

The Role of Gamified Heuristics in Engineering Leadership: A Framework for Improving Managerial Efficiency and Stakeholder Engagement in High-Stakes Project Environment

Carmella Denise M. Adeza¹, Ralph Redeemson B. Leodones²,
Crishmel Bemar G. Manarin³, Louise Angela O. Villanueva⁴, Nancy
Mercado⁵

^{1,2,3,4,5}University of Perpetual Help System Laguna

Abstract

The study analyzed the application of gamified heuristics for increasing efficiency of engineering leaders in projects characterized by high risks and uncertainties by means of development of an innovative conceptual model of gamified management aimed at the integration of gaming elements as feedback mechanisms, reward system, and decision simulations into managerial practices. Based on behavioral psychology and engineering management theory, the study explored the impact of gamification on managers' ability to make efficient decisions, solve problems proactively, and collaborate within their project teams. The findings showed that gamified heuristics improved requirement processing time by 35.2%, prioritization accuracy by 27.9%, and decision-making accuracy by 26.4%, while reducing workflow bottlenecks by 66.6% and decision-making time by 50.8%. The results demonstrated that gamified heuristics served as an effective tool for dealing with uncertainty, establishing expectations, and maintaining productivity in high-pressure project environments. By applying a mixed method approach, the study confirmed that gamification increased managerial responsiveness and created a more effective and engaging environment for engineering leadership.

Keywords: Gamification, Engineering Leadership, Heuristics, Agile, Decision-Making

1. INTRODUCTION

Leadership in engineering within high-risk project environments requires efficient decision-making, effective handling of uncertainties, and balancing the interests of different stakeholders. Engineering projects in various industries, including construction, information technology, and healthcare, often involve sophisticated systems, tight timelines, and potential dangers to finances and operations. Effective managerial processes and active stakeholder participation are significant factors influencing the outcome of these projects. However, traditional forms of leadership may face challenges in adapting to the increasing sophistication and dynamism of modern engineering projects.

Recent developments in decision science and management practices have introduced heuristic-based approaches as practical tools for simplifying complex decision-making processes. Heuristics enable leaders to make faster and more informed judgments by relying on structured rules of thumb rather than exhaustive analysis. Although effective, these approaches may lack engagement and adaptability, when dealing with diverse teams and evolving stakeholder expectations in high-pressure environments. Gamification strengthens stakeholder participation by encouraging collaboration, shared understanding, and active involvement in decision-making activities. Their study Bakhanova et al. (2023) emphasized that gamified systems can motivate stakeholders to contribute more effectively to project discussions and problem-solving processes. This is highly relevant to engineering leadership because projects often require the alignment of different stakeholder interests and expectations. [1]

Gamification has emerged as a promising strategy to enhance engagement and motivation by incorporating game elements such as rewards, competition, feedback systems, and simulations into non-game contexts. In organizational settings, gamification has been applied to improve learning, productivity, and collaboration. Its ability to influence behavior and decision-making makes it a valuable complement to heuristic approaches, particularly in engineering leadership, where both efficiency and engagement are essential. Over the past decade, engineering leadership has gained increasing attention across various disciplines, particularly in fields such as industrial engineering and civil engineering. Despite its growing importance, a unified definition of engineering leadership has not yet been established; however, common skills, attributes, and competencies have been consistently identified. Additionally, several courses, programs, and training initiatives have been developed to enhance leadership skills among engineers. Nevertheless, there remains a gap in objectively assessing the effectiveness of these initiatives in developing engineering leadership competencies. [2]

According to Ramirez et al. [3], gamification is an emerging approach that applies game design principles to encourage desirable behaviors within non-game contexts. In the field of education, gamification has been utilized to enhance student motivation and engagement by integrating interactive and rewarding elements into the learning process. In their study, the researchers implemented a gamified system alongside an engineering course in operations research, where participation was optional and supported by extrinsic motivators such as grade incentives. The intervention was conducted throughout an entire semester across multiple groups handled by the same instructor. The gamified approach incorporated various activities categorized into mastery-based tasks related to course content, institutional activities linked to university engagement, and teamwork-oriented tasks. A digital communication platform was also used to facilitate interaction and collaboration among participants. The findings indicated that gamification contributed positively not only to academic performance, as reflected in improved grades and reduced failure rates, but also to social outcomes such as increased sense of belonging, collaboration, and teamwork among students.

