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Connected Futures: Exploring IoT Development in Malaysian SMEs for Industry 4.0

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Abstract: This qualitative study explores the current state of Internet of Things (IoT) implementation in Malaysian small- and medium-sized enterprises (SMEs) within the framework of Industry 4.0. Through online interviews and a focus group involving five participants from three SMEs, the research reveals a relatively low adoption of Industry 4.0 in Malaysian manufacturing SMEs. Challenges include the imperative for education and training, budget constraints, and a lack of experience among workers. Despite these hurdles, positive outcomes of IoT implementation emerge, such as enhanced internal communication, error reduction, and improved product quality and safety. The study concludes by presenting an IoT framework, developed collaboratively with experts, offering a strategic tool for Malaysian SMEs navigating the landscape of Industry 4.0 and facilitating advancements in the manufacturing sector.

Keywords: Industry 4.0, IoT Implementation, Malaysian SMEs

1. Introduction

The advent of Industry 4.0 marks a transformative era in manufacturing, leveraging advanced information and communication technologies to optimize production processes. Central to this revolution is the integration of the Internet of Things (IoT), reshaping manufacturing sectors globally. While Industry 4.0 promises enhanced efficiency and competitiveness, its adoption poses challenges, particularly for Small and Medium-sized Enterprises (SMEs) grappling with limited resources.[1] Defined as a service-oriented, optimized, integrated, and interoperable manufacturing paradigm, Industry 4.0 redefines how products are conceived, produced, and maintained. This paradigm shift, fueled by rapid technological advancements, not only impacts operational procedures but also influences energy footprints, management practices, and skill requirements within the manufacturing landscape.[2] In the context of a globalizing economy and rapid technological strides, SMEs emerge as key players, and Industry 4.0 offers them a gateway to heightened productivity, adaptability, and cost-effectiveness. This article explores the current status of Industry 4.0 adoption in Malaysian SMEs,

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emphasizing the vital role of IoT integration in enhancing manufacturing efficiency. Against the backdrop of the ongoing COVID-19 pandemic, the article also underscores the potential for a new wave of entrepreneurship driving the next industrial revolution, with innovative business models leveraging cutting-edge technology. Through an examination of Malaysia's economic reliance on SMEs, the article positions Industry 4.0 as a catalyst for economic growth and competitiveness, drawing parallels with developments in neighboring Asian countries like China and Singapore. As Malaysia embarks on the Industry 4.0 journey, the article seeks to shed light on its implications for the nation's industrial sectors, emphasizing the need for comprehensive insights into the impact and cost-effectiveness of Industry 4.0 initiatives.

2. Related Work

2.1 Current Status and Practices of Industry 4.0

Adoption of Industry 4.0 is essential for Malaysia to stay competitive, as SMEs make up the bulk of manufacturing establishments. But just 30% of Malaysian businesses are aware of Industry 4.0. The COVID-19 pandemic has made slow technological adoption, particularly among SMEs, even more difficult. This is despite government initiatives and budget allocations to support digitalization.

The manufacturing sector in Malaysia is dealing with challenges such as the requirement for increased resources, skilled labor, infrastructure, and technical facilities. The National Policy on Industry 4.0 aims to coordinate this shift, but obstacles related to public accessibility stand in the way. Despite being positioned between Industry 2.0 and 3.0, Malaysia makes a substantial contribution to the nation's GDP and continