IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Date of publication xxxx 00, 0000, date of current version xxxx 00, 0000.

Digital Object Identifier 10.1109/ACCESS.2023.1120000

Transition from Waterfall to Agile Methodology - An Action Research Study

THAMIZHINIYAN NATARAJAN[1], SHANMUGAVADIVU PICHAI[2]

[1]Department of Computer Science and Applications, The Gandhigram Rural Institute-Deemed to be University, Gandhigram , Tamil Nadu, India (email: thamizhiniyan@gmail.com)

[2]Department of Computer Science and Applications, The Gandhigram Rural Institute-Deemed to be University, Gandhigram, Tamil Nadu, India (e-mail: p.shanmugavadivu@ruraluniv.ac.in)

Corresponding author: Shanmugavadivu Pichai(e-mail: p.shanmugavadivu@ruraluniv.ac.in).

ABSTRACT In recent years, software companies have shifted from plan-based software development(PBSD) to Agile software development (ASD) for improved efficiency and product delivery, with ASD demonstrating superior benefits compared to traditional approaches. This paper presents an in-depth exploration of an action research study detailing the transition of a software development team from a plan-based paradigm to Agile methodology. The primary goal is to provide a comprehensive account of the Agile transition journey within the context of action research and to underscore the associated benefits derived from this iterative and participatory research approach. Spanning two years, the study progresses through four cycles of iterations, allowing for continuous refinement of the Agile adoption process. Findings derived from the action research study showcase positive and tangible outcomes of the transition to Agile methodology. Notable improvements include heightened deliverable quality, enhanced intra-team communication, strengthened collaboration with stakeholders, and an increased frequency of software releases. Comparative analysis with PBSD highlights Agile advantages, especially in defect trend, the number of releases, defect lifecycle, and total automation percentage. Agile metrics, including the Burndown Chart, Velocity, Say-Do Ratio, In-sprint Automation, Defect Density, Execution Maturity, and Defect-less Stories, demonstrate substantial improvements, reinforcing the effectiveness of the Agile transition process. The study concludes that the transition to Agile methodology demonstrates significant improvements in various aspects of software development. Positive outcomes support the trend of adopting Agile methodologies in the software industry, emphasizing the effectiveness of the Agile transition process.

INDEX TERMS Agile Methodology, Scrum, Agile Transition, Agile Transformation, Action Research

I. INTRODUCTION

IN the domain of software development methodologies, there has been a significant shift from the traditional approach of Plan-Based Software Development (PBSD) to a more dynamic and flexible Agile Software Development (ASD). While PBSD relied on creating a rigid plan at the beginning of a project, ASD emphasizes adaptability, collaboration, and iterative development [1]. This transition from PBSD to ASD has been driven by the recognition that traditional approaches often struggled to meet project deadlines and deliver software that aligned with customer expectations [2].

The PBSD approach followed a well-defined sequence of phases, with different teams handling specific aspects of software development. However, teams faced challenges in delivering software on committed deadlines with the desired quality. This prompted the need for a new approach that could address these issues and enable the teams to respond effectively to the changing requirements.

Agile Software Development emerged in 2001, introducing a set of principles and practices that provided a solution to the challenges faced by those teams following PBSD. Agile emphasizes collaboration, adaptability, continuous improvement, and iterative development, enabling teams to deliver high-quality software in a more efficient manner [3]. The transition from PBSD to ASD has gained significant traction as organizations seek to leverage the benefits of Agile methodologies.

However, the adoption of Agile also presents its own set of challenges. One significant challenge is the need for a mindset change within teams accustomed to the structured nature of PBSD. Moving from a plan-driven approach to an Agile mindset can be a complex change management process for companies [4].

Another challenge lies in the transition to self-organized teams in Agile. Unlike PBSD, where different teams handle specific phases of development, Agile promotes cross-functional teams that collaborate on all aspects of the project. This shift requires a redefinition of roles and responsibilities, as well as adjustments in team dynamics and communication. Additionally, conflicts may arise between traditional management roles and the new roles introduced in Agile, such as Scrum Master and Product Owner. The traditional command-and-control management style may not align with the collaborative and empowered nature of Agile, leading to potential conflicts and resistance to change [2].

Furthermore, Agile places less emphasis on extensive documentation, favouring working software and face-to-face communication [1]. This shift in documentation practices can be a challenge for organizations accustomed to comprehensive documentation requirements. Agile teams must strike a balance between documentation needs and the Agile principle of delivering high-quality software increments. The Agile approach also requires teams to deliver a smaller number of features within shorter timeframes, often in iterative cycles [5]. The shift towards frequent and incremental delivery can pose challenges for teams accustomed to longer development cycles. Moreover, Agile promotes a fail-fast and fail-often mentality, encouraging teams to take risks, learn from failures, and iterate quickly. This approach requires a high level of confidence and psychological trust within the team to foster experimentation and innovation. Lastly, the implementation of Agile may require modifications to the existing infrastructure and tools to support the collaborative and iterative nature of Agile development.

Considering these challenges, organizations embarking on the Agile transition can benefit from in-depth case studies that provide valuable insights into the transition process. This paper aims to contribute to the body of knowledge on Agile adoption by presenting a detailed account of a software development team's successful transition from PBSD to ASD. The paper explores the Agile transition strategy employed, summarizes the action research cycles undertaken, presents both qualitative and quantitative results of the transition, discusses the encountered challenges, and highlights the benefits realized through the adoption of Agile practices.

The transition to Agile is a nuanced and complex journey, characterized by a multitude of challenges that each team confronts and addresses uniquely. The significance of documented evidence showcasing enhanced team performance post the Agile transition becomes paramount, offering profound insights not only into the intricacies of this transformative journey but also illuminating the diverse solutions teams devise to surmount challenges. At the heart of this exploration lies a fundamental research question:

"How does the transition from a plan-driven process to Agile methodology impact the development outcomes and practices of a software development team?"

By examining this action research study, organizations can gain a better understanding of the critical success factors and best practices for navigating the Agile transition. The insights shared in this paper can serve as a practical guide for organizations seeking to embrace Agile principles and achieve successful outcomes in their software development endeavours.

The structure of this paper is as follows: Section II presents an overview of the related work in the research area. The research design is explained in Section III. Summary of action research cycles is provided in Section IV and the execution of action research cycles are presented in Section V, which provides detailed explanations of the four iterations, including results and lessons learned. Section VI presents the details of results and interpretations and the validity evaluation is discussed in Section VII. Implications are discussed in Section VIII and finally, Section IX presents the conclusions of this research.

II. BACKGROUND AND RELATED WORK

Over the past few years, software development teams have embraced agile development methods and reaped the rewards outlined in the Agile manifesto and its accompanying 12 principles [3]. Agile methods prioritize customer satisfaction, releasing software in smaller parts, teamwork, and adaptability to changing requirements [5]. The advantages of Agile include increased productivity, cost savings, enhanced employee engagement and job satisfaction, quicker time to market, better quality deliverables, and heightened stakeholder satisfaction [6]. Scrum, Extreme Programming, Lean Software Development, and Kanban are among the agile methods used by software development teams, with Scrum and Extreme Programming being the most widely adopted [7].

Agile transition is examined through two key dimensions: Challenges in Agile transitions and their subsequent resolution via case studies and frameworks. The former delves into the multifaceted challenges inherent in the adoption of Agile methodologies, addressing critical aspects such as cultural shifts, organizational alignment, and the transformation of mindsets. Meanwhile, the latter subsection meticulously examines a varied collection of case studies and frameworks that illuminate the concrete complexities of success in Agile transitions. Simultaneously, these thematic explorations lay a strong groundwork for understanding the complex dynamics, challenges, and successes linked to the paradigm shift from traditional to Agile software development methodologies.

A. AGILE TRANSITION CHALLENGES

Transitioning from traditional methods to Agile approaches in software development is no easy feat, and it comes with its set of challenges. These include issues like inadequate training, communication problems, clashes of culture, and organizational structure mismatches. To tackle these challenges, it's crucial to treat Agile adoption as an improvement project for the entire organization. This involves defining Agile processes early on, creating a suitable organizational structure, running pilot projects, providing training, assessing progress,

gaining top management support, implementing ways to improve processes, and recognizing the value of individuals in the organization [8].

In the strategic planning phase of Agile transitions, meticulous considerations play a pivotal role. Essential components such as training, transition facilitators, frameworks, strategy, assessments, and coaching must be carefully integrated. The authentic rationale behind the transition, attention to human aspects, project selection, and method selection are critical elements that contribute to the success of the transition [9].

Effective management is a key factor in successfully navigating the transition process. Focusing on individuals and their support is essential. This approach involves preparing a well-thought-out action plan, identifying potential challenges, establishing support structures, and conducting thorough assessments throughout the transition [10].

The challenges also extend to the broader context of software development methodologies. The dynamic nature of technologies and user demands poses challenges when migrating to Agile methodologies. Traditional methods are criticized for being inflexible in adapting to these dynamic processes. While Agile aligns with the principles of complex adaptive systems, organizations are advised to carefully assess their readiness for this shift, considering factors like culture, readiness, and compatibility [1].

Insights from a survey among practitioners by A. S. Campanelli et al provides a closer look at the difficulty of implementing success factors in Agile transformation. According to expert practitioners, the most challenging factors include developing a measurement model and changing the mindset of project managers [11]. A survey on Agile project management by S. Obrutsky delves into prevalent obstacles hindering the adoption of Agile methodologies, unveiling a spectrum of challenges. These include organizational resistance, a lack of available users, existing rigid frameworks, a shortage of personnel experienced in Agile, concerns about losing management control, and worries about upfront planning [4].

The challenges in Agile adoption are further explored through a systematic analysis of frameworks, issues, and situational factor by M. Jovanović et al. Among the situational factors influencing Agile transition are organizational or corporate culture, team size or scale, management support, training, organizational maturity level, team distribution or co-location, and the team's previous experience [12].

The shift to Agile methodologies presents the challenge of altering organizational mindsets, underscoring the necessity for effective strategies. Successful transitions prioritize clear communication, management support, training, and a phased introduction of Agile practices aligned with organizational culture. Collaborative and decentralized leadership styles play a crucial role, underscoring the importance of harmonizing Agile practices with existing organizational norms for successful implementation [13].

Top management support emerges as a critical success factor for Agile transformations, with an emphasis on its commonality in successful change efforts [14]. Evolving into an Agile state broadens the conventional viewpoint, illustrating agility as a continual network of transitions across various dimensions, including software development practices, team dynamics, management approach, reflective practices, and organizational culture [15].

B. AGILE TRANSITION CASE STUDIES AND FRAMEWORKS

In a study spanning 2.5 years and involving three software-intensive companies in Finland, M. Pikkarainen et al. investigated the strengths and barriers associated with Agile deployment. The findings highlight the importance of management support, well-defined process models, and empowering developers for continuous improvement. These insights serve as a practical checklist for organizations planning and monitoring the effectiveness of their Agile deployment [16]. A literature review on the role of project management in Agile methodologies by T. J. Gandomani et al addresses the debate on whether Agile teams require a project manager. Findings suggest a structural difference between traditional project managers and Agile roles, emphasizing the need for a tailored approach. While Agile methodologies lack an independent project manager role, pre-defined roles often assume project management duties, providing valuable insights for Agile teams seeking success [17].

Drawing insights from Nokia's transition journey, M. Laanti et al emphasizes the widespread agreement on the benefits of Agile, including increased satisfaction and transparency. However, challenges in deployment, flexible planning, and visibility are identified. Despite these challenges, the study suggests that positive attitudes toward Agile increase with hands-on experience, highlighting the importance of practical exposure to Agile practices, especially in large-scale industrial settings [18]. A comparative investigation into agile adoption strategies by B. Julian et al reveals two distinct approaches: "big bang" and "gradual adoption." Teams adopting an entire agile framework upfront contrast with those introducing specific practices gradually. The study underscores the importance of continuous improvement, autonomy, flexibility, and ongoing assessment in shaping the agile transition process [19].

The LEGO Group's Agile transformation stands out as a compelling case, showcasing a significant reduction in response time to change within a year of implementation. The success stories have spurred interest across different departments, leading to Agile pilots in various areas. The emphasis here is on exploring governance in a traditional manufacturing firm and adapting job structures and financial processes, highlighting the centrality of Agile values and principles in the transformation journey [20]. An investigation into the evolutionary shift to Agile in a German SME, as highlighted by P. Diebold et al, underscores positive experiences and perceived benefits throughout the transition. The study concludes that an evolutionary approach is well-suited for small companies, emphasizing the ongoing nature of the agile transition, driven by employees adapting to a mindset shift towards agility [21]. An action research initiative led by A. Anwar et al,

focused on Agile adoption, reveals promising outcomes with a notable decrease in the rework rate. The study underscores the significance of addressing challenges stemming from both technical and human aspects in the agile adoption process. Additionally, it suggests the extension of successful adoption plans to other delivery units [22].

In a longitudinal case study conducted by K. Korhonen, the assessment of agile transformation at Nokia Siemens Networks confirms positive outcomes, including enhanced motivation, increased visibility of achievements, and improved reactive capabilities. The study highlights improvements in defect data metrics, suggesting potential enhancements in working practices and code quality over time. The findings underscore the importance of organizational-wide implementation and active participation in realizing the full benefits of agile transformation [23].

Shift from traditional to agile methodologies in large and distributed projects has resulted in superior performance in terms of product quality, customer perception, and employee satisfaction. The agile framework's benefits include accommodating late requirement changes, fostering improved team communication, collaboration, and positively impacting the development process. Despite these advantages, the need for meticulous planning, particularly in large companies with traditional processes is critical. Successful implementation involves monitoring activities, addressing project-specific issues, and crafting customized agile guiding principles aligned with project requirements and individual competencies [24].

A case study of Cisco Systems by R. (Ronxin) Chen et al identifies two major challenges in transitioning to the agile product development model: assisting teams in the transition and developing new management practices to support agile development. The study advocates for a holistic, systematic approach applicable to both large and small to medium-sized companies, emphasizing the need to explore new management practices [25].

