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Implementation of Internet of Things in the Production Process of MSMEs: Quality Improvement and Process Control

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Abstrak

This research explores the application of IoT in MSME production to enhance quality and process control. The focus is on addressing challenges such as high costs, lack of technical understanding, and data security. The aim is to highlight the benefits of IoT, evaluate implementation challenges, and provide strategic guidance for MSMEs to thrive in the digital era. This research adopts a descriptive qualitative approach using purposive area sampling, focusing on Surabaya, an industrial city supported by the government for MSMEs. The goal is to understand the application of IoT in improving quality and process control in Surabaya MSMEs. This research method provides in-depth insights into the observed phenomena aligned with the objectives set. Awareness and adoption of IoT in MSMEs are low due to constraints such as technological understanding, costs, data security, and lack of perceived benefits. Barriers include limited technical knowledge, high costs, and data security concerns. Solutions include enhancing technological understanding, integrating ERP, and utilizing IoT-based quality control systems. MSMEs can improve their efficiency, quality, and competitiveness with the right strategy. Implementing IoT technology can enhance MSMEs' quality, process control, operational efficiency, and competitiveness. MSMEs are advised to carefully plan and implement IoT solutions, considering their needs and potential benefits, and collaborate with experienced technology solution providers to address technical and operational challenges.

Keywords: IoT, MSMEs, Technology Implementation, Challenges, IoT Strategies

1. Introduction

In the current digital era, Internet of Things (IoT) technology has become a focal point across various industry sectors, including Micro, Small, and Medium Enterprises (MSMEs). Implementing IoT in MSME production processes promises improvements in quality and more efficient process control. SMEs often face challenges in adopting advanced technologies like IoT, but with its significant potential benefits, this implementation becomes increasingly attractive to explore.

One of the essential aspects of implementing IoT in MSME production processes is addressing product quality challenges. By leveraging interconnected sensors in IoT networks, MSMEs can monitor and analyze various production parameters in real-time, enabling early detection of potential defects or quality non-conformities. However, IoT implementation in MSMEs can pose several challenges, such as high implementation costs, lack of technical understanding, and data security issues [1].

The Internet of Things (IoT) is relevant to micro, small, and medium enterprises (MSMEs) that apply technology to enhance performance and operational efficiency. Implementing IoT in MSMEs can benefit various aspects, such as production process monitoring, quality control, inventory management, and data analysis, for better decision-making [2][3]. In the context of MSMEs, IoT implementation can help improve operational efficiency, optimize resource utilization, and expand market reach. By leveraging IoT technology, MSMEs can enhance competitiveness, product innovation, and customer service [4][5][6].

Moreover, IoT implementation in MSME production processes also opens up new opportunities for developing more adaptive and responsive manufacturing systems. With sensors providing real-time information about production conditions, MSMEs can respond to market changes or customer demands more quickly and effectively. This research aims to demonstrate how the presence of IoT also enables MSMEs to optimize resource usage, such as raw materials and energy, through more accurate monitoring and analysis of

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consumption and efficiency in the production process. This can reduce production costs and support sustainability and environmental friendliness efforts. Furthermore, IoT can also assist MSMEs in strengthening business sustainability, improving financial performance, and expanding access to global markets [7].

The novelty of this research also lies in comparing aspects of facing increasingly fierce market competition, where MSMEs need to improve operational efficiency continuously. By leveraging IoT technology in production, MSMEs can create competitive advantages by enhancing productivity, reducing wastage, and improving responsiveness to market demand. However, despite its great potential, the implementation of IoT in MSME production processes also faces several challenges, including initial implementation costs, the complexity of integration with existing infrastructure, and data security and privacy concerns that need to be seriously considered.

The production processes in MSMEs considerably require technological innovation because technology adoption, such as the Internet of Things (IoT), can provide several significant benefits for MSMEs. Research suggests that adopting IoT can influence technology decision-making within MSMEs [8]. IoT technology enables MSMEs to improve operational efficiency, enhance product quality, and optimize production processes. By leveraging IoT, MSMEs can monitor production processes in real-time, quickly identify potential issues, and respond flexibly to market changes.

This research is interesting to explore because sensor technology and internet connectivity developments are becoming more affordable for MSMEs, making it easier for them to integrate IoT solutions into their production processes. With increasingly affordable implementation costs, many MSMEs can access IoT technology without heavy financial burdens. Therefore, MSMEs must consider these aspects and adequately prepare themselves before adopting IoT technology. Furthermore, a study underscores the obstacles MSMEs encounter in embracing IoT [9], including concerns related to halal issues and emerging market scandals. However, with technological innovations like IoT, MSMEs can enhance their competitiveness, product innovation, and customer service. IoT technology can also help MSMEs strengthen business sustainability, improve financial performance, and expand access to global markets.

