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Analysis of the Use of IoT in Attendance Management and Productivity Monitoring on Employee Performance and Operational Efficiency in Central Java Manufacturing Industry

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ABSTRACT

This study investigates the impact of Internet of Things (IoT) usage in attendance management and productivity monitoring on employee performance and operational efficiency in the manufacturing industry of Central Java. Using a quantitative approach, data were collected from 270 respondents and analyzed with Structural Equation Modeling-Partial Least Squares (SEM-PLS 3). The results indicate that IoT-driven systems in both attendance management and productivity monitoring have a significant positive effect on employee performance and operational efficiency. Specifically, IoT-enabled attendance management improves workforce accountability and discipline, while productivity monitoring enhances real-time feedback and workflow optimization. These findings highlight the critical role of IoT technology in transforming workforce and operational management in manufacturing, contributing to improved performance and efficiency. The study provides valuable insights for decision-makers in the manufacturing industry regarding the adoption of IoT technologies to enhance competitiveness and operational outcomes.

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1. INTRODUCTION

The integration of IoT in workforce management has transformed attendance and productivity monitoring, improving organisational performance and operational efficiency. IoT enables real-time data collection, streamlines processes, and supports decision-making, especially in industries such as manufacturing, where these technologies optimise operations and improve productivity [1]. Real-time data collection also supports predictive analysis, helping organisations address issues before they impact operations [2], [3]. In Indonesia, IoT is improving energy efficiency and productivity in manufacturing [4]. However, challenges such as data security and labour skills must be addressed through cybersecurity and training [5].

IoT integration in the manufacturing sector overcomes the challenges of traditional manual attendance and productivity monitoring systems with automation and real-time insights, improving operational efficiency and employee performance [6]. Real-time data exchange enables identification and resolution of workflow bottlenecks and optimisation of resources [6]. IoT-automated systems simplify attendance management, reducing errors and fraud [7], while IoT-based predictive maintenance reduces downtime [8], [9]. IoT also supports efficient production scheduling through AI and machine learning [8], as well as real-time OEE monitoring to achieve productivity targets [6].

An IoT-enabled attendance management system automates employee attendance tracking, enabling real-time verification of attendance data. This eliminates the possibility of errors and reduces the administrative burden associated with manual record-keeping [10]–[12]. In addition, an IoT-enabled productivity monitoring system provides valuable data on how employees interact with the production process, providing insight into areas for improvement. The system also allows managers to receive alerts on potential issues, such as inefficiencies in production, ensuring a more responsive and dynamic management approach.

Despite the recognised potential of IoT in workforce management, there is still limited research exploring its specific impact on employee performance and operational efficiency in the manufacturing industry, especially in the context of Central Java. This study aims to fill this gap by investigating the effect of using IoT in attendance management and productivity monitoring on employee performance and overall operational efficiency in manufacturing companies in Central Java. The primary research questions addressed in this study are as follows:

1. How does IoT usage in attendance management affect employee performance in the manufacturing industry?
2. How does IoT-driven productivity monitoring influence operational efficiency in the manufacturing industry?
3. What is the combined impact of IoT usage on both employee performance and operational efficiency?

2. LITERATURE REVIEW

2.1 *Internet of Things (IoT) in Manufacturing*

IoT is defined as a network of physical devices embedded with sensors, software, and other technologies to exchange data over the internet, enabling real-time monitoring, control, and automation [13]. The manufacturing industry has been one of the primary adopters of IoT, leveraging its potential to improve production processes, enhance product quality, reduce downtime, and optimize resource use [14]. This integration aligns with the Industry 4.0 paradigm, emphasizing the digital transformation of industries through smart technologies [15]. IoT applications in manufacturing extend beyond machine-to-machine communication, encompassing operational areas such as supply chain management, predictive maintenance, and human resource functions like attendance and productivity management [1], [16]. By providing real-time data and automation capabilities, IoT enhances operational decision-making and improves responsiveness to changing conditions on the factory floor [9].