A survey-based ex-post-facto study by S. C. Misra et al identifies factors influencing the success of projects adopting Agile Software Development (ASD) practices. Factors include customer satisfaction, collaboration, commitment, decision time, corporate culture, control, personal characteristics, societal culture, and training and learning [26]. A longitudinal case study by J. Li et al explores the transition from a plan-driven process to Scrum highlights the enhancement of project success through early issue resolution and improved defect fixing efficiency. Daily Scrum meetings facilitate knowledge sharing, leading to better understanding of the system and early learning from mistakes. The study acknowledges challenges, such as stress and time pressure on developers, emphasizing the need for balancing pressure with the need for supplementary tasks in future investigations [27]. A systematic literature review by M. F. Abrar et al identifies 21 motivators for large-scale Agile adoption from a management perspective. Critical motivators include strong executive support, agile development environment training, agile development expertise, team competency, and briefing of top management on agile [28].

III. RESEARCH DESIGN

The research design implemented in this study serves as a guide for navigating the complex process of transitioning a software development team from a plan-based approach to Agile methodology. Rooted in the principles of action research methodology, this approach is selected to actively involve stakeholders in the transformation process, fostering collaboration in problem-solving and decision-making [29]. The aim is not just observation but active participation in the dynamic evolution of the Agile adoption journey. Covering a period of two years from Jul 2019 to Jun 2021, this study encompasses a sequence of distinct cycles, each symbolizing an iteration within the continuous process. These iterative cycles are crucial, providing the necessary structure to refine and optimize the Agile adoption strategy.

A. RESEARCH METHODOLOGY

This study employed the action research methodology to facilitate the transition of the development team from a plan-based development process to Agile Software Development (ASD). Action research is a systematic and iterative approach that involves cycles of diagnosis, planning, action taken, evaluation and learning [30]. The five phases of action research are as follows:

- **Diagnosis**: The researcher identifies and examines the problem or issue through data collection, observations, and stakeholder engagement. The objective is to understand the root causes and explore the context of the problem.
- **Action Planning**: After diagnosing the problem, stakeholders collaborate with the researcher to develop a clear and strategic action plan. This plan outlines specific interventions, objectives, and a timeline for implementation, providing a roadmap for subsequent activities.
- **Action Taken**: In this phase, planned interventions and actions are implemented through active stakeholder engagement. The researcher and stakeholders collaborate to execute and monitor the planned strategies.
- **Evaluation**: The evaluation phase measures the effectiveness of implemented actions and assesses their outcomes. Data collection is conducted to determine if the desired results were achieved and to gain insights for future improvements.
- **Learning**s: The learning phase is about gathering the outcomes and experiences gained from the action research process. It involves critical analysis on data, identifying lessons learned, and generating new knowledge.

This research extended over two years, encompassing four distinct cycles of interactions as essential elements of the action research process. Each cycle involved collaborative efforts between the research team and the development team to identify challenges, devise strategies, implement changes, and assess the outcomes. This iterative approach allowed for

continuous learning, adaptation, and improvement throughout the transition process, ultimately guiding the team towards successful adoption of Agile practices.

Throughout the action research process, continuous reflection and adaptation occur. Findings and insights from each cycle inform subsequent cycles, enabling continuous learning and improvement. This collaborative and iterative approach makes action research a powerful method for creating meaningful change in organizations and communities.

B. CONTEXT

This research was initiated with a central objective: to enhance the overall development methodology employed by a team within a well-established software company. The specific focus was on their ongoing project dedicated to developing and maintaining a web portal designed for user management. In the initial phases of this study, the team grappled with significant challenges arising from the constraints inherent in a traditional waterfall model. Notably, the challenges manifested in various facets, particularly concerning limitations on flexibility, adaptability, and collaborative efforts. As the team was tasked with developing and maintaining a user management portal, they consistently received frequent and time-sensitive requirements from teams such as marketing and eCommerce. These recurring challenges, coupled with the rapid pace of expected deliveries, made it evident that the traditional waterfall model was ill-suited for this dynamic and fast-paced environment. The recognition of these challenges served as a catalyst for the imperative shift towards adopting a more dynamic and responsive approach to the software development process, marking the initiation of the Agile transition.

Comprising 40 members, the team underwent a transformative shift into four Scrum teams as part of their Agile transition. This structural change aimed at bolstering productivity, efficiency, and responsiveness by integrating Agile principles and practices into their workflow. The Scrum teams, characterized by cross-functional collaboration, included developers, testers, designers, and other pertinent roles.

Driving the Agile adoption process was an integral action research team, consisting of Scrum Masters, product owners, architects, and development managers. Their pivotal role involved not only facilitating the transition but also offering guidance and support to ensure a seamless implementation of Agile practices. This collaborative effort extended to continuous monitoring and evaluation, allowing the team to adapt to evolving circumstances effectively.

C. THEORETICAL FRAMEWORK

The theoretical framework of this research is anchored in several key principles and methodologies that collectively shape the trajectory of the study. At its core lies the Agile approach, a contemporary methodology in software development renowned for its emphasis on iterative processes, collaboration, and adaptability. The Agile framework provides the fundamental structure for the study, guiding the process of transitioning a software development team from a traditional plan-driven approach to the dynamic and flexible Agile methodology.

Drawing inspiration from T J Gandomani et al suggested framework, shaped by the PDCA (Plan-Do-Check-Adjust) methodology, this action research study underscores the significance of iterative cycles in the selection, adaptation, assessment, and adjustment of practices [31]. Complementing the Agile framework is the methodological backbone of action research. This systematic and iterative approach, involving cycles of diagnosis, planning, action taken, evaluation, and learning, stands as a robust guide for actively engaging stakeholders in the transformation process. Action research facilitates collaboration, reflection, and adaptation, aligning seamlessly with the dynamic nature of Agile principles. It serves as more than just a methodological choice; it becomes a philosophy guiding the study to actively participate in and influence the evolving landscape of Agile adoption.

The waterfall model, a traditional plan-driven approach, provides a contrasting backdrop against which the benefits and challenges of Agile adoption are measured. This model, with its sequential phases and rigid structure, sets the stage for understanding the limitations that Agile seeks to address. Concurrently, the Scrum framework, a specific Agile methodology chosen for this study, introduces a structured approach to Agile implementation. With its distinctive roles, events, and artifacts, Scrum guides the team through the intricacies of Agile practices.

Continuous improvement, a central tenet of Agile philosophy, underpins the entire theoretical framework. Regular reflection, adaptation, and refinement, inherent in both Agile and action research, create a cyclical process of enhancement. Stakeholder engagement, another pivotal aspect, ensures that the study incorporates diverse perspectives and fosters a sense of ownership among team members. Lastly, productivity and efficiency metrics serve as tangible indicators for evaluating the impact of Agile adoption, providing a quantitative dimension to the qualitative insights garnered through the study. Together, these theoretical underpinnings form a comprehensive framework, guiding the exploration of the Agile transition journey within the context of action research.

IV. SUMMARY OF ACTION RESEARCH CYCLES

The focus of this research paper is on four key action research cycles: Assemble, Initiate, Build, and Enhance. These cycles represent distinct phases within the Agile transformation process, wherein specific goals and activities are undertaken. Acting as a guiding roadmap, the stages of planning, implementation, and refinement are navigated through these cycles.

In the first cycle, Assemble, the groundwork is laid for the Agile transformation. This phase involves the identification of crucial stakeholders, sponsors, and champions who will spearhead the initiative. A dedicated team is carefully assembled, ensuring robust support and alignment with the organization's strategic objectives. During this stage, the vision and goals of the Agile transformation are clearly defined, specific roles and responsibilities are assigned to each team member,

and training initiatives are initiated to equip the team with essential Agile principles and practices.

Building upon the foundational steps of the Assemble cycle, the second phase, Initiate, signifies the commencement of the Agile transformation journey. In this critical stage, an initial assessment of the organization's readiness for Agile adoption is meticulously conducted. This assessment yields valuable insights into the current state, potential challenges, and identifies suitable strategies for a successful transition. Notably, the Initiate cycle introduces a pivotal element — an Agile pilot project. This project serves as a controlled experiment, allowing the team to test and validate Agile practices in a real-world scenario. Simultaneously, an Agile transition plan is meticulously developed, delineating specific activities, timelines, and success criteria. The implementation of training and education initiatives takes centre stage during this phase, fostering a shared understanding and commitment to the Agile journey among team members.

Entering the third cycle, Build, the focus shifts to the practical implementation of Agile methodologies. Building upon experiences from previous cycles, Agile ceremonies and practices, including daily stand-ups, sprint planning, and retrospectives, are refined. Collaboration tools and techniques are actively employed to enhance communication and coordination among team members. The Build cycle underscores the importance of transparency, collaboration, and continuous improvement as the team becomes more accustomed to Agile practices. Following the successful execution of the pilot project in Cycle 2, the plan is to extend the Agile transition to all remaining projects.

Lastly, the fourth cycle, Enhance, represents an ongoing phase of continuous improvement and scaling of Agile practices. Within this cycle, the effectiveness of Agile implementation is evaluated through metrics and assessments. Feedback is collected from team members, stakeholders, and customers to identify areas for improvement and refine Agile practices. Lessons learned and best practices are disseminated across the organization, fostering a culture of learning and adaptability. The Enhance cycle encourages the optimization of Agile practices, leading to greater success in the Agile transformation journey.

The action research cycles are summarised in Table 1.

TABLE 1. Action Research Cycles

Action Research Cycle	Time Period	Duration
Cycle 1: Assemble	Jul 2019 – Sep 2019	3 Months
Cycle 2: Initiate	Oct 2019 – Dec 2019	3 Months
Cycle 3: Build	Jan 2020 – Jun 2020	6 Months
Cycle 4: Enhance	Jul 2020 – Jun 2021	12 Months

V. EXECUTION OF ACTION RESEARCH CYCLES

In this section, a detailed exploration is conducted into the thoughtfully designed action research cycles: Assemble, Initiate, Build, and Enhance. Each cycle undergoes thorough examination across five distinct phases: Diagnosis, Action Planning, Action Taken, Evaluation, and Learnings. This section offers a detailed insight into decisions made, actions taken, and subsequent outcome evaluations, presenting a comprehensive view of the Agile transition journey. It will illuminate the challenges faced, strategies employed, and valuable insights gained at each phase.

A. ACTION RESEARCH CYCLE 1: ASSEMBLE

During Cycle 1 of the Agile transition, known as ASSEMBLE, the primary focus was on preparing the team for the impending transformation. The ASSEMBLE cycle encompassed the execution of the ensuing action research phases.

1) DIAGNOSIS

In the diagnosis phase of Cycle 1, the primary emphasis was on evaluating the team's preparedness for the impending Agile transition. The central question addressed was, *"How can we effectively equip the team for a successful Agile transformation?"* This entailed a comprehensive analysis of the team's existing state, pinpointing areas necessitating attention and enhancement. Additionally, it was recognized that training was imperative to ensure the team's understanding of Agile principles and their practical application to ongoing projects.

2) ACTION PLANNING

Based on the diagnosis, an action plan was formulated to guide the Agile transition process. The plan included comprehensive Agile training for team members, aiming to equip them with the necessary knowledge and skills to embrace Agile principles and practices. Additionally, defining Agile roles, such as Scrum Master, Product Owner, and Architects, played a crucial role in clarifying responsibilities and promoting collaboration.

3) ACTION TAKEN

During this phase, the planned actions were implemented. The team members underwent Agile training, which provided them with a solid foundation for the transition. Agile roles were assigned to streamline workflow and enhance team organization and efficiency.

4) EVALUATION

In assessing the effectiveness of Cycle 1, a comprehensive analysis of relevant data was conducted. The focus extended to the outcomes of training sessions, team preparedness for Agile practices, and the anticipated challenges of the impending transition. By concentrating on these aspects, the evaluation aimed to glean insights into the team's readiness for the Agile journey and identify areas for enhancement in the subsequent cycles of the transition process.

5) LEARNINGS

In the Learnings phase, Cycle 1 illuminated several key insights that shaped the Agile transition journey. The impor-

tance of comprehensive Agile training emerged prominently, as it not only equipped the team with essential knowledge but also fostered a shared understanding of Agile principles. Clear delineation of Agile roles proved instrumental in streamlining collaboration and enhancing accountability. Additionally, the significance of effective communication and regular feedback became apparent, paving the way for improved team dynamics. The evaluation process, with its focus on project metrics and stakeholder satisfaction, acted as a compass for continuous learning, guiding the team towards further refinements. The adaptability and openness of the team to embrace change were recognized as crucial factors in the success of the Agile transition, emphasizing the need for a culture that values continuous improvement and embraces the Agile mindset.

B. ACTION RESEARCH CYCLE 2: INITIATE

During the INITIATE cycle, which marks the second phase of the Agile transition, the primary emphasis was on kick-starting the Agile transformation. This involved a meticulous exploration of the most effective approaches and a thorough validation of the feasibility of Agile practices within the team. A significant aspect of this cycle revolved around the initiation of the Agile transformation process through the strategic implementation of action research phases. These phases were designed to provide a comprehensive overview of the steps taken to initiate the Agile transformation journey. Central to this initiation was the experimentation with a pilot project, a crucial step that allowed the team to test and validate Agile methodologies in a controlled setting. The outcomes and learnings from this pilot project would serve as the foundation for extending Agile practices to other projects within the team. The execution of the following action research phases was integral to the INITIATE cycle.

1) DIAGNOSIS

In the Diagnosis phase of Cycle 2, INITIATE, the team strategically explored the initiation of the Agile transformation, placing a specific focus on experimenting with a pilot project. The central question guiding this phase was, *"How can the Agile transformation be effectively initiated through a pilot project?"* This necessitated a comprehensive exploration of the existing state, a discerning identification of potential challenges, and the formulation of a precise action plan tailored to steer the transition process successfully.

2) ACTION PLANNING

In response to the insights gained from the diagnosis, an action plan is created, concentrating notably on the meticulous planning of a pilot project. The primary objective behind this pilot initiative was to create a controlled environment, enabling rigorous testing and validation of the efficacy of Agile practices. This involved several strategic steps, including the careful selection of a specific scope, the definition of clear objectives and success criteria, the establishment of realistic timelines and milestones, the setup of essential infrastructure and tools, and the development of a comprehensive communication plan.

3) ACTION TAKEN

During the action taken phase, the team embarked on the implementation of the pilot project, putting Agile practices into action. They judiciously selected a subset of work items conducive to Agile methodologies, breaking them down into smaller, actionable tasks or user stories. The team, in this dynamic Agile environment, maintained flexibility, closely monitoring progress, adapting plans as needed, and engaging in a continuous cycle of learning and refinement of their practices throughout the pilot project.