Hence, MSMEs need to take a careful approach to planning and implementing IoT solutions, considering specific needs and potential benefits that can be obtained. Collaboration with experienced technology solution providers can also help MSMEs overcome technical and operational challenges in adopting IoT. By providing an overview of this background, it is hoped that the analytical study results on MSMEs implementing IoT in MSME production processes can become a strategic step supporting their growth and sustainability in this digital era. With the potential to improve product quality, operational efficiency, and market responsiveness, IoT promises positive transformation for MSMEs in facing challenges and leveraging opportunities in competitive markets.

2. Research Methods

This research utilizes a qualitative descriptive approach to elucidate subjects through words, enabling a deep understanding of the observed phenomena. The purposive area method is employed to determine the research location, meaning that the research site is selected according to the predetermined research objectives. In this context, the chosen research location is Micro, Small, and Medium Enterprises (MSMEs) in Surabaya City. Surabaya was selected because it has a somewhat developed industrial area, support from the local government for MSME development, and adequate infrastructure. Additionally, the high concentration of MSMEs in these cities will enable the adoption of IoT technology, which will significantly improve the quality and efficiency of production processes. Thus, this research aims to understand better how IoT can be applied to enhance the quality and control of production processes in MSMEs in that city.

The decision to focus on MSMEs as the research subject is based on their significant role in the local economy and their essential contribution to employment. Through this research, it is hoped that strategies and solutions can be found to help MSMEs improve their efficiency and competitiveness in the production process. Furthermore, this research can also provide new insights for stakeholders regarding the potential application of IoT in enhancing the overall performance of MSMEs.

The selection of the qualitative descriptive method as a research approach is based on the need to understand the context and complexity of the observed phenomena deeply. Using this approach, researchers can explore stakeholders' perceptions, opinions, and experiences regarding the implementation of IoT in MSME production processes. This allows for generating rich and relevant insights to help formulate appropriate stakeholder recommendations.

In the research process, data will be collected through interviews, observations, and analysis of relevant literature studies. This approach enables researchers to understand the challenges, needs, and potential of MSMEs in adopting IoT technology in their production processes. Thus, the results of this research are expected to significantly contribute to the development of MSMEs in South Tangerang City and knowledge about the application of IoT in the context of small and medium industries more broadly. Data analysis is conducted

through data reduction, data display, and drawing conclusions. The research is conducted for one month, namely in January 2024.

3. Results and Discussion

Table 1. Interview Guideline

No.	Question
1	Have you implemented Internet of Things (IoT) technology in the production process of your MSME?
2	Do you have expertise in sensors or IoT devices as an MSME business owner?
3	How effective is the use of IoT in improving operational efficiency in your MSME?
4	How does IoT affect the quality of products produced by your MSME?
5	How do you control and monitor the production process with the help of IoT?
6	Have you encountered challenges in integrating IoT technology with existing production systems in your MSME?
7	How do you manage the security and privacy of data generated by IoT devices in the production process?
8	Have you seen an increase in efficiency in energy usage and other resources after implementing IoT?
9	How have changes in the use of IoT technology affected employees and work culture in your MSME?
10	Do you have plans to enhance or expand the use of IoT in the production process of your MSME in the future?

Based on the results obtained from the interview, it depict that there is still a lack of awareness among the community to utilize IoT in their businesses. Several obstacles that may cause MSMEs not to conduct business through IoT could include various factors. One is the limitation in understanding and technological skills among MSME actors [10]. Additionally, constraints related to limited marketing and product quality standards can hinder IoT technology adoption [11]. External environmental factors, such as issues related to halal and market scandals, can also affect the use of e-commerce in MSMEs [12].

Furthermore, factors such as implementation costs, unstable internet connections, transaction limits, and costs and insufficient IT skills can also pose obstacles to adopting IoT technology [13]. By understanding these obstacles, MSMEs can identify areas that need improvement to facilitate the implementation of IoT technology. Training, technical assistance, and a better understanding of the benefits of IoT technology can help MSMEs overcome these obstacles and harness the potential of technology to enhance efficiency, productivity, and business competitiveness.

There are several reasons why some MSME business owners are still reluctant to use the Internet of Things (IoT) in their businesses. One is the lack of understanding and technical knowledge of IoT among MSME actors [14]. High implementation costs and lack of financial resources can also be barriers to adopting IoT technology [15]. Data security and privacy constraints are often the primary considerations for MSMEs when using IoT [16]. Furthermore, a lack of understanding of the concrete benefits gained from IoT can also be why some MSMEs are still reluctant to adopt this technology [17]. Besides these factors, concerns about technological complexity, lack of technical support, and uncertainty about expected outcomes can also be why some MSMEs have not yet conducted business through IoT [18]. With a better understanding of the benefits, risks, and appropriate implementation strategies, MSMEs can overcome these barriers and harness the potential of IoT technology to enhance efficiency, productivity, and business competitiveness.

