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To Improve The Efficiency and Productivity of Engineering Department by Implementing Computerized Maintenance Management System

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Abstract

This study focuses on the implementation of a Computerized Maintenance Management System (CMMS), commonly referred to as CMMS, to enhance efficiency and productivity within ECO Special Waste Management PTE LTD's engineering department. The manual work order management method has demonstrated its inefficiency, causing disruptions due to frequent breakdowns, extended downtime, inadequate asset and inventory management, absence of effective preventive and predictive maintenance programs, and recurrent miscommunication among ground-level workers, managers, and stakeholders. CMMS offers a swift and predictable resolution to these challenges, backed by data showcasing its significant efficacy in boosting engineering department productivity. Nevertheless, successful implementation requires more than just adoption – it necessitates proper training, techniques, and consistent follow-up to ensure optimal utilization of the automated system's capabilities. This research identifies and examines three key elements: work order management/analysis, downtime analysis, and daily job planning/scheduling, all integral to the successful integration of CMMS in the engineering department, ultimately resulting in heightened efficiency and productivity.

Keywords: CMMS Implementation, Efficiency Enhancement, Productivity, Productivity Improvement, Engineering Department, Cost Reduction, Maintenance.

Introduction

This study focuses on implementing a Computerized Maintenance Management System (CMMS), also known as CMMS, to enhance efficiency and productivity in the engineering department of ECO Special Waste Management PTE LTD. The traditional manual approach to maintenance management has resulted in inefficiencies and challenges, including frequent breakdowns, increased downtime, inadequate asset management, poor inventory control, and communication issues (Carnero, 2006). CMMS offers a solution by streamlining maintenance processes, optimizing asset utilization, and automating work order management (Fair-Wright, 2021). The case company, ECO Special Waste Management, operates in waste management and holds various licenses and certifications for proper waste disposal. The research investigates the impact of CMMS implementation on the engineering department's efficiency and productivity. Through PESTEL analysis, economic incentives, technological advancements, and legal regulations emerge as potential opportunities for CMMS adoption. The absence of CMMS has led to issues like high machine breakdown frequency, poor asset management, and communication gaps. The study's research questions aim to uncover factors affecting efficiency, propose suitable interventions, and provide recommendations for optimization. By conducting interviews, surveys, and data analysis, the study aims to demonstrate how CMMS can significantly improve the engineering department's productivity and efficiency. This research contributes to understanding the benefits of CMMS adoption and its role in elevating maintenance management practices within the organization.

Research Objective

- To identify the factors that affecting the productivity and efficiency of engineering department.
- To propose and implement a suitable intervention to improve the productivity and efficiency of engineering department.
- To provide the recommendation to optimize the productivity and efficiency of engineering department.

Research Philosophy

Table 2.1
Research Philosophy

Research		
Data Collection	**Instrument**	**Data Analysis**
Interview - Qualitative	Interview protocol	Thematic Analysis
Survey - Quantitative	Questionnaires	Descriptive Parametric Comparative Cost – Benefit
Observations – Quantitative (Secondary data)	Observation Protocol	

Epistemology delves into the academic exploration of knowledge's essence and the methods of its acquisition. Within research philosophy, epistemology concerns a researcher's beliefs regarding valid knowledge and how it is obtained. This study examines factors contributing to comprehending challenges faced by the engineering team when using a manual work order maintenance system at ECO Special Waste Management PTE LTD. By analyzing these factors and their correlation with identified issues, a comprehensive grasp of the inherent complexities in the manual system is developed. The researcher aims to propose effective solutions for addressing these concerns, drawing knowledge from both subjective insights gathered through interviews and observable phenomena derived from the manual work order system. These distinct viewpoints are integrated for a thorough data interpretation, aligning with the research philosophy of pragmatism in accordance with the chosen epistemological approach. The research adopts a mixed-methods approach that combines data collection and analysis, employing qualitative and quantitative components to compensate for the limitations of each method, thus enhancing the understanding of study challenges.

Research Design

Table 2.2

Research Design

Type of data	Unit of Analysis	Degree of Involvement	Population	Sampling
Qualitative	Individuals (Middle managers, Engineers, Technicians, Procurement executives and Operation Managers)	Medium level	ECO SWM Employees	Purposive Sampling n=7
Quantitative				Purposive Sampling n=30

A research design encompasses a comprehensive strategy outlining the methods employed in conducting a study (Almanasreh et al., 2019). This design comprises various elements, including the study's purpose, time horizon, unit of analysis, degree of research involvement, and population and sampling. A mixed-method research design integrates both data collection and analysis, incorporating qualitative and quantitative components (Côté & Turgeon, 2005). The problem is identified as the initial step, and the solution is tailored based on the problem diagnosis. According to Labib (2004), the crucial stage for a researcher is selecting the optimal study design after formulating research questions and selecting a topic. Prior research conducted by other scholars was utilized to develop the theory and model applied to address a similar challenge. Consequently, recommendations and outcomes are presented after examining previous studies. To assess its effectiveness, a survey is conducted both before and after the intervention (Devi et al., 2023).

In terms of unit analysis, this pertains to the primary level under scrutiny in the research, which could encompass individuals, groups, artifacts, or geographic units. The determination of the unit was grounded in the study's analysis. For quantitative analysis data, a unit analysis approach was adopted, utilizing pre- and post-survey questionnaires to evaluate the implementation of the Computerized Maintenance Management System (CMMS) in the engineering department. Furthermore, for qualitative analysis data, a purposive sampling technique was employed to select participants from ECO Special Waste Management's Engineering, Procurement, and Operations departments, who were engaged in in-depth informational interviews.

