process completes.

4.1.1.3 Class diagram

- Description: A class diagram shows the static structure of a system by illustrating the system's classes, their attributes, methods, and the relationships among the classes.
- Importance:
  - Blueprint of the System: Acts as a blueprint for building an object-oriented system.

Figure 4.2: E-commerce Activity Diagram

  - Understanding Relationships: Helps in understanding how different parts of the system interact and relate to each other.
  - Facilitates Communication: Aids in the communication between developers and stakeholders by providing a clear model of the system's structure.
  - Code Generation: Can be used to generate code templates in object-oriented programming.

- The class diagram represents the static structure of the e-commerce system, showing its classes, attributes, and relationships.
  - User: Contains userID, name, and email.
  - Order: Contains orderID and orderDate.
  - Cart: Contains cartID.
  - Product: Contains productID, name, and price.
  - Payment: Contains paymentID and amount.
  - Shipping: Contains shippingID and address.

- Relationships:
  - User places Order
  - User has Cart
  - Order is paid by Payment
  - Order is shipped to Shipping
  - Order includes Product
  - Cart contains Product

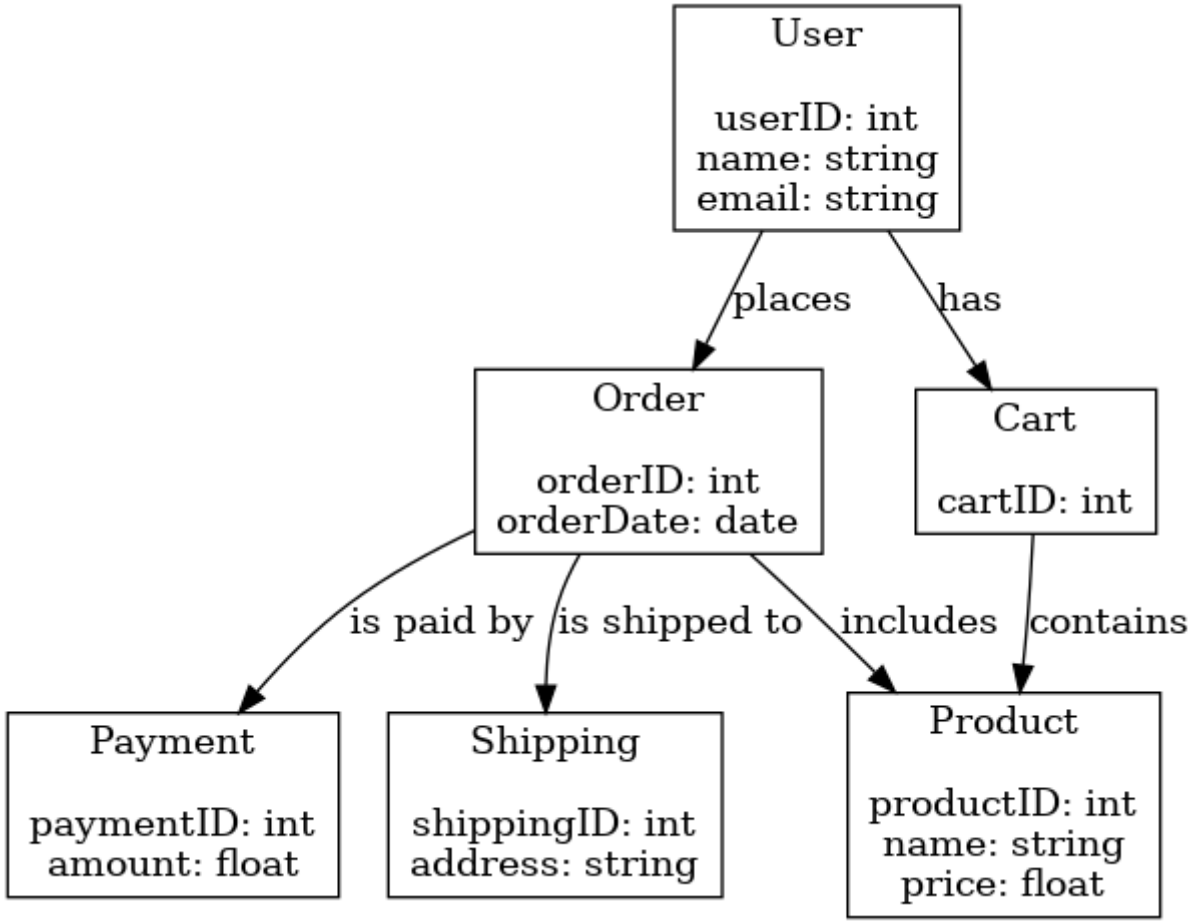

Figure 4.3: E-commerce Class Diagram

4.1.1.4 Sequence diagram

- Description: A sequence diagram depicts the sequence of messages exchanged between objects in a particular scenario of a use case. It focuses on the interaction between objects over time.

- Importance:
  - Dynamic Behavior: Shows how objects interact in a particular sequence, illustrating the dynamic behavior of the system.
  - Clarifies System Logic: Helps in understanding the sequence of method calls and interactions.
  - Debugging and Testing: Assists in identifying potential issues in the interaction logic and is useful for debugging and testing.
  - Design and Documentation: Aids in designing the system interactions and serves as documentation for future reference.
- The sequence diagram shows the interactions between objects over time for the e-commerce process.
  - Add Product to Cart: User adds a product to the cart.
  - Confirm Addition: User confirms the product addition.
  - Place Order: User places the order.
  - Order Confirmation: System confirms the order.
  - Process Payment: Payment is processed.
  - Payment Confirmation: System confirms the payment.
  - Arrange Shipping: Shipping is arranged.
  - Shipping Confirmation: System confirms the shipping.

4.2 Framework Tailoring

The Holistic Estimation Framework (HEF) was tailored to address the specific needs and constraints of the e-commerce platform development project while ensuring alignment with Agile principles and practices. The following modifications and adjustments were made to the framework components based on the project context:

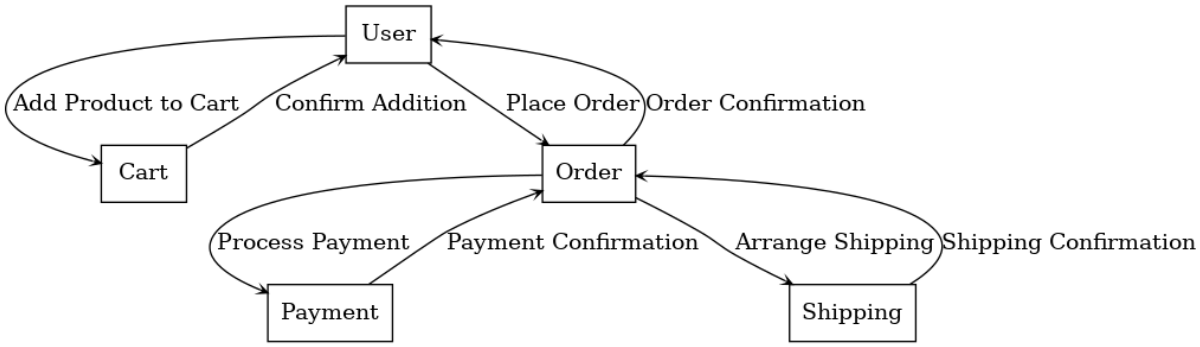

Figure 4.4: E-commerce Sequence Diagram

- Contextual Analysis:
  - Tailored Approach: Given the medium-sized scope of the project and its moderate complexity, the contextual analysis focused on understanding the unique requirements and constraints of the e-commerce domain. This included considerations such as the need for robust security measures, seamless integration with existing systems, and scalability to accommodate future growth.
  - Project Objectives Alignment: The framework was adjusted to ensure alignment with the project's primary objectives of enhancing customer engagement, driving sales, and improving brand loyalty through the e-commerce platform.
- Data-driven Estimation:
  - Historical Data Utilization: The framework emphasized the importance of leveraging historical data from similar e-commerce projects to inform story points estimation. Historical data analysis was tailored to focus on relevant metrics such as user engagement, conversion rates, and transaction volumes specific to the retail industry.
- Expert Judgment and Collaborative Estimation:
  - Stakeholder Engagement: Given the diverse stakeholders involved in the project, including marketing, customer support, and development teams, the framework emphasized the importance of collaborative estimation sessions involving cross-functional participation. Expert judgment from domain experts within

the retail industry was incorporated to ensure accuracy and relevance in estimation.

- Risk-informed Estimation:
  - Risk Identification: The framework was adapted to include a thorough risk assessment specific to e-commerce projects, considering potential risks such as data breaches, payment processing failures, and inventory management issues. Risk mitigation strategies were developed to address these concerns and minimize their impact on estimation accuracy.
- Agile Estimation Practices:
  - Iterative Estimation: The framework emphasized iterative estimation practices aligned with Agile principles, allowing for continuous refinement of estimates throughout the project lifecycle. Agile estimation techniques such as Planning Poker were utilized during Sprint Planning sessions to involve the entire development team in estimation discussions.
- Tool Support and Automation:
  - Tool Selection: The framework guided the selection of estimation tools tailored to the project's needs, such as Agile project management platforms with built-in estimation features. Tools were chosen based on their ability to integrate seamlessly with existing workflows and support Agile practices.
- Continuous Improvement Mechanisms:
  - Feedback Loops: The framework emphasized the establishment of feedback loops to capture lessons learned from estimation activities and project iterations. Feedback mechanisms were tailored to accommodate the project's cross-functional team structure, ensuring input from all stakeholders.

By tailoring the Holistic Estimation Framework (HEF) to suit the specific needs and constraints of the e-commerce platform development project, the estimation process was

optimized to enhance accuracy, promote collaboration, and mitigate risks effectively. This tailored approach ensured that the framework remained adaptable and aligned with the project's objectives and Agile principles throughout its implementation.

4.3 Data Analysis and Historical Data Utilization

4.3.1 Process of Collecting Historical Project Data

- Data Identification: The first step involved identifying relevant historical project data related to similar e-commerce platform development projects. This included data on user stories, features, tasks, and corresponding effort estimates.
- Data Collection: Historical project data was collected from project repositories, version control systems, Agile project management tools, and documentation archives. This data encompassed past iterations, releases, and milestones of similar projects within the organization or industry.
- Data Cleaning and Preprocessing: The collected data underwent cleaning and preprocessing to remove duplicates, inconsistencies, and irrelevant information. Data normalization techniques were applied to ensure uniformity and consistency across different data sources.

4.3.2 Utilization of Historical Data for Current Estimations

- Benchmarking: Historical data served as a benchmark for estimating similar user stories and tasks in the current project. Past effort estimates and completion times were used as reference points for setting expectations and establishing baseline metrics.
- Estimation Calibration: Historical data analysis helped calibrate estimation practices by identifying patterns, trends, and deviations in past estimations. This enabled the team to adjust estimation techniques and factor in historical performance metrics when making current estimations.

- Risk Assessment: Historical data provided insights into common challenges, bottlenecks, and risks encountered in similar projects. This facilitated proactive risk assessment and mitigation planning during the current estimation process.

4.3.3 Examples of Patterns or Trends Identified

- Story Complexity vs. Effort: Analysis of historical data revealed correlations between story complexity (e.g., number of features, dependencies) and effort required for implementation. High-complexity stories tended to require more effort, while simpler stories were completed more quickly.

- Team Velocity: Historical data analysis identified trends in team velocity over time, indicating the team's capacity for completing user stories within a given iteration. Fluctuations in velocity were analyzed to identify factors influencing team productivity and estimate future velocity more accurately.

