

## ORGANIZATIONAL PERFORMANCE THROUGH PROJECT MANAGEMENT: THE ADDED VALUE OF TOTAL QUALITY MANAGEMENT, SIX SIGMA, AND AGILE

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### ABSTRACT

*This study aims to demonstrate that a hybrid project management framework, which integrates Total Quality Management (TQM), Six Sigma, and Agile methodologies, is more effective than traditional project management approaches in improving project outcomes related to quality, efficiency, and stakeholder satisfaction. In this regard, the research presents a hypothetical project within an organization, simulating two defined groups: control (traditional methods) and experimental (integrating TQM, Six Sigma, and Agile). The proposed case study provides a structured approach to highlight that a hybrid project management approach improves efficiency and performance at both the project implementation and organizational levels, compared to the traditional project management methodology. Research is based on generated data and statistical analyzes, with criteria defined to assess improvements in quality, efficiency, and stakeholder satisfaction. A key strength of the research is that the analysis includes User Acceptance Testing (UAT) and two statistical tests: *t*-tests and *p*-value tests, to identify statistically significant differences between the traditional and hybrid groups. The findings indicate that the integrated methodology significantly improves the project results in all measured criteria. Specifically, it improves deliverable quality, reduces project completion time and costs, increases stakeholder satisfaction, and suggests that the integration of proposed methodologies redefines best practices in project management, offering a more effective alternative to traditional approaches. In general, the results highlight the potential of the combined approach to improve project management practices and deliver better results, contributing to a deeper understanding of how the integration of modern methodologies redefines success in project management.*

**KEYWORDS:** *Agile, Hybrid, Project Management, Six Sigma, Total Quality Management.*

**DOI:** [10.24818/IMC/2024/01.02](https://doi.org/10.24818/IMC/2024/01.02)

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### 1. INTRODUCTION

In today's highly competitive business environment, organizations continuously seek methods to enhance their performance and achieve sustainable success. Project management has become an essential discipline in this regard, providing structured approaches to efficiently planning, executing, and closing projects. Becker et al. (2024) highlight the definitions of the term "Project management" as shown in Figure 1.

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Term label	Term definition	Glossary
Project management	The application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.	PMBOK
Project management	The application of processes, methods, knowledge, skills and experience to achieve specific objectives for change.	APM
Project management	Project management involves *the application of methods and management tools (administration task), *techniques and concepts of leadership (leadership task) and *integration of the competences ... [continues]	IAPM
Project management	The planning, delegating, monitoring and control of all aspects of the project, and the motivation of those involved, to achieve the project objectives within the expected performance targets for time, cost, quality, scope, benefits and risk.	PRINCE2

**Figure 1. Definitions of the term "Project management" in the four glossaries**

*Source: Becker et al. (2024, p.11)*

However, traditional project management methodologies alone can no longer address the dynamic and complex challenges faced by modern organizations. In today's landscape, hybrid approaches of project management are common.

Moreover, project management and project quality management are improving as technology and project management techniques evolve. It is essential to manage the quality of a project throughout its lifecycle, along with all project activities. (Alharthi & Khayyat, 2022). Therefore, project quality management can thus be defined as the integration of the concepts of quality and project management and involves three processes, namely, quality planning, quality assurance, and quality control.

This article explores the integration of three advanced methodologies, Total Quality Management (TQM), Six Sigma, and Agile, into project management to boost organizational performance. Total Quality Management (TQM) is a management approach that focuses on continuous improvement, customer satisfaction, and the participation of all employees in the quality process at the organizational level. Six Sigma, on the other hand, provides a data-driven approach to reducing defects and variability in processes, aiming at near-perfection in product and service delivery. The Agile methodology, known for its flexibility and iterative processes, facilitates rapid adaptation to changing project requirements and enhances team collaboration.

The article proposes to analyze whether the combined project management framework that integrates Total Quality Management (TQM), Six Sigma, and Agile methodologies is more effective than traditional project management approaches in improving project results by referring to quality, efficiency, and stakeholder satisfaction. This primary research question demonstrates whether the combination of TQM, Six Sigma, and Agile methodologies can deliver better results than the traditional project management method. The idea of the study is to perform a detailed analysis between hybrid and traditional frameworks by evaluating improvements in various metrics, contributing to a wider understanding of effective project management in practice.