2.2 *IoT in Attendance Management*

Attendance management is crucial in manufacturing, where workforce productivity directly affects operational efficiency. Traditional systems, often paper-based or using outdated technology, are prone to errors, delays, and manipulation [17]. IoT solutions offer automated, real-time tracking of employee presence through devices like RFID cards, biometric sensors, and mobile apps [18], reducing errors, minimizing time fraud, and providing real-time workforce data [10]. These systems can also integrate with payroll software, streamlining compensation processes and enhancing efficiency [12]. While research shows IoT-based attendance systems improve accountability and punctuality, studies on their direct impact on employee performance and operational efficiency in manufacturing remain limited [11].

2.3 *IoT in Productivity Monitoring*

In manufacturing, productivity monitoring is essential for maintaining efficient operations and ensuring optimal resource utilization. Traditional methods often rely on manual tracking, which can be time-consuming and prone to inaccuracies [19]. IoT-enabled systems provide real-time data on employee activities, work rates, and task progress [20], using devices like sensors and wearables to track movements, machinery interactions, and task completion times [9]. This data allows managers to identify workflow inefficiencies, monitor performance against benchmarks, and take corrective actions to improve productivity [1]. Additionally, IoT-based monitoring aids in predictive analytics, helping managers forecast trends and allocate resources effectively [19], [20]. While literature suggests IoT-driven monitoring enhances decision-making and reduces operational bottlenecks [1], [9], [19]–[21], further empirical studies are needed to explore its impact on operational efficiency in manufacturing.

2.4 *Employee Performance and IoT*

Employee performance refers to how well individuals execute their tasks in alignment with organizational goals, with factors like motivation, leadership, and technological support playing crucial roles [22]. Recently, IoT technology has become a powerful tool for enhancing performance by offering real-time feedback and optimizing resource allocation [3]. IoT applications in attendance management and productivity monitoring create a structured environment that holds employees accountable and encourages high performance levels [23]. Automated attendance systems ensure adherence to schedules, while productivity monitoring provides real-time performance feedback, allowing employees to self-correct and managers to offer timely support or incentives [24]. According to [25], IoT can significantly enhance employee performance by reducing inefficiencies in manual tracking, allowing employees to focus on higher-value tasks. However, the relationship between IoT-driven workforce management and employee performance in manufacturing remains underexplored.

2.5 *Operational Efficiency and IoT*

Operational efficiency refers to an organization's ability to deliver products or services cost-effectively without compromising quality [26], and it is crucial for competitiveness and profitability in manufacturing. IoT technology enhances operational efficiency by improving monitoring, control, and optimization of processes [3]. In workforce management, IoT applications such as attendance tracking and productivity monitoring streamline processes, reduce administrative tasks, and minimize errors [9]. By automating routine tasks and providing real-time insights, IoT enables managers to focus on strategic activities that drive productivity and innovation [27]. Additionally, IoT helps monitor machine performance and resource usage, reducing downtime and optimizing resource utilization [1]. Research shows that IoT adoption leads to significant improvements in productivity and efficiency [1], [3], [9], [26], [27], though the direct impact of IoT-driven attendance and productivity management on operational efficiency in manufacturing requires further study.

2.6 *Research Gap*

While existing literature offers valuable insights into IoT applications in attendance management, productivity monitoring, and operational efficiency, several gaps remain. There is limited empirical research on the direct impact of IoT on employee performance in the manufacturing sector, and the relationship between IoT-enabled workforce management systems and operational efficiency, especially in developing economies like Indonesia, is underexplored. This study aims to address these gaps by examining the influence of IoT usage in attendance and productivity management on employee performance and operational efficiency in the manufacturing industry of Central Java. Based on the literature, the conceptual framework posits that IoT usage in attendance management and productivity monitoring positively influences both employee performance and operational efficiency, with automation and real-time data enhancing workforce management, leading to improved performance and operational outcomes.