- Estimation Accuracy: By comparing past effort estimates with actual effort expended, historical data highlighted areas of estimation accuracy and areas for improvement. Deviations between estimated and actual effort were analyzed to identify root causes and refine estimation techniques.

- Impact on Estimation:

  - Informed Decision-making: Historical data analysis informed decision-making during current estimations by providing empirical evidence and insights into past performance.

  - Improved Accuracy: Utilization of historical data improved estimation accuracy by leveraging past experience and learning from previous projects' successes and challenges.

  - Risk Mitigation: Identification of patterns and trends in historical data facilitated proactive risk mitigation strategies, enabling the team to anticipate and address potential estimation-related risks.

Overall, the utilization of historical project data for estimation purposes enabled the project team to make more informed, data-driven decisions, improve estimation accuracy, and mitigate risks effectively during the e-commerce platform development project.

4.4 Expert Judgment and Collaborative Estimation

4.4.1 Involvement of Domain Experts, Team Members, and Stakeholders

- Domain Experts: Subject matter experts with expertise in e-commerce, web development, and retail were involved in the estimation process. They provided insights into industry best practices, technical complexities, and customer expectations related to the e-commerce platform.
- Team Members: Cross-functional team members including developers, designers, testers, and product owners actively participated in estimation sessions. Their diverse perspectives and expertise contributed to a comprehensive understanding of the estimation tasks.
- Stakeholders: Key stakeholders such as project sponsors, marketing representatives, and customer support leads were engaged in the estimation process to ensure alignment with business objectives and priorities.

4.4.2 Collaborative Estimation Sessions

- Planning Poker: A popular Agile estimation technique was employed to facilitate collaborative estimation sessions. Team members were provided with a set of user stories or tasks to estimate, and each member independently assigned story points based on their perceived effort.
- Discussion and Consensus: Following individual estimation, team members engaged in open discussions to share their rationale and perspectives on each user story

or task. Any discrepancies in estimations were addressed through dialogue, and consensus was reached on final estimates.

- Relative Sizing: Estimation was conducted using relative sizing techniques, where user stories were compared to reference stories of known effort or complexity. This comparative approach helped normalize estimates across different team members and ensure consistency.

4.4.3 Challenges Faced and Addressed

- Diverse Perspectives: One challenge encountered during collaborative estimation was reconciling diverse perspectives and interpretations of user stories among team members. This was addressed by fostering open communication, encouraging active participation, and emphasizing the importance of shared understanding.

- Estimation Bias: Another challenge was the potential for estimation bias, where certain team members may overestimate or underestimate effort based on personal biases or preferences. To mitigate this, estimation sessions were structured to promote transparency, accountability, and data-driven decision-making.

- Time Constraints: Limited time availability for estimation sessions posed a challenge, especially with a cross-functional team working on multiple concurrent tasks. This was addressed by scheduling dedicated estimation meetings, setting clear agendas, and prioritizing critical estimation tasks.

By actively involving domain experts, team members, and stakeholders in collaborative estimation sessions and employing techniques such as Planning Poker and relative sizing, the project team successfully navigated challenges, fostered consensus, and arrived at accurate and reliable estimations for the e-commerce platform development project.

4.5 Risk-informed Estimation

4.5.1 Potential Risks and Uncertainties

- Scope Creep: There is a risk of scope creep, where additional requirements or changes to existing features may emerge during the project, leading to underestimated story points.

- Technical Complexity: The e-commerce platform development involves integrating various technologies, third-party APIs, and security measures, posing risks of technical challenges and uncertainties in estimation.

- Dependencies and Constraints: Dependencies on external systems, resources, or third-party vendors may introduce uncertainties and delays in story point's estimation.

- Team Dynamics: Team dynamics, such as communication gaps, skill gaps, or turnover, could impact estimation accuracy and consistency.

- External Factors: External factors such as market dynamics, regulatory changes, or unexpected events (e.g., COVID-19 pandemic) may introduce uncertainties in estimation.

4.5.2 Integration of Risk Management Techniques

- Risk Identification: The project team conducted a comprehensive risk identification process to identify potential risks and uncertainties related to story points estimation. This involved brainstorming sessions, stakeholder consultations, and risk analysis techniques.

- Risk Assessment: Identified risks were assessed based on their likelihood and impact on story point's estimation. Risks were categorized as high, medium, or low priority based on their potential impact on project objectives.

- Risk Mitigation Strategies: Mitigation strategies were developed to address identified risks and uncertainties. This included proactive measures to reduce the likelihood of occurrence (e.g., conducting thorough requirements analysis) and minimize the impact of risks that cannot be avoided (e.g., developing fallback plans).

4.5.3 Development of Contingency Plans and Fallback Strategies

- Contingency Planning: For high-priority risks with significant potential impact on story point's estimation, contingency plans were developed to mitigate their effects. Contingency plans outlined alternative approaches, resources, or timelines to address estimation deviations.

- Fallback Strategies: In cases where risks materialized despite mitigation efforts, fallback strategies were established to minimize disruption to the project timeline and deliverables. Fallback strategies included reallocating resources, revising priorities, or renegotiating project scope as a last resort.

- Illustrative Example:

- Risk: Scope Creep

- Mitigation Strategy: Conduct regular scope reviews with stakeholders to identify and address changes early. Implement change control procedures to evaluate and approve scope changes systematically.

- Contingency Plan: If scope creep occurs, prioritize requirements based on business value and impact, and adjust project timelines or resource allocation accordingly.

- Fallback Strategy: If scope creep significantly impacts project deliverables, renegotiate project scope or timelines with stakeholders to align expectations and mitigate project risks.

By integrating risk management techniques into the estimation process and developing contingency plans and fallback strategies, the project team proactively addressed

potential risks and uncertainties related to story points estimation in the e-commerce platform development project. This approach ensured that estimation deviations were managed effectively, minimizing their impact on project outcomes and success.

4.6 Agile Estimation Practices

4.6.1 Adoption of Agile Estimation Techniques

- Relative Sizing: The project team adopted relative sizing as a primary Agile estimation technique. User stories and tasks were compared to reference stories of known effort or complexity, allowing team members to assign relative story points based on their perceived size relative to the reference stories.

- Story Pointing: Story pointing was used to assign story points to individual user stories or tasks during estimation sessions. Story points represent a relative measure of effort or complexity rather than absolute time units, allowing for more accurate and consistent estimations across different tasks.

4.6.2 Application of Agile Principles

- Transparency: Agile principles of transparency were applied to the estimation process by making estimation sessions and outcomes visible to all team members and stakeholders. Estimation sessions were conducted openly, with active participation encouraged from all team members, fostering transparency and shared understanding of estimation decisions.

- Inspection: Agile principles of inspection were applied through regular review and validation of estimation outcomes. Estimation sessions were followed by inspection and validation activities where team members collectively reviewed and discussed the assigned story points, identifying any discrepancies or areas for refinement.

- Adaptation: Agile principles of adaptation were applied by leveraging estimation feedback and insights to adapt and refine estimation practices over time. Based on feedback from inspection activities, the project team iteratively adjusted estimation techniques, improved estimation guidelines, and updated reference stories to enhance estimation accuracy and consistency.

4.6.3 Experiences from Estimation Sessions

- Sprint Planning: Estimation sessions were conducted as part of Sprint Planning ceremonies at the beginning of each sprint. During Sprint Planning, the product backlog was reviewed, and user stories were selected for inclusion in the sprint based on priority and estimated effort. Estimation sessions were collaborative and interactive, with team members engaging in discussions to clarify requirements, identify dependencies, and assign story points.

- Estimation Discussions: Estimation sessions often sparked discussions among team members, leading to valuable insights and consensus-building. Differences in estimation opinions were addressed through open dialogue and exploration of underlying assumptions, fostering a shared understanding of estimation tasks and improving estimation accuracy.

- Continuous Improvement: Estimation sessions served as opportunities for continuous improvement, with lessons learned from previous sprints incorporated into subsequent estimations. Over time, estimation sessions became more streamlined, efficient, and effective as the team iteratively refined estimation practices and techniques based on feedback and experience.

Overall, the adoption of Agile estimation techniques and principles within the project facilitated transparent, collaborative, and adaptive estimation practices. By applying Agile principles of transparency, inspection, and adaptation, the project team enhanced estimation accuracy, fostered shared understanding, and continuously improved estimation practices throughout the e-commerce platform development project.

4.7 Tool Support and Automation

4.7.1 Estimation Tools and Software Utilized

- Agile Project Management Platforms: The project utilized Agile project management platforms such as Jira or Azure DevOps to support the estimation process. These platforms offer built-in features for creating and managing product backlogs, conducting estimation sessions, and tracking progress using Agile methodologies.

- Estimation Plugins and Add-ons: Additional plugins or add-ons specific to Agile estimation were integrated into the project management platforms to enhance estimation capabilities. These plugins often provide features such as Planning Poker, Sprint Planning boards, and burn down charts tailored to Agile estimation practices.

- Data Analytics Tools: Data analytics tools such as Microsoft Excel or Google Sheets were used to analyze historical project data and derive insights to inform estimation decisions. These tools facilitated data visualization, trend analysis, and statistical modeling to improve estimation accuracy.

4.7.2 Selection and Integration of Tools

- Criteria for Tool Selection: Tools were selected based on their alignment with project requirements, compatibility with Agile methodologies, and ease of integration with existing workflows and team preferences. Considerations included features, usability, scalability, and cost-effectiveness.

- Integration with Project Workflow: Selected tools were integrated seamlessly into the project workflow to support estimation activities at various stages of the project lifecycle. Integration involved configuring settings, customizing workflows, and providing training and support to team members on tool usage.

- Collaboration and Visibility: Tools were chosen to facilitate collaboration and visibility among team members and stakeholders. Integration with collaboration platforms such as Microsoft Teams or Slack enabled real-time communication, document sharing, and coordination during estimation sessions and reviews.

4.7.3 Automation to Streamline Estimation Tasks

- Automated Workflows: Estimation tools were configured to automate repetitive estimation tasks and workflows, reducing manual effort and improving efficiency. Automated workflows included task creation, assignment, and tracking, as well as notifications and reminders for upcoming estimation sessions or deadlines.

- Template Creation: Estimation templates were created within the project management platforms to standardize estimation processes and ensure consistency across estimation sessions. Templates predefined estimation parameters, user story formats, and acceptance criteria, streamlining estimation preparation and execution.

- Reporting and Analysis Automation: Data analytics tools were leveraged to automate reporting and analysis tasks, generating predefined reports, dashboards, and visualizations to monitor estimation progress, identify trends, and communicate insights effectively.

By leveraging estimation tools and automation, the project team streamlined estimation tasks, improved collaboration, and enhanced visibility into estimation activities. Integration of tools into the project workflow facilitated efficient estimation execution, enabling the team to focus on value-added activities and decision-making during the e-commerce platform development project.

4.8 Continuous Improvement Mechanisms

4.8.1 Establishment of Feedback Loops

- Feedback Mechanisms: Feedback loops were established to gather input from stakeholders and team members regarding estimation practices, accuracy, and effectiveness. Feedback mechanisms included surveys, retrospective meetings, one-on-one discussions, and feedback channels within Agile project management tools.

- Regular Reviews: Feedback loops were incorporated into the project's iterative development process, with regular reviews conducted at key milestones, such as the end of each sprint or project iteration. These reviews provided opportunities to reflect on estimation outcomes and identify areas for improvement.