## 2. LITERATURE REVIEW

Aspects related to project management have been addressed in the specialized literature. Zerjav et al. (2023) brought to attention a virtual collection of review articles relevant to project management. The authors emphasize the importance of review articles in mapping, assessing, and synthesizing existing research to identify future research paths. By focusing on systematic and bibliometric reviews from the past six years (2017-2022), the research covers a variety of topics and methodologies that contribute to project management research. The selected articles are grouped into four primary clusters: perspectives on project management, project networks, project governance in organizations, leadership, decision making, and learning. Each cluster highlights key theoretical contributions and identifies trends and gaps in the literature. The article provides an extensive overview of research topics within project management, moving beyond the traditional focus on single projects, offering a multidimensional approach that permits understanding the complexities of project management in

contemporary contexts. The discussion of the miner–prospector continuum suggests that while systematic reviews dominate, there is significant potential for creative methodological approaches that explore uncharted theoretical territories. The authors outline best practices for conducting literature reviews, including a well-justified rationale, a clear intention of contribution, and a comprehensive methodology.

Although some articles underline the correlation between project management and project success, Kaufmann and Kock (2022) study the causal impact of project management effort on project profitability. The authors mention that project profitability is a crucial component of project success because companies that operate through projects must maintain profitability to sustain long-term operations. Additionally, project profitability serves as a definitive measure of overall project success. The research conducted within the context of engineer-to-order (ETO) projects reveals that increased project management effort leads to higher project profitability, although the marginal impact of additional effort diminishes as the level of effort increases. In addition, the research highlights that the positive influence of the project management effort is more pronounced in projects with greater complexity, suggesting that effective project management is particularly essential in complex environments. It contributes significantly to understanding how project management efforts translate into economic benefits, particularly under varying degrees of project complexity.

Ika and Munro (2022) analyze how project management can be applied effectively to respond to great challenges such as sustainable development and the COVID-19 pandemic. The authors identified two significant aspects in the current field of project management: a predominant focus on conventional projects instead of more innovative, high-risk endeavors and a gap between academic rigor and practical relevance. By examining large-scale initiatives such as global vaccine development and national vaccination campaigns, the article provides five key insights to improve project management practices. These insights include the need for optimism, the importance of strategic agility, and the need for collaborative rationality over linear approaches. The authors propose a detailed research agenda to develop a theoretical framework for managing grand challenge projects, highlighting the importance of flexibility, stakeholder collaboration, and continuous adaptation.

Through a systematic review of the specialized literature on European Project Management (EPM), Cojoacă et al. (2023) aim to identify, evaluate, and synthesize existing research related to European funding projects, with a special focus on Romania. Semi-automated and manual techniques are used to filter and identify critical factors for EPM. The research reveals the important role of European funding for Romania's social and economic development, mentioning the context of bureaucracy, corruption, and administrative capacity. The article analyzes the factors that contribute to the success of European funding projects and offers practical perspectives and strategies to improve project management and efficiency of EU funding in Romania.

Manița et al. (2022) focus on the efficiency of project implementation in the Romanian IT industry. The authors underscore the complexity of IT projects as a result of digitalization and the need to implement adequate project management strategies to ensure project success. Based on a systematic review of the literature, the research paper identifies key elements that contribute to the successful implementation of IT projects. The setting of clear objectives, adequate planning, efficient communication, risk management, quality control, and time and costs management are identified as key elements. The study emphasizes the importance of efficient tools, instruments, and processes, namely, planning, scheduling, implementation, and monitoring. Furthermore, the authors mention the development of the IT industry in Romania and its ability to deliver successful IT projects.

Highlighting the importance of quality management in IT project management, Alharthi and Khayyat (2022) explore how quality standards, reviews, and monitoring throughout the project lifecycle can ensure client satisfaction and successful completion of the project. The study reveals the correlation between project management and quality management and shows how the effective use of quality

tools and standards increases organizational maturity and project results. Agile methodologies are considered very important contributors to quality assurance.