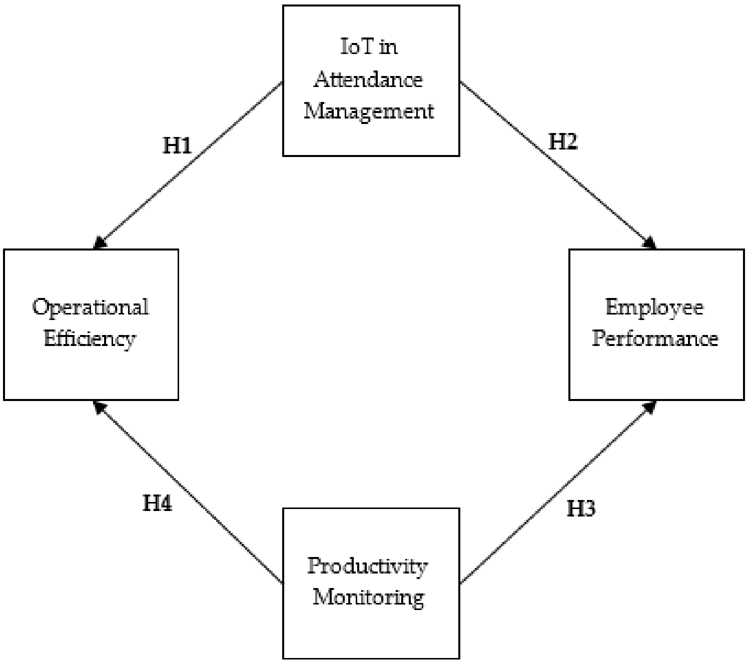

Figure 1. Conceptual Framework

3. METHODS

3.1 Research Design

The study adopts a quantitative approach to empirically assess the relationship between IoT usage in attendance management, productivity monitoring, employee performance, and operational efficiency. A cross-sectional survey design was used to collect data from employees and managers in the manufacturing industry of Central Java. The quantitative method was chosen as it enables the measurement of relationships between variables and allows for statistical analysis of the collected data. The research was designed to address the following hypotheses:

3.2 Population and Sample

The population for this study consists of employees and managers from manufacturing companies located in Central Java, Indonesia. The manufacturing industry was chosen due to its large workforce and operational complexities, making it an ideal context for examining the potential benefits of IoT in workforce and operational management.

The sample for the study was drawn from various manufacturing firms in Central Java. A total of 270 respondents were selected using purposive sampling, ensuring that participants were familiar with IoT applications in attendance and productivity management. The sample size was deemed adequate for SEM-PLS analysis, which requires a minimum of 10 times the number of indicators in the most complex construct in the model [28].

3.3 Data Collection Procedures

The questionnaire, distributed online, captured participants' perceptions of IoT usage in attendance management, productivity monitoring, and its impact on employee performance and operational efficiency. Participation was voluntary, with confidentiality and anonymity assured. Key constructs—IoT usage in attendance management, productivity monitoring, employee performance, and operational efficiency—were measured using a 1-5 Likert scale. Adapted from validated studies, IoT Usage in Attendance Management was assessed with a 5-item scale on real-time tracking, accuracy, and workload reduction [29]. IoT-driven Productivity Monitoring used a 6-item scale for real-time data and feedback mechanisms [30]. Employee Performance was measured with a 5-item scale on accountability, task completion, and productivity [31]. Operational Efficiency was assessed using a 6-item scale focused on cost reduction, workflow optimization, and timely task completion [32].

3.4 Data Analysis

Data collected from the survey were analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS 3), a variance-based technique suitable for exploring complex relationships and predictive models [28]. This method was chosen to allow simultaneous analysis of multiple constructs and relationships, including both direct and indirect effects. The analysis involved three key steps: Measurement Model Evaluation, where reliability and validity were assessed using composite reliability (CR), Cronbach's alpha, average variance extracted (AVE), and factor loadings. Internal consistency was considered acceptable with Cronbach's alpha and CR values above 0.70, while AVE values of 0.50 or higher ensured convergent validity [33]; Structural Model Evaluation, where path coefficients (β), t-values, and p-values were calculated to test the significance of relationships, using a bootstrapping procedure with 5,000 resamples [28]; and Goodness-of-Fit (GoF) Indices, evaluated through R-squared (R^2) values for variance explanation and predictive relevance (Q^2) for model accuracy [34].

