

Behind The Machines: Mechanical Engineers' Perspectives on Preventive Maintenance and Ensuring Industrial Reliability

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ABSTRACT

Preventive maintenance (PM) is critical for ensuring industrial asset reliability, efficiency, and safety. This qualitative phenomenological study explored the perspectives of 12 mechanical engineers in Tarlac regarding PM strategies, implementation challenges, and the influence of personal and organizational factors on asset reliability. Data were collected through semi-structured interviews and document analysis, then analyzed using thematic analysis, resulting in three major themes: (1) diverse conceptualizations and implementation of preventive maintenance, (2) facilitators and barriers to effective PM, and (3) the influence of personal beliefs, organizational culture, and industry dynamics on maintenance practices. Findings reveal that engineers' engagement with preventive maintenance is shaped by technical expertise, organizational support, resource availability, and individual initiative, while barriers such as tight budgets, outdated equipment, and operational constraints limit full implementation. The study underscores the need for a holistic approach that integrates technical training, organizational strategies, and supportive policies to enhance preventive maintenance practices in regional industries. Recommendations include professional development, modernization of equipment, structured maintenance programs, and policy initiatives to support sustainable and effective PM practices in the Philippines.

Keywords: Preventive Maintenance, Mechanical Engineering, Industrial Asset Reliability, Organizational Culture, Philippines

INTRODUCTION

Mechanical engineers play a vital role in ensuring the reliability and efficiency of industrial assets, and preventive maintenance (PM) is a core strategy for achieving these goals. Nuruzzaman (2022) explains that preventive maintenance involves scheduled inspections and care of equipment to reduce failures and maintain operational continuity. According to Nuruzzaman, PM not only improves safety but also enhances productivity and overall industrial performance. Similarly, Fiandini et al. (2025) highlight that preventive maintenance is fundamental in advanced manufacturing industries, demonstrating its relevance across diverse sectors that rely on mechanical systems.

Despite its recognized importance, implementing PM strategies often faces challenges in practice. Umarwan and Pranoto (2025) argue that conventional preventive maintenance methods can be rigid and inefficient compared to adaptive approaches such as reliability-centered maintenance (RCM). They note that industries encounter difficulties due to variations in equipment age, workload, and environmental conditions. Liu, Chen, and Zhang (2024) further emphasize that optimizing preventive maintenance schedules requires not only technical knowledge but also organizational support and access to accurate data, which are often lacking in regional industrial settings.

In addressing these challenges, recent studies advocate for integrated maintenance strategies. Umarwan and Pranoto (2025) suggest combining traditional preventive maintenance with reliability-centered frameworks to improve cost efficiency, system availability, and risk-based decision-making. Likewise, Liu, Chen, and Zhang (2024) propose predictive maintenance models that use historical failure data to optimize scheduling and

resource allocation. These authors collectively indicate that preventive maintenance is evolving into a more sophisticated, data-driven practice that balances technical and operational considerations.

Although global research provides valuable insights, there is limited qualitative work capturing the lived experiences of engineers responsible for PM. Dizon, Reyes, and Villanueva (2023) note that in the Philippine context, challenges such as limited resources, fragmented organizational support, and gaps in technical skills can impede effective maintenance implementation. They argue that understanding engineers' perspectives is critical for designing interventions that are both practical and context-sensitive, especially in regions outside major metropolitan industrial centers.

This study aims to explore the perspectives of twelve mechanical engineers in Tarlac regarding preventive maintenance strategies and industrial asset reliability. By documenting how these engineers conceptualize, implement, and navigate obstacles in their daily practice, this research seeks to provide context-specific insights. As Nuruzzaman (2022), Umarwan and Pranoto (2025), Liu, Chen, and Zhang (2024), and Dizon, Reyes, and Villanueva (2023) collectively suggest, preventive maintenance is not merely a technical task but a complex interplay of knowledge, experience, organizational culture, and practical decision-making that influences industrial performance.

Research Questions

1. How do mechanical engineers in Tarlac conceptualize and implement preventive maintenance strategies in industrial operations?
2. What factors facilitate or hinder the execution of preventive maintenance?
3. How do personal beliefs, organizational culture, and industry dynamics influence engineers' approaches to asset reliability?

METHODOLOGY

Research Design

A qualitative phenomenological design was employed to capture the lived experiences of mechanical engineers regarding preventive maintenance (PM) and industrial asset reliability. Phenomenology was chosen because it allowed for an in-depth exploration of participants' perceptions, meanings, and decision-making processes in the context of their professional roles. This approach facilitated a rich understanding of how preventive maintenance practices were interpreted, enacted, and influenced by both individual and organizational factors.