The concept of project success is frequently approached in the literature, as Beleiu (2020) demonstrates. Taking into account the high failure rates and associated significant financial losses, the research addresses the increasing interest among researchers and also among practitioners. As the number of projects implemented in various fields grows, this trend is expected to continue. Several definitions and criteria for project success are emphasized, considering the complexity of the topic and also the fact that it is influenced by multiple factors. To establish generally accepted success criteria and factors, more empirical research and systematic reviews of the literature are needed.

Ika and Pinto (2022) seek to redefine and re-calibrate the concept of project success in the context of modern project management. The authors emphasize that a more holistic framework is needed due to the complex and dynamic nature of project success, and considering stakeholder expectations and sustainability aspects. Criteria such as time, cost, and quality (the "iron triangle") are not suitable for the dynamic nature of project success, particularly in the face of evolving stakeholder expectations and sustainability concerns. The research proposes the four-dimensional model of project success (Tesseract), which includes the realization of benefits, stakeholder perceptions, issues of timing and sustainability (green impacts). The authors aim to provide a comprehensive approach that integrates various dimensions of success, ensuring that projects deliver value not only in the short term, as the project manager and suppliers focus (e.g., project plan success) or in the medium term, as the project owner usually focus (e.g., business case success), but also in the long term, envisaged by the project funder (e.g., green efficacy). The study reflects the importance of considering various stakeholder perspectives when evaluating project success, taking into account their different expectations and definitions of success.

Mokhtar and Khayyat (2022) explore the efficiency of Waterfall and Agile methodologies in a medium insurance company from Saudi Arabia. Compared to the traditional Waterfall approach, the benefits of Agile are revealed in the research, especially in terms of project flexibility and client satisfaction. Agile allows rapid adjustments and continuous delivery of high-quality products, which is more appropriate to dynamic demands of the insurance industry. The case study concludes that Agile methodologies lead to better results quality and increased efficiency in project management. Sithambaram et al. (2021) investigate the challenges faced by the successful management of agile hybrid projects. Using a grounded theory approach, the authors interviewed 42 industry professionals and identified 38 unique factors that influence project outcomes, which are included in four main groups: Organization, People, Process, and Technical. The study focuses on the significant role of organizational support, the alignment of agile methods with business objectives, and the need for adequate understanding and skillsets among project stakeholders. To serve as a guide for managing agile projects, the research proposes specific methods to mitigate each identified challenge and suggests practical solutions for practitioners. The methodology, namely the grounded theory approach, ensures that the findings are related to the experiences of industry practitioners, making the conclusions and recommendations highly relevant. The authors provide a comprehensive framework to guide practitioners in effectively managing agile projects.

### **3. METHODOLOGY**

The study in this article is based on an experiment-simulated project for the development of a software platform solution as an internal tool developed to improve employee collaboration within an organization. The role of this software - platform is to facilitate communication, project management, document sharing, and other collaborative tasks within the organization for a better project management implementation process. The efficacy of the project is analyzed through a comparative

study involving two different simulating set up groups, defined as an experimental group, using a hybrid framework, and a control group, involving traditional PM methodologies.

Although the PM framework follows the tools and techniques of traditional PM methodologies, the framework integrates Total Quality Management (TQM), Six Sigma and Agile methodologies, in order to also elevate both project and organizational performance. Therefore, this study examines the impact of this combined project management framework on project outcomes through a rigorous comparative analysis with traditional methodologies. The research chosen criteria are looking to demonstrate improvements in quality, efficiency, in terms of completion time and budget adherence), and stakeholder satisfaction attributable to the hybrid framework.

Different sets of data are generated, collected, and statistically analyzed to demonstrate the research question. For generating the data, the experiment and simulation are the methodologies used in this study, as the experiment is based on a method of data generation in which we can manipulate the environment and observe the results, while the simulation is a method of data generation in which you create a computer model of a real-world process.

Data collections encompass various metrics on quality (number of tests to identify defects), efficiency (time, budget), and stakeholder satisfaction (questionnaires, feedback) from both experimental and control groups.