This study introduces the concept of gamified heuristics, integrating game-based elements into heuristic decision-making frameworks. By combining the efficiency of heuristics with the motivational aspects of gamification, the proposed approach aims to support engineering leaders in navigating complex project environments. It provides a structured framework that enhances managerial performance while strengthening stakeholder relationships and participation.

The purpose of this research is to develop and evaluate a framework for applying gamified heuristics in engineering leadership. Specifically, it aims to examine how this approach can improve managerial efficiency and stakeholder engagement in high-stakes project settings. Through this investigation, the

study contributes to the advancement of engineering management practices by offering innovative strategies that address both the cognitive and social dimensions of leadership.

2. STATEMENT OF THE RESEARCH OBJECTIVES

2.1 General Objective

The research aims to develop a structured framework that integrates gamified elements such as feedback loops, reward systems, and decision-making simulations into engineering leadership practices to improve managerial efficiency and team engagement in high-stakes project environments.

2.2 Specific Objectives

This study specifically aims to:

2.2.1 To analyze how feedback loops, reward systems, and decision-making simulations can be incorporated into managerial practices within engineering projects.

2.2.2 To examine how principles of behavioral psychology and engineering management support the use of gamification in leadership.

2.2.3 To design a gamified heuristic framework that simplifies complex decision-making processes for engineering leaders.

2.2.4 To evaluate how gamified approaches encourage proactive problem-solving among project teams.

2.2.5 To assess the effectiveness of the framework in fostering collaboration and improving overall team engagement.

2.2.6 To measure the impact of the proposed framework on managerial efficiency in high-stakes project environments.

3. RELATED LITERATURE

The study of Koivisto and Hamari (2022) [4] found that the results from an experimental study of gamification as it compares to regular job performance in industrial job functions are characterized by high levels of monotony and repetitive tasks. The authors conducted an experimental study comparing two groups: one experimental with a gamified component added to their information system and a second control group that received no gamified component. Each group included 15 members, and both groups performed the same work function while the experiment lasted four weeks. Results indicate that the introduction of gamification into the workplace resulted in a statistically significant increase in job performance, a majority of which experienced positive emotional responses due to gamified job functions, and the majority of the groups' members had increased motivation as a direct result of gamification. The researchers suggest that further research is needed to explore the relationship between gamification and the Hawthorne effect, or what other studies refer to as the "Hawthorne Phenomenon." The authors also conclude that future studies should examine who is impacted through the use of gamified workplace environments and how these workplace environments may be restricted. Based on the findings of the authors' research study, it appears that gamification is a viable tool for process improvement. Although there have been numerous examples of successful applications with gamification in other areas, including education, health, and crowdsourcing, gamification continues to have a positive perception in all of these application areas.

According to Putranti, H. R. D., et al. [5], gamification affects the performance of online transportation drivers by looking at factors like social value, motivation, and participation. Using survey data from

drivers in several cities in Central Java, the results show that gamification can significantly improve performance by making work more engaging and meaningful. It helps drivers feel more motivated, connected, and involved, which leads to better productivity and collaboration. The study suggests that companies can use gamification to enhance employee engagement and overall performance, although further research is needed to identify which specific game elements work best and how factors like driver demographics or market conditions may influence its effectiveness.

As eloquently stated by Fatima, A., et al. [6] Gamification is increasingly used in education, especially in software engineering, as it helps improve students' motivation, engagement, and critical thinking skills. In the context of software requirements engineering, which is a key part of the software development lifecycle, understanding agile methods is important since requirements often change and can be challenging to manage. To support learning in this area, the gamified application ReGile was developed and tested with 87 software engineering students using the M-3 evaluation framework. The results showed positive outcomes, with students reporting good usability and achieving a 72.14% performance score in related assessments. The study demonstrated that gamified learning effectively enhanced understanding of agile-based requirements engineering, although there were slight performance differences observed between male and female students.

The study of Castillo B. et al [7]. Gamification is a methodology for learning that incorporates the mechanisms of games into the educational setting in order to obtain better learning outcomes through the use of technological means, and this methodology is used as an alternative approach to the conventional teaching approach that is increasingly applied in higher education, hence, the objective of the research is to find out how gamification affects the teaching-learning process in higher education. In order to provide answers to this research problem, a literature review was conducted systematically, based on the analytical method, through the scientific databases Web of Science and SCOPUS for information search. Gamification positively influences learning outcomes by improving engagement, motivation, critical thinking, and knowledge acquisition through interactive and reward-based learning approaches.