4) EVALUATION

In the evaluation phase, the team meticulously examined the results and extracted valuable insights from the pilot project. Through this hands-on experience, they not only grasped the core Agile principles but also effectively applied Agile practices in their daily routines. The team gathered valuable insights, drawing attention to both commendable aspects and areas requiring refinement in their Agile adoption. This evaluation process encompassed feedback mechanisms such as sprint retrospectives, one-on-one meetings between team members and managers, and periodic surveys, ensuring a comprehensive assessment of the Agile practices' effectiveness.

5) LEARNINGS

The INITIATE cycle emphasized the significance of commencing the Agile transformation with a thoughtfully designed pilot project. This initiative enabled the team to not only validate the feasibility of Agile practices but also garnered invaluable insights into their effectiveness. The experiential knowledge acquired served as a robust foundation for continual improvements and adaptations in subsequent cycles, thereby ensuring a successful and progressive Agile transition.

C. ACTION RESEARCH CYCLE 3: EXECUTE

During the EXECUTE cycle, which marks the third phase of the Agile transition, the primary objective was to conclude the Agile transformation initiated in the pilot project and extend its application to a broader spectrum of projects. Leveraging the successes and benefits obtained from the initial pilot, the team aimed to fully integrate Agile methodologies into their practices. This section outlines the strategic steps taken to realize the objectives of the Agile transformation process by detailing the action research phases executed during the EXECUTE cycle:

1) DIAGNOSIS

In the diagnosis phase of Cycle 3, EXECUTE, the team dedicated efforts to include the Agile transformation across multiple projects, addressing the question: *"How can Agile*

practices be effectively scaled and integrated across multiple projects?" Strategic initiatives were formulated to ensure the effective scaling of Agile practices. This involved identifying and allocating resources optimally, defining roles clearly to enhance team dynamics, establishing robust communication channels, and addressing potential challenges in extending Agile methodologies to a broader project spectrum. The focus was on creating a comprehensive framework for Agile adoption that could be seamlessly applied across various projects within the organization.

2) ACTION PLANNING

In the Action Planning phase, the team strategically devised plans to extend the application of Agile practices, ceremonies, and principles to a diverse range of projects. The objective was to cultivate a collaborative, communicative, and empowered environment within Agile teams, tailoring practices to align with the unique requirements of each project. The emphasis lay on adapting Agile methodologies to suit the specific dynamics and challenges presented by a broader spectrum of projects.

3) ACTION TAKEN

In the Action Taken phase, the team adeptly implemented Agile methodologies across additional projects. The transition involved fostering a culture of self-organization, empowering team members to take ownership of their work and responsibilities. To achieve this, the team initiated regular sprint planning sessions, encouraging open communication and collaborative decision-making. Agile practices underwent continuous refinement through iterative project implementations, with a particular focus on enhancing daily stand-ups, sprint retrospectives, and backlog grooming sessions. Additionally, the team established cross-functional collaboration channels to ensure a holistic and streamlined approach to project delivery.

4) EVALUATION

In the Evaluation phase, the team conducted a thorough and data-driven assessment of Agile practices and overall progress. Metrics, including velocity, and burn-down charts, were scrutinized to gain quantitative insights into the efficiency and effectiveness of Agile implementation. Feedback mechanisms were robust, encompassing insights from Sprint retrospectives, regular 1:1 meetings between team members and managers, team-wide surveys, and self-assessment sessions. Challenges identified during this evaluation phase were systematically addressed through continuous improvement efforts. Collaborations with Agile coaches and external experts provided valuable perspectives and recommendations, contributing to the refinement and optimization of Agile practices. This multifaceted evaluation approach ensured a comprehensive understanding of the team's Agile journey and guided targeted enhancements in subsequent cycles.

5) LEARNINGS

The Learnings phase of Cycle 3 provided deep insights obtained from introspective activities and collaborative discussions. Key takeaways emphasized the critical significance of effective communication, seamless collaboration, and adaptability in ensuring the success of Agile projects. The team identified the pivotal role of clear and well-defined roles and responsibilities, emphasizing alignment with core Agile principles. Furthermore, a commitment to the continuous development of Agile practices emerged as an essential element for sustained improvement. These learnings served as guiding principles for the team, influencing their approach in subsequent cycles and contributing to the ongoing refinement of Agile methodologies.

D. ACTION RESEARCH CYCLE 4: ENHANCE

In the fourth cycle of the Agile transition, denoted as ENHANCE, the team directed its focus toward the perpetual betterment of Agile practices. Recognizing the significance of continuous improvement, the team aimed to cultivate a culture of ongoing enhancement within its members. Building upon the successful transition to Agile in the preceding cycle, Cycle 4 was strategically designed to address specific areas of enhancement and optimization within Agile practices. This phase recognizes the dynamic nature of Agile methodologies, where adaptability and responsiveness to evolving challenges are key. The forthcoming sections detail the meticulously executed action research phases that encapsulate the team's proactive efforts to elevate and fine-tune Agile practices during the ENHANCE cycle.

1) DIAGNOSIS

In Cycle 4, appropriately named "ENHANCE," the team diligently explored the task of consistently improving its Agile practices addressing the question: *"How can the team foster a culture of continuous improvement within its Agile processes?"* Recognizing the pivotal role of continuous improvement, the team aimed to instil a culture valuing and actively seeking ongoing enhancements. The analysis, drawing insights from metrics and retrospective feedback, uncovered specific areas for advancement. This encompassed not only refining sprint planning and communication but also optimizing the agile infrastructure, including areas like agile automation, continuous integration, and deployment. The Diagnosis phase emerged as a crucial step, not only identifying existing strengths and areas for growth but also laying the foundation for strategic action planning in subsequent phases.

2) ACTION PLANNING

In response to the insights gathered during the Diagnosis phase of Cycle 4, the Action Planning phase took shape as a strategic endeavour to chart the course for continuous improvement within the Agile framework. The team, propelled by a commitment to refinement, commenced the planning process with a holistic perspective. It involved not only addressing the nuances identified in sprint planning and com-

munication but also formulating a comprehensive strategy for optimizing the agile infrastructure.

The Action Planning phase unfolded as a collaborative effort between stakeholders and the research team. Together, they devised a clear and strategic roadmap that delved into specific interventions aimed at enhancing various facets of Agile practices. The planning process considered the intricacies of refining sprint ceremonies, bolstering communication channels, and strategically augmenting the agile infrastructure with a focus on automation, continuous integration, and deployment.

3) ACTION TAKEN

The Action Taken phase marked the execution of the meticulously crafted action plan designed during the preceding phase. As the team embarked on implementing the planned interventions, the emphasis was not only on refining sprint ceremonies and communication channels but also on bolstering the agile infrastructure, incorporating automation, continuous integration, and deployment practices.

Active collaboration between the research team and stakeholders was paramount during this phase. The planned strategies were put into motion, and the team demonstrated agility in its approach. Refinement of sprint ceremonies involved realigning team practices with agile principles, ensuring a seamless and efficient workflow. Communication channels were enhanced to foster a culture of transparency, collaboration, and rapid feedback.

Simultaneously, the team delved into optimizing the agile infrastructure. Automation processes were introduced to streamline repetitive tasks, while continuous integration and deployment practices were implemented to facilitate a more fluid and iterative development lifecycle. The Action Taken phase was characterized by a dynamic and iterative process, with the team actively monitoring progress, adapting plans as necessary, and continuously learning and refining practices.

4) EVALUATION

In the Evaluation phase of Cycle 4, the team employed various metrics and feedback mechanisms to assess the impact of their refined Agile practices:

- **Self-Assessment Surveys**: The results of self-assessment surveys indicated that the team excelled in Agile ceremonies, showcasing a strong understanding and adherence to Agile principles.
- **Retrospective Feedback**: Insights gathered from retrospective feedback highlighted the team's positive sentiment towards Agile, with members expressing a preference for Agile over the traditional waterfall model.
- **Metrics Analysis**: Comprehensive metrics analysis revealed notable improvements in feature delivery and overall team productivity, signifying the positive outcomes of the enhanced Agile practices.
- **Automation Advancements**: Automation efforts demonstrated substantial improvements, empowering the testing teams to shift focus from repetitive testing tasks to strategic activities such as scripting, thereby enhancing overall efficiency.
- **CI/CD Enhancements**: The team leveraged enhanced Continuous Integration/Continuous Deployment (CI/CD) capabilities, resulting in improved efficiency across the development lifecycle. This streamlined process facilitated faster and more reliable software releases.

5) LEARNINGS

In the Learnings phase of Cycle 4, the team gained the following valuable insights:

- **Proficiency in Agile Ceremonies**:Surveys confirmed the team's proficiency in Agile ceremonies, demonstrating a mature execution of rituals like sprint planning and retrospectives.
- **Positive Team Sentiment**: Retrospective feedback highlighted a positive shift, with team members favouring Agile for its increased collaboration and adaptability.
- **Quantifiable Improvements**: Metrics reflected overall progress in feature delivery and team productivity, validating the effectiveness of continual enhancements.
- **Empowered Testing Teams**: Automation metrics showed substantial efficiency gains, allowing testing teams to focus on strategic activities over repetitive tasks.
- **Streamlined CI/CD**: Enhanced CI/CD capabilities significantly contributed to a more efficient development life cycle and a streamlined release process.

These insights not only strengthened the team's Agile foundation but also provided targeted guidance for ongoing refinement. The team emerged from Cycle 4 with enhanced practices and a clear understanding of areas poised for continued growth.

VI. RESULTS AND INTERPRETATIONS

In this section, a comprehensive examination of the outcomes and interpretations arising from the transition journey is undertaken.

A. COMPARATIVE ANALYSIS OF PRE-AGILE AND POST-AGILE PERFORMANCE

Comparative Study involves a meticulous analysis of the team's performance in the Pre-Agile and Post-Agile Adoption phases. The "Pre-Agile" phase signifies the period before the adoption of Agile methodologies, while the "Post-Agile Adoption" phase denotes the timeframe after the incorporation of Agile practices into the development workflow. The comparative study aims to thoroughly analyse the team's performance during these two phases by examining key metrics such as defects trend, number of releases, defect lifecycle and percentage of automation executed. This analysis provides valuable insights into the tangible improvements and changes brought about by the transition to Agile methodologies.

1) DEFECT TREND

The defect trend involves analyzing patterns in the number of reported defects over a specified period, offering valuable insights into the quality of software development [32, 33]. It functions as an indicator of the effectiveness of defect management practices, showcasing the trajectory of reported issues. In Fig 1, a visual representation illustrates the defect trend, enabling a comparative analysis between the pre-Agile and post-Agile phases. A reference period of 75 days during the pre-Agile and post-Agile phases is chosen for the comparative analysis. The aim of this analysis is to assess the impact of Agile practices on the overall defect rate, furnishing essential information about the efficacy of the Agile transition in improving defect management and ensuring software quality.

The defect trend analysis reveals significant improvements in defect management following the Agile transition. The peak defects during the pre-agile period were as high as 59, with an average of 27 defects. However, in the post-agile period, the peak defects reduced to 14, with an average of 6 defects. This demonstrates a substantial decrease in defects, highlighting the positive impact of Agile practices on software quality.

The consistent reduction in both peak and average defects indicate the effectiveness of Agile methodologies in identifying and addressing issues more efficiently. Agile principles such as early and continuous testing, frequent feedback, and iterative development contribute to the early detection and resolution of defects. This allowed the team to proactively address quality issues, resulting in a significant improvement in software quality.

Furthermore, the stable state of defect counts in the post-agile period suggests that the team had established a more controlled and predictable software development process. By continuously refining their Agile practices, the team had achieved a steady state in defect management, enabling them to deliver higher quality software products.

2) NUMBER OF RELEASES

The analysis of the number of releases during the pre-agile and post-agile phases provides valuable insights into the impact of the Agile transition on the frequency of software releases. Fig 2 provides a visual representation of the quarterly release count over a span of 8 quarters.

The data on release frequency during the Agile transition clearly demonstrates a substantial increase in the number of releases per quarter. In the pre-Agile phase, the average number of releases per quarter was around 2, while in the post-Agile phase, this number consistently rose to 6 releases per quarter. This significant improvement signifies the successful implementation of Agile practices, enabling the team to deliver software increments more frequently and respond to customer needs with enhanced speed and flexibility. The higher release frequency reflects the team's improved efficiency and their ability to adapt to changing requirements in a more agile and responsive manner.

3) DEFECT LIFECYCLE

The defect lifecycle metric, capturing the journey of defects from identification to resolution, is a crucial aspect of software development [33]. It provides valuable insights into the efficiency and effectiveness of defect management processes within an organization. The time taken to detect, triage, fix, and validate defects is tracked, offering a comprehensive view of the defect resolution process.

The understanding of defect lifecycle is vital for software development teams as bottlenecks, areas for improvement, and the overall quality of the development process can be identified. The analysis of defect lifecycle data enables organizations to assess their defect management strategies, identify trends, and make informed decisions to optimize their software development practices.

Fig 3 visually presents the defect lifecycle across 12 releases, highlighting the various stages and transitions that defects undergo during the software development process.

The data clearly shows a substantial decrease in the number of days required to resolve defects during the post-Agile period compared to the pre-Agile period. This reduction indicates that the implementation of Agile practices has led to more efficient defect resolution and shorter defect lifecycles. The shorter defect lifecycles in the post-Agile period indicate an increased level of responsiveness to defect identification and resolution. Agile practices, such as daily stand-ups and regular retrospectives, have fostered a collaborative environment where defects are identified and addressed in a timely manner, leading to improved software quality.

4) AUTOMATION PERCENTAGE

The metric of automation percentage, representing the proportion of automated testing in relation to the overall testing effort, was analyzed to assess the level of automation implemented during the pre-agile and post-agile phases. Automation percentage is defined as the ratio of automated test cases to the total number of test cases, providing insights into the extent of automated testing within a software development process. This metric serves as a crucial indicator of testing efficiency and resource optimization. The objective of this analysis was to comprehend the impact of Agile adoption on the automation practices within the organization. Fig 4 and 5 illustrate the automation percentage during the pre-Agile and post-Agile phases, respectively.

The data collected during the pre-Agile phase revealed relatively lower automation percentages, indicating a higher reliance on manual processes. This finding aligns with the common challenges faced by organizations prior to adopting Agile methodologies, where manual efforts dominated the development and testing activities.

However, with the implementation of Agile methodologies, a significant improvement in automation percentages was observed. The data from the post-agile phase exhibited a consistent upward trend, indicating a deliberate focus on automation and the successful integration of Agile.