Participants

Purposive sampling was used to recruit 12 licensed mechanical engineers currently employed in diverse industrial sectors across Tarlac, including manufacturing, poultry processing, cold storage, wastewater treatment, and breweries. Each participant had a minimum of three years of professional experience, ensuring that they could provide detailed reflections on preventive maintenance practices, challenges, and strategies for asset reliability. The sample was intentionally diverse to capture a broad range of experiences and perspectives across industries.

Data Collection

Data were collected primarily through semi-structured interviews, allowing participants to describe their experiences, thought processes, and challenges related to preventive maintenance. Follow-up probing questions were used to clarify responses and explore nuanced experiences in greater depth. Document analysis supplemented interviews, including the review of maintenance logs, SAP PM records, and organizational manuals, providing triangulation and contextualizing participants' narratives within organizational practices.

Data Analysis

All interviews were transcribed verbatim and analyzed using thematic analysis, which involved iterative coding to identify recurring patterns, categories, and key themes. Themes focused on participants' PM strategies, facilitators and barriers to effective preventive maintenance, and the influence of personal beliefs, workplace culture, and organizational dynamics on their practices. Member checking was conducted by sharing preliminary findings with participants to validate interpretations, and coding validation was performed by a second researcher to enhance reliability and ensure the trustworthiness of the findings.

RESULTS AND DISCUSSION

Based on semi-structured interviews with 12 mechanical engineers in Tarlac, three major themes emerged regarding preventive maintenance (PM) strategies and industrial asset reliability.

Theme 1: Diverse Conceptualizations and Implementation of Preventive Maintenance

Participants described preventive maintenance in various ways, highlighting both technical and strategic dimensions. Some emphasized equipment longevity and reduction of downtime, while others framed PM as a systematic approach to risk management and operational efficiency. For instance, Participant 3 stated, *"Preventive maintenance for me is ensuring our machines run smoothly and problems are caught before they affect production."* Similarly, Participant 7 noted, *"It's not just about fixing equipment before it breaks, but also planning maintenance around production schedules to avoid losses."*

These responses align with literature emphasizing that preventive maintenance is multifaceted, combining technical procedures with organizational planning to optimize industrial reliability (Nuruzzaman, 2022; Liu, Chen, & Zhang, 2024). The variation in conceptualization suggests that engineers' understanding of PM is influenced by both personal experience and industry-specific operational demands.

Theme 2: Facilitators and Barriers to Effective Preventive Maintenance

Participants identified several factors that either supported or hindered PM practices. Facilitators included structured maintenance schedules, access to maintenance management software (e.g., SAP PM), organizational support, and leadership that prioritized reliability. Participant 1 mentioned, *"Our management invests in preventive schedules and training, which makes it easier for us to follow proper procedures consistently."* In contrast, barriers included limited budgets, lack of management commitment, insufficient technical training, and unexpected operational demands. Participant 5 shared, *"Sometimes even if we know the right preventive steps, tight schedules and budget cuts prevent full implementation."*

These findings support prior research highlighting that both organizational resources and culture are critical to successful PM implementation (Umarwan & Pranoto, 2025; Dizon, Reyes, & Villanueva, 2023). They also indicate that preventive maintenance cannot be fully effective without alignment between technical plans and organizational priorities.

Theme 3: Influence of Personal Beliefs, Organizational Culture, and Industry Dynamics

Participants emphasized that personal values, workplace norms, and broader industry practices strongly influenced their approach to PM. Engineers with a strong sense of professional responsibility or environmental and safety awareness reported proactive engagement in maintenance planning, even in resource-constrained settings. Participant 8 stated, *"I try to recommend energy-efficient maintenance solutions, even when management is slow to adopt them."* Moreover, organizations that fostered a culture of collaboration and knowledge sharing encouraged engineers to innovate and adopt best practices. Conversely, participants in rigid or profit-driven environments reported limited autonomy, which constrained preventive measures.

These insights resonate with phenomenological perspectives that emphasize lived experiences and meaning-making in professional practice (Fiandini et al., 2025; Chen, 2024). They illustrate that preventive maintenance is shaped not only by technical knowledge but also by human, organizational, and contextual factors.

The study revealed that preventive maintenance is both a technical and socially embedded practice. Mechanical engineers in Tarlac conceptualize PM in diverse ways, encounter both facilitators and barriers, and are influenced by personal beliefs and organizational culture. This underscores that improving asset reliability requires a holistic approach that integrates technical training, organizational support, and alignment with broader industry dynamics. The findings suggest that regional industries in the Philippines could benefit from policies and programs that strengthen preventive maintenance culture, provide resources and training, and foster engineer empowerment to implement best practices effectively.