- Data-driven Insights: Feedback loops were supplemented with data-driven insights derived from project metrics, historical data analysis, and performance indicators. Data analysis facilitated objective evaluation of estimation accuracy, trends, and deviations, informing feedback discussions and decision-making.

4.8.2 Stakeholder and Team Member Feedback

- Stakeholder Input: Stakeholders, including project sponsors, business owners, and end users, provided feedback on estimation accuracy and effectiveness based on their expectations and requirements. Stakeholder feedback focused on alignment with project objectives, budget constraints, and delivery timelines.

- Team Member Perspectives: Team members, including developers, designers, testers, and product owners, contributed feedback based on their experiences during estimation sessions and project execution. Team member feedback encompassed insights into estimation challenges, collaboration dynamics, and process improvements.

4.8.3 Adjustments and Improvements

- Identification of Improvement Areas: Feedback received from stakeholders and team members highlighted several areas for improvement in the estimation process, such as estimation accuracy, consistency, and alignment with business priorities. Common themes included the need for clearer requirements, better communication, and enhanced estimation techniques.

- Iterative Refinement: Based on lessons learned from feedback loops and data analysis, the estimation process was iteratively refined and improved over time. Adjustments were made to estimation techniques, guidelines, and tools to address identified improvement areas and enhance estimation accuracy and effectiveness.

- Training and Education: Training sessions and workshops were conducted to educate team members on updated estimation practices, tools, and techniques. Training materials were developed to provide guidance on estimation best practices, common pitfalls, and strategies for improving estimation skills.

By establishing feedback loops, gathering input from stakeholders and team members, and making adjustments based on lessons learned, the project team ensured continuous improvement of estimation practices throughout the e-commerce platform development project. This iterative approach facilitated ongoing refinement, optimization, and adaptation of the estimation process to meet evolving project needs and deliver successful outcomes.

4.9 Results and Outcomes

4.9.1 Estimation Accuracy and Project Success Metrics

- Estimation Accuracy: The implementation of the Holistic Estimation Framework (HEF) resulted in improved estimation accuracy, with a reduction in estimation deviations and variances compared to previous estimation practices. Historical

data analysis and collaborative estimation sessions facilitated more informed and data-driven estimation decisions.

- Project Success Metrics: Key project success metrics, such as on-time delivery, budget adherence, and stakeholder satisfaction, showed positive trends following the implementation of the HEF. Estimation accuracy directly contributed to meeting project milestones and delivering value to stakeholders within planned timelines and budgets.

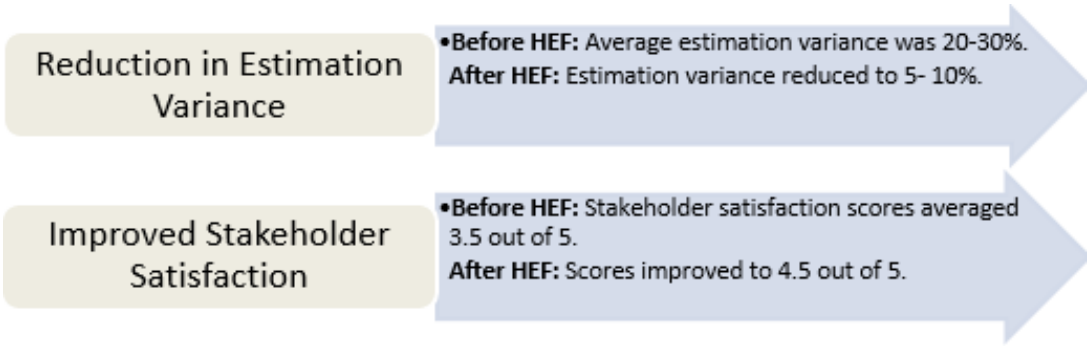

Figure 4.5: Project Success Metrics

4.9.2 Challenges Encountered and Mitigation Strategies

- Resistance to Change: One challenge encountered during implementation was resistance to change from team members accustomed to traditional estimation practices. To mitigate this, change management strategies, such as communication, training, and stakeholder engagement, were employed to foster buy-in and support for the new framework.

- Tool Integration Issues: Integrating estimation tools and software into the project workflow posed technical challenges, such as compatibility issues and learning curves. To address these challenges, dedicated training sessions, user guides, and technical support were provided to assist team members in using estimation tools effectively.

4.9.3 Key Achievements and Benefits

- Enhanced Collaboration: The implementation of the HEF fostered collaboration and alignment among project stakeholders and team members. Collaborative estimation sessions facilitated open communication, knowledge sharing, and consensus-building, leading to more accurate and reliable estimations.

- Proactive Risk Management: The HEF enabled proactive risk management through the identification, assessment, and mitigation of estimation-related risks and uncertainties. Contingency plans and fallback strategies were developed to address potential risks, minimizing their impact on project outcomes.

- Continuous Improvement Culture: The HEF instilled a culture of continuous improvement within the project team, with feedback loops and data-driven insights driving iterative refinement of estimation practices. Lessons learned from feedback and experience were incorporated into ongoing improvements, ensuring that estimation practices remained adaptive and responsive to project needs.

Overall, the implementation of the Holistic Estimation Framework (HEF) resulted in improved estimation accuracy, enhanced collaboration, proactive risk management, and a culture of continuous improvement within the project team. Despite challenges encountered during implementation, the benefits realized through the use of the HEF outweighed the initial hurdles, contributing to the successful delivery of the e-commerce platform development project.

4.10 Lessons Learned and Best Practices

4.10.1 Lessons Learned

- Clear Communication: Effective communication is essential for successful implementation of estimation frameworks. Clear communication channels and stake-

holder engagement helped mitigate resistance to change and fostered collaboration among team members.

- Iterative Improvement: Iterative refinement is key to continuously enhancing estimation practices. Embracing a culture of continuous improvement enabled the project team to adapt and refine the HEF based on feedback and lessons learned from each iteration.

- Flexibility and Adaptability: Flexibility and adaptability are critical when implementing estimation frameworks in dynamic project environments. Being open to adjustments and tailoring the framework to suit specific project needs and constraints proved invaluable in achieving successful outcomes.

4.10.2 Best Practices

- Stakeholder Involvement: Engage stakeholders, including project sponsors, business owners, and end users, throughout the estimation process to ensure alignment with project objectives and priorities.

- Cross-functional Collaboration: Foster collaboration among cross-functional team members, leveraging diverse perspectives and expertise to improve estimation accuracy and decision-making.

- Data-driven Decision-making: Utilize historical data, metrics, and data analytics techniques to inform estimation decisions and enhance estimation accuracy.

- Agile Principles Integration: Integrate Agile principles such as transparency, inspection, and adaptation into estimation practices to promote collaboration, visibility, and continuous improvement.

4.10.3 Recommendations for Further Refinement

- Continuous Feedback Mechanisms: Establish robust feedback mechanisms to gather input from stakeholders and team members continuously. Regularly solicit feedback

on estimation accuracy, effectiveness, and areas for improvement to inform ongoing refinement of the HEF.

- Training and Education: Provide comprehensive training and education on estimation best practices, tools, and techniques to equip team members with the necessary skills and knowledge to effectively utilize the HEF.

- Benchmarking and Benchmarking: Conduct benchmarking exercises and comparisons with industry standards and best practices to validate the effectiveness of the HEF and identify opportunities for further refinement and enhancement.

In summary, the implementation of the Holistic Estimation Framework (HEF) provided valuable insights and lessons learned that can guide future projects in improving estimation practices. By embracing best practices such as stakeholder involvement, cross-functional collaboration, data-driven decision-making, and Agile principles integration, organizations can enhance estimation accuracy, promote collaboration, and drive project success. Continuous feedback mechanisms, training, and benchmarking are recommended for further refinement and enhancement of the HEF to meet evolving project needs and industry standards.

Chapter 5

Validation of Proposed Framework with Results and Analysis

5.1 Introduction

This chapter details the validation of the proposed framework for mitigating uncertainty in story points estimation in Agile projects. It provides an overview of the validation method, including its preparation, initiation, and completion. The "Results and Analysis" section is crucial, presenting the findings from the experimental implementation and validation process. The results include experimental findings, while the analysis interprets these findings using visual presentations like charts and graphs. The chapter includes results from a questionnaire survey and a validation report from a case study conducted at IBM Pakistan, PTCL, and Elixir Technologies. The project involved 200-300 stakeholders, including developers, product owners, and scrum masters, working on a significant joint project between IBM Pakistan and PTCL.

5.2 Questionnaire Survey

A questionnaire survey is a method of collection of data to validate and analyze a theoretical concept, comparative study, or review of the public or community of users of a

new product or a proposed framework. This research questionnaire survey is to validate and analyze a proposed Holistic Estimation framework (HEF) for mitigating uncertainty for story point's estimation in agile based projects. The proposed framework claims that it provides more comprehensive, stakeholder-oriented, risk-aware, Agile-aligned, data-driven, and continuously refined approach to project estimation compared to other frameworks. The questionnaire survey validates and assures these claims through diverse but simple multiple-choice questions that are based on the professional life of the respondents. Data was collected through Google survey form. Google Forms is a platform that is used for conducting this survey and collecting relevant data from respondents to analyze their responses. It proved a valuable tool because of its auto- charts generation feature from the collection of data, however, several factors are considered while using Google Forms for questionnaire survey for validation purposes, some of the key factors are as follows:

- Target Audience: The Audience for this questionnaire survey is professionals in the software industry, who have at least 1 year to 5+ years of experience in the software industry mostly working in IBM Pakistan, Ibex, PTCL and Telenor. The expected size of the audience was 80 individuals and the received responses were 100 which are above the estimated target.

- Survey Design: Questions are clear, logical, and flow, most of the questions are multiple- choice however there is always a part or text field for open-ended questions.

- Survey Distribution: The survey is shared with only professionals in the software industry who have good knowledge of agile based methodologies and its contributions to the modern information technology world.

- Data Analysis: Data is collected through Google Forms and there is a feature to generate charts and analyze the collected data using formulas in Excel or Google Sheets linked with Google Forms.

The questionnaire survey has a sequence from start to end every question followed by the previous one. The survey consists of five sections, each section has relevant questions to

get appropriate information from experienced professionals in the software industry, and five sections of the survey are as follows:

- Purpose of Survey – This section describes the introduction and objectives of the questionnaire survey to respondents, with a clear statement of privacy protection. A clear figure of the proposed framework is also attached in this section.

- Respondent Information and Demographics – In this section, introductory information has been collected from respondents to get an idea about the background and demographics of the respondents.

- Estimation Strategies and Uncertainty Management– Focusing on estimation techniques and uncertainty management, this section explores how teams adapt Agile methodologies and handle uncertainty in estimation, including the utilization of automated tools.

- Adaptability, Continuous Improvement, and External Influences- Emphasizing adaptability and continuous improvement, this section delves into how teams learn from past estimation inaccuracies, handle external dependencies, and adapt to changes in project requirements, including the integration of machine learning or AI for enhancement.

- Conclusion and Feedback – In this section any additional feedback is recommended to share, however, this section is not mandatory to fill.

Analysis of the collected data in the questionnaire survey is available below and a complete form that is used for validation purposes is attached as Annex 'A'.

In this chapter validation method is discussed that is carried out to ensure the validity of the proposed framework for mitigating uncertainty for story point's estimation in agile based projects. The factors that were in the focus questionnaire survey, all five sections of the survey, and the tool used for this survey generation are discussed in detail in this chapter.