Enhancing Production Efficiency in IoT-based MSMEs

Steps to enhance production efficiency in IoT-based MSMEs can involve several strategies supported by related research. One crucial step is to improve understanding and skills in IoT technology among MSME stakeholders. Training and technical assistance can help MSMEs grasp the potential and benefits of IoT technology in enhancing their production efficiency. Additionally, MSMEs must consider technical factors such as the selection of hardware, software, and networks that align with their production needs [19]. Furthermore, MSMEs can consider integrating simplified and affordable Enterprise Resource Planning (ERP) systems designed explicitly for MSMEs [20]. ERP can assist MSMEs in efficiently managing production processes, inventory, and resource management.

Moreover, MSMEs must consider data security and privacy when implementing IoT technology. Ensuring that data generated by IoT systems are secure and protected is a crucial step in maintaining business sustainability. Additionally, MSMEs can utilize IoT to monitor and optimize production processes in real time [21]. By leveraging data generated by IoT sensors, MSMEs can conduct in-depth analysis to identify potential production efficiency improvements. An MSME must consider sustainability, social responsibility, and IoT integration into business activities [22]. By following these steps and considering relevant factors, MSMEs can enhance their production efficiency by implementing IoT technology. With good understanding, adequate technical support, and appropriate implementation strategies, MSMEs can harness the potential of IoT technology to improve their operational performance and business competitiveness.

Optimization of Production Processes and Product Quality in IoT-Based MSMEs

Implementing an IoT-based product quality control system to ensure quality standards are met [23]. Utilize IoT for production process automation to ensure consistency in product quality. Optimization ensures that the IoT-based product quality control system meets quality standards. MSMEs can efficiently enhance their product quality based on the Internet of Things (IoT) through technology for monitoring, controlling, and analyzing product quality. Without leveraging technologies like IoT, MSMEs may struggle to reach broader and diverse markets. They might fail to capitalize on the potential of digital trade and international market penetration offered by digital technology. The results of this research then lead to the creation of a table describing the steps and implementation of technology as follows.

Table 2. Steps and Technology Implementation

No.	Steps	Implementation
1	Real-Time Production Process Monitoring	MSMEs can monitor the production process in real-time by utilizing connected sensors and IoT devices. These sensors can measure various parameters such as temperature, humidity, pressure, or the presence of raw materials, thus providing accurate visibility into each production stage.
2	Early Detection of Defects or Non-Conformities	IoT sensors enable MSMEs to detect defects or non-conformities in product quality swiftly. For instance, dimension or weight measuring sensors can provide alerts if a product fails to meet the specified standards, allowing for a prompt intervention to rectify issues before the product is completed.
3	Monitoring Raw Material and Component Quality	By utilizing RFID (Radio Frequency Identification) technology or sensors attached to raw materials and components, MSMEs can monitor the quality and origin of their raw materials. This enables the identification of defective or substandard raw materials from the outset, thereby preventing the entry of poor-quality materials into production.
4	Utilization of Automated Control Systems	MSMEs can implement IoT-based automated control systems to regulate and control production parameters such as temperature, humidity, or machine speed. With this system, variations in the production process can be minimized, thereby enhancing product quality consistency.
5	Continuous Improvement Data Analysis	Data collected from sensors and IoT devices can be analyzed to identify trends and patterns related to product quality. MSMEs can use this analysis to continuously improve production processes and product design continuously, enhancing overall product quality.
6	Machine Monitoring and Maintenance	MSMEs can utilize IoT sensors to monitor the performance of their machines and production equipment. By monitoring machine conditions in real time, MSMEs can prevent unforeseen machine failures affecting product quality.
7	Utilization of Identification and Tracking Technology	Utilization of Identification and Tracking Technology By employing identification technologies such as QR codes or barcodes, MSMEs can track each product individually from the beginning of production to delivery to the customer. This enables tracking of production traces and provides quality assurance to customers.

Challenges in Improving Quality and Process Control for IoT-Based MSMEs

Technology enables MSMEs to automate processes that previously consumed significant time and human resources. This enhances operational efficiency and allows MSMEs to accomplish more with limited resources. The challenges in conducting business involving the Internet of Things (IoT) can be complex because adopting this technology brings forth several benefits and challenges that need to be considered. Some identified benefits

include IoT integration within organizational supply chains to enhance efficiency [24], designing business models that consider privacy and internet security aspects [25], and leveraging IoT in business process automation and decision-making [26].

However, emerging challenges include multidisciplinary complexity in teaching IoT due to involvement across various fields such as computing, electrical engineering, business, and humanities studies. Designing reliable IoT systems to address these challenges is essential to identifying existing trust models and recognizing four critical challenges in creating value and building trustworthy IoT systems [27]. Additionally, it is important to consider business models appropriate for IoT, such as the IoT as a service model [28], and understand the role of capabilities and alliances emerging from IoT in the relationship between strategic orientation and product and process innovation.