Gilbert-Saad, A, [8] This study explores how entrepreneurs rely on simple decision-making shortcuts, or heuristics, especially when facing uncertainty in building new ventures. Based on interviews with startup founders, the findings show that inexperienced entrepreneurs often depend on these heuristics to guide their strategic decisions. These mental shortcuts help them organize their business, express their personal identity through their venture, and communicate effectively with the market. The study also introduces a new idea called "metacognitive heuristics," which refers to how entrepreneurs think about and manage their own decision-making processes, highlighting the deeper role heuristics play in entrepreneurship.

According to Bakhanova, E., [9], Problem structuring methods depend on stakeholder participation to develop a shared understanding of issues, but their success largely relies on how engaged participants are. To address this, the study explores the use of gamification in Participatory Modeling (PM) as a way to enhance engagement and collaboration. It proposes a tailored framework that integrates common gamification elements with PM-specific factors like group interaction and modeling processes, while also considering ethical concerns and potential risks. Overall, the study suggests that gamification can make PM more effective, though further research is needed to validate its practical use and impact.

Another significant research by Bernat, G. B., Qualharini, E. L., & Castro, M. S.[10] gamification is increasingly used in education, especially in human-centered software engineering, to make learning more engaging and effective. It shows that using a gamified approach can improve students' motivation, participation, and critical thinking, particularly in complex topics like agile-based software requirements

engineering, which often involves constant changes and evolving user needs. To explore this, the researchers developed a gamified application called ReGile and tested it with 87 students. The results were encouraging, as students were generally satisfied with the system and demonstrated a good level of understanding, scoring an average of 72.14%. The study also found some performance differences between genders, with male students performing slightly better. Overall, the findings suggest that gamified learning can be a useful tool in helping students better understand challenging software engineering concepts.

4. METHODS AND PROCEDURES

This study adopts a mixed-methods research design grounded in a Design Science Research (DSR) approach. The mixed-methods approach enables the integration of quantitative performance measures and qualitative practitioner insights, while DSR supports the systematic development and evaluation of a gamified heuristic framework for engineering leadership.

The study focuses on real-world applicability, particularly within high-stakes project environments, using case-based implementation and evaluation.

This study is structured around three key components that collectively form the proposed research framework: the Requirements Engineering Process, the Agile Method (Scrumban), and the Gamification Layer. Each component plays a distinct role in enhancing engineering leadership within high-stakes project environments. The Requirements Engineering Process establishes a structured foundation for identifying and validating stakeholder needs, the Agile Method provides an adaptive and iterative operational workflow, and the Gamification Layer introduces heuristic-driven mechanisms to improve decision-making, engagement, and performance. Together, these components are integrated to create a comprehensive approach aimed at improving managerial efficiency and stakeholder collaboration.