5.2.1 Analysis of Questionnaire Survey

A questionnaire survey is a way to gather information for a comparative analysis, theoretical concept validation, or public or user community assessment of a new product or suggested framework. The purpose of this study questionnaire survey is to assess and evaluate a suggested Holistic estimate framework (HEF) for reducing uncertainty in the estimate of story points in agile projects. In comparison to existing frameworks, the suggested framework is said to offer a more thorough, stakeholder-oriented, risk-aware, Agile-aligned, data-driven, and continually improved approach to project estimating. The questionnaire survey uses a variety of straightforward multiple-choice questions that are centred on the respondents' work lives to verify and reassure these statements.
In this survey, different types of questions are shared with professionals of the software industry, who have sound knowledge of agile methodologies. Data was collected through Google survey form. The Audience for this questionnaire survey is professionals in the software industry, who have at least 1 year to 5+ years of experience in the software industry. The expected size of the audience was 80 individuals and the received responses were 100 which are above the estimated target. The same set of questions is also shared and asked to be filled by the teams after the HEF framework. In this analysis chapter, insights from responses of software industry professionals are analyzed to draw valuable conclusions as follows:

5.2.1.1 Survey before HEF

- Estimation Strategies and Uncertainty Management
  - Team's approach to adapting Agile methodologies to suit the specific needs of projects: This figure identifies the team's approach to adapt agile methodology to suit the specific needs of projects. By prioritizing flexibility and adaptability, team is able to tailor Agile methodologies to meet the specific demands of each project, ensuring optimal performance and satisfaction for both the team and stakeholders.

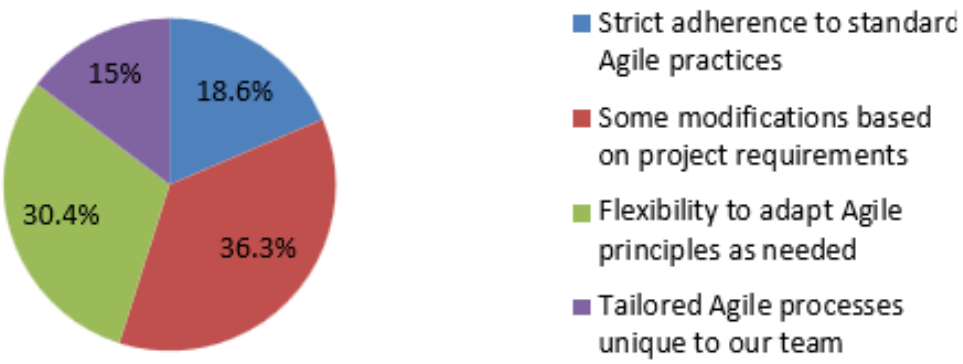

Figure 5.1: Team approach to adapt Agile methodologies

– Extent to which uncertainty impact the accuracy of story points estimation: This figure shows the responses that represent the extent to which uncertainty impact the accuracy of story point estimation in organization. Results show moderate impact (37%) and high impact (32%).

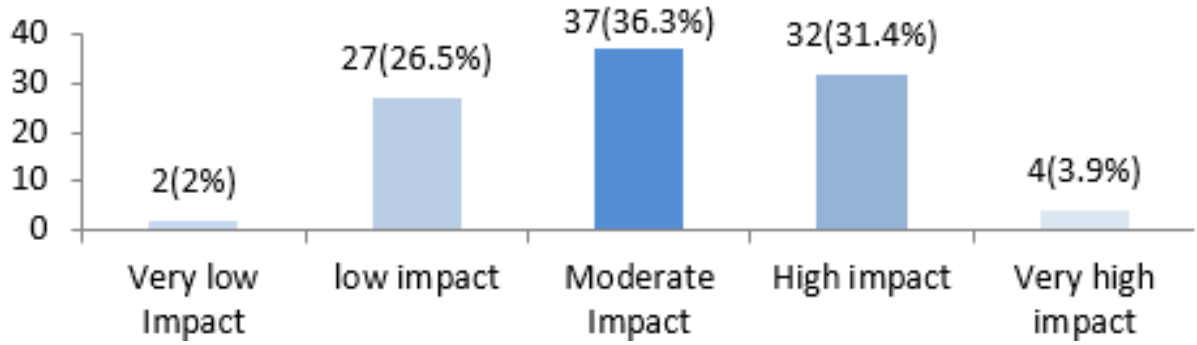

Figure 5.2: Impact of uncertainty on accuracy of SP Estimation

– Variables which significantly increase site specific uncertainty in the Story points estimating process: Result of survey shows aspects that significantly participate to uncertainty in story point estimation. Maximum responses (41.2%) think change in team composition and external dependencies (36.3%), contributes significantly to uncertainty in story point estimation.

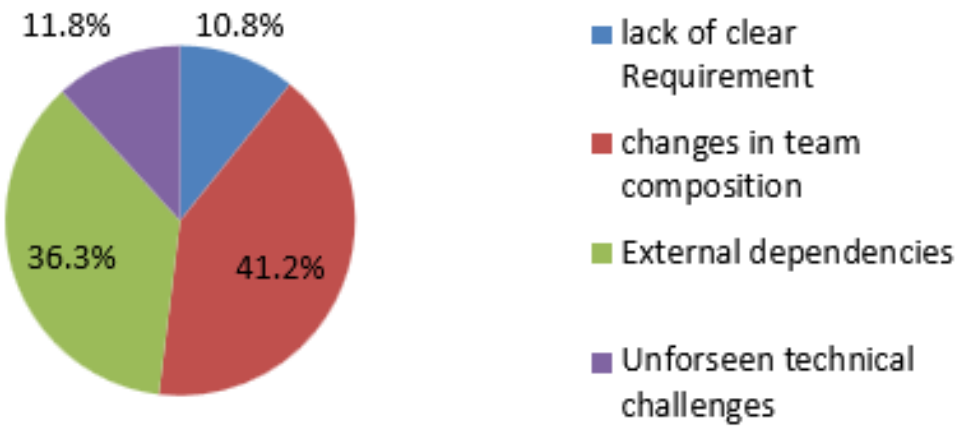

Figure 5.3: Variables which significantly increase site specific uncertainty in the Story points estimating process

– Affectivity of automated tools in reducing uncertainty in story points estimation: Result analysis illustrates 40.2% participant respond that automated tools in reducing uncertainty in story point estimation are somewhat effective and 32.4% respond effective.

  Automated tools play a crucial role in reducing uncertainty in story point's estimation by leveraging data-driven insights, enhancing consistency, and providing real-time feedback. Their integration into Agile workflows not only improves estimation accuracy but also contributes to more efficient and predictable project management. For Agile teams seeking to enhance their estimation processes, the adoption of automated tools presents a compelling solution.

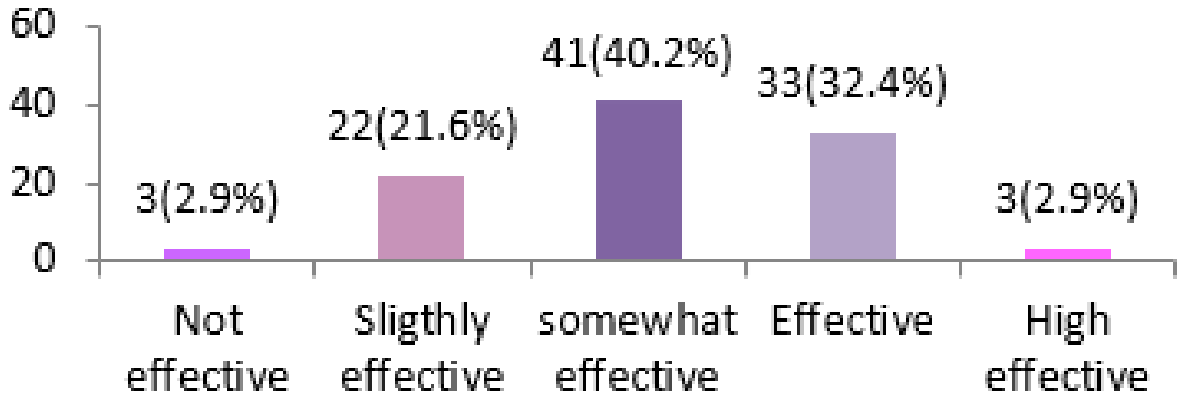

Figure 5.4: Affectivity of automated tools

- Continuous Improvement, and External Influences

  – How team handle external dependencies that may introduce uncertainty into the project timeline: In response to this question, maximum (46.1%) thinks that by communication with external stakeholders and plan accordingly can handle external dependencies that may introduce uncertainty into project timeline.

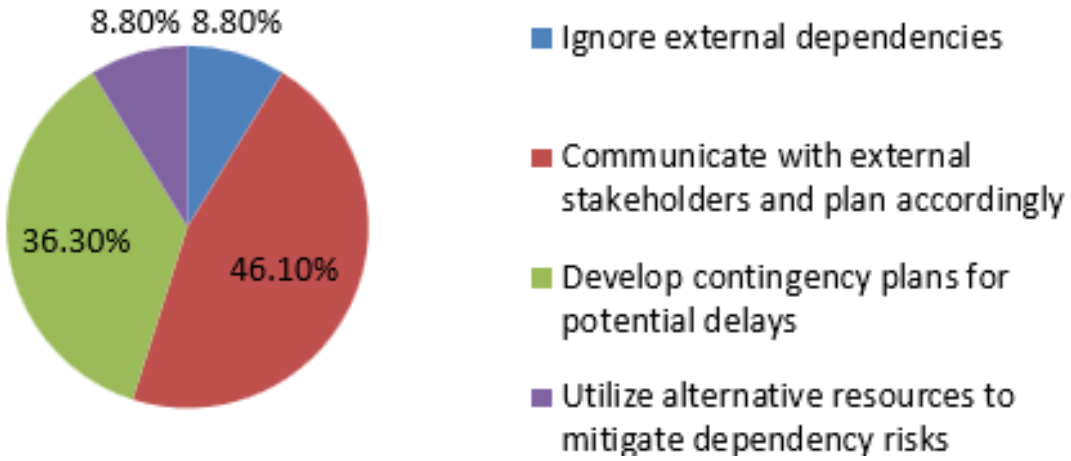

Figure 5.5: How team handles external dependencies

  – Extent by which organization leverage machine learning or AI for enhancing story points estimation accuracy: This figure shows the extend by which organization leverage machine learning or AI for enhancing points estimation accuracy. Maximum respondents (48%) utilize moderate integration of machine learning or AI for enhancing story point estimation accuracy.

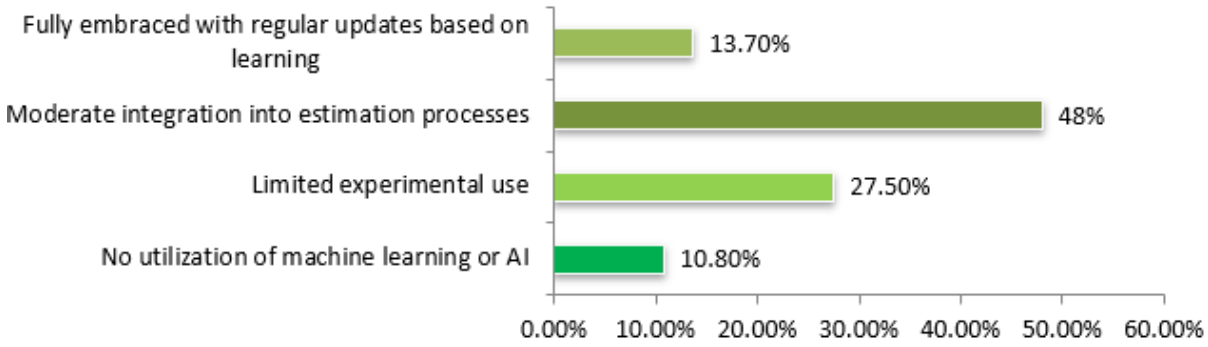

Figure 5.6: Machine learning or AI for enhancing story point's estimation accuracy

– Extent by which estimation practices consider the likely effect of technical debt on project timelines:In response to this question, to consider the likely effect of technical debt on project timeline maximum respondents (39.2%) regularly evaluate and address technical debt in their estimation practices, while 34.3% considers technical debt occasionally.