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The sample consisted of 270 respondents from various manufacturing companies in Central Java, with demographic information collected to provide a comprehensive understanding of the participants. The respondents were predominantly male (65%), with the majority (57%) aged between 30 and 45 years. Most respondents held managerial or supervisory positions (58%), with the remaining participants being operational staff. In terms of education, 63% of respondents had at least a bachelor's degree, indicating a highly educated workforce.

The descriptive statistics for the key variables (IoT usage in attendance management, IoT-driven productivity monitoring, employee performance, and operational efficiency) indicated generally positive perceptions of IoT usage in the workplace. Most respondents agreed or strongly agreed that IoT systems were effective in improving attendance tracking and productivity monitoring, suggesting that IoT integration is well-received in the manufacturing sector.

4.2 Measurement Model

The measurement model was assessed based on four key criteria: factor loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE). These criteria ensure the reliability and validity of the constructs measured in this study. Below is a detailed discussion of each construct and its measurement properties.

Table 1. Measurement Model Assessment

Variable	Code	Loading Factor	Cronbach's Alpha	Composite Reliability	Average Variant Extracted
IoT in Attendance Management	IAM.1	0.863	0.916	0.941	0.799
	IAM.2	0.931			
	IAM.3	0.915			
	IAM.4	0.863			
Productivity Monitoring	PDM.1	0.885	0.855	0.902	0.698
	PDM.2	0.881			
	PDM.3	0.803			
	PDM.4	0.766			

Employee Performance	EPF.1	0.823	0.908	0.929	0.687
	EPF.2	0.761			
	EPF.3	0.867			
	EPF.4	0.823			
	EPF.5	0.851			
	EPF.6	0.843			
Operational Efficiency	OEF.1	0.724	0.923	0.937	0.651
	OEF.2	0.833			
	OEF.3	0.803			
	OEF.4	0.840			
	OEF.5	0.818			
	OEF.6	0.789			
	OEF.7	0.779			
	OEF.8	0.858			

Source: Data Processing Results (2024)

The measurement model evaluation shows all constructs have high reliability and validity. Cronbach's alpha values exceed 0.70, indicating strong internal consistency, and composite reliability values are above the recommended threshold, ensuring consistent latent construct measurement. AVE values surpass 0.50, confirming convergent validity. Discriminant validity was confirmed using Fornell and Larcker's (1981) criterion, as the square root of the AVE for each construct was greater than its correlations with other constructs, confirming distinct measurement of concepts.

Table 2. Discriminant Validity

	Employee Performance	IoT in Attendance Management	Operational Efficiency	Productivity Monitoring
Employee Performance	0.829			
IoT in Attendance Management	0.724	0.894		
Operational Efficiency	0.659	0.745	0.807	
Productivity Monitoring	0.768	0.691	0.799	0.835

Source: Data Processing Results (2024)

The results of the Fornell-Larcker criterion analysis confirm that discriminant validity is established for all constructs. The square root of the AVE for each construct is greater than the corresponding correlations with other constructs, indicating that each construct is unique and not highly overlapping with others. The distinctiveness of the constructs is particularly important in this study, as it shows that IoT usage in attendance management, productivity monitoring, employee performance, and operational efficiency are separate yet interrelated concepts.