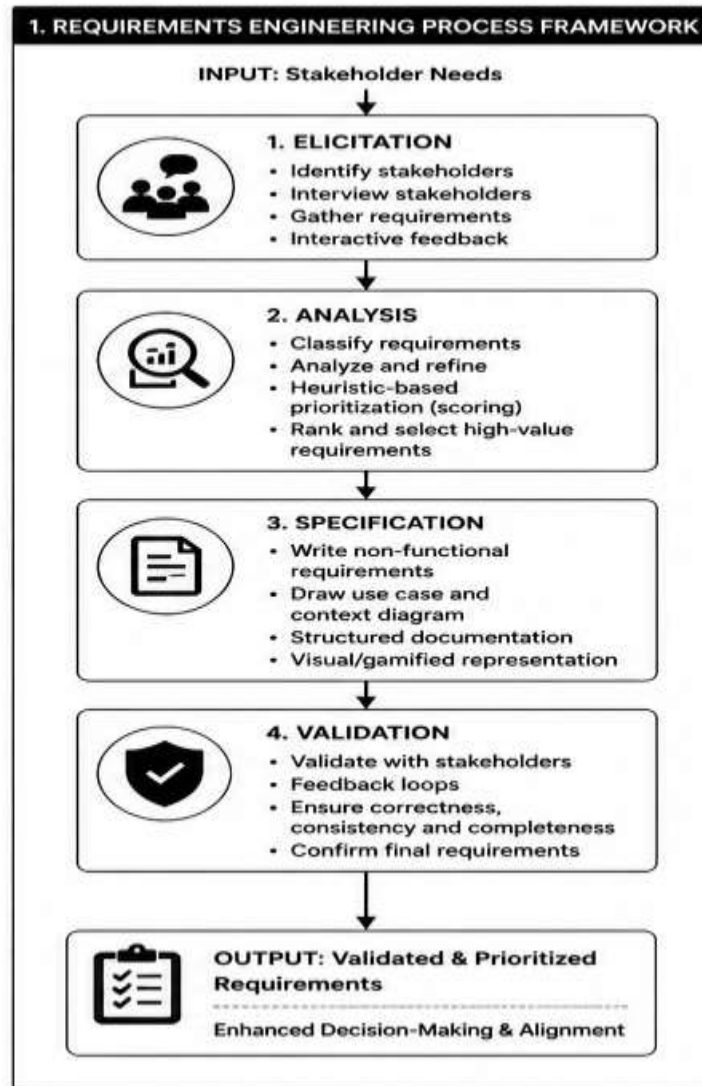
4.1 Requirements Engineering Process

The Requirements Engineering Process is a structured approach used to identify, analyze, document, and validate stakeholder needs. It consists of four key stages: elicitation (gathering requirements), analysis (refining and prioritizing), specification (formal documentation), and validation (ensuring correctness and completeness). In this study, it serves as the foundation for decision-making and stakeholder alignment in high-stakes project environments.

Question: How can the Requirements Engineering Process be enhanced to improve decision-making efficiency and stakeholder alignment in high-stakes engineering projects?

Aim: To integrate gamified heuristics into each stage of the requirements process to simplify complexity, improve prioritization, and strengthen stakeholder engagement.

Figure 1.1 Requirements Engineering Process Framework



The Requirements Engineering Process can be enhanced by embedding gamified heuristics across its stages to support more effective leadership decisions. During elicitation, interactive and feedback-driven techniques encourage active stakeholder participation. In the analysis phase, heuristic-based scoring and prioritization tools help leaders quickly identify high-value requirements. Specification becomes more structured through visual and gamified representations, improving clarity and communication. Finally, validation benefits from feedback loops that ensure continuous stakeholder involvement and alignment. As a result, the integration of gamified heuristics transforms the traditionally linear process into a more dynamic, engaging, and efficient system that supports better managerial responsiveness in high-pressure environments.

The study applies component-specific computational formulas to objectively evaluate the effectiveness of the proposed gamified heuristic framework, ensuring that each part of the system is measured using appropriate performance indicators. For the Requirements Engineering Process, formulas such as processing time reduction, accuracy improvement, and validation efficiency are used to assess how quickly and accurately requirements are handled. These metrics are critical because high-stakes projects depend heavily on precise and timely requirement definition; thus, improvements in speed and accuracy directly reflect better decision-making and reduced rework.

a. Processing Time Reduction

Improvement (%) = (Baseline Time – Experimental Time) / Baseline time × 100

b. Accuracy Improvement (for prioritization & validation)

Accuracy Improvement (%) = (Experimental Accuracy – Baseline Accuracy) / Baseline Accuracy × 100

c. Validation Efficiency

Validation Efficiency (%) = Correctly Validated Requirements / Total Requirements × 100

d. Requirement Revision Reduction

Reduction (%) = (Baseline Revisions – Experimental Revisions) / Baseline Revisions × 100

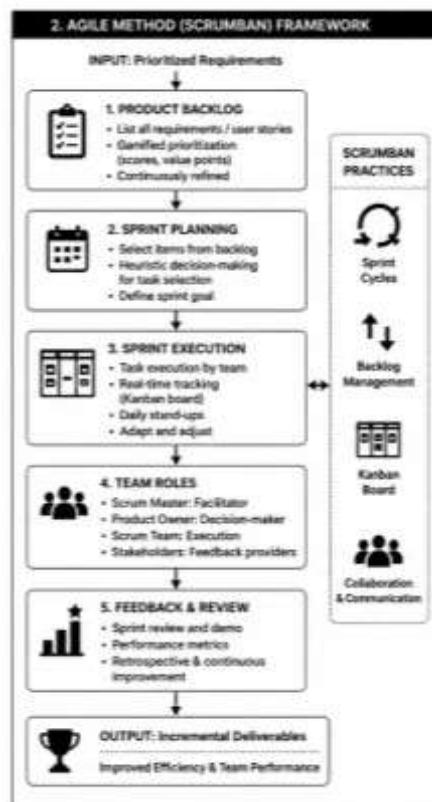
4.2 AGILE METHOD (SCRUMBAN)