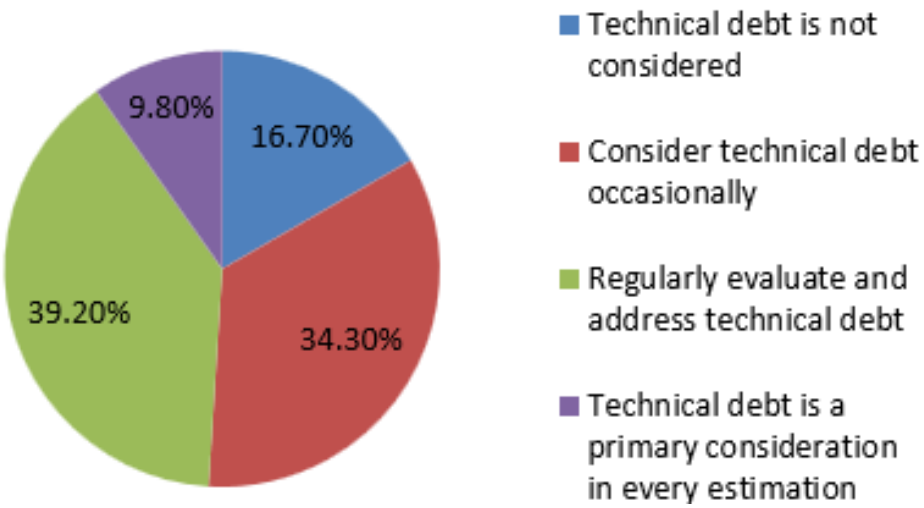

Figure 5.7: Estimation practices consideration of the potential impact

– Addressing uncertainties introduced by changes in project requirements after the initial estimation: In order to address uncertainties introduced by changes in projects requirements after the initial estimation, 41.2% incorporate adjustment of estimates for any change during the project, 27.5% re-estimate for significant changes only while 24.5% do not accommodate changes after initial estimation.

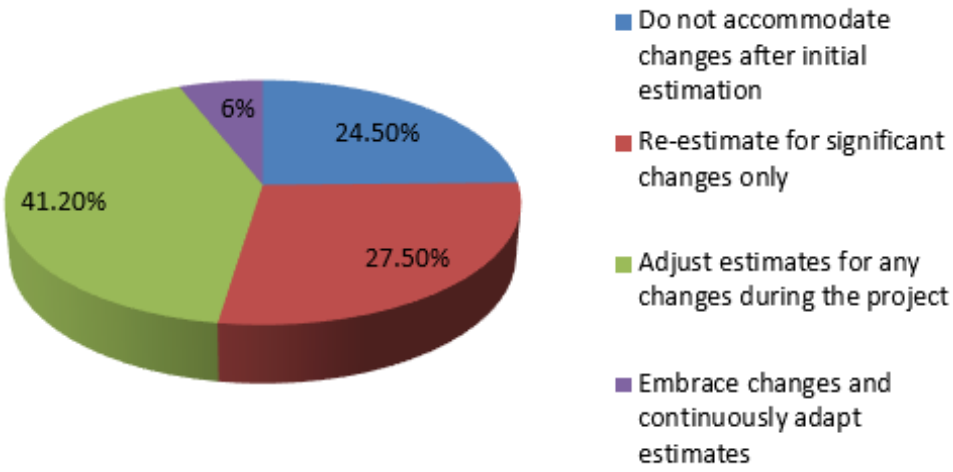

Figure 5.8: Addressing uncertainties

– Handling the impact of external events, such as market shifts or global crises, on project timelines and estimation: In order to handle the impact of external events, 41.2% considers development of contingency plans for potential external impacts, 34.3% monitor events but do not incorporate into estimation while 20.6% uses no specific consideration for external events.

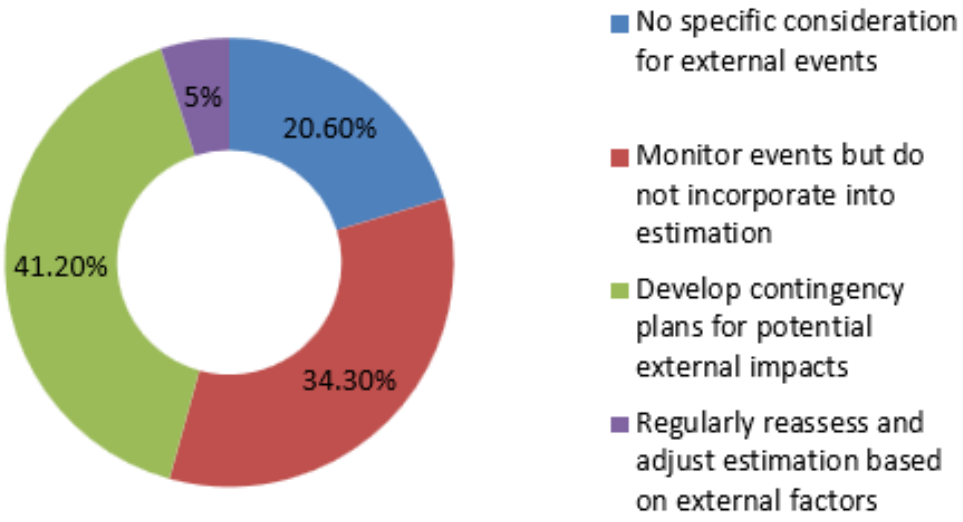

Figure 5.9: Handling the impact of external events

– How well does team adapt to changes in project requirements during a sprint: This following graph shows that maximum (41%) prefer to adapt to changes in project requirements during a sprint.

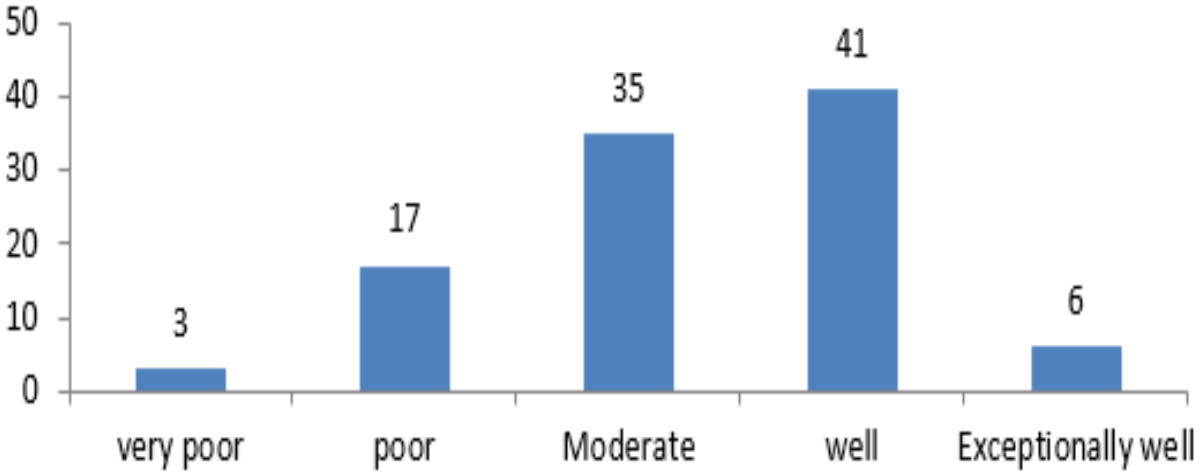

Figure 5.10: This figure shows how well does team adapt to changes in project requirements during a sprint

– Team prioritization of user stories within a sprint to minimize uncertainty and optimize delivery: In order to answer this question, maximum (45.10%) consider prioritization which bases on the order they were added to the backlog, 35.30% prioritized by business value and dependencies. 11.80% consider no specific prioritization.

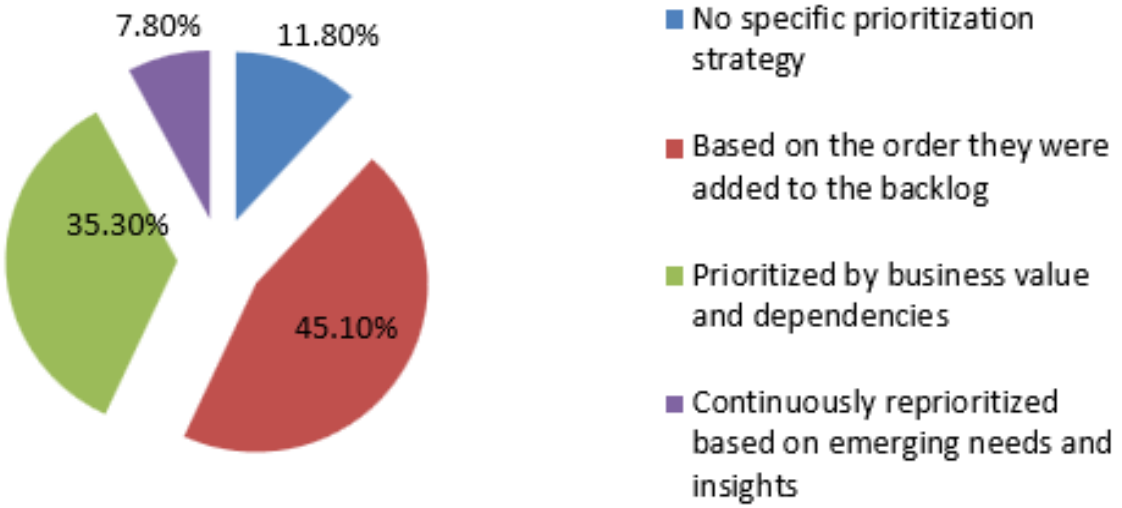

Figure 5.11: Team prioritization within a sprint to minimize uncertainty

– Agile methodologies that team primarily follow for project management and story point's estimation: This figures shows the agile methodologies that team primarily follow for project management and story point's estimation. Maxi-

mum respondents (38.20%) prefer hybrid approach and 31.40% prefer Scrum.