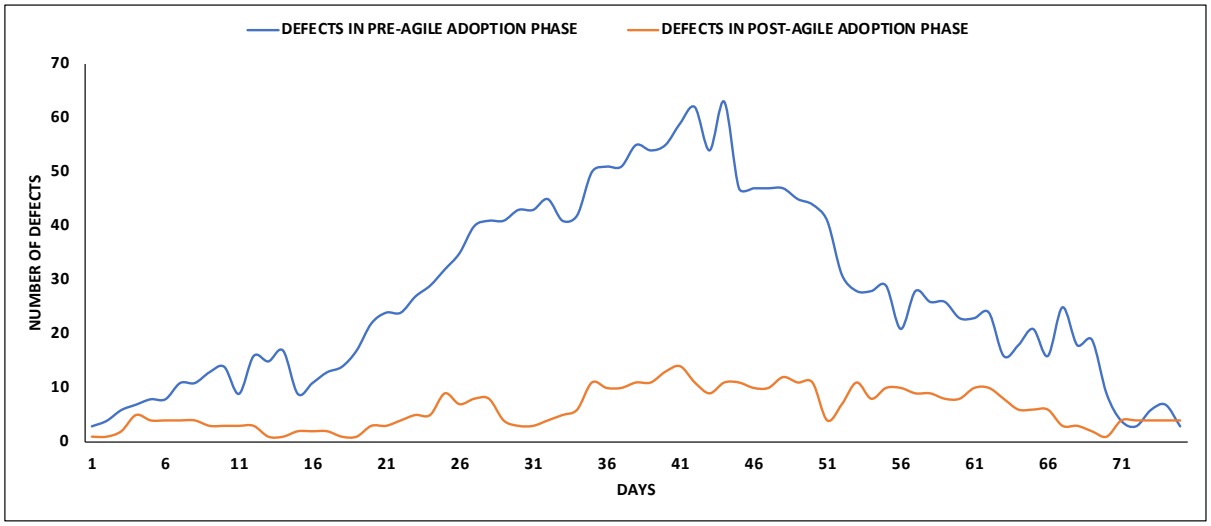

FIGURE 1. **Defect Trend in Pre-Agile and Post-Agile Adoption**

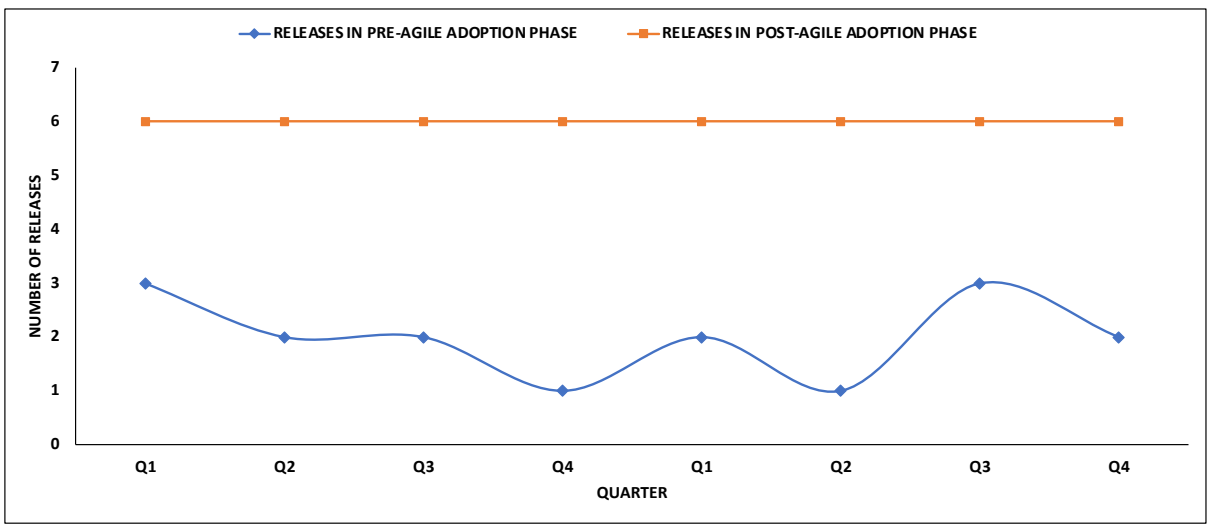

FIGURE 2. **Number of Releases in Pre-Agile and Post-Agile Adoption**

Following the implementation of Agile methodologies, a remarkable enhancement in automation percentages became evident. The data obtained from the post-Agile phase consistently portrayed an upward trend, reflecting a deliberate emphasis on automation and the successful assimilation of Agile principles into the development process.

The surge in automation percentages post-Agile signifies a heightened reliance on automated testing. This shift is indicative of potential benefits such as accelerated feedback cycles, minimized manual testing efforts, and an overall improvement in software quality. This evaluation provides valuable insights into the transformative journey of testing practices during the Agile transition, illuminating the organization's dedication to bolstering efficiency and upholding software quality standards.

The notable increase in automation percentages during the post-Agile phase highlights the successful transition to a more automated development environment. The integration of automated tools, frameworks, and practices has played a pivotal role in fostering increased efficiency, reduced time-to-market, and an overall enhancement of software quality. This substantiates the successful execution of Agile methodologies and showcases the organization's commitment to embracing modern development practices for sustained excellence.

B. ANALYZING TEAM PROGRESS: TRANSITIONING FROM ADOPTING TO EMBRACING AGILE PRACTICES

Exploring the team's evolution from initial adoption to a more profound acceptance of Agile practices, this section investigates crucial metrics. Metrics including the Burndown Chart, Velocity, Say-Do Ratio, In-sprint Automation, Defect Density, Execution Maturity, and Defect-less Stories are in-

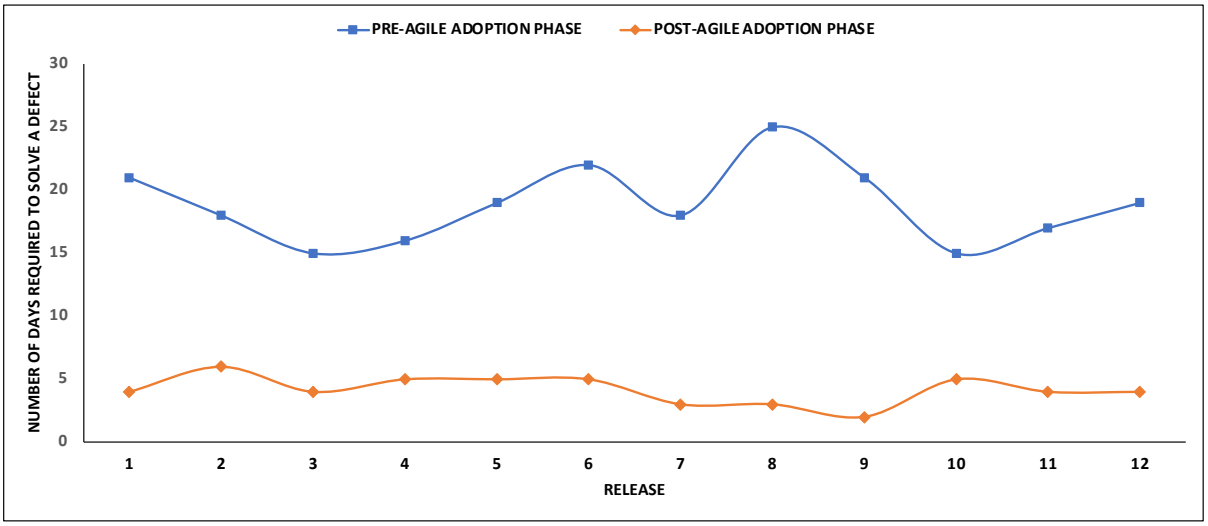

FIGURE 3. **Defect Lifecycle during Pre-Agile and Post-Agile Adoption**

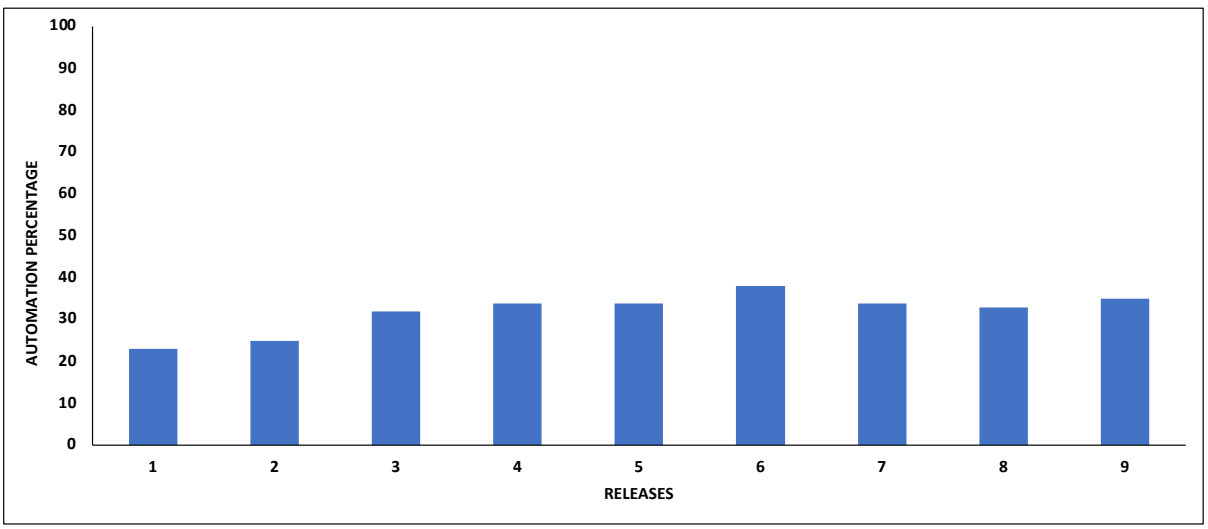

FIGURE 4. **Automation Percentage during Pre-Agile Adoption Period**

tricately examined. These metrics contribute to a nuanced understanding of the team's progress and effectiveness in embracing Agile practices.

1) BURNDOWN CHART

The Burndown chart, a vital instrument in Agile project management, visually represents a team's progress throughout a sprint, providing a dynamic depiction of work completion against time [34]. This chart is instrumental in offering real-time insights into a team's ability to meet its sprint goals. It is constructed by plotting the work planned against the time available, enabling teams to track their performance and make informed decisions. In this comparative analysis, the Burndown charts for June 2020 and June 2021 are meticulously examined to discern the evolution of the team's efficiency in both adopting and embracing Agile practices. This scrutiny of the Burndown charts serves as a valuable lens into the team's adaptive journey, illustrating their responsiveness to changing requirements and iterative improvement.

June 2020 signifies the initial phase of the team's Agile journey, and Fig 6 visually showcases their initial adoption of Agile practices through the Burndown chart. The sprint begins with a backlog of 170 story points, and over the course of ten days, the team diligently works through the tasks. The chart displays a distinctive downward trend as story points are completed, yet there are noticeable fluctuations in the completion rate.

Notably, the team faces challenges during the mid-sprint phase, where the completion rate temporarily slows. However, a remarkable surge towards the end of the sprint results in the successful completion of all planned story points. The actual trajectory is not aligned to the ideal burndown line,

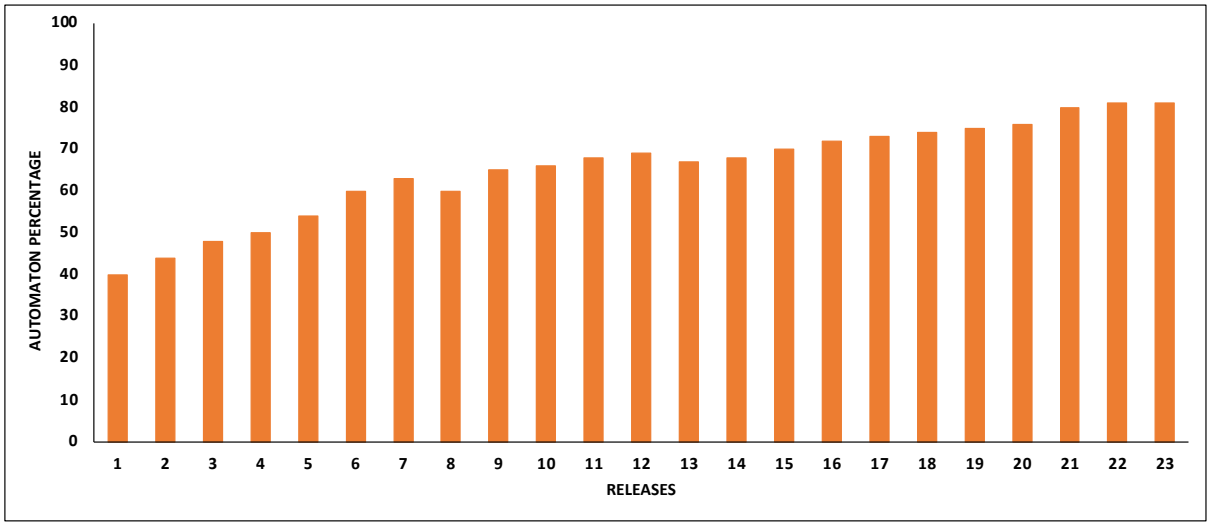

FIGURE 5. **Automation Percentage during Post-Agile Adoption Period**

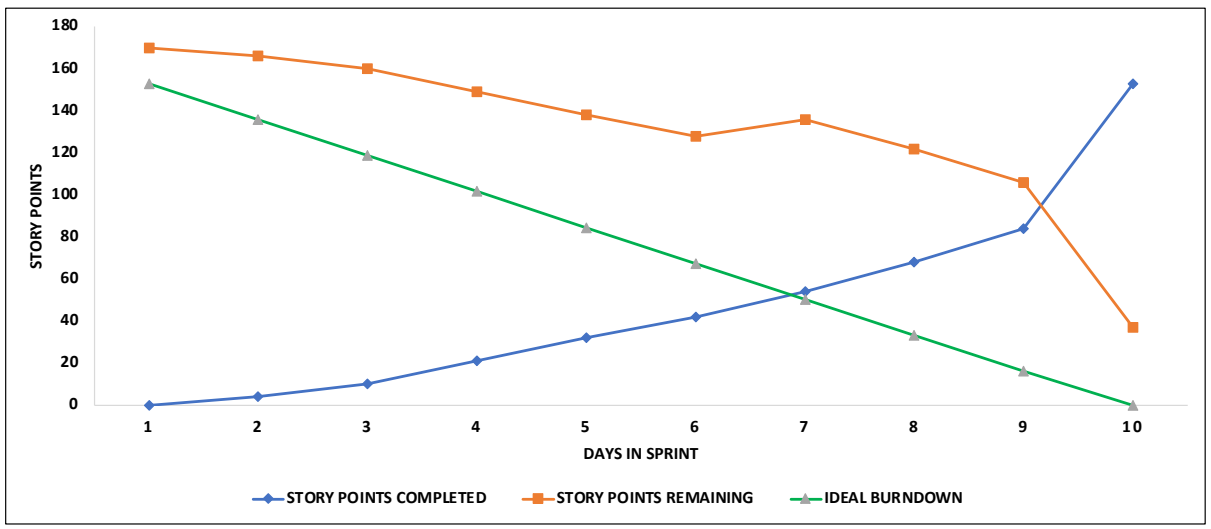

FIGURE 6. **Burndown chart in June 2020**

indicating that there is room for improvement in the team's Sprint execution. Additionally, the team should focus on enhancing their ability to recover from setbacks.