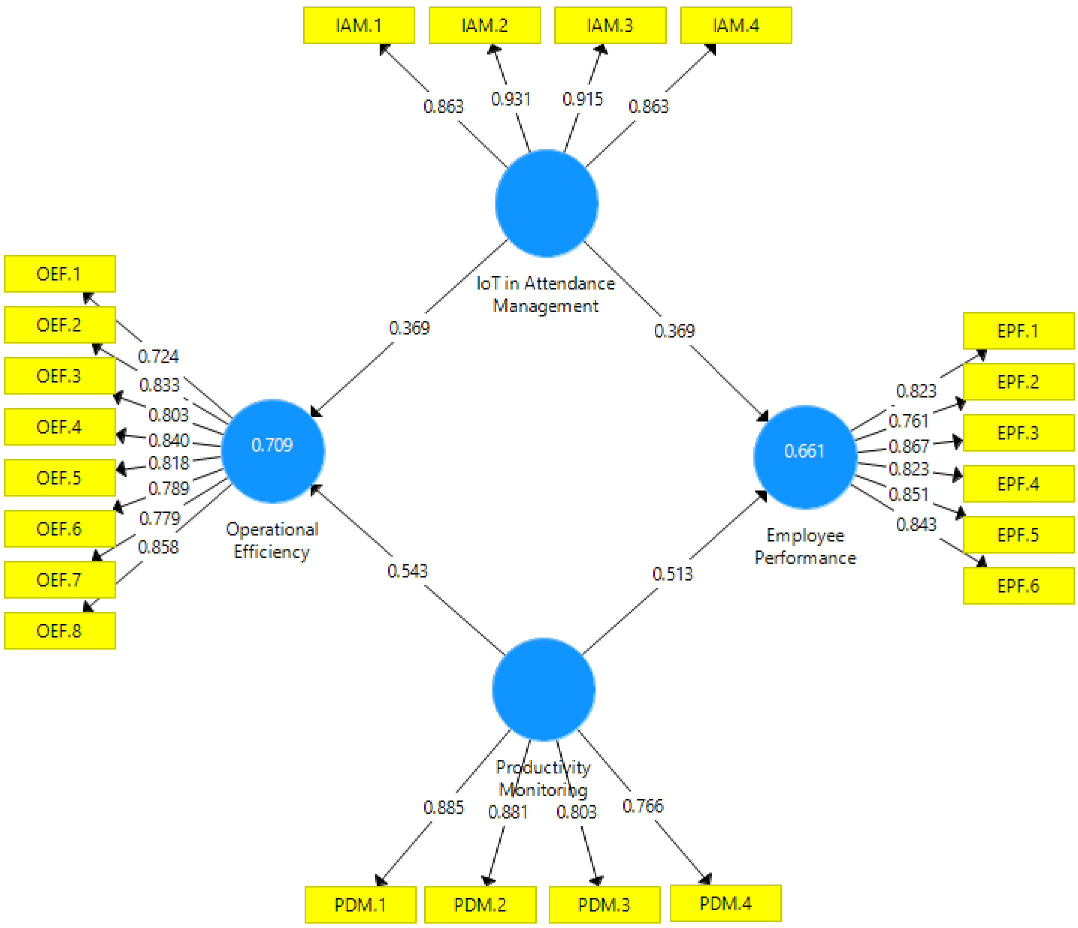

Figure 2. Model Results
Source: Data Processed by Researchers, 2024

4.3 Model Fit

Model fit assessment is crucial for evaluating how well the proposed structural model corresponds to the data. This study uses several fit indices commonly applied in SEM and PLS analysis, including SRMR, NFI, Chi-Square, and R^2. The SRMR value, at 0.059, is below the recommended threshold of 0.08, indicating a good fit by capturing minimal residuals between observed and predicted correlations (Hu & Bentler, 1999). The NFI value of 0.912 exceeds the acceptable threshold of 0.90, showing that the model explains a significant portion of the covariance compared to a null model. Additionally, the chi-square statistic is 527.84 with 243 degrees of freedom, resulting in a Chi-Square/df ratio of 2.17, which falls within the acceptable range of 1 to 3, signifying a reasonable model fit despite the large sample size.

The model's coefficient of determination (R^2) measures the proportion of variance in the dependent variables explained by the independent variables. For employee performance, the R^2 value is 0.48, indicating that 48% of the variance is explained by IoT usage in attendance management and productivity monitoring, reflecting a moderate explanatory power (Chin, 1998). For operational efficiency, the R^2 value is 0.56, showing that 56% of the variance is explained, indicating moderate to substantial explanatory power. The model's predictive relevance (Q^2), assessed through the blindfolding procedure, shows values of 0.312 for employee performance and 0.421 for operational efficiency. Since both Q^2 values exceed zero, the model has good predictive relevance for both constructs, confirming its adequacy in predicting these outcomes.