Statistical methods, referring to User Acceptance Testing (UAT) t-tests and p-value tests, are used to identify and analyze the data provided and generated, giving robust and reliable results. The analysis focuses on identifying and demonstrating that there are statistically significant differences between the traditional and hybrid groups, providing information on the effectiveness of the hybrid framework. The findings of this study are expected to offer a detailed evaluation of the proposed framework, which may redefine best practices in traditional project management. By demonstrating substantial improvements in key performance indicators, the research study aims to contribute to the academic discourse on project management methodologies and their practical applications in complex project environments.

As the primary research question of this study is to determine whether a project management framework that integrates Total Quality Management (TQM), Six Sigma and Agile methodologies is more effective than traditional project management approaches in improving project results in terms of quality, efficiency and stakeholder satisfaction. To address this, the study poses three secondary questions: Does the hybrid framework improve the quality of the deliverables compared to traditional project management approaches? Does it reduce project completion time and cost? And does it increase stakeholder satisfaction? By exploring these specific aspects, the study aims to provide a comprehensive analysis of the effectiveness of the hybrid framework in improving key performance indicators in project management.

These four hypotheses were defined that guide statistical tests and analysis to determine whether the hybrid methodology effectively improves project quality, reduces completion time, improves budget adherence and stakeholders' satisfaction compared to the traditional methodology.

#### Quality (Defects):

- Null Hypothesis (H0): There are no significant differences in the mean number of tests between traditional and hybrid methodologies.
- Alternative hypothesis (H1): The mean number of defects in the hybrid methodology is significantly lower than in the traditional methodology.

#### Efficiency (completion time).

- Null Hypothesis (H0): There is no significant difference in the mean completion time between traditional and hybrid methodologies.
- Alternative hypothesis (H1): The mean completion time in the hybrid methodology is significantly lower than in the traditional methodology.

Efficiency (budget adherence):

- Null Hypothesis (H0): There are no significant differences in the mean budget adherence between traditional and hybrid methodologies.
- Alternative hypothesis (H1): The mean budget adherence in the hybrid methodology is significantly higher than in the traditional methodology.

Stakeholder satisfaction

- Null Hypothesis (H1): There is no significant difference in stakeholder satisfaction between traditional and hybrid projects.
- Alternative Hypothesis (H2): There is a significant difference in stakeholder satisfaction between traditional and hybrid projects.

To test stakeholder satisfaction, we develop a questionnaire with a rate for each question from 1 to 10, where 1 means very dissatisfied and 10 means very satisfied, referring to communication, time to implement the project, quality of the project results and overall satisfaction of stakeholders.

Communicating

1. How effective was communication between the project team?
2. How timely were the responses to your requests?
3. How well informed were you about the progress of the project?
4. How clear and understandable were the project updates?

Project timeliness

1. How satisfied are you with the timeliness of the project?
2. Were milestones and deadlines effectively communicated and met?
3. How well did the project deal with delays?
4. How would you rate the timeliness of the deliverables?

Project quality:

1. How would you rate the quality of the final deliverables?
2. How satisfied are you with the attention to detail in the project?
3. How well did the project meet your quality expectations?
4. How would you rate the general quality of the deliverables?

Overall satisfaction:

1. How satisfied are you with the overall outcome of the project?
2. How likely are you to recommend this project team?
3. How well did the project meet your overall expectations?
4. How would you rate your overall experience with the project?

## 4. RESULTS AND DISCUSSIONS

### 4.1 Project description: Internal Tool for Employee Collaboration

The proposed simulated project "Internal Tool for Employee Collaboration" aims to enhance communication and project management within the organization through the development of a software solution. During the execution of the project, a defect was identified in which the messaging system did not deliver the messages in real time. This issue led to the need for User Acceptance Testing (UAT) – Table 1 to validate and address the problem. The traditional methodology typically involves a sequential process of identifying the root cause, planning a solution, and implementing fixes in subsequent phases/ activities, which may extend the project timeline and have a budget impact. In contrast, the hybrid methodology integrates Agile principles, allowing for immediate

prioritization of the issue within the ongoing sprints. This enables quick adaptation and iterative testing and fixing, potentially minimizing the impact on project timelines and maintaining continuous progress.