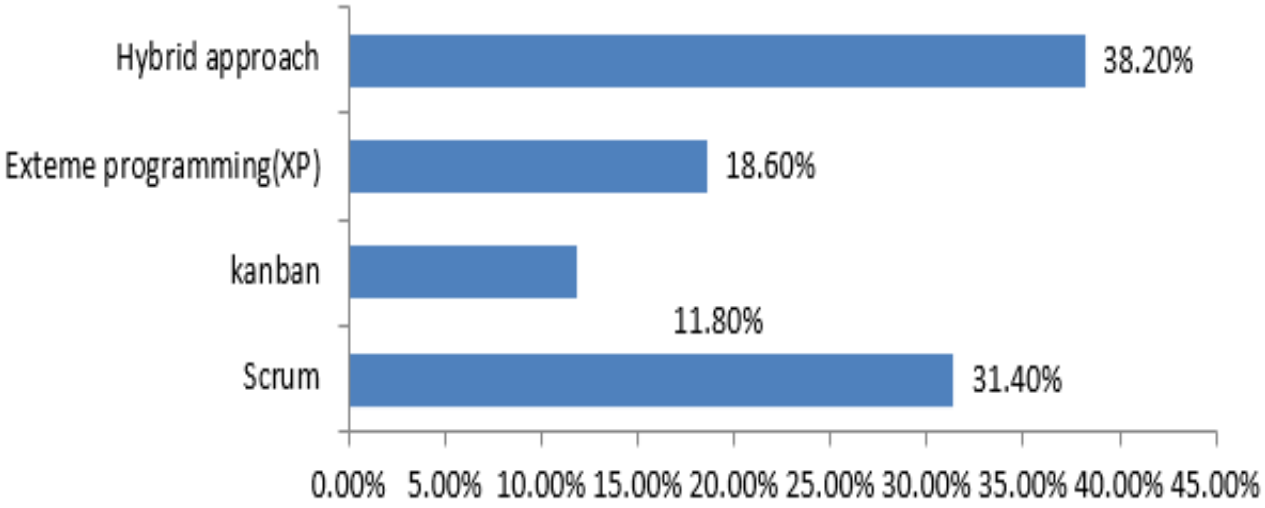

Figure 5.12: Agile methodologies that team primarily follows

– Team approach of sprint planning in the perspective of story points estimation: For sprint planning in the perspective of story points estimation, maximum respondent (37.6%) consider high level planning with flexibility for scope changes, 29.7% considers adaptive planning based on continuous feedback while 18.8% considers no formal sprint planning process.

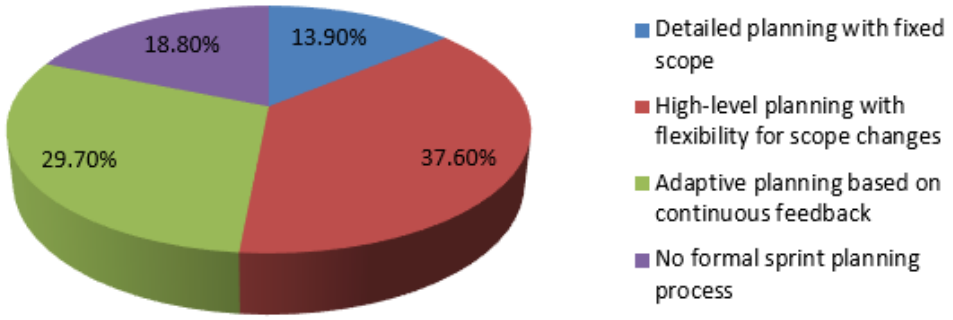

Figure 5.13: Team approach of sprint planning in the context of story point's estimation

5.2.1.2 Survey after HEF

- Estimation Strategies and Uncertainty Management

  – Team's approach to adapting Agile methodologies to suit the specific needs of projects: The figure identifies the team's approach to adapt agile methodology

to suit the specific needs of projects. By prioritizing flexibility and adaptability, team is able to tailor Agile methodologies to meet the specific demands of each project, ensuring optimal performance and satisfaction for both the team and stakeholders.

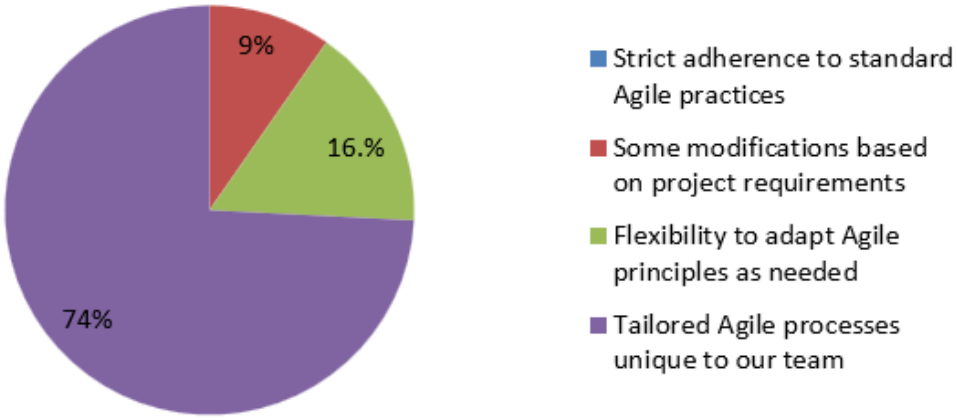

Figure 5.14: Team approach to adapt Agile methodologies

– Extent to which uncertainty impact the accuracy of story points estimation: This figure shows the responses that represent the extent to which uncertainty impact the accuracy of story point estimation in organization. Results show high impact (77.4%).

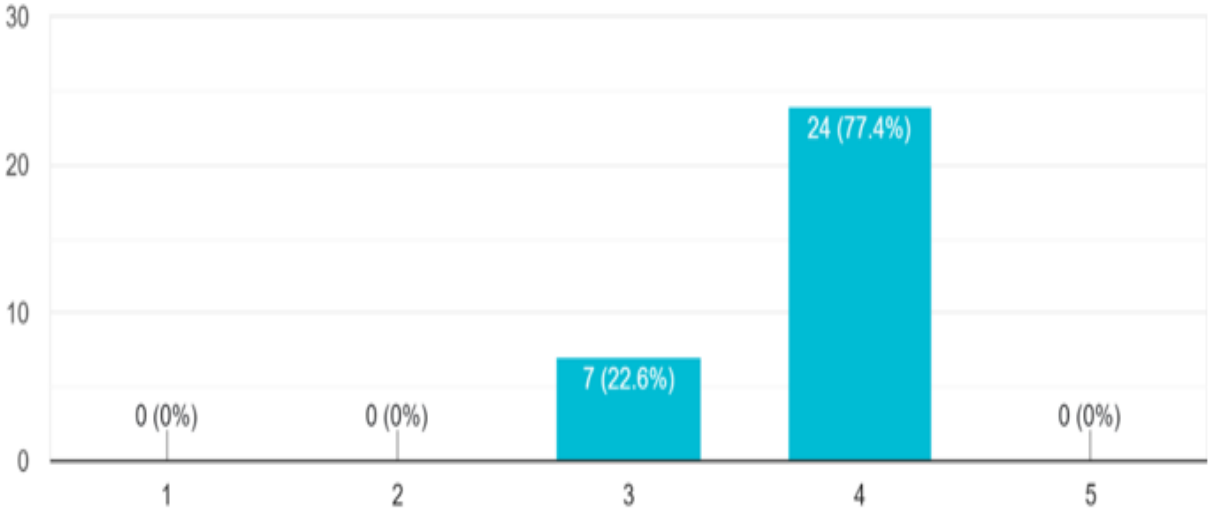

Figure 5.15: Impact of uncertainty on accuracy of SP Estimation

– Aspects that support uncertainty significantly in story points estimation: The result of survey shows the aspects that support uncertainty significantly story

point estimation. Maximum responses (61.3%) think unforeseen technical challenges, contributes significantly to uncertainty in story point estimation.

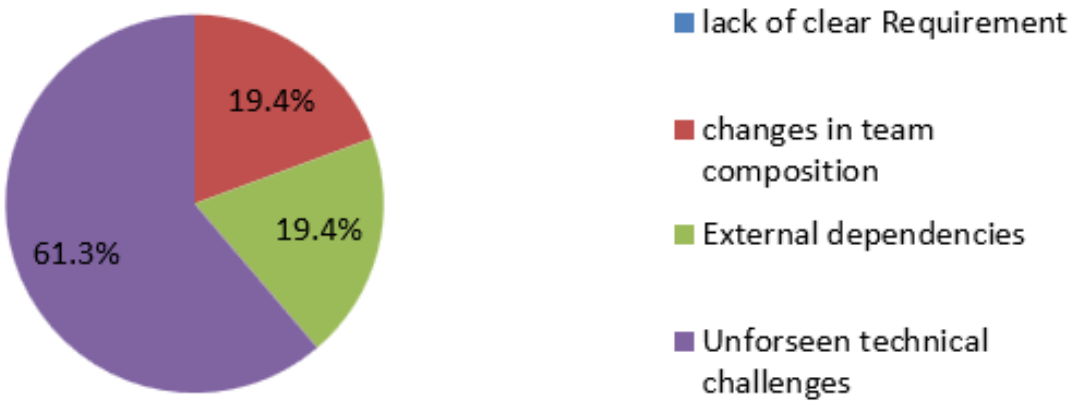

Figure 5.16: Aspects that support uncertainty significantly in story points estimation

– Affectivity of automated tools in reducing uncertainty in story points estimation: Result analysis illustrates 83.9% participant respond that automated tools in reducing uncertainty in story point estimation are very effective. Automated tools play a crucial role in reducing uncertainty in story point's estimation by leveraging data-driven insights, enhancing consistency, and providing real-time feedback. Their integration into Agile workflows not only improves estimation accuracy but also contributes to more efficient and predictable project management. For Agile teams seeking to enhance their estimation processes, the adoption of automated tools presents a compelling solution.

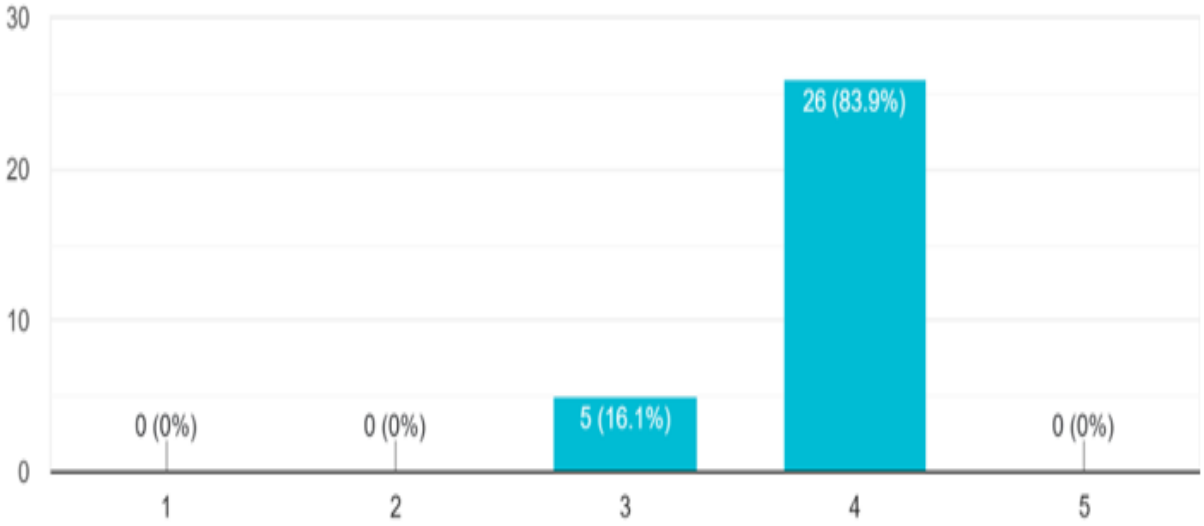

Figure 5.17: Affectivity of automated tools

- Continuous Improvement, and External Influences
  - How team handle external dependencies that may introduce uncertainty into the project timeline: In response to this question, maximum (48%) & (45%) thinks that by developing contingency plans for potential delays and by utilizing alternative resources to mitigate dependencies risk can handle external dependencies that may introduce uncertainty into project timeline.