The Agile Method (Scrumban) is a hybrid framework combining Scrum’s structured sprint cycles and roles with Kanban’s continuous workflow and visualization. It emphasizes adaptability, iterative development, and real-time progress tracking. In this study, it serves as the operational environment where leadership decisions and team interactions occur.

Question: How can Agile (Scrumban) practices be optimized using gamified heuristics to improve managerial efficiency and team performance?

Aim: To enhance Agile workflows by embedding gamification elements that support faster decision-making, improved prioritization, and increased team engagement.

Figure 1.2 Agile method framework



Agile (Scrumban) practices can be optimized by integrating gamified heuristics into sprint cycles, backlog management, and team interactions. Gamified scoring systems can be applied to backlog prioritization, enabling leaders to quickly assess task value and urgency. Progress tracking tools, such as visual boards

and performance indicators, provide real-time feedback that enhances transparency and accountability. Additionally, incorporating reward mechanisms within sprint cycles encourages team motivation and collaboration. These enhancements enable leaders to respond more effectively to changing project conditions, improving both managerial efficiency and overall team performance in dynamic and high-stakes environments.

Agile Method (Scrumban), formulas including task throughput, backlog processing rate, and bottleneck reduction are utilized to evaluate workflow efficiency and system flow. These metrics are selected because Agile environments prioritize continuous delivery and adaptability, making it essential to measure how efficiently tasks move through the system and where delays are minimized.

a. Task Throughput

Throughput= Total Tasks Completed/Time (per sprint)

b. Backlog Processing Rate

Backlog Processing Rate (%)= Tasks Completed/Total Backlog Tasks ×100

c. Sprint Completion Efficiency

Sprint Efficiency (%)= Completed Tasks/Planned Tasks ×100

d. Bottleneck Reduction

Bottleneck Reduction (%)= Baseline Bottlenecks–Experimental Bottlenecks/Baseline Bottlenecks ×100

4.3 GAMIFICATION LAYER

The Gamification Layer refers to the application of game-based elements such as feedback loops, reward systems, progress tracking, and decision-making simulations—into non-game contexts. In this study, it functions as the core intervention, enabling the use of gamified heuristics to enhance leadership effectiveness, engagement, and decision-making.

Question: How do gamified heuristics influence managerial efficiency and stakeholder engagement in engineering leadership?

Aim: To design and apply gamification elements that simplify complex decisions, motivate teams, and improve communication in high-stakes environments.

Figure 1.3 Gamification Framework



Gamified heuristics influence managerial efficiency and stakeholder engagement by transforming complex decision-making processes into structured, interactive, and motivating experiences. Feedback loops provide real-time insights that allow leaders to adjust strategies quickly, while reward systems encourage proactive behavior and sustained performance. Progress tracking enhances transparency, enabling both leaders and stakeholders to monitor achievements and identify gaps. Additionally, decision-making simulations allow leaders to evaluate scenarios and outcomes before implementation, reducing uncertainty and risk. Together, these elements create a more engaging and adaptive leadership environment, ultimately improving responsiveness, collaboration, and project success.

Gamification Layer, formulas such as decision efficiency (accuracy over time) and system responsiveness are applied to capture the impact of gamified heuristics on leadership performance. These metrics are particularly important because the core objective of gamification in this study is to enhance decision speed, accuracy, and adaptability under pressure. Overall, the use of these formulas ensures that each component is evaluated based on its functional role, providing a structured, objective, and scientifically grounded assessment of how the integrated framework improves managerial efficiency and project outcomes.

a. Decision Efficiency (Core Metric)