Fast forward to June 2021, and the Burndown chart depicted in Fig 7 reveals a more refined and consistent approach to Agile execution. The sprint begins with a backlog of 94 story points, and the team proceeds to complete tasks with a steady and controlled pace. Unlike the fluctuations observed in the previous year, the completion rate in June 2021 follows a smoother trajectory.

The team's ability to maintain a consistent pace throughout the sprint is evident, with minimal deviations from the ideal burndown line. By the tenth day, the team successfully completes all planned story points, demonstrating a higher level of maturity and control in Agile practices.

Comparing the two Burndown charts provides valuable insights into the team's progress in transitioning from adopting to embracing Agile practices. June 2021 reflects a more stable and predictable workflow, indicating a higher level of maturity in Agile execution. The team has moved beyond initial challenges and fluctuations, embracing a steady and controlled pace for delivering work.

This evolution in Burndown chart patterns suggests that the team has not only adopted Agile practices but has internalized and optimized them, resulting in improved predictability and efficiency. The journey from June 2020 to June 2021 signifies the team's growth and maturation in Agile methodologies, setting the stage for continued success in future sprints.

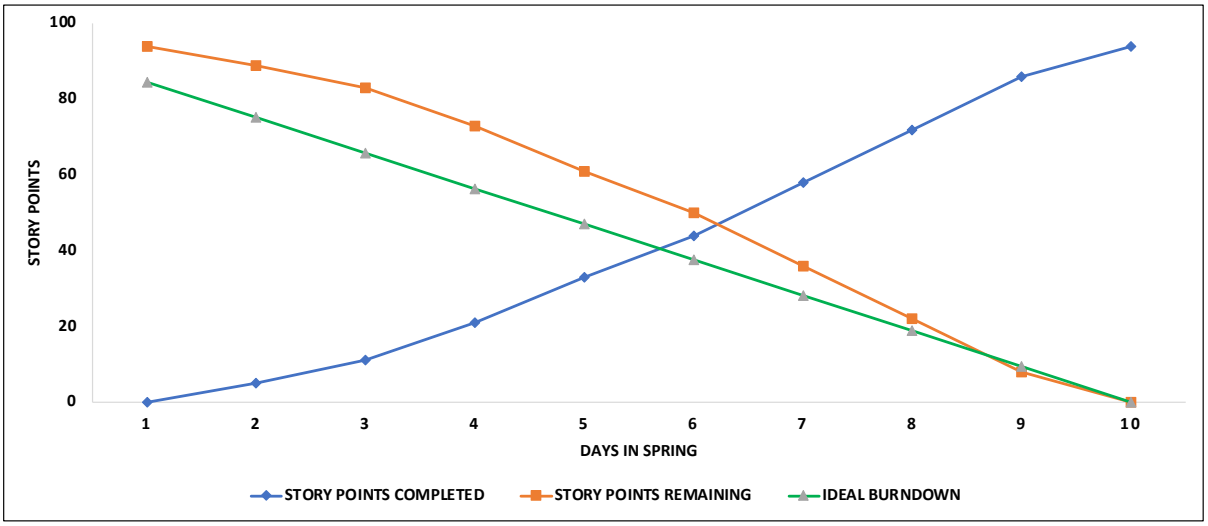

FIGURE 7. Burndown chart in June 2021

2) EXECUTION MATURITY ANALYSIS USING BURNDOWN CHARTS

Execution maturity, a pivotal dimension in Agile methodologies, is intricately linked with a team's performance, and a key gauge of this is the intersection point on the Burndown chart. This critical juncture represents the day within a sprint when the team's completed work aligns with the ideal trajectory, serving as a tangible indicator of their efficiency in meeting sprint goals. The intersection point is a significant milestone reflecting the team's ability to manage workload and adapt to evolving requirements. The evolution of execution maturity is illuminated by a comparative analysis of the intersection points on Burndown charts for 2020 and 2021. In Fig 8, a visual representation offers insights into the team's journey, showcasing the tracking of intersection points on the Burndown charts. This comparative exploration delves into the team's capacity for iterative improvement and adaptability, providing a nuanced understanding of their maturation in executing Agile practices over time.

In the Sprint 1 of 2020, the team demonstrates an initial intersection on Day 8, indicating that they could not achieve an alignment with the ideal trajectory during the course of Sprint execution. As subsequent sprints unfold, the team undergoes consistent efforts to enhance execution maturity, yet the intersection points persistently range from Day 7 to Day 9. Notably, by Sprint 6, the team achieves an intersection on Day 7, showcasing a trend towards improved efficiency and synchronization with the ideal trajectory.

Advancing to 2021, the team showcases a refined execution maturity. In Sprint 1, the intersection occurs on Day 5, highlighting a more rapid alignment with the ideal trajectory compared to the previous year. As the sprints unfold, the team maintains a consistently earlier intersection point, ranging from Day 5 to Day 7. This signifies a higher level of execution maturity, with the team consistently delivering work ahead of schedule and in closer adherence to the ideal trajectory. The ideal intersection, set at Day 6 for both years, serves as a benchmark for optimal execution maturity. In 2020, the team occasionally met the ideal intersection, but in 2021, they consistently exceeded expectations by aligning with the ideal trajectory earlier during most sprints.

Comparing the intersection points between year 2020 and 2021 reveals a significant improvement in execution maturity. In 2021, the team consistently reached intersections with the ideal trajectory earlier in the sprints, indicating enhanced efficiency, predictability, and a more refined mastery of Agile practices. This evolution in execution maturity suggests that the team has not only adopted but has embraced and optimized Agile methodologies for enhanced performance and timely delivery.

3) SAY-DO-RATIO VS VELOCITY

Within the domain of Agile practices, the Say-Do Ratio and Velocity serve as vital metrics for gauging a team's commitment to their planned work and their actual delivery performance, respectively. The Say-Do Ratio serves as a powerful indicator, revealing the team's commitment to planned tasks by measuring the alignment between stated intentions and actualized actions. It serves as a guide for the team's dedication and execution consistency [35]. At the same time, Velocity functions as an indicator of delivery efficiency, encapsulating the team's capability to transform plans into tangible results within specified timeframes [34]. The comparison of these metrics between year 2020 and 2021 offers valuable insights into the team's evolving efficiency and alignment with commitments. Fig 9 depicts the Say-Do-Ratio and Velocity during the 2020 timeframe.

In 2020, the team's Say-Do Ratio exhibited fluctuations across sprints, with values spanning from 59 to 95. The Velocity, representing the actual delivery performance, shows

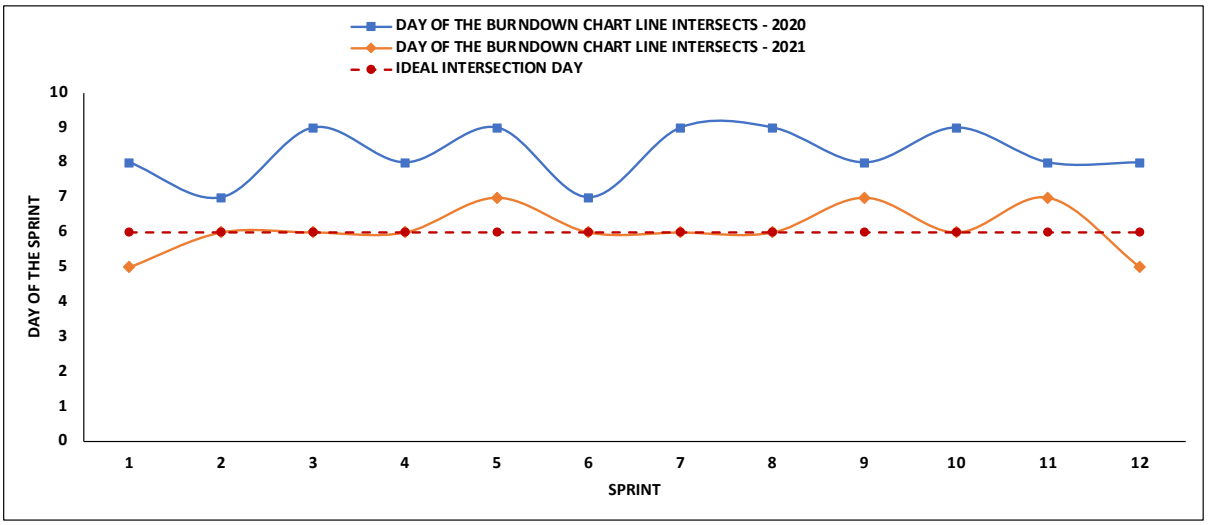

FIGURE 8. **Execution Maturity in 2020 and 2021**

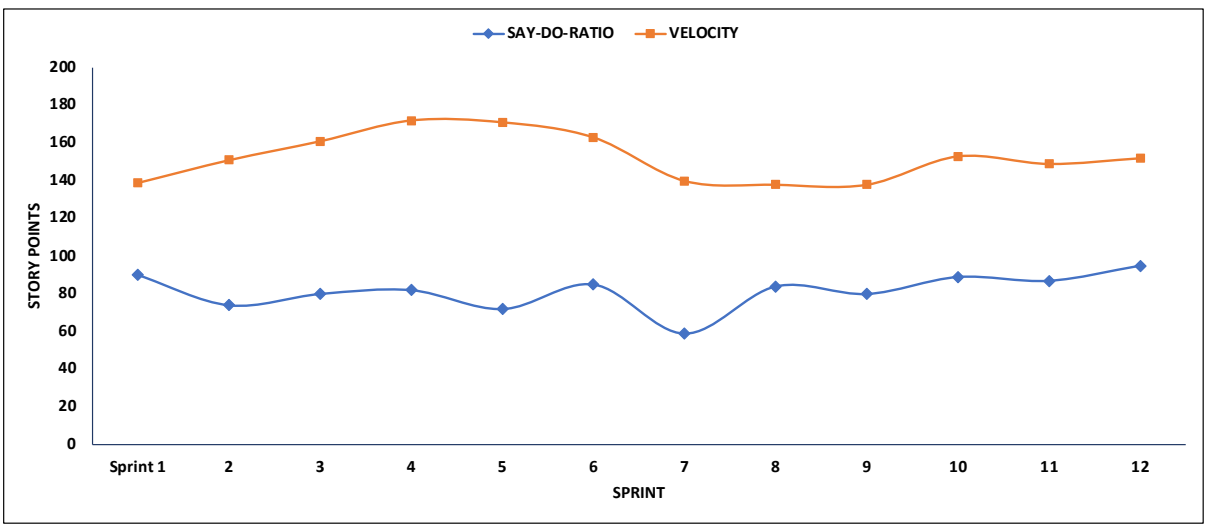

FIGURE 9. **Say-Do-Ratio and Velocity in 2020**

a parallel variation, ranging from 138 to 172. Sprint-wise, an observable pattern of synchronization is noted between the Say-Do Ratio and Velocity, with higher Say-Do Ratios often corresponding to higher Velocities.

Noteworthy is the peak in Sprint 12, where a high Say-Do Ratio of 95 aligns with a Velocity of 152, showcasing a strong commitment to planned work translated into substantial delivery. Overall, the correlation between Say-Do Ratio and Velocity in 2020 suggests a team striving to meet commitments effectively.

Advancing to 2021, the team's Say-Do Ratio depicted in Fig 10 experiences less fluctuation, ranging from 91 to 100 across sprints. In tandem, Velocity maintains a consistently high performance, fluctuating between 76 and 108. Sprint by sprint, the team showcases a remarkable alignment between Say-Do Ratio and Velocity, indicating a robust commitment translating into consistently high delivery performance.

Comparing the two years, 2021 reflects a more mature and stable state of affairs. The team not only maintains a high Say-Do Ratio but also exhibits a consistently strong Velocity, demonstrating an enhanced ability to commit to planned work and successfully deliver on those commitments.

This evolution suggests that the team has moved beyond fluctuations in commitment and delivery seen in 2020 to establish a more refined and reliable workflow. The correlation between Say-Do Ratio and Velocity in 2021 signifies a higher level of predictability, efficiency, and maturity in the team's Agile practices. This improvement bodes well for the team's ability to meet commitments and deliver valuable increments consistently.