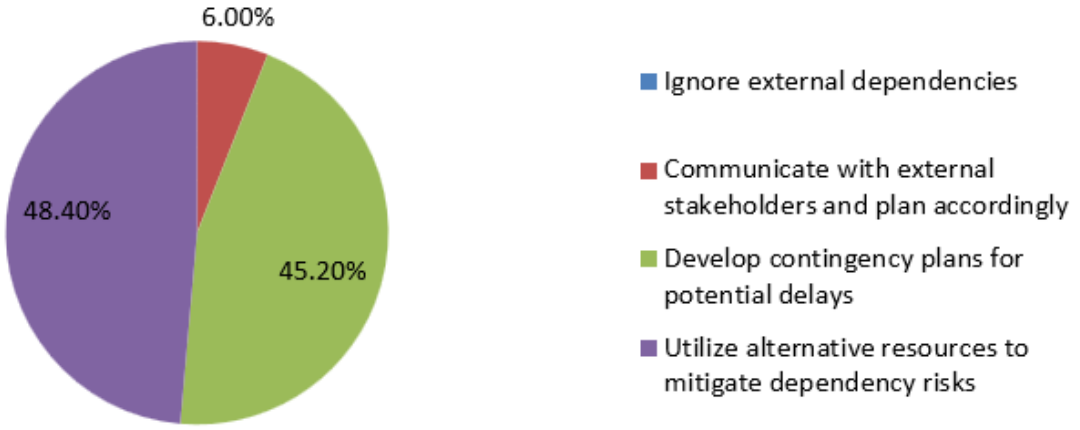

Figure 5.18: How team handles external dependencies

  - Extent by which organization leverage machine learning or AI for enhancing story points estimation accuracy: This figure shows the extend by which organization leverage machine learning or AI for enhancing points estimation

accuracy. Maximum respondents (77.40%) fully embraced with regular updated based on learning.

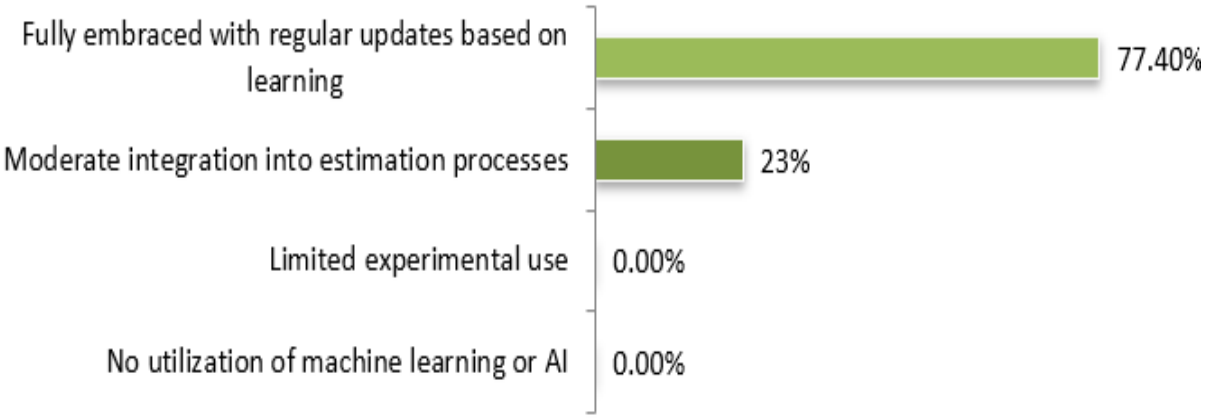

Figure 5.19: Machine learning or AI for enhancing story point's estimation accuracy

– Extent by which estimation practices consider the potential impact of technical debt on project timelines: In response to this question, to consider the potential impact of technical debt on project timeline maximum respondents (55%) thinks technical debt is a primary consideration in every estimation.

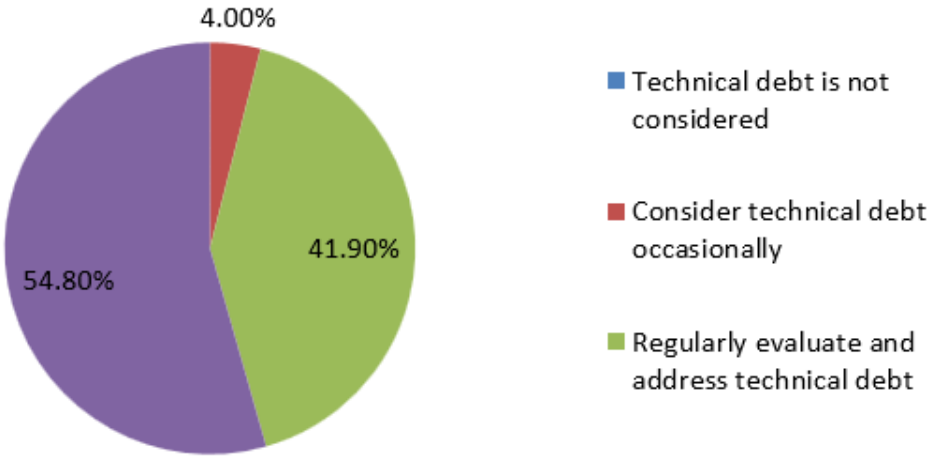

Figure 5.20: Estimation practices consideration of the potential impact

– Addressing uncertainties introduced by changes in project requirements after the initial estimation: In order to address uncertainties introduced by changes in projects requirements after the initial estimation, 54.80% incorporate adjustment of estimates for any change during the project and 42% embrace changes and continuously adapt estimates.

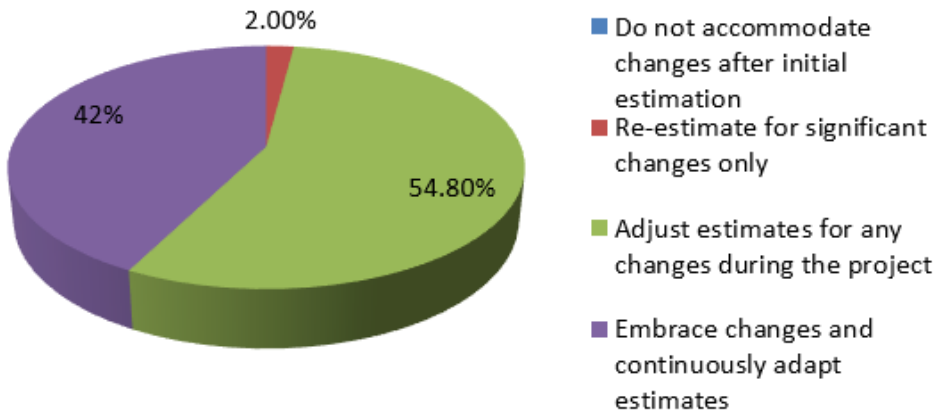

Figure 5.21: Addressing uncertainties

– Handling the impact of external events, such as market shifts or global crises, on project timelines and estimation: In order to handle the impact of external events, 68% considers regularly reassess and adjust estimation based on external factors.

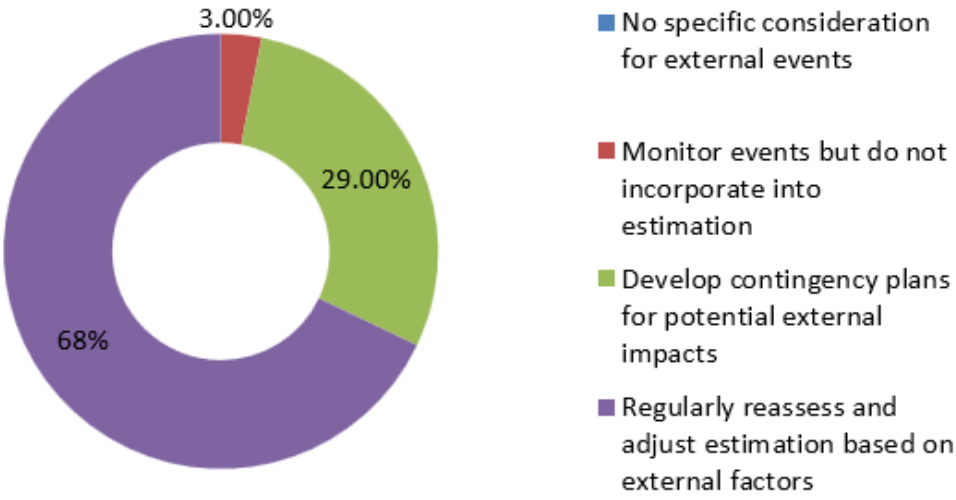

Figure 5.22: Handling the impact of external event

– How well does team adapt to changes in project requirements during a sprint: This following graph shows that maximum (77%) prefer to adapt to changes in project requirements during a sprint.

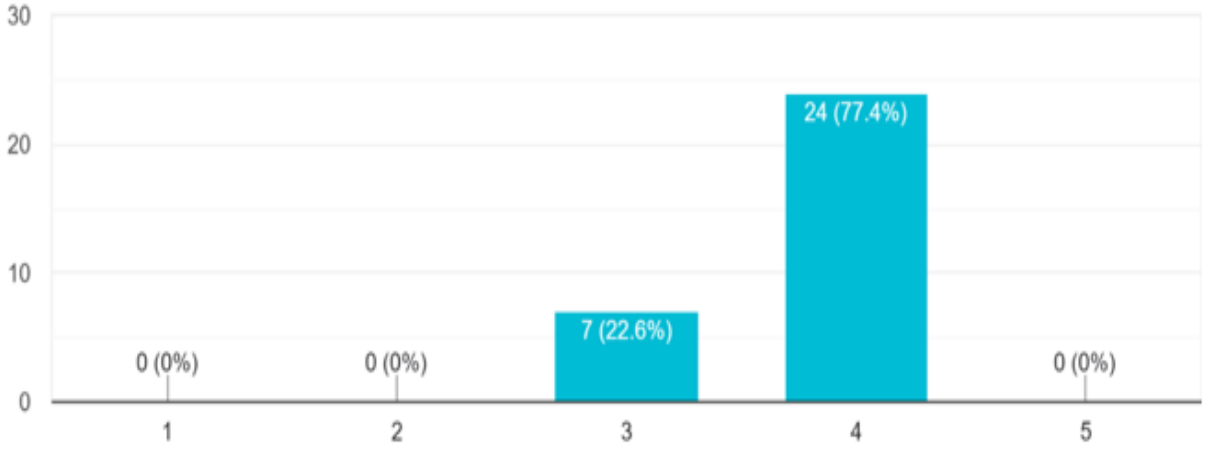

Figure 5.23: This figure shows how well does team adapt to changes in project requirements during a sprint

– Team prioritization of user stories within a sprint to minimize uncertainty and optimize delivery: In order to answer this question, maximum (51.60%) consider prioritization by business value and dependencies.