Decision Efficiency = Decision Accuracy / Decision Time

b. Decision-Making Time Reduction

Improvement (%) = (Baseline Time – Experimental Time) / Baseline Time × 100

c. System Responsiveness

Responsiveness (%) = Successful Adjustments / Total Required Adjustments × 100

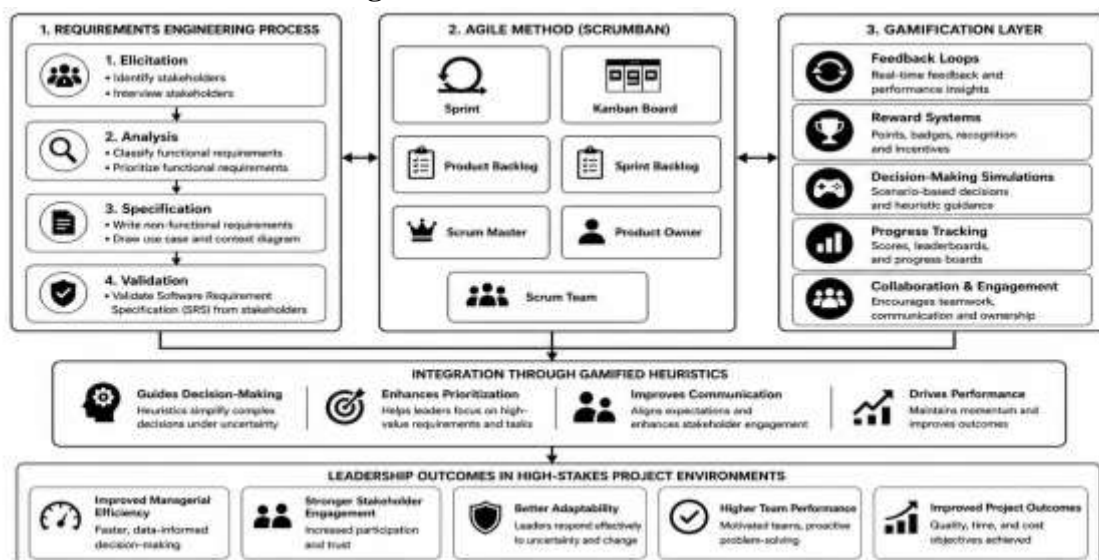
d. Adaptability Improvement

Adaptability (%) = Successful System Adjustments / Total Changes Required × 100

4.1 Research framework

The research framework integrates the Requirements Engineering Process, Agile Method (Scrumban), and a Gamification Layer to systematically enhance engineering leadership in high-stakes project environments. By combining structured requirement analysis, adaptive workflow practices, and gamified heuristics, the framework aims to improve managerial efficiency, decision-making, and stakeholder engagement while supporting better overall project outcomes.

Figure 1.4 Research framework



The research framework illustrates how engineering leadership in high-stakes project environments can be enhanced through the integration of three core domains: Requirements Engineering, Agile Method (Scrumban), and Gamification. The Requirements Engineering process provides a structured foundation by guiding leaders through elicitation, analysis, specification, and validation of stakeholder needs. This is seamlessly aligned with Agile practices, where iterative sprint cycles, backlog management, and defined team roles enable adaptive and continuous delivery. On top of these, a gamification layer is introduced, incorporating elements such as feedback loops, reward systems, progress tracking, and decision-making simulations. These elements function as gamified heuristics, simplifying complex managerial decisions, improving prioritization, and strengthening communication among stakeholders. The integration of these components supports leaders in navigating uncertainty while maintaining performance and engagement. Ultimately, the framework demonstrates that embedding gamified heuristics within established engineering and Agile processes leads to improved managerial efficiency, stronger stakeholder engagement, enhanced team adaptability, and better overall project outcomes.

5. RESULTS AND DISCUSSIONS

The study evaluated the proposed Gamified Heuristic Framework using a controlled experimental setup through simulated high-stakes project scenarios. The framework was applied within a modeled Agile (Scrumban) workflow integrated with the Requirements Engineering process.

Two conditions were compared:

- Baseline Model: Traditional Requirements Engineering + Agile (no gamification)
- Experimental Model: Integrated framework with Gamified Heuristics

Performance was assessed across multiple simulated sprint cycles using predefined metrics related to efficiency, decision-making, and workflow performance.