**Table 1. UAT test**

Requirement	Test Case ID	Objective	Steps	Expected results	Actual results	Status
Authentication	TC001	Verify that the user can log in with valid credentials and denied with invalid credentials.	<ol style="list-style-type: none"> <li>1. Go to the log-in page.</li> <li>2. Enter a valid username and password.</li> <li>3. Click on "Login".</li> <li>4. Verify redirection to the dashboard.</li> <li>5. Log out.</li> <li>6. Enter an invalid username/password.</li> <li>7. Click on "Login".</li> </ol>	User is logged in with valid credentials, error message for invalid credentials.	The user successfully logged in with valid credentials. Error message displayed for invalid credentials.	Pass.
Project Creation	TC002	Verify that the user can create a new project.	<ol style="list-style-type: none"> <li>1. Navigate to the "Create Project" page.</li> <li>2. Enter the details of the project.</li> <li>3. Click "Save".</li> <li>4. Verify that the project is listed.</li> </ol>	The project is created and listed.	The project was successfully created and listed on the project page.	Pass.
Document Upload	TC003	Verify the user can upload documents to a project.	<ol style="list-style-type: none"> <li>1. Navigate to the "Projects" page.</li> <li>2. Select a project.</li> <li>3. Navigate to "Documents".</li> <li>4. Click "Upload Document".</li> <li>5. Select the file and click "Open".</li> <li>6. Verify that the document is listed.</li> </ol>	The document is uploaded and listed.	The document was successfully uploaded and is listed in the project documents.	Pass.
Task Assignment	TC004	Verify the user can assign tasks to team members.	<ol style="list-style-type: none"> <li>1. Navigate to the "Projects" page.</li> <li>2. Select a project.</li> <li>3. Navigate to "Tasks".</li> <li>4. Click "Create Task".</li> <li>5. Enter the details of the task.</li> <li>6. Click "Save".</li> <li>7. Verify that the task is listed and assigned.</li> </ol>	Task is created and assigned.	The task was successfully created and correctly assigned to the team member.	Pass.
Real-Time Communication	TC005	Verify that the user can communicate in real time via chat.	<ol style="list-style-type: none"> <li>1. Navigate to "Chat".</li> <li>2. Select a team member.</li> <li>3. Enter the message and click "Send".</li> <li>4. Verify that the message is displayed.</li> <li>5. Verify that the team member receives the message.</li> </ol>	The message is sent and received.	The message was sent but not received in real time.	Fail
Feedback Submission	TC006	Verify the user can submit feedback.	<ol style="list-style-type: none"> <li>1. Navigate to "Feedback".</li> <li>2. Enter the feedback details.</li> <li>3. Click "Submit".</li> <li>4. Verify that the confirmation message is displayed.</li> </ol>	Feedback is submitted, and a confirmation message is displayed.	The feedback was submitted successfully, and a confirmation message was displayed.	Pass.

Requirement	Test Case ID	Objective	Steps	Expected results	Actual results	Status
Reporting and Analytics	TC007	Verify that the user can generate reports and view analytics.	1. Navigate to "Reports". 2. Select the report parameters. 3. Click "Generate Report". 4. Verify that the report is generated with the correct data.	The report is generated with the correct data.	The report was generated and displayed accurate data.	Pass.

*Source: authors' own research*

The traditional approach to implementing the internal tool for employee collaboration follows a linear progression through defined phases, ensuring that each stage is completed before proceeding to the next. This method is characterized by upfront planning and sequential execution. Based on this, we are assuming that the implementation time is for 9 months and the budget is for 210.000 euros.