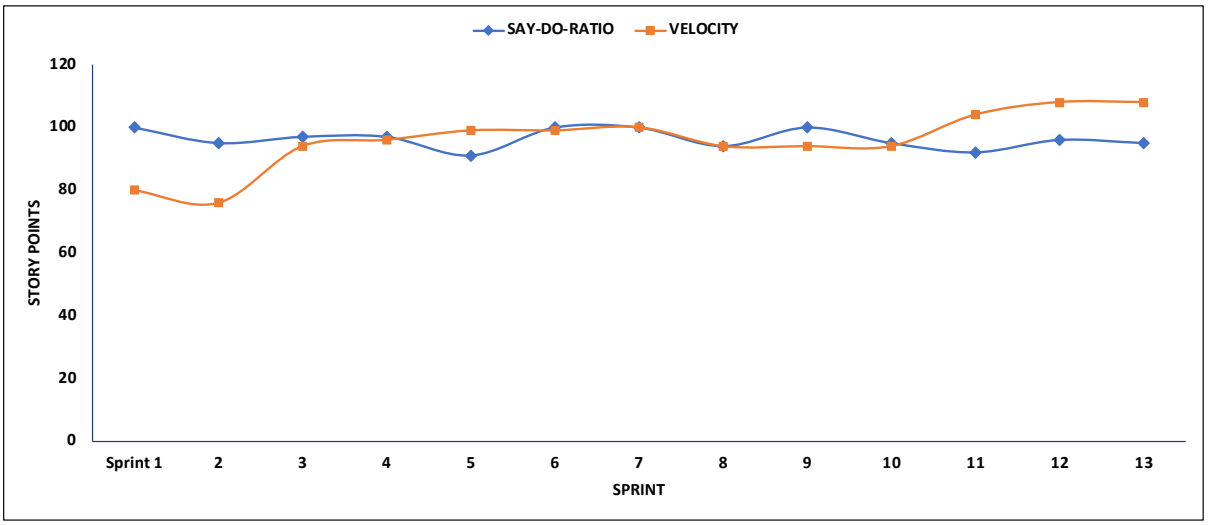

FIGURE 10. Say-Do-Ratio and Velocity in 2021

4) DEFECT DENSITY

Defect Density, a critical metric in software development, is instrumental in assessing software quality by quantifying the number of defects identified per unit of software size or functionality [36]. In the context of this study, Defect Density is specifically applied to measure the quality of software development at the story level within a sprint. A story refers to a user story, a concise, user-focused description of a software feature from an end user's perspective, typically expressed in plain language. The comparative analysis of Defect Density between the years 2020 and 2021 unveils intriguing patterns in the team's defect management. Figure 11 displays the trends in defect density for the periods of 2020 and 2021, providing a visual representation of the quality metrics over these two years.

In 2020, the journey commenced with the initial sprint exhibiting a relatively high defect density of 1.25, indicating potential challenges at the outset of the Agile adoption. As subsequent sprints unfolded, the graph depicted fluctuations in defect densities, with noticeable peaks observed in Sprint 1, Sprint 7, and Sprint 8. These variations suggested diverse challenges and areas requiring improvement in defect management and overall software quality control.

In 2021,the team showcased a consistent reduction in defect densities across all twelve sprints compared to the previous year. Particularly noteworthy were the low defect densities observed in Sprints 3, 6, and 10, reflecting optimized performance and effective defect management during these periods. The graph in 2021 demonstrates a stable and descending pattern, indicative of the team's enhanced control over the software development process and their ability to deliver high-quality software consistently.

This comparative analysis suggests that the team has not only addressed historical challenges but has also adopted effective measures to prevent and manage defects in new releases. The evolving trend towards lower Defect Densities signifies a commitment to software quality and continuous improvement in the development process. This improvement is crucial for delivering reliable and high-quality software products to end-users.

5) DEFECT-LESS STORIES

A Defect-less Story is characterized by the absence of any reported defects during a given sprint. It signifies that a user story, from conception to implementation, has successfully met the specified requirements without introducing any functional or technical issues that require correction. The Defect-less Stories metric provides valuable insights into the team's ability to deliver stories without encountering any defects during a sprint execution. The analysis of Defect-less Stories in 2020 and 2021 reveals trends and improvements in the team's defect management and overall sprint performance. Figure 12 illustrates the Defect-less metric across 12 sprints for the years 2020 and 2021.

In 2020, the team experienced varying levels of success in achieving Defect-less Stories across different sprints. Notably, Sprint 1 started with a relatively low percentage of Defect-less Stories at 0.2, indicating that a small portion of stories did not encounter any defects. Subsequent sprints saw fluctuations, with some sprints achieving higher percentages of Defect-less Stories, while others showed a decrease.

Fast forward to 2021, and there is a notable improvement in the team's ability to deliver Defect-less Stories. Many sprints consistently achieve higher percentages of Defect-less Stories, demonstrating enhanced efficiency in defect management. Sprint 6 stands out with a remarkable 0.62 Defect-less Stories percentage, indicating that a significant portion of the delivered stories in that sprint did not have any associated defects.

The Ideal Benchmark set at 0.4 serves as a target for the

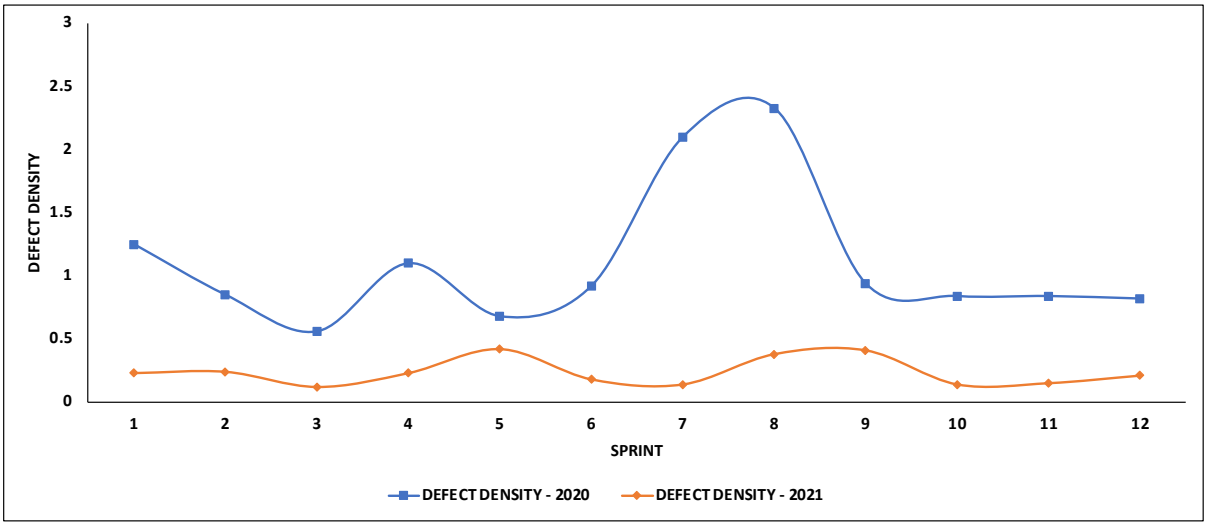

FIGURE 11. **Defect Density in 2020 and 2021**

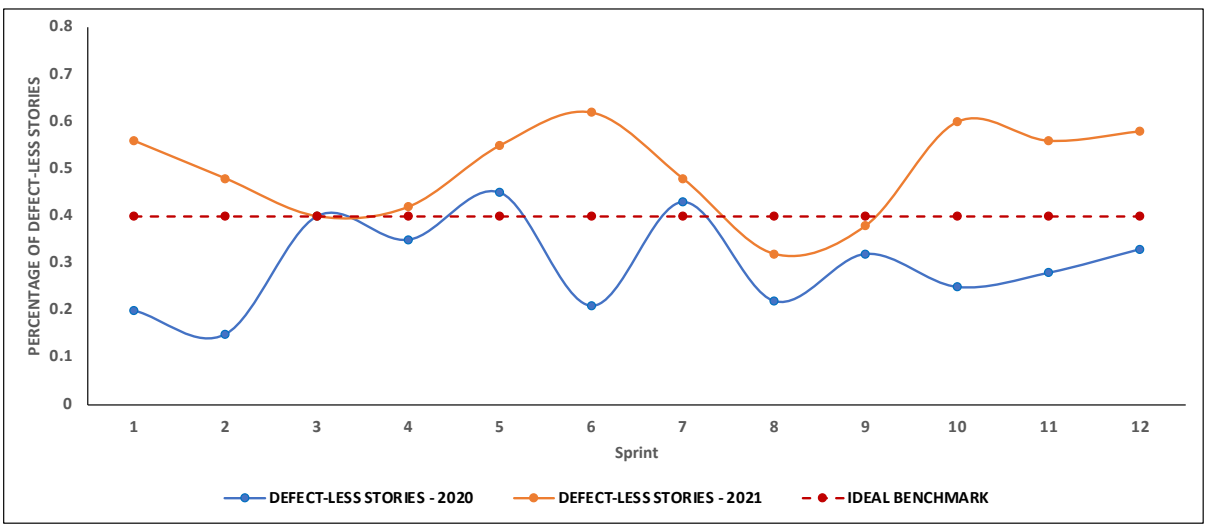

FIGURE 12. **Defect-less Stories Metric in 2020 and 2021**

team to achieve a significant percentage of Defect-less Stories in each sprint. Interestingly, some sprints in both 2020 and 2021 surpass this benchmark, showcasing instances where the team's performance exceeded expectations.

Comparing 2020 and 2021, there is a clear improvement in the team's ability to deliver Defect-less Stories consistently. The increased percentages in several sprints in 2021 suggest that the team has implemented effective defect prevention and resolution strategies. The positive trend in achieving Defect-less Stories aligns with the overall improvement observed in other metrics, such as Defect Density.

This analysis indicates a maturation in the team's defect management practices and emphasizes their commitment to delivering high-quality software by minimizing the occurrence of defects in the delivered stories. The consistent pursuit of the ideal benchmark and the surpassing of expectations in certain sprints highlight the team's dedication to continuous improvement in defect management and overall sprint performance.

C. QUALITATIVE INSIGHTS INTO AGILE ADOPTION

Examining the team's viewpoint on Agile adoption, insights are shared through self-assessment surveys, contributing to a collective understanding of our Agile journey. Additionally, experiences, challenges, and successes are expressed by individual team members in quarterly anonymous surveys. Through this combined approach, capturing both the team's overall perspective and individual insights, a comprehensive view of our Agile transition is provided.

TABLE 2. Self-Assessment Survey on Agile Performance

Agile Parameters	Assessment Areas	June 2020	June 2021
Team - Practices and Ceremonies	Daily Standup	2	3
	Sprint Planning	2	3
	Sprint Retrospective	1	3
	Sprint Demo & Review	2	3
Team Collaboration	Team Collaboration	2	3
	Delivery - Say-Do Ratio/Throughput	1	3
	Delivery Defect Ratio	2	3
	Scrum Master / Facilitator	3	3
	Product Owner - Backlog Management	2	3
	Product Owner - Collaboration	3	3
Team - Quality	Unit Testing	1	3
	Functional Testing	2	2.5
	Continuous Integration	1.5	3
	Definition of Done	1	3
Release Level	Release Planning	2.5	3
	Release Delivery	3	3
Organizational Level	Impediments	1	3
	Product Vision / Roadmaps	1	3
	Quality Improvements	2	2.5

1) Self-Assessment as a Team to Evaluate the Progress of Agile Transition

The aim was to evaluate the success of the Agile transition through a comprehensive self-assessment survey as a team. The survey focused on Agile parameters, with participants rating them on a scale of 1 to 3. Conducted over four quarters, the data allowed for meaningful comparisons and progress analysis.

- **Survey Design**:Development of a comprehensive questionnaire designed to capture essential Agile parameters and gather insights into the team's experiences.
- **Data Collection**: Administration of the survey to the entire team, with participants providing their ratings and feedback.
- **Data Analysis**: Rigorous examination of the collected data to calculate average scores for each parameter during both the first and fourth quarters.
- **Drawing Inferences**: Thorough analysis of the scores to evaluate the success of the Agile transition and identify areas for improvement and refinement.

Table 2 depicts the scores for each parameter in Q1 and Q4 and analysis of the survey scores.

The in-depth examination of score differentials between Q1 and Q4 yields a comprehensive understanding of the team's dynamic journey in Agile practices throughout the year. This comparative analysis enables us to carefully examine different aspects of the team's performance and perceive the meaningful implications arising from changes in the assigned scores.

a: POSITIVE TRENDS

The positive trends identified through the comparative analysis underscore areas where the team has demonstrated significant improvement and progress in their Agile practices from Q1 to Q4. These trends underscore the team's dedication to continuous enhancement and their adeptness in adapting and refining their processes over time.

- *Daily Stand-up*: The improvement from a score of 2 in Q1 to 3 in Q4 signifies the team's commitment to enhancing their daily stand-up meetings. This likely indicates better communication, increased participation, and a more focused approach to daily planning and coordination.
- *Sprint Planning*: The score increased from 2 in Q1 to 3 in Q4, suggesting that the team worked on improving the planning process. This positive trend indicates a more effective and efficient sprint planning process, contributing to better alignment and clarity on sprint goals.
- *Sprint Retrospective*: There was notable progress in this area, with the score increasing from 1 in Q1 to 3 in Q4. This signifies the team's enhanced ability to reflect and improve during sprint retrospectives. The positive trend suggests a proactive approach to continuous improvement and a culture of learning within the team.
- *Sprint Demo & Review*: Like the sprint retrospective, the score improved from 2 in Q1 to 3 in Q4, indicating the team's effectiveness in showcasing their work and gathering feedback. This positive trend suggests improved transparency and stakeholder engagement in the sprint review process.
- *Team Collaboration*: The score increased from 2 in Q1 to 3 in Q4, highlighting improved collaboration among team members. This positive trend indicates strengthened teamwork, better communication, and a more cohesive working environment.
- *Delivery - Say-Do Ratio/Throughput*: There was significant advancement, with the score rising from 1 in Q1 to 3 in Q4. This suggests that the team became more reliable in delivering what they committed to. The positive trend indicates enhanced predictability and consistency in meeting delivery commitments.
- *Delivery Defect Ratio*: The score improved from 2 in Q1 to 3 in Q4, indicating reduced defects in the team's deliverables. This positive trend signifies a maturation in the team's quality assurance practices, leading to higher-quality software releases and increased customer satisfaction.
- *Product Owner: Backlog Management*: The score improved from 2 in Q1 to 3 in Q4, suggesting that the team and product owner met for more grooming sessions to increase the understanding of product requirements. This positive trend indicates a proactive approach to backlog refinement, contributing to better sprint planning and execution.
- *Unit Testing*: The score increased from 1 in Q1 to 3 in Q4, indicating improvement in the team's unit testing practices. This positive trend suggests a focus on code quality and thorough testing, leading to more reliable

software.

- *Continuous Integration*: The score improved from 1.5 in Q1 to 3 in Q4, suggesting increased effectiveness in continuous integration practices. This positive trend indicates streamlined development processes, quicker identification of integration issues, and a more efficient workflow.
- *Definition of Done / Explicit Policies*: The score increased from 1 in Q1 to 3 in Q4, indicating a clearer definition of done and explicit policies within the team. This positive trend suggests improved clarity and agreement on the acceptance criteria for user stories, contributing to higher-quality deliverables.
- *Release Planning*: The score improved from 2.5 in Q1 to 3 in Q4, reflecting enhanced planning for releases. This positive trend signifies the team's commitment to aligning release plans with business objectives, improving coordination, and ensuring successful release outcomes.
- *Impediments*: The score increased from 1 in Q1 to 3 in Q4, suggesting the team's ability to effectively address impediments. This positive development indicates improved collaboration and communication within the team and with external stakeholders, resulting in quicker issue resolution.
- *Product Vision / Roadmaps*: The score improved from 1 in Q1 to 3 in Q4, indicating team and product owner worked together to increase clarity in the product vision and roadmaps. This positive trend suggests a shared understanding of long-term goals and better alignment between development efforts and overall product direction.

b: AREAS FOR FURTHER FOCUS

The identification of areas for further focus directs attention to aspects where the team has made strides but recognizes the potential for additional refinement. This section underscores the team's proactive approach to continual improvement, pinpointing specific domains that could benefit from concentrated efforts and strategic interventions in future Agile iterations.