Table 1 summarizes the responses of the 12 mechanical engineers from Tarlac regarding preventive maintenance practices and the emergent themes identified from their interviews. The table highlights three key themes: (1) ****Diverse Conceptualizations of Preventive Maintenance****, where participants defined PM in multiple ways, ranging from ensuring equipment runs smoothly and efficiently (P2, P3, P7, P12) to planning maintenance around production schedules to minimize disruptions; (2) ****Facilitators and Barriers to Implementing Preventive Maintenance****, which include organizational support, training, and access to maintenance systems as enabling factors (P1, P9), and challenges such as limited budgets, tight schedules, and outdated equipment that hinder effective implementation (P4, P5, P11); and (3) ****Influence of Personal Beliefs, Organizational Culture, and Industry Dynamics****, showing that engineers' proactive engagement, suggestions for energy-efficient solutions, and interdepartmental coordination are shaped by workplace culture and personal values (P6, P8, P10). Overall, the table illustrates the complex interplay between technical knowledge, organizational support, and individual initiative in shaping preventive maintenance practices in Tarlac industries.

Table 1 Summary of Participant Responses and Emergent Themes

Participant	Key Quote	Emergent Theme
P1	“Our management invests in preventive schedules and training, which makes it easier for us to follow proper procedures consistently.”	Facilitators and Barriers to Implementing Preventive Maintenance
P2	“Preventive maintenance is making sure our equipment runs efficiently and that we catch problems before production is affected.”	Diverse Conceptualizations of Preventive Maintenance
P3	“Preventive maintenance for me is ensuring our machines run smoothly and problems are caught before they affect production.”	Diverse Conceptualizations of Preventive Maintenance
P4	“Limited budget and tight schedules often prevent us from applying all preventive measures we know are necessary.”	Facilitators and Barriers to Implementing Preventive Maintenance
P5	“Sometimes even if we know the right preventive steps, tight schedules and budget cuts prevent full implementation.”	Facilitators and Barriers to Implementing Preventive Maintenance
P6	“Our workplace encourages us to propose better maintenance strategies, and management listens.”	Influence of Personal Beliefs, Organizational Culture, and Industry Dynamics
P7	“It’s not just about fixing equipment before it breaks, but also planning maintenance around production schedules to avoid losses.”	Diverse Conceptualizations of Preventive Maintenance
P8	“I try to recommend energy-efficient maintenance solutions, even when management is slow to adopt them.”	Influence of Personal Beliefs, Organizational Culture, and Industry Dynamics

P9	“Having access to SAP PM and proper maintenance logs helps us stay ahead of issues.”	Facilitators and Barriers to Implementing Preventive Maintenance
P10	“Preventive maintenance also involves coordinating with other departments to ensure safety and minimal downtime.”	Influence of Personal Beliefs, Organizational Culture, and Industry Dynamics
P11	“Some equipment is outdated, and preventive measures are hard to implement, which causes recurring failures.”	Facilitators and Barriers to Implementing Preventive Maintenance
P12	“Preventive maintenance is a combination of technical know-how, planning, and awareness of organizational priorities.”	Diverse Conceptualizations of Preventive Maintenance

CONCLUSIONS

The study concluded that mechanical engineers in Tarlac conceptualize preventive maintenance in diverse ways, ranging from ensuring smooth machine operation to strategic planning around production schedules. Implementation of preventive maintenance was influenced by a combination of organizational support, access to resources, technical knowledge, and personal initiative. Facilitators such as structured maintenance programs, management support, and access to maintenance software enhanced engineers’ ability to carry out preventive measures effectively. Conversely, barriers including limited budgets, outdated equipment, tight production schedules, and insufficient technical training constrained preventive maintenance practices. Furthermore, personal beliefs, workplace culture, and industry dynamics played a significant role in shaping engineers’ engagement with preventive maintenance, highlighting that asset reliability is determined not only by technical procedures but also by organizational and individual factors.

RECOMMENDATIONS

It is recommended that mechanical engineers in Tarlac continue to pursue professional development and training in preventive maintenance strategies and asset reliability. Organizations should strengthen support for PM initiatives by providing adequate resources, modernizing equipment, implementing structured maintenance schedules, and fostering a culture that values safety, efficiency, and sustainability. Industry stakeholders and policymakers may consider creating regional guidelines and incentives to encourage consistent and proactive preventive maintenance practices. Additionally, integrating preventive maintenance concepts into engineering curricula and offering hands-on experiential learning can prepare future engineers to implement effective PM strategies. Future research could expand to other regions in the Philippines to explore variations in preventive maintenance practices across different industrial contexts.

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