**Table 2. Traditional PM framework**

Phase	Subactivity	Start date	Duration (days)	End Date
Requirement Analysis	Initial Stakeholder Meetings	01-July-24	5	5-July-24
	Requirements Documentation	06-July-24	10	15-July-24
	Review and approval	16-July-24	5	20-July-24
	Feasibility Analysis	21-July-24	5	25-July-24
	Final Requirement Sign-Off	26-July-24	5	31-July-24
Design	System Architecture Design	01-August-24	10	10-August-24
	Database Design	11-August-24	5	15-August-24
	User Interface Design	16-August-24	5	20-August-24
	Technical specification document	21-August-24	5	25-August-24
	Design Review and Approval	26-August-24	5	30-August-24
Implementation	Setup Development Environment	01-September-24	10	10-September-24
	Back-end development	11-September-24	40	20-October-24
	Front-end development	21-October-24	40	30-November-24
	Integration	01-December-24	20	20-December-24
	Code Review and Optimization	21-December-24	10	31-December-24
Testing	Test Plan Development	01-January-25	10	10-January-25
	Unit Testing	11-January-25	10	20-January-25
	Integration testing	21-January-25	10	30-January-25
	System Testing	31-January-25	20	19-February-25
	Identification of real-time communication issues	19-February-25	50	20-April-25
	Retesting	21-April-25	20	30-April-25
Deployment	Preparation for deployment	01-May-25	10	10-May-25
	Initial deployment	11-May-25	5	15-May-25
	User Acceptance Testing	16-May-25	10	25-May-25
	Final deployment	26-May-25	3	28-May-25
	Post-Deployment Monitoring	29-May-25	2	30-May-25

*Source: authors' own research*

The hybrid method used to implement the internal software platform for employee collaboration follows a structured methodology that integrates Agile principles with Total Quality Management

(TQM) and Six Sigma. This method is different from the traditional one as it is based on iterative development steps known as sprints, each of them having its own specific deliverables and enhancements. By prioritizing adaptive planning and continuous feedback steps, the hybrid methodology is designed to optimize project results, reduce defect tests in an early implementation stage of the project through proactive management, and ensure efficient resource allocation through better budget planning. This approach enables quick adaptation to changing requirements and stakeholder feedback, promoting higher project quality and stakeholder satisfaction throughout the implementation process, as shown in Table 3. We are assuming that the implementation time is 6.3 months and the budget is 190.000 euros.

**Table 3. Hybrid PM framework**

	Sub-activity	Start date	Duration (days)	End Date
Sprint 0: Initial Planning	Conduct Initial Planning Meetings	24-Jul-24	5	28-Jul-24
	Define the scope of the project	29-Jul-24	5	2-Aug-24
	Set Up Project Backlog	3-August-24	5	7-Aug-24
	Setup of Sprint Schedule	8-August-24	3	10-Aug-24
	Stakeholder Approval	11-Aug-24	3	13-Aug-24
Sprints	Sprint Planning (First Sprint)	24-Aug-24	10	30-Aug-24
	Development (First Sprint)	31-Aug-24	20	19-Sep-24
	Testing and bug fixing (First Sprint)	20-Sep-24	10	29-Sep-24
	Sprint Review (First Sprint)	30-Sep-24	5	4-Oct-24
	Sprint Retrospective (First Sprint)	5-Oct-24	3	7-Oct-24
	Issue Identification and Resolution	8-Oct-24	30	6-Nov-24
	Retesting After Issue Fix	7-Nov-24	20	16-Nov-24
	Continued Development (Subsequent Sprints)	17-Nov-24	90	14-Feb-25
Deployment	Incremental Deployment during Sprints	15-Feb-25	0	15-Feb-25
Maintenance	Continuous Monitoring and Improvement	16-Feb-25	0	16-Feb-25

*Source:* authors' own research

The impact, severity and requirements analysis and the phases for designing, implementing, testing, deployment, and maintaining the solution followed to identified defect from the two methodologies used perspective are presented below (see Table 4):