Results and Discussion

Findings

During the fieldwork of both intervention cycles, crucial steps ensured successful Computerized Maintenance Management System (CMMS) implementation in engineering. This process involved planning, stakeholder involvement, software selection, integration, customization, training, assessment, and feedback collection. Cycle 1 introduced CMMS, while cycle 2 integrated a Preventive Maintenance module for higher efficiency. The researcher meticulously executed data collection, observation, analysis, and evaluation, leading to improved work order completion, downtime reduction, and job planning, enhancing operational effectiveness.

Table 3.1
Thematic and descriptive analysis comparison

Type of data	Content	Findings
Qualitative	Problem Identification	1) Inefficient workflow 2) Lack of automation 3) Inadequate resource allocation 4) Communication challenges 5) Redundant data entry
	Idea for intervention	1) Training 2) Centralized system
Quantitative	Assessment of the effectiveness of the intervention.	Descriptive - Overall quality is good
		Parametric analysis Normality test T-test
		Comparative analysis - secondary data Cost-Benefit analysis

Table 3.2
T-outcomes with different variables

Variables	Pre vs cycle 1 Intervention	Cycle 1 vs Cycle 2 Intervention
Work Order Analysis (V1)	0.000	0.000
Downtime Analysis (V2)	0.000	0.000
Job Planning Analysis (V3)	0.000	0.000

This table provides a concise overview of the t-test outcomes, encompassing work order, downtime, and job planning analyses. The analysis examines the mean values during pre-intervention, cycle 1, and cycle 2, revealing noticeable increases from pre-intervention to cycle 1, and cycle 1 to cycle 2. The color coding highlights different phases: green represents pre-intervention, blue denotes cycle 1 intervention, and yellow signifies cycle 2 interventions. Hypotheses were established, where the Null hypothesis (H0) suggests no impact from the intervention, while the alternative hypothesis (H1) proposes an intervention impact on efficiency and productivity in the engineering department. The sigma results indicate significance (below 0.05) across all variables in pre-intervention vs. cycle 1 and cycle 1 vs. cycle 2 interventions, leading to the rejection of the Null hypothesis. This underscores the statistical significance and proven impact of both cycle 1 and cycle 2 interventions on efficiency and productivity enhancement.

Result Comparison
Table 3.3
Non- Financial Impact

NO	Interventions variable	Pre - Intervention (Jan 2022 - May 2022)	Cycle 1 (June 2022 - Nov 2022)	Cycle 2 (Dec 2022 - May 2023)	Remark
1	Number of work order completion	62.5	100.67	112.83	Productivity
2	Average work order completion time	16.63	10.38	9.1	Efficiency
3	Breakdown hours	547	417	332	Productivity

Table 3.4
Financial Impact

Cost and Benefits	Pre - Intervention (Jan 2022 - May 2022)	Cycle 1 (June 2022 - Nov 2022)	Cycle 2 (Dec 2022 - May 2023)
OPEX	$376,336.00	$286,896.00	$228,416.00
Opportunity Cost	$89,440.00	$58,480.00	NA
Total Net Benefit / year	$82,683.00		
Return of Investment (ROI)	5 Months		

The tables presented offer a comprehensive assessment of both non-financial and financial impacts. Notably, the non-financial analysis reveals an upward trajectory in work order completions, indicative of increased productivity across cycles. Concurrently, the average work order completion time consistently decreases, reflecting improved operational efficiency and breakdown hours exhibit a decline, underlining heightened productivity. Transitioning to the financial aspect, Operational Expenditure (OPEX) sees a steady reduction from pre-intervention to cycle 1 and cycle 2, indicating substantial cost savings. Opportunity costs calculations demonstrate potential savings with strategic implementation. The cumulative net benefit and commendable Return on Investment (ROI) achieved within a short period further underscore the advantageous outcomes of the CMMS system implementation in enhancing both productivity and financial efficiency.

Conclusion

The implementation of a Computerized Maintenance Management System (CMMS) holds significant importance for enhancing maintenance efficiency, reducing costs, and extending the lifespan of engineering assets (Jamkhaneh et al., 2018). CMMS provides improved asset management, preventive maintenance, work order management, and data analysis, enabling efficient scheduling and increased asset utilization. By automating inspections and maintenance, CMMS adopts preventive measures, reducing downtime and enhancing reliability. Effective CMMS utilization requires thorough user training and ongoing support, while enhancing reporting and analysis necessitates data review and cleanup. The research interventions highlight CMMS's potential for engineering department enhancement and suggest future integration with IoT and data analytics. The study contributes to maintenance practices knowledge through KPIs and metrics evaluation, while recommendations focus on continuous improvement culture fostering and advanced data analytics exploration. Overcoming challenges and limitations of CMMS implementation ensures sustained efficiency gains and effectiveness within the engineering domain.

Contribution

During this research journey, the research have helped to explored the complexities associated with the implementation of a Computerized Maintenance Management System (CMMS) with the aim of improving efficiency and productivity within the engineering department. The research holds significance due to its dual contribution to both theoretical and practical knowledge. The present study contributes to the expanding body of scholarly work on maintenance management, particularly in the realm of implementing Computerized Maintenance Management Systems (CMMS). It offers empirical evidence about the effects of CMMS deployment on reducing work orders and optimizing resource allocation. The results of this study further support and enhance the existing ideas pertaining to process efficiency and productivity. Within a larger framework, this research provides practical insights and suggestions for industries aiming to enhance their maintenance practices and overall operating efficiency. This study elucidates the concrete advantages of Computerized Maintenance Management Systems (CMMS), thereby facilitating the integration of organizations with the evolving field of engineering management. Consequently, this research contributes to the broader framework of industrial and organizational advancement.

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