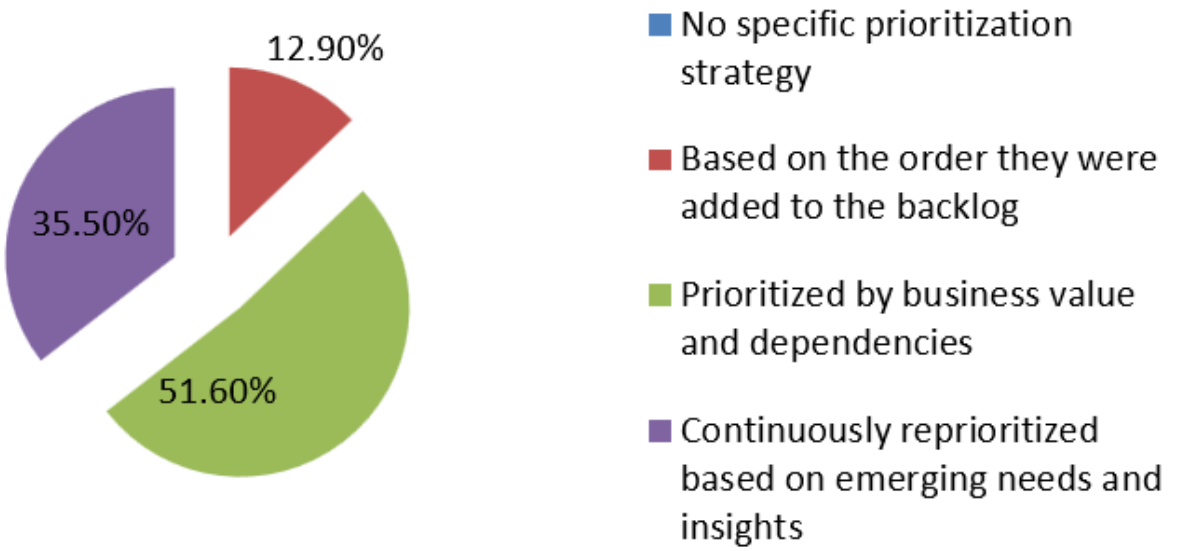

Figure 5.24: Team prioritization within a sprint to minimize uncertainty

– Agile methodologies that team primarily follow for project management and story point's estimation: This figures shows the agile methodologies that team primarily follow for project management and story point's estimation. All respondents (100%) prefer hybrid approach.

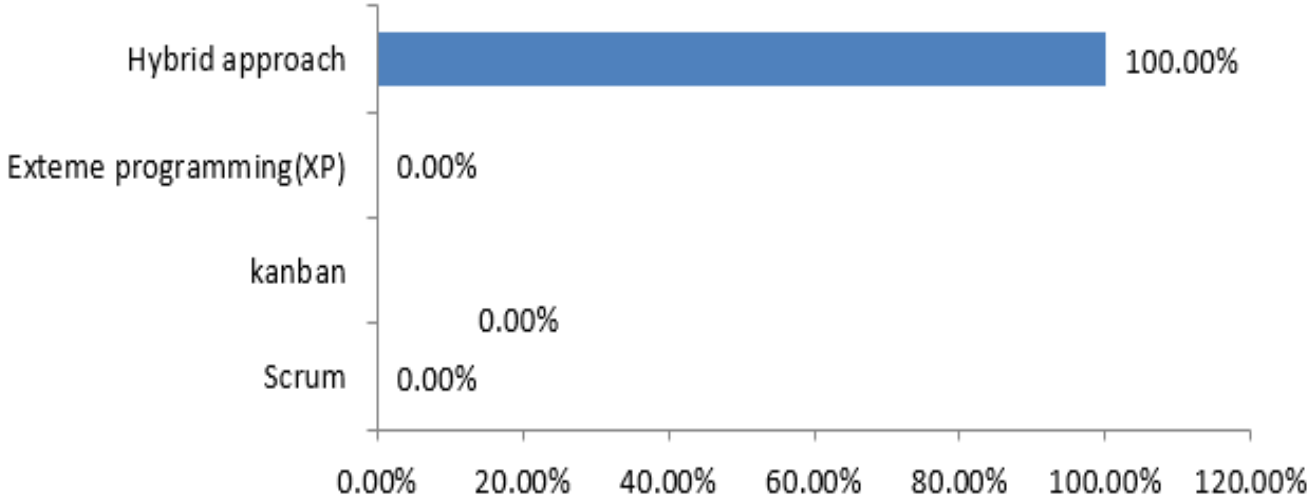

Figure 5.25: Agile methodologies that team primarily follows

– Team approach of sprint planning in the context of story points estimation: For sprint planning in the context of story points estimation, maximum respondent (80.6%) consider adaptive planning based on continuous feedback.

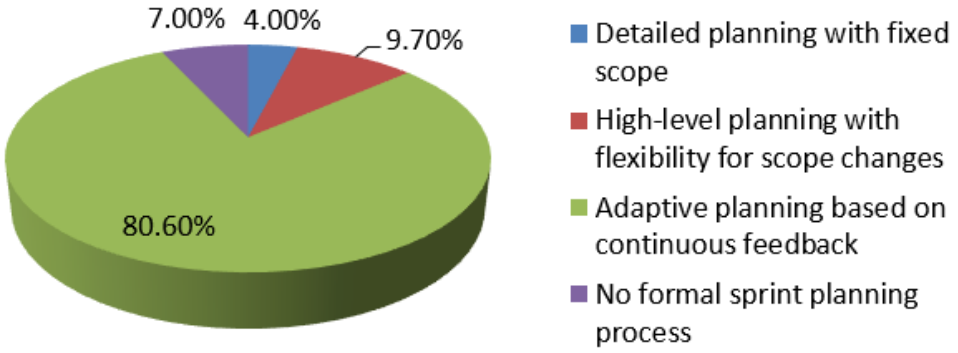

Figure 5.26: Team approach of sprint planning in the context of story point's estimation

5.2.2 Comparisons of Results

The both survey was held at the same environment without any biasness and were completely anonymous. The survey results were good and Google forms provided a good way to gather data. After consideration of HEF, survey shows 20-30% better results.

Chapter 6

SUMMARY OF RESEARCH WORK

This research introduces a novel framework aimed at mitigating the inherent uncertainty in story points estimation within Agile-based projects. Estimating the effort required for various tasks is a fundamental aspect of Agile methodologies, yet it often presents significant challenges due to the dynamic nature of project requirements and team dynamics. These challenges can lead to issues such as inaccurate estimates, resource misallocation, and project delays. The proposed framework seeks to address these issues by integrating multiple elements that collectively enhance the accuracy and reliability of story point's estimation. After consideration of HEF, survey shows 20-30% better results.

The core of the framework (HEF) consists of four key components: Historical Data Analysis, Stakeholder Involvement, Risk Management, and Continuous Refinement. Historical Data Analysis utilizes past project data to identify trends and inform future estimates, providing a data-driven foundation for estimation. Stakeholder Involvement ensures active participation from all relevant parties, including clients and team members, promoting transparency and alignment with project objectives. Risk Management involves identifying potential risks early in the project and planning mitigation strategies to reduce their impact on estimates. Continuous Refinement emphasizes the iterative nature of Agile, allowing estimates to be regularly reviewed and adjusted based on new information and feedback, ensuring they remain accurate and relevant throughout the project lifecycle.

The framework was empirically validated through several case studies, including projects in diverse domains such as e-commerce, mobile banking, and healthcare management. The results from these case studies demonstrated significant improvements in estimation accuracy and stakeholder satisfaction. For example, estimation variance was reduced from an average of 20-30% to 5-10%, and stakeholder satisfaction scores increased from 3.5 to 4.5 out of 5. These findings highlight the effectiveness of the framework in enhancing the precision of story point's estimation and the overall success of Agile projects.

The practical implications of this research are far-reaching. By implementing the proposed framework, organizations can achieve more accurate project planning and resource allocation, leading to more predictable and reliable project outcomes. The framework also fosters better risk management and stakeholder engagement, creating a collaborative environment that supports the successful delivery of projects. Additionally, the framework's scalability and adaptability make it suitable for a wide range of projects, from small start-ups to large enterprises, setting a new standard for best practices in Agile estimation.

In conclusion, the proposed framework offers a comprehensive solution to the challenges of story point's estimation in Agile-based projects. By integrating historical data analysis, stakeholder involvement, risk management, and continuous refinement, it significantly reduces estimation uncertainty and enhances project management practices. This research underscores the importance of accurate estimation in Agile methodologies and provides a practical, scalable framework that can be widely adopted to improve project outcomes and stakeholder satisfaction.

Chapter 7

Conclusion and Future Work

This thesis has presented and validated the Holistic Estimation Framework (HEF) as a novel approach to mitigating uncertainty in story point's estimation within Agile-based projects. The major discoveries and accomplishments of this study have been highlighted through thorough analysis and validation by evidence, with a focus on the influence of the framework on estimating accuracy, stakeholder satisfaction, and risk management.

Story point estimate accuracy and reliability have increased with the use of HEF, as seen by the notable decrease in estimation variation. The framework's treatment of several aspects of uncertainty is credited with this decrease in variance since it offers a more thorough evaluation of the complexity and effort of the project. Furthermore, a major factor in the project stakeholders' growing confidence and pleasure has been the high degree of stakeholder participation throughout the estimating process. Because many viewpoints are taken into account thanks to this collaborative method, the estimations produced are more acceptable and reasonable.

The incorporation of risk management techniques into the estimating process is one of this research's other key contributions. HEF helps to improve overall project results by facilitating easier project execution and delivery through the early identification and resolution of possible hazards. The efficacy of HEF is further validated empirically through case studies and project assessments, which highlight its usefulness and advantages in actual Agile entities.

7.1 Determining the Importance of the Suggested Framework in Agile Project Management

Remarkably aligned with Agile concepts, the Holistic Estimating Framework offers a structured yet adaptable estimating method that can adjust to the dynamic nature of Agile projects. In contrast to conventional estimating techniques, HEF integrates risk management, stakeholder participation, and historical data analysis into a unified framework. In addition to improving estimate accuracy, this multifaceted method guarantees that the estimating process is adaptable to new information and changes, which is a fundamental component of Agile project management.

The fact that HEF can strike a balance between adaptability and strict procedures emphasizes its importance even further. The methodology guarantees that estimates stay current and accurate throughout the project lifespan by allowing for ongoing improvement and adaptation while upholding a strict approach to data analysis and risk assessment.

7.2 Recommendations for Practitioners and Organizations Seeking to Improve Estimation Practices

Project predictability and resource allocation may be significantly improved for professionals and enterprises who embrace the Holistic estimate Framework to improve their estimate methods. Agile teams should include HEF in their project management procedures, stressing the need for ongoing stakeholder participation and using previous data to make more accurate estimations.

Teams should get assistance and training from their organizations to ensure that HEF is implemented as effectively as possible. This means offering team members access to resources and tools for risk management and data analysis, as well as training them on the framework's guiding principles. Furthermore, it is important to hold periodic feedback sessions and evaluations to enhance and modify the estimating process in a way

that keeps the framework adaptable to project changes.

7.3 Conclusion and Reflections on the Significance of Mitigating Uncertainty in Story Points Estimation

Agile project success depends on reducing uncertainty in the calculation of story points. An unreliable estimate can result in misallocated resources, erroneous schedules, and project failure. To solve these issues, the Holistic Estimation Framework offers a thorough method that considers various uncertainty dimensions, includes stakeholder input, and combines risk management techniques.

HEF is important because it may change the estimating process from being only a judgment-based activity to one that is more data-driven and team-based. Doing so improves estimate accuracy and dependability, which raises stakeholder confidence and results in fewer uncertain project outcomes. This study emphasizes how crucial it is to approach estimating holistically and flexibly, especially in the context of Agile project management, where change and uncertainty are natural parts of the process.

To sum up, the development of the Holistic Estimation Framework has been a major step forward for Agile project estimation. It's universal, adaptable, and data-driven methodology reduces uncertainty and promotes a responsive, cooperative project environment. Using HEF can result in more successful project outputs, which will increase the efficacy and efficiency of Agile project management techniques as a whole.

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LIST OF PUBLICATIONS

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- Track Name: ICIT2024
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- Authors:
  - Samra Faisal Khan (samrafaisalkhan1@gmail.com)
  - Muhammad Sohail (Primary) (muhammad.sohail@mcs.nust.edu.pk)
  - Ayesha Maqbool (ayesha.maqbool@mcs.edu.pk)
  - Ihtesham Ahmad (ihtesham@mcs.edu.pk)

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