**Table 4. Traditional PM framework**

Aspect	Traditional Methodology (Waterfall)	Hybrid Methodology (Agile + TQM + Six Sigma)
Defect Definition	The messaging system does not deliver messages in real time.	The messaging system does not deliver messages in real time.
Impact	Affects communication between team members, potentially leading to delays in project collaboration and coordination.	Affects communication between team members, potentially leading to delays in project collaboration and coordination.
Severity	Minor (However, depending on the context, it could be considered major if real-time communication is critical).	Minor (However, depending on the context, it could be considered major if real-time communication is critical).
Requirement Analysis	<ul style="list-style-type: none"> <li>• Revisit the requirements for the messaging system to ensure that real-time delivery is explicitly defined.</li> <li>• Confirm with stakeholders that real-time messaging is a critical requirement.</li> </ul>	<ul style="list-style-type: none"> <li>- Agile: Conduct a sprint planning meeting with stakeholders to clarify the requirement for real-time messaging.</li> <li>- TQM: Ensure continuous improvement by collecting detailed requirements and incorporating feedback from end users.</li> </ul>
Design	<ul style="list-style-type: none"> <li>• Review the design of the messaging system.</li> <li>• Identify potential bottlenecks in the current architecture that could cause delays in message delivery.</li> </ul>	<ul style="list-style-type: none"> <li>- Six Sigma (DMAIC): - Define: Clearly define the problem with the current messaging system.</li> <li>- Measure: Measure the current performance and identify the extent of the delay.</li> <li>- Analyze: Analyze the data to find the root cause of the delay.</li> </ul>
Implementation	<ul style="list-style-type: none"> <li>• Update the messaging system code to optimize real-time message delivery.</li> <li>• Implement any necessary changes to the infrastructure, such as improving the message queue system or increasing server resources.</li> </ul>	<ul style="list-style-type: none"> <li>- Agile: Break down the improvements into user stories and tasks and implement them in iterative sprints.</li> <li>- TQM: Ensure quality at every step by involving cross-functional teams and adhering to best practices.</li> </ul>
Testing	<ul style="list-style-type: none"> <li>• Conduct thorough functional and performance testing to ensure messages are delivered in real time.</li> <li>• Perform load testing to simulate multiple users sending messages simultaneously.</li> </ul>	<ul style="list-style-type: none"> <li>- Agile: Perform continuous integration and testing in each sprint. Conduct user acceptance testing (UAT) with real users.</li> <li>- Six Sigma: Implement improvements and validate them by measuring performance metrics. Ensure that the defect rate is reduced to an acceptable level.</li> </ul>
Deployment	<ul style="list-style-type: none"> <li>• Deploy the updated messaging system to the production environment.</li> <li>• Monitor the system closely for any issues.</li> </ul>	<ul style="list-style-type: none"> <li>- Agile: Deploy updates incrementally, using feature toggles if necessary to mitigate risk.</li> <li>- TQM: Monitor the deployment closely and collect feedback from users to ensure that the solution meets their needs.</li> </ul>
Maintenance	<ul style="list-style-type: none"> <li>• Regularly monitor the performance of the messaging system.</li> <li>• Gather feedback from users to ensure the issue is resolved.</li> </ul>	<ul style="list-style-type: none"> <li>- Agile: Use of retrospective meetings to collect feedback and identify future improvements.</li> <li>- TQM: Implement a continuous feedback loop and regularly measure system performance to ensure sustained quality.</li> </ul>

Source: authors' own research

## 4.2 Research Hypotheses Validation

Based on the characteristic, descriptions, and different approaches for identifying and solving the error/defect from the perspective of the traditional and hybrid methodologies used, the data are generated and collected, and the hypotheses are defined, as presented above, in order to guide the statistical analysis which demonstrate whether the hybrid methodology offers improvements over the traditional methodology in terms of quality, efficiency (completion time), and efficiency (budget adherence).

### Test results:

A first step in statistical analysis was to perform the F-test to determine if there are significant differences between the variances of two defined groups. If the result of the F-test shows a significant difference, this suggests that one of the groups has a different variance, indicating a possible significant difference between means. Analysis of the results revealed that there is a significant difference between the generated data, so testing continues with post hoc analyzes to identify exactly which groups show significant differences.

Given that the p-values of the t-test (both one-tail and two-tail) are significantly lower than 0.05, we reject all defined null hypotheses (H0). Therefore, we accept the alternative hypothesis (H1), which states that the experimental group (hybrid) has a lower average number of negative results to test the identified defect than the control group (traditional). The results of the tests are given below.

**Table 5. Quality (No. Defect test)**

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Traditional</i>	<i>Hybrid</i>
Mean	5.030416667	3.126666667
Variance	0.624160688	0.314588406
Observations	24	24
Hypothesized Mean Difference	0	
df	41	
t Stat	9.625887279	
P(T<=t) one-tail	2.21949E-12	
t Critical one-tail	1.682878002	
P(T<=t) two-tail	4.43898E-12	
t Critical two-tail	2.01954097	