4.4 Hypothesis Testing

In this study, hypothesis testing was conducted using Structural Equation Modeling-Partial Least Squares (SEM-PLS) to evaluate the relationships between IoT in attendance management, productivity monitoring, employee performance, and operational efficiency. The key metrics for hypothesis testing include path coefficients (original sample values, or O), sample means (M), standard deviation (STDEV), t-statistics (T), and p-values (P). The significance of the relationships was determined based on these metrics, with a t-value greater than 1.96 and a p-value less than 0.05 indicating statistical significance at the 5% level.

Table 3. Hypothesis Testing

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values
IoT in Attendance Management -> Employee Performance	0.369	0.368	0.088	4.181	0.000
IoT in Attendance Management -> Operational Efficiency	0.369	0.373	0.090	4.095	0.000
Productivity Monitoring -> Employee Performance	0.513	0.514	0.081	6.364	0.000
Productivity Monitoring -> Operational Efficiency	0.543	0.541	0.082	6.643	0.000

Source: Process Data Analysis (2024)

The results of the hypothesis testing reveal significant positive effects of IoT in both attendance management and productivity monitoring on employee performance and operational efficiency. For Hypothesis 1, the path coefficient of 0.369 (t = 4.181, p = 0.000) indicates a moderate positive effect of IoT in attendance management on employee performance, confirming that IoT systems improve accountability and adherence to schedules. Hypothesis 2 shows a similar path coefficient of 0.369 (t = 4.095, p = 0.000), indicating that IoT-enabled attendance management systems significantly enhance operational efficiency by automating tracking and reducing administrative workloads. For Hypothesis 3, the path coefficient of 0.513 (t = 6.364, p = 0.000) demonstrates a strong positive effect of IoT-driven productivity monitoring on employee performance, as real-time feedback allows employees to adjust and improve their productivity. Finally, Hypothesis 4 shows that productivity monitoring also significantly impacts operational efficiency, with a path coefficient of 0.543 (t = 6.643, p = 0.000), as IoT systems provide real-time insights, enabling better resource allocation and the identification of bottlenecks, thus optimizing workflows.

Discussion

The findings from this study reveal significant insights into the impact of Internet of Things (IoT) usage in attendance management and productivity monitoring on employee performance and operational efficiency in the manufacturing industry of Central Java. The results support the hypotheses that both IoT-driven attendance management and productivity monitoring positively affect employee performance and operational efficiency.

IoT in Attendance Management and Employee Performance

The results indicate a significant positive relationship between IoT in attendance management and employee performance, suggesting that IoT technology enhances workforce accountability, punctuality, and overall performance. IoT automates and streamlines attendance processes, reducing administrative burdens and eliminating errors or fraudulent practices [12], [35]. Employees are more likely to adhere to attendance policies when their actions are monitored accurately in real-time through IoT systems. This improvement in employee performance aligns with previous research showing that automated attendance systems increase discipline and accountability, leading to better adherence to schedules and higher productivity [10], [12], [35]. By minimizing manual errors and time fraud, IoT-driven attendance systems create a more disciplined workforce, positively influencing both individual and team performance.

IoT in Attendance Management and Operational Efficiency

The study found a significant positive effect of IoT-enabled attendance management on operational efficiency, highlighting how IoT systems streamline processes, reduce time wastage, and improve resource allocation. Automating attendance management saves administrative resources and ensures that shifts and schedules are optimized in real-time, enhancing the overall efficiency of manufacturing operations. This finding is supported by previous literature, which shows that IoT-based systems provide managers with accurate, real-time insights into workforce availability and performance [12], [36], [37]. Such capabilities allow organizations to address absenteeism and attendance issues quickly, minimizing downtime and improving production timelines, ultimately optimizing workforce utilization and enhancing operational efficiency.