- *Functional Testing*: While there is improvement from 2 to 2.5, the team should continue focusing on enhancing their functional testing practices to achieve higher scores. A more robust testing process contributes to increased software reliability and a higher level of product quality.
- *Quality Improvements*: While there is improvement from 2 to 2.5, there is still potential for further improvement in this area. The team should continue their efforts to enhance overall quality practices, addressing any identified areas of weakness.

c: CONSISTENT EXCELLENCE

The consistent high scores across various assessment areas in both Q1 and Q4 affirm the team's unwavering commitment to maintaining exceptional standards and practices. It showcases a stable and reliable performance that contributes to the overall success and efficiency of the team in its Agile journey.

- *Product Owner: Collaboration*: The consistent high score of 3 in both Q1 and Q4 indicates strong collaboration between the team and the Product Owner. This stable excellence suggests an ongoing positive relationship, effective communication, and shared alignment on product goals.
- *Release Delivery*: The consistent high score of 3 in both Q1 and Q4 indicates the team's continued success in delivering releases. This stability suggests that the team has maintained a reliable and efficient release delivery process throughout the year.
- *Scrum Master / Facilitator*: The score remained consistently high at 3 in both Q1 and Q4, indicating the team's satisfaction with the ScrumMaster's facilitation. This stability implies continued effective facilitation, fostering a positive team environment and removing impediments.

2) REFLECTIONS: QUARTERLY TEAM SURVEY

The Agile transition demands a shift in mindset, practices, and organizational culture. Regular evaluation of the team's performance is essential to ensure sustained effectiveness. To facilitate this evaluation, a non-anonymous survey named "Reflections" was implemented. This survey assessed the team's performance in crucial areas such as Process, Product, Innovation, People, and Leadership. The primary objective was to pinpoint challenges or gaps requiring attention and to gather insights for continuous improvement.

By bringing the team together in a conference room, Reflections facilitates face-to-face interactions and discussions. This collaborative environment allows team members to share their perspectives, exchange feedback, and gain a collective understanding of the team's strengths and areas for improvement. The open dialogue nurtured by Reflections promotes a shared sense of purpose and aligns the team towards continuous improvement.

The assessment process involved the following steps:

- **Survey Design:** The action research team identified five crucial assessment areas — process, product, innovation, people, and leadership. Team members marked their feedback on a whiteboard, categorizing sentiments as "Doing Good," "Doing Okay," or "Disaster" for each parameter.
- **Data Collection:** Participants rated each parameter, and the data collection process involved tallying the responses as "Doing Good," "Doing Okay," or "Disaster." This systematic approach provided a comprehensive view of the team's perceptions.
- **Data Analysis:** A collaborative data analysis session helped the team identify patterns and insights within each parameter. This thorough examination informed the team about current standings and areas for improvement.

- **Drawing Inferences:** The team drew meaningful inferences from the analysis, guiding subsequent actions. Defined actionable items aimed at improving scores in the next survey, emphasizing a culture of continuous improvement.

The Table 3 and 4 represents the Reflections survey conducted in quarter June 2020 and June 2021.

TABLE 3. Reflections Survey in June 2020

Assessment Area	Practice	June 2020		
		Doing Good	Doing Okay	Disaster
Process	Agile	15	20	5
	Accepting New Requirements	3	27	10
	Empowerment	8	30	2
Product	Product Quality	0	34	6
	Release Validation	8	30	2
	Delivering Value	8	29	3
	Road Map	6	31	3
Innovation	Learning	21	19	0
	Idea Generation	5	20	15
People	Team	31	9	0
	Help	32	8	0
	Appreciation	36	4	0
	Fun	8	22	10
Leadership	Support	34	6	0
	Focus	36	4	0

TABLE 4. Reflections Survey in June 2021

Assessment Area	Practice	June 2021		
		Doing Good	Doing Okay	Disaster
Process	Agile	33	7	0
	Accepting New Requirements	35	5	0
	Empowerment	34	4	2
Product	Product Quality	37	3	0
	Release Validation	36	3	1
	Delivering Value	40	0	0
	Road Map	36	4	0
Innovation	Learning	40	0	0
	Idea Generation	10	29	1
People	Team	40	0	0
	Help	40	0	0
	Appreciation	40	0	0
	Fun	35	5	0
Leadership	Support	35	5	0
	Focus	39	1	0

a: POSITIVE TRENDS

Following are the positive trends observed in the survey, representing parameters that have shown improvement compared to previous quarters. These positive trends reflect the team's commendable progress and enhanced satisfaction in various parameters, showcasing a continuous commitment to improvement and adaptability in their practices.

- *Agile Process*: The team progressed significantly from June 2020 to June 2021. Initially balanced, with 15 members indicating "Doing Good," 20 "Doing Okay," and 5 "Disaster" in June 2020, there was a notable improvement in June 2021. Now, 33 members perceive Agile practices as "Doing Good," 7 as "Doing Okay," with none marking it as a "Disaster." This signals increased satisfaction and mastery of Agile methodologies.
- *Accepting New Requirements*: The team exhibited a positive shift from June 2020 to June 2021. Initially, the majority perceived it as "Doing Okay," with 27 members, and 10 marked it as a "Disaster" in June 2020. However, by June 2021, there was a notable improvement, with 35 members perceiving it as "Doing Good," only 5 as "Doing Okay," and none indicating a "Disaster." This positive trend suggests an enhanced level of adaptability within the team, reflecting a more flexible and responsive approach to evolving requirements.
- *Product Quality*: There has been a notable improvement from June 2020 to June 2021. Initially, in June 2020, the majority perceived it as "Doing Okay," with 34 members, and 6 marked it as a "Disaster." However, by June 2021, there was a significant positive shift, with 37 members now perceiving product quality as "Doing Good," and only 3 expressing "Doing Okay." Importantly, no members marked it as a "Disaster," indicating a considerable enhancement in the team's perception of product quality, reflecting increased satisfaction and confidence in the delivered products.
- *Delivering Value*: There was a significant positive shift from June 2020 to June 2021. Initially, in June 2020, the majority, with 29 members, felt that the team was "Doing Okay," and 3 marked it as a "Disaster." However, by June 2021, there was a substantial improvement, with all 40 members now perceiving the team as "Doing Good," and none marking it as a "Disaster." This remarkable progress indicates the team's enhanced confidence in their ability to deliver the expected value to the customer. The improvement suggests a refined and more effective approach to value delivery, contributing to increased satisfaction and trust in the team's outcomes.
- *Roadmap*: There has been a noticeable improvement from June 2020 to June 2021. Initially, in June 2020, the majority of the team felt the roadmap was "Doing Okay," with 31 members, and 3 marked it as a "Disaster." However, by June 2021, there was a positive shift, with 36 members feeling "Doing Okay," and none marking it as a "Disaster." This improvement suggests that the team has made strides in refining and communicating their roadmap effectively. The enhanced satisfaction and understanding among team members indicate a more cohesive and aligned approach to planning and executing the team's strategic objectives.
- *Learning*: There has been a positive evolution from June 2020 to June 2021. Initially, in June 2020, there was a positive sentiment, with 21 members feeling "Doing Good" about learning and 5 expressing a positive outlook for idea generation. Fast forward to June 2021,

the team has achieved consistent excellence, with all 40 members perceiving learning as "Doing Good," and 10 members also marking idea generation as "Doing Good." This signifies a collective and sustained commitment to continuous learning and creative idea generation within the team, showcasing a positive and evolving mindset towards innovation and knowledge acquisition.

- *Fun*: There has been a noticeable positive shift in the "Fun" aspect from June 2020 to June 2021. Initially, in June 2020, the sentiments were mixed, with 22 members feeling "Doing Okay" and 10 marking it as a "Disaster." However, by June 2021, a significant improvement was evident, with 35 members feeling "Doing Okay," 5 marking it as "Doing Good," and none perceiving it as a "Disaster." This positive change indicates an improved team atmosphere, reflecting a more positive and engaging work environment that fosters a sense of enjoyment and camaraderie among team members.
- *Team and Leadership Support*: The assessment of team and leadership support reveals a positive trajectory from June 2020 to June 2021. This reflects a sustained and collective satisfaction with the support structures in place, highlighting the team's ability to maintain high standards of collaboration and leadership assistance over time.

b: AREAS FOR FURTHER FOCUS

The following areas warrant further focus and attention. These parameters are identified as focus areas due to the presence of at least one team member rating them as "Disaster." It is imperative for the team to prioritize these aspects and take appropriate actions to address any underlying issues effectively.

- *Empowerment*: There has been a positive transformation from June 2020 to June 2021. Initially, in June 2020, the majority perceived it as "Doing Okay," with 30 members, and 2 marked it as a "Disaster." In contrast, by June 2021, there was a notable improvement, with 34 members feeling "Doing Good," 4 expressing "Doing Okay," and 2 marking it as a "Disaster." This positive change indicates an enhanced sense of empowerment within the team, reflecting improved satisfaction and confidence in their ability to make decisions and contribute effectively.
- *Release Validation*: Notable improvements have been observed from June 2020 to June 2021. Initially, in June 2020, 30 members expressed a sentiment of "Doing Okay," while 2 members marking it as a "Disaster." However, by June 2021, there was a positive shift in outlook, with 36 members now feeling "Doing Okay," and 1 member marking it as a "Disaster." This improvement indicates that the team has worked towards refining their release validation processes, leading to a more optimistic perception of their capabilities in this area. The positive shift suggests increased efficiency and effectiveness in ensuring the quality and reliability of their releases.
- *Idea Generation*: Idea Generation: A significant improvement has transpired from June 2020 to June 2021. Initially, in June 2020, 20 members perceived idea generation as "Doing Okay," while 15 marked it as a "Disaster." However, by June 2021, a positive shift was evident, with 29 members feeling "Doing Okay," 10 marking it as "Doing Good," and only 1 member marking it as a "Disaster." The team management proactively organized periodic hackathons and fostered a culture that encourages and supports the exploration of new ideas in the development efforts. This deliberate effort contributed to the observed positive transformation in the team's approach to idea generation.

c: CONSISTENT EXCELLENCE

The following parameters have consistently received high ratings in the quarterly surveys. It is imperative for the team to persistently maintain this level of performance through continuous efforts and dedication.

- *Help and Appreciation*: The parameters of "Help" and "Appreciation" have consistently reflected excellence from June 2020 to June 2021. Initially, in June 2020, the majority of the team felt that "Help" was "Doing Good," with 32 members, and "Appreciation" was perceived positively by 36 members. This positive trend continued and even strengthened by June 2021, where all 40 members consistently perceived both "Help" and "Appreciation" as "Doing Good." This consistent excellence suggests a supportive team culture, emphasizing mutual assistance and recognition, contributing to a positive and collaborative work environment.
- *Leadership Focus*: The parameter of "Focus" has demonstrated consistent excellence from June 2020 to June 2021. Initially, in June 2020, the majority of the team perceived leadership focus as "Doing Good," with 36 members. This positive trend continued and solidified by June 2021, with all 39 members consistently perceiving leadership focus as "Doing Good." This sustained excellence indicates strong and effective leadership, with a continued ability to maintain a focused and strategic approach, fostering a sense of direction and purpose within the team.

VII. VALIDITY EVALUATION

This section critically examines the validity of the research conducted on Agile Transition within a software development team. Four important validity concerns, namely mono-operation bias, experimenter expectancies, selection bias, internal and external validity are considered and discussed.

A. MONO-OPERATION BIAS

One primary concern is the potential presence of mono-operation bias. The research was carried out in a single specific setting, which may limit the generalizability of the findings. To address this concern, it is recommended to extend the

research to include multiple teams within the same organization and across different software development organizations. By broadening the study's scope to encompass a diverse range of teams, the validity and applicability of the findings can be enhanced.

B. EXPERIMENTER EXPECTANCIES

Experimenter expectancies can introduce bias in the research. In this study, the experiment was conducted with a mature Agile team that exhibited a high willingness to adopt new initiatives, along with cohesive team leadership. However, it should be acknowledged that not all software development teams possess the same level of cooperation and leadership qualities. To mitigate this bias, future projects should carefully assess the characteristics of the teams before undertaking the research. Establishing specific criteria or prerequisites related to team maturity, cooperation, and leadership qualities can ensure a more representative sample, thereby improving the reliability and generalizability of the results.

C. SELECTION BIAS

An additional concern is the potential for selection bias. The research was conducted within a specific software development team, which may not be representative of all teams. It is important to consider that different teams may have varying levels of experience, skill sets, and prior exposure to agile practices. To mitigate this bias, future studies should aim to include a diverse range of teams, ensuring a more comprehensive representation of the software development context.

By acknowledging and addressing these validity concerns, the research aims to enhance the trustworthiness and applicability of the findings. Future studies should endeavour to expand the research scope by including multiple teams, considering specific team selection criteria, and mitigating any potential biases that may influence the outcomes of the Agile Transition research.

D. INTERNAL AND EXTERNAL VALIDITY

Internal validity is crucial in ensuring that the observed effects of the Agile transition can be directly attributed to the implemented interventions or practices. To strengthen internal validity, future research endeavors could consider incorporating control groups or adopting more rigorous experimental designs. By doing so, the study can effectively isolate the effects of specific Agile practices, thereby establishing a clearer causal relationship between these practices and the observed outcomes.

External validity is another important consideration, focusing on the extent to which the findings of the Agile Transition Action Research Study can be generalized to diverse settings or contexts. To enhance external validity, future studies should aim to include a broader range of organizations, teams, and projects. This approach should account for variations in size, industry, and cultural aspects, thereby validating the findings across different Agile environments and increasing the practical relevance and applicability of the proposed Agile transition framework.