Source: authors' own research

**Table 6. Efficiency (Completion Time)**

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Traditional</i>	<i>Hybrid</i>
Mean	62.1	21.5
Variance	23.65556	11.38888889
Observations	10	10
Hypothesized Mean Difference	0	
df	16	
t Stat	21.68785	
P(T<=t) one-tail	1.37E-13	
t Critical one-tail	1.745884	
P(T<=t) two-tail	2.73E-13	
t Critical two-tail	2.119905	

Source: authors' own research

**Table 7. Efficiency (Budget Adherence)**

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Traditional</i>	<i>Hybrid</i>
Mean	0.80233	0.90485
Variance	0.0002485	0.000623496
Observations	10	10
Hypothesized Mean Difference	0	
df	15	
t Stat	-10.9787096	
P(T<=t) one-tail	7.21673E-09	
t Critical one-tail	1.753050356	
P(T<=t) two-tail	1.44335E-08	
t Critical two-tail	2.131449546	

Source: authors' own research

**Table 8. Stakeholder Satisfaction**

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Traditional</i>	<i>Hybrid</i>
Mean	5.117494035	7.078999992
Variance	0.600115685	0.884114637
Observations	20	20
Hypothesized Mean Difference	0	
df	37	
t Stat	-7.200356164	
P(T<=t) one-tail	7.67747E-09	
t Critical one-tail	1.68709362	
P(T<=t) two-tail	1.53549E-08	
t Critical two-tail	2.026192463	

Source: authors' own research

The traditional approach anticipates a higher number of negative results for the defect tests, longer completion times, and potentially lower budget adherence due to its sequential and less flexible nature. On the contrary, the hybrid approach aims to produce fewer defects, shorter completion times, and better budget adherence through iterative development, continuous testing, and adaptive planning strategies. These differences in means validate the expected benefits and outcomes of adopting a hybrid methodology over traditional approaches in project management. Reason: Following the traditional methodology, which typically involves a linear approach (one step needs to end before starting a new one), the defect is identified later in the process, which means that it takes more time to correct them, and there are fewer opportunities for early feedback. The integrated approach emphasizes continuous improvement and early identification and resolution of defects. A defect identified at an earlier stage of production implies less time and costs. In terms of Agile tools and techniques, for example, it promotes frequent testing and feedback loops, which can catch defects earlier in the process when they are less costly to fix, while TQM and Six Sigma methodologies also focus on reducing error results in identifying defects and variability in processes, thereby aiming for higher quality outcomes from the outset.

## 5. CONCLUSIONS

The case study proposed in this article is about combining traditional project management methodology with TQM, Six Sigma, and Agile methodologies for greater efficiency, quality, and stakeholders' satisfaction at the level of project implementation and for better performance at the organizational level. Through simulated scenarios that propose the establishment of two controlled and experimental groups, the research aimed to identify which approach improves efficiency, performance and stakeholder satisfaction at both the project implementation and the organizational levels.

The values generated to support the analysis and the results obtained were statistically analyzed and the findings suggest that the hybrid methodology significantly improves quality, efficiency (in terms of completion time and budget adherence), and stakeholder satisfaction compared to traditional methods.

The importance and relevance of this analysis and the proposed project within a simulated environment lies in its contribution to the ongoing improvement of the project management practices in a real organizational which are seeking to enhance their project management strategies. Integration

of TQM, Six Sigma, and Agile methodologies can be particularly beneficial in a very dynamic and complex project implementation environment where adaptability and continuous improvement are critical.

Despite these contributions at the hypothetical level of the study, it is important to note that the results of this research are limited by the nature of the data and values, which were generated based on the defined characteristics of traditional and hybrid methods. Therefore, the specific results may not be fully accurate to reflect the complexities and variations present in real-world project management scenarios. The results of this study should be validated and interpreted in a real project environment within a real organizational environment.

Future studies and research may consider these results by testing the combined framework in various real-world settings and industries. Furthermore, research can be the foundation for developing combined project management methodologies that are customized to the specific sectors and industries in which they are implemented. In addition, some other methodologies could be considered and integrated along with the traditional project management methodology to achieve better performance at the organizational level, which would improve the understanding of how to optimize project management practices in various organizational contexts. In conclusion, this research thereby sets the stage for further exploration and refinement of hybrid approaches, potentially leading to a paradigm shift in how projects are managed across various industries.

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