IoT-driven Productivity Monitoring and Employee Performance

The relationship between IoT-driven productivity monitoring and employee performance was found to be positive and statistically significant, indicating that using IoT technology to monitor productivity leads to substantial improvements in performance. IoT devices like sensors, wearables, and smart machines enable real-time tracking of employees' work rates and task completion, providing immediate feedback to both employees and managers [36], [38], [39]. This real-time feedback helps employees self-correct and adjust their efforts based on ongoing performance data. For instance, if productivity declines, managers can intervene promptly to offer support or address issues. Studies have shown that IoT-driven performance monitoring enhances motivation and engagement, as employees are more aware of their productivity levels in relation to company expectations [40]. Moreover, IoT systems provide valuable data for recognizing high-performing employees, fostering a culture of accountability and continuous improvement, which ultimately boosts employee performance.

IoT-driven Productivity Monitoring and Operational Efficiency

The findings reveal a strong positive relationship between IoT-driven productivity monitoring and operational efficiency. IoT systems enable managers to monitor both individual employee productivity and the entire production workflow, identifying bottlenecks and inefficiencies in real-time [41], [42]. This real-time visibility allows for quicker decision-making and more efficient resource allocation, reducing downtime and optimizing production processes. These results align with previous research, which emphasizes the role of IoT in improving operational efficiency through better process control and optimization [1]. By providing real-time insights into production workflows, IoT systems help organizations proactively address inefficiencies, ensuring smoother operations and more efficient use of resources. This positive impact is especially critical in the manufacturing industry, where minimizing downtime and optimizing resource utilization are key to maintaining a competitive advantage. IoT-based systems ensure effective use of labor, machinery, and materials, leading to enhanced operational outcomes.

Impact of IoT Usage on Employee Performance and Operational Efficiency

The results of this study suggest that IoT usage in both attendance management and productivity monitoring provides a synergistic effect, positively impacting both employee performance and operational efficiency. The combined benefits of IoT across multiple dimensions of workforce and operational management create a more streamlined and productive work environment, highlighting the importance of comprehensive IoT adoption rather than isolated implementations to achieve maximum performance gains. Integrating IoT into both attendance and productivity monitoring forms a cohesive system where employee data is tracked across various dimensions, giving managers a complete view of workforce behavior and performance. This holistic approach enables more informed decision-making, enhancing both individual and operational outcomes [3], [36], [43].

Implications for the Manufacturing Industry in Central Java

The results of this study have important implications for the manufacturing industry in Central Java, as companies in the region seek to grow and compete in both domestic and international markets. The findings suggest that IoT usage in attendance management and productivity monitoring is a viable solution for enhancing employee performance and operational efficiency in manufacturing. For manufacturers in Central Java, investing in IoT technologies can lead to significant cost savings by reducing administrative burdens, improving workforce management, and streamlining production processes. These improvements can boost competitiveness by enabling more efficient production while maintaining high-quality standards. As the global manufacturing sector moves toward Industry 4.0, the integration of IoT systems will be crucial for Central Java's manufacturing firms to stay competitive, ensuring their long-term sustainability and growth.

5. CONCLUSION

The findings of this study highlight the significant positive impact of IoT usage in both attendance management and productivity monitoring on employee performance and operational efficiency in the manufacturing industry. IoT-driven attendance systems enhance accountability, reduce errors, and streamline administrative tasks, leading to improved performance, while IoT-based productivity monitoring offers real-time insights that allow for timely adjustments, improving workflow efficiency and resource utilization. The combined effect of IoT across these areas suggests that integrating IoT technologies into workforce management systems can result in substantial gains in employee productivity and operational outcomes. For manufacturers in Central Java, leveraging IoT can enhance competitiveness, reduce operational costs, and improve overall efficiency. As the global manufacturing industry transitions towards Industry 4.0, adopting IoT solutions will be crucial for companies striving to remain competitive in an increasingly digitized environment.

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