VIII. IMPLICATIONS

The comprehensive action research study detailed in this paper holds profound implications for both academia and the software development industry. The transition from a plan-driven process to Agile methodology undertaken by the software development team offers valuable insights into the nuanced dynamics and transformative potential of Agile adoption. Here, the implications of this study are explored across various dimensions:

A. ENHANCED DEVELOPMENT APPROACH

The transition from a traditional waterfall model to Agile methodology has demonstrated tangible improvements in the development approach of the software development team. Through meticulous action research cycles, the team not only identified challenges but actively engaged in addressing them. The emphasis on flexibility, adaptability, and collaboration, which were initially constrained by the waterfall model, saw marked improvements. This suggests that a more dynamic and responsive approach, as facilitated by Agile practices, positively impacts the overall development process.

B. ITERATIVE AND PARTICIPATORY RESEARCH APPROACH

The adoption of an action research methodology has implications for the research community. The iterative and participatory nature of action research, demonstrated through the four cycles - Assemble, Initiate, Build, and Enhance, provides a robust framework for studying complex phenomena like Agile transitions. This approach offers a systematic way to engage with the evolving dynamics of a transitioning team, making it a valuable methodology for researchers studying organizational change and software development methodologies.

C. CONTINUOUS IMPROVEMENT CULTURE AND AGILE INFRASTRUCTURE

The ENHANCE cycle (Cycle 4) unearthed the significance of cultivating a culture of continuous improvement within Agile processes. By addressing the question - "How can the team foster a culture of continuous improvement within its Agile processes?" - the study emphasizes the ongoing nature of Agile improvement. Moreover, the optimization of Agile infrastructure, including agile automation, continuous integration, and deployment, showcases the importance of not only refining processes but also leveraging tools and technologies to enhance efficiency.

D. QUANTIFIABLE METRICS AND QUALITATIVE INSIGHTS

The Results and Interpretations section provides a comprehensive analysis, both quantitative and qualitative, of the Agile transition. Comparative studies between pre-Agile and post-Agile performance, metrics such as defect trends, burndown charts, and qualitative insights from self-assessment

surveys collectively offer a holistic view of the transition's impact. This data-driven approach enhances the credibility and applicability of the study's findings.

IX. CONCLUSION

In conclusion, this paper presents a thorough examination of a software development team's transition from plan-based software development (PBSD) to Agile software development (ASD) through a comprehensive action research study. The two-year journey, structured across four cycles, showcases a successful Agile adoption with positive outcomes.

A comparative analysis between Waterfall and ASD highlights the advantages of Agile practices, revealing positive shifts in defect trends, the number of releases, defect lifecycle, and total automation percentage. Furthermore, the study incorporates the insights derived from the team's self-assessment survey and quarterly team surveys, providing an additional layer of positive outcomes. These assessments underscore the team's progress in embracing Agile methodologies, contributing to enhanced communication, collaboration, and a more positive team culture. Agile improvement metrics, including the Burndown Chart, Velocity, Say-Do Ratio, In-sprint Automation, Defect Density, Execution Maturity, and Defect-less Stories, further solidify the efficacy of the Agile transition process.

Derived from the experiences gained during the transition from Waterfall to Agile Software Development (ASD), several key learnings were identified that organizations can leverage when embarking on a similar journey:

- *Cultural Adaptation*: The critical importance of cultural adaptation was highlighted by the transition journey. Embracing Agile principles necessitates a shift in mindset and values, emphasizing collaboration, adaptability, and continuous improvement. A culture conducive to Agile practices was found to be essential for driving successful adoption.
- *Continuous Learning*: Throughout the transition process, the value of continuous learning and improvement was emphasized. Agile adoption is not a one-time event but an ongoing journey of discovery and refinement. Encouraging teams to embrace a mindset of continuous learning and experimentation proved instrumental in navigating the complexities of Agile practices.
- *Leadership Engagement*: Leadership engagement and support were identified as fundamental drivers of the Agile transition. The importance of leadership commitment, active participation, and alignment with Agile values was underscored by experiences. A pivotal role in shaping the transition journey was played by leaders who championed the Agile mindset and provided resources and guidance.
- *Iterative Approach*: An iterative and incremental approach to Agile adoption allowed us to manage risk, learn from experiences, and adapt our strategies accordingly. Starting small, experimenting with Agile practices, and gradually scaling our efforts helped mitigate challenges and maximize the benefits of Agile methodologies.
- *Stakeholder Collaboration*: Stakeholder engagement throughout the transition process proved invaluable. Collaboration and alignment between development teams, management, customers, and other stakeholders fostered shared understanding and commitment to Agile principles. Regular communication and collaboration helped build trust and facilitate buy-in for Agile practices.
- *Measurement and Feedback*: Clear metrics and feedback mechanisms were established to monitor progress and evaluate the effectiveness of Agile practices. Regularly collecting feedback, measuring outcomes, and soliciting input from team members and stakeholders allowed identification of areas for improvement and adaptation of strategies accordingly.
- *Change Management*: Effective change management strategies were critical for managing resistance and facilitating smooth transitions. Transparent communication, stakeholder engagement, and proactive change management approaches addressed concerns, mitigated risks, and built momentum for Agile adoption.

In considering future work, it is imperative to conduct long-term evaluations to assess the sustainability of Agile practices. Additionally, exploring the applicability of Agile methodologies in different organizational contexts and industries could provide further insights and broaden the understanding of Agile adoption beyond the scope of this study. Continuous monitoring, learning, and adaptation will be crucial to ensuring the enduring success of Agile practices in the evolving landscape of software development.

REFERENCES

[1] S. Nerur, R. Mahapatra, and G. Mangalaraj, "Challenges of migrating to agile methodologies," *Communications of the ACM*, vol. 48, no. 5, pp. 72–78, 2005.

[2] T. J. Gandomani and M. Z. Nafchi, "Agile transition and adoption human-related challenges and issues: A Grounded Theory approach," *Computers in Human Behavior*, vol. 62, pp. 257–266, 2016.

[3] K. Beck, M. Beedle, A. van Bennekum, A. Cockburn, W. Cunningham, M. Fowler,J. Grenning, J Highsmith, A. Hunt, R. Jeffries, J. Kern, B. Marick, R.C. Martin, S. Mellor, K. Schwaber, J. Sutherland, D. Thomas, *Manifesto for Agile Software Development*, 2007. [Online]Available: https://agilemanifesto.org/

[4] S. Obrutsky and E. Erturk, "The Agile transition in software development companies: The most common barriers and how to overcome them," *Business and Management Research*, vol. 6, no. 4, p. 40, 2017.

[5] S. Nerur and V. Balijepally, "Theoretical reflections on agile development methodologies," *Communications of the ACM*, vol. 50, no. 3, pp. 79–83, 2007.

[6] M. Cohn, "Succeeding with agile: software development using Scrum". *Pearson Education*, 2010.

[7] T. Dingsøyr, S. Nerur, V. Balijepally, and N. B. Moe, "A decade of agile methodologies: Towards explaining agile software development," Dingsøyr, T., Nerur, S., Balijepally, V., & Moe, N. B. (2012). A decade of agile methodologies: Towards explaining agile software development. *Journal of systems and software*, vol. 85, no. 6, pp. 1213–1221, 2012.

[8] F. Reginaldo and G. Santos, "October). challenges in agile transformation journey: A qualitative study," in *Proceedings of the XXXIV Brazilian Symposium on Software Engineering*, 2020, pp. 11–20

[9] T. J. Gandomani, H. Zulzalil, and M. Z. Nafchi, "Agile transformation: What is it about?" in 2014 8th. *Malaysian Software Engineering Conference (MySEC)*, 2014.

[10] T. J. Gandomani, H. Zulzalil, A. A. A. Ghani, A. B. Md. Sultan, and K. Y. Sharif, "An exploratory study on managing agile transition and adoption," in *Advances in Intelligent Systems and Computing*, Cham: Springer International Publishing, 2014, pp. 177–188.

[11] S. Campanelli, D. Bassi, and F. S. Parreiras, "Agile transformation success factors: A practitioner's survey," in *Advanced Information Systems Engineering*, Cham: Springer International Publishing, 2017, pp. 364–379.

[12] M. Jovanović, A. -L. Mesquida, A. Mas and R. Colomo-Palacios, "Agile Transition and Adoption Frameworks, Issues and Factors: A Systematic Mapping," in *IEEE Access*, vol. 8, pp. 15711-15735, 2020, doi: 10.1109/ACCESS.2020.2967839.

[13] M. Pinton and A. S. Torres Junior, "Human aspects of agile transition in traditional organizations," *Journal of technology management & innovation*, vol. 15, no. 3, pp. 62–73, 2020.

[14] D. Naslund and R. Kale, "Is agile the latest management fad? A review of success factors of agile transformations," *International Journal of Quality and Service Sciences*, vol. 12, no. 4, pp. 489–504, 2020.

[15] R. Hoda and J. Noble, "Becoming agile: A grounded theory of agile transitions in practice," in 2017 *IEEE/ACM 39th International Conference on Software Engineering (ICSE)*, 2017.

[16] M. Pikkarainen, O. Salo, R. Kuusela, and P. Abrahamsson, "Strengths and barriers behind the successful agile deployment—insights from the three software intensive companies in Finland," *Empirical Software Engineering.*, vol. 17, no. 6, pp. 675–702, 2012.

[17] T. J. Gandomani, Z. Tavakoli, H. Zulzalil and H. K. Farsani, "The Role of Project Manager in Agile Software Teams: A Systematic Literature Review," in *IEEE Access*, vol. 8, pp. 117109-117121, 2020.

[18] M. Laanti, O. Salo, and P. Abrahamsson, "Agile methods rapidly replacing traditional methods at Nokia: A survey of opinions on agile transformation," *Information and Software Technology*, vol. 53, no. 3, pp. 276–290, 2011.

[19] B. Julian, J. Noble, and C. Anslow, "Agile practices in practice: Towards a theory of agile adoption and process evolution," in *Lecture Notes in Business Information Processing*, Cham: Springer International Publishing, 2019, pp. 3–18.

[20] A. Sommer, "Agile Transformation at LEGO Group: Implementing Agile methods in multiple departments changed not only processes but also employees' behavior and mindset," *Research-Technology Management*, vol. 62, no. 5, pp. 20–29, 2019.

[21] P. Diebold, S. Theobald, J. Wahl, and Y. Rausch, "Stepwise transition to agile: From three agile practices to Kanban adaptation," *Journal of Software: Evolution and Process*, vol. 31, no. 5, p. e2167, 2019.

[22] A. Anwar, A. A. Kamel, and E. Ahmed, "Agile Adoption Case Study, Pains, Challenges & Benefits," in *Proceedings of the 2nd Africa and Middle East Conference on Software Engineering*, 2016.

[23] K. Korhonen, "Evaluating the impact of an agile transformation: a longitudinal case study in a distributed context," *Software Quality Journal*, vol. 21, no. 4, pp. 599–624, 2013.

[24] G. Papadopoulos, "Moving from traditional to agile software development methodologies also on large, distributed projects," *Procedia-Social and Behavioral Sciences*, vol. 175, pp. 455–463, 2015

[25] R. (Ronxin) Chen, R. Ravichandar, and D. Proctor, "Managing the transition to the new agile business and product development model: Lessons from Cisco Systems," *Business Horizons*, vol. 59, no. 6, pp. 635–644, 2016.

[26] S. C. Misra, V. Kumar, and U. Kumar, "Identifying some important success factors in adopting agile software development practices," *Journal of systems and software*, vol. 82, no. 11, pp. 1869–1890, 2009.

[27] J. Li, N. B. Moe, and T. Dybå, "Transition from a plan-driven process to scrum: a longitudinal case study on software quality," in *Proceedings of the 2010 ACM-IEEE international symposium on empirical software engineering and measurement*, 2010, pp. 1–10.

[28] M. F. Abrar et al., "Motivators for large-scale agile adoption from management perspective: A systematic literature review," *IEEE Access*, vol. 7, pp. 22660–22674, 2019.

[29] K. Petersen, C. Gencel, N. Asghari, D. Baca, and S. Betz, "Action research as a model for industry-academia collaboration in the Software Engineering Context," *Proceedings of the 2014 international workshop on Long-term industrial collaboration on software engineering*, 2014.

[30] M. Staron, Action research in software engineering theory and applications. Cham:Springer, 2020.

[31] T. J. Gandomani and M. Z. Nafchi, "An empirically-developed framework for Agile transition and adoption: A Grounded Theory approach," *Journal of Systems and Software*, vol. 107, pp. 204–219, 2015.

[32] M. Staron, W. Meding, and B. Söderqvist, "A method for forecasting defect backlog in large streamline software development projects and its industrial evaluation," *Information Software Technology*, vol. 52, no. 10, pp. 1069–1079, 2010.

[33] K. Korhonen, "Exploring defect data, quality and engagement during agile transformation at a large multisite organization," in *Lecture Notes in Business Information Processing*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2010, pp. 88–102.

[34] K. V. J. Padmini, H. M. N. Dilum Bandara, and I. Perera, "Use of software metrics in agile software development process," in 2015 *Moratuwa Engineering Research Conference (MERCon)*, 2015.

[35] J. Smart, "To Transform to Have Agility, Dont Do a Capital A, Capital T Agile Transformation", *IEEE Software*, vol. 35, no. 06, pp. 56-60, 2018.

[36] S. M. A. Shah, M. Morisio, and M. Torchiano, "The impact of process maturity on defect density," in *Proceedings of the ACM-IEEE international symposium on Empirical software engineering and measurement*, 2012.

THAMIZHINIYAN NATARAJAN received his master's degree in computer applications from the Gandhigram Rural Institute, India. He is currently pursuing his PhD from Gandhigram Rural Institute. Previously he was working as Director of Software Development in Gen Digital, India and has experience delivering products based on mobile, virtualization and eCommerce domains. His research interest include software engineering, Agile software development, Agile metrics, automated software engineering, continuous testing, behaviour driven development and continuous integration /delivery.

SHANMUGAVADIVU PICHAI serves as a Professor of Computer Science and Applications, at The Gandhigram Rural Institute (Deemed to be University), with 30 years of academic experi-ence. Her research areas include Medical Im-age amp; Data Analytics, Machine Vision, Par-allel Computing, Software Engineering, Content-Based Image Retrieval and AI Models. Dr.Pichai holds a Master's degree in Computer Applications (REC, Tiruchirapalli, 1990), Ph.D. in Digital Image Restoration (GRI-DTBU, Gandhigram, 2008), MBA (IGNOU, New Delhi 2017) and M.Sc.-Applied Psychology (Bharathiar University, Coimbatore, 2019).