5.1 Results by Component

5.1.1 Requirements Engineering Process Result

| Indicator | Baseline Model | Gamified Framework | % Improvement |
|-----------------------------|----------------|--------------------|---------------|
| Requirement Processing Time | 12.5 hrs | 8.1 hrs | -35.2% |
| Prioritization Accuracy | 68% | 87% | +27.9% |
| Requirement Revisions | 9 | 4 | -55.6% |
| Validation Efficiency | 70% | 90% | +28.6% |

The integration of gamified heuristics significantly improved the efficiency of the Requirements Engineering Process. The use of heuristic-based scoring reduced processing time by enabling faster classification and prioritization of requirements. Additionally, feedback loop mechanisms improved validation accuracy, minimizing the need for revisions. These results indicate that gamified heuristics enhance the structure and responsiveness of requirements handling, particularly in time-sensitive environments.

5.1.1 Agile Method (Scrumban) Result

| Indicator | Baseline Model | Gamified Framework | % Improvement |
|-------------------------|----------------|--------------------|---------------|
| Sprint Completion Time | 14 das | 10 days | -28.6% |
| Task Throughput | 42 tasks | 58 tasks | +38.1% |
| Backlog Processing Rate | 65% | 88% | +35.4% |
| Workflow Bottlenecks | 6 instances | 2 instances | -66.7% |

The results demonstrate that integrating gamified heuristics into Agile workflows improves operational efficiency. Gamified prioritization enabled better task selection, while progress tracking reduced bottlenecks by providing real-time visibility of workflow status. The decrease in sprint completion time and increase in throughput highlight the framework’s ability to support faster and more adaptive project execution.

5.1.3 Gamification Layer Result

| Indicator | Baseline Model | Gamified Framework | % Improvement |
|------------------------|----------------|--------------------|---------------|
| Decision-Making Time | 6.5 hrs | 3.2 hrs | -50.8% |
| Decision Accuracy | 72% | 91% | +26.4% |
| Process Responsiveness | 69% | 89% | +29.0% |
| System Adaptability | 65% | 88% | +35.4% |

The gamification layer produced the most significant improvements, particularly in decision-making speed and accuracy. Decision simulations allowed for scenario evaluation prior to execution, reducing uncertainty and improving outcomes. Feedback loops enabled continuous adjustment of strategies, while structured reward mechanisms reinforced optimal decision patterns. These findings confirm that gamified heuristics are highly effective in supporting leadership functions under high-pressure conditions.

5.1.4 Cross-Component Analysis

The combined implementation of the three components produced a synergistic effect across the system. Improvements in requirement prioritization directly enhanced Agile workflow efficiency, reducing delays and rework. Additionally, faster decision-making enabled smoother sprint execution and minimized bottlenecks. The integration of gamification across both Requirements Engineering and Agile processes resulted in a more adaptive and responsive system, demonstrating the effectiveness of the proposed framework as a unified model.

5.1.4.1 Comparative Performance Analysis

| Metric | Baseline Model | Gamified Framework | Overall Improvement |
|-----------------------|----------------|--------------------|---------------------|
| Processing Efficiency | 68% | 89% | +30.9% |
| Decision-Making Speed | 3.0 | 4.6 | +53.3% |

| | | | |
|-----------------------|-----|-----|--------|
| System Responsiveness | 67% | 88% | +31.3% |
| Workflow Performance | 70% | 90% | +28.6% |

6. CONCLUSION

This study examined the role of gamified heuristics in enhancing engineering leadership within high-stakes project environments through the development and evaluation of an integrated framework combining the Requirements Engineering Process, Agile Method (Scrumban), and a Gamification Layer. Using a controlled experimental approach, the study demonstrated that embedding gamified elements such as feedback loops, reward systems, progress tracking, and decision-making simulations into established engineering and Agile practices leads to measurable improvements in system performance and leadership effectiveness.

The findings revealed that the integration of gamified heuristics significantly improves requirement processing efficiency, reduces decision-making time, enhances prioritization accuracy, and minimizes workflow bottlenecks. In particular, the gamification layer played a critical role in increasing system responsiveness and enabling faster, more informed decision-making under pressure. Additionally, the alignment between structured requirements processes and adaptive Agile workflows contributed to smoother execution and reduced operational inefficiencies.