In a business context, IoT integration within business models can bring about specific business model innovations for IoT. However, little is known about how IoT transforms business models, with most research focused on technical IoT challenges and few empirical studies investigating business model innovations specific to IoT. Therefore, it is crucial to continue research efforts to identify suitable approaches and methods to integrate IoT technology within the business process paradigm.

There are several challenges to be addressed in improving quality and process control in Micro, Small, and Medium Enterprises (MSMEs) based on the Internet of Things (IoT), including:

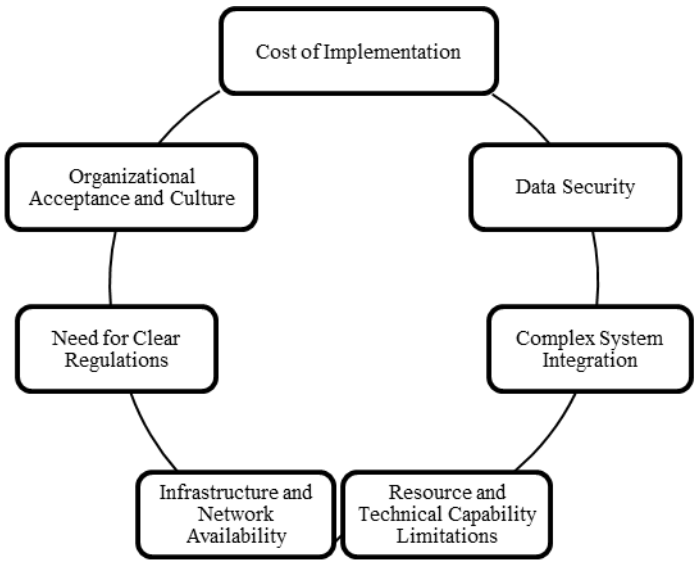

Figure 1. Diagram of IoT-Based SME Challenges

Figure Description:

1. Implementation Costs: One of the main challenges is implementing IoT technology. Procuring hardware and software and the infrastructure needed to connect all IoT devices can be expensive, especially for MSMEs with limited budgets.
2. Data Security: The use of IoT increases risks related to data security. With numerous connected devices, MSMEs are vulnerable to cyber-attacks and data theft. Strong data protection and effective security strategies are required to safeguard sensitive information from these threats.
3. Complex System Integration: Integrating IoT systems with existing technological infrastructure in MSMEs can be challenging. Various platforms, hardware, and software must communicate and cooperate effectively for IoT technology to function efficiently.
4. Resource and Technical Capability Limitations: Many MSMEs may have limitations in terms of human resources and technical capabilities to implement and manage IoT technology. Additional training and education may be needed to ensure employees have sufficient knowledge and skills to use this technology effectively.
5. Infrastructure and Network Availability: MSMEs in remote or developing areas may face challenges accessing the technological infrastructure and networks needed to support IoT implementation. The availability of affordable and stable internet access is crucial for the success of IoT implementation.
6. Need for Clear Regulations: Clear and technology-friendly regulations are needed to support IoT adoption in MSMEs. Supportive policies, including adequate data protection and security standards, must provide legal certainty and promote technological growth.

7. Organizational Acceptance and Culture: Lack of organizational acceptance and supportive culture can also be barriers to adopting IoT. MSMEs need to ensure that the entire organization, from management to employees, has an open attitude towards change and is ready to adopt new technology.

Overcoming these challenges requires commitment, investment, and appropriate strategies from MSMEs, as well as support from the government, industry, and relevant institutions. By addressing these challenges, MSMEs can achieve significant benefits in enhancing product quality and process control through the adoption of IoT technology.

4. Conclusion

This research highlights that the implementation of the Internet of Things (IoT) in the production processes of Micro, Small, and Medium Enterprises (MSMEs) has the potential to enhance product quality, operational efficiency, and market responsiveness. By leveraging IoT technology, MSMEs can monitor production processes in real-time, swiftly identify potential issues, and respond to market changes more flexibly. Additionally, IoT implementation can also assist MSMEs in strengthening business sustainability, improving financial performance, and expanding access to global markets.

However, implementing IoT in MSMEs also poses several challenges, such as initial implementation costs, complexity in integration with existing infrastructure, as well as data security and privacy concerns that need to be addressed seriously. Therefore, MSMEs need to take a careful approach in planning and implementing IoT solutions, considering specific needs and potential benefits that can be obtained. Collaboration with experienced technology solution providers can also help MSMEs overcome technical and operational challenges in adopting IoT.

With the potential to enhance product quality, operational efficiency, and competitiveness of MSMEs, the implementation of IoT in production processes can be a strategic step supporting the growth and sustainability of MSMEs in this digital era.

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