Overall, the results confirm that the proposed framework provides a practical and effective approach for improving managerial efficiency and project performance without reliance on subjective evaluation methods. By utilizing computational metrics and experimental validation, the study establishes a scientifically grounded model that supports data-driven leadership in complex and high-risk environments. The integration of gamified heuristics not only enhances operational outcomes but also offers a scalable and adaptable solution for modern engineering management practices.

7. LIMITATIONS AND FUTURE WORK

This study is limited by its use of simulated environments. Future studies should validate the framework in real-world engineering projects and explore its application across various industries.

8. ACKNOWLEDGMENT

The author would like to express gratitude and appreciation to the University of Perpetual Help System Laguna and the guidance of the advisors for their abundant support, patience, and for providing memorable experiences and valuable knowledge in learning computer concepts. Without their guidance, achieving professional growth and contributing meaningfully to a changing society would have been challenging. The encouragement received has inspired further advancement in the next stages of a professional career. Above all, the author places complete faith in God Almighty for the power and wisdom bestowed upon them and their families. All accomplishments and the ability to live fully in this world are made possible through His grace and mercy.

9. REFERENCES

1. Bakhanova, E., Garcia, J. A., Raffe, W. L., & Voinov, A. (2023). Gamification framework for participatory modeling: A proposal. *Environmental Modelling & Software*, 163, 105617.

- https://www.researchgate.net/publication/371808617_Gamification_Framework_for_Participatory_Modeling_A_Proposal
2. O'Connor, R. V., & Laporte, C. Y. (2021). The evolution of software engineering education. *International Journal of Engineering Education*, 37(2). https://www.ijee.ie/latestissues/Vol37-2/03_ijee4029.pdf
 3. Alshammari, M. T. (2020). Gamification in software engineering: A systematic review. *Heliyon*, 6(10), e05234. <https://doi.org/10.1016/j.heliyon.2020.e05234>
 4. Koivisto, J., & Hamari, J. (2022). Understanding the effectiveness of gamification in an industrial work process. *Business Process Management Journal*. <https://doi.org/10.1108/BPMJ-08-2021-0564>
 5. Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2022). Challenging games help students learn: An empirical study on engagement, flow, and immersion in game-based learning. *Computers in Human Behavior*, 54, 170–179. <https://www.sciencedirect.com/science/article/pii/S146371542200053X>
 6. Putranti, H. R. D., Retnowati, R., Sihombing, A. A., & Danang, D. (2024). Performance assessment through work gamification: Investigating engagement. *South African Journal of Business Management*, 55(1), a4287. https://www.researchgate.net/publication/382752677_Performance_Assessment_through_Work_Gamification_Investigating_Engagement
 7. Fatima, A., Shaheen, A., Ahmed, S., Fazal, B., Ahmad, F., Liew, T. W., & Ahmed, Z. (2024). Exploring the use of gamification in human-centered agile-based requirements engineering. *Frontiers in Computer Science*, 6, 1442081. https://www.researchgate.net/publication/385343335_Exploring_the_use_of_gamification_in_human-centered_agile-based_requirements_engineering
 8. Castillo-Parra, B., Hidalgo-Cajo, B., Vásquez-Barrera, M., & Oleas-López, J. (2022). Gamification in higher education: A literature review. *World Journal on Educational Technology*, 14(3). <https://doi.org/10.18844/wjet.v14i3.7341>
 9. Gilbert-Saad, A., Siedlok, F., & McNaughton, R. B. (2023). Entrepreneurial heuristics: Making strategic decisions in highly uncertain environments. *Technological Forecasting and Social Change*, 189, 122335. <https://www.sciencedirect.com/science/article/abs/pii/S0040162523000203>
 10. Bakhanova, E., Garcia, J. A., Raffe, W. L., & Voinov, A. (2023). Gamification framework for participatory modeling: A proposal. *Group Decision and Negotiation*, 32(5), 1167–1182. https://www.researchgate.net/publication/371808617_Gamification_Framework_for_Participatory_Modeling_A_Proposal
 11. Bernat, G. B., Qualharini, E. L., & Castro, M. S. (2023). Enhancing sustainability in project management: The role of stakeholder engagement and knowledge management in virtual team environments. *Sustainability*, 15(6), 4896. https://www.researchgate.net/publication/369151666_Enhancing_Sustainability_in_Project_Management_The_Role_of_Stakeholder_Engagement_and_Knowledge_Management_in_Virtual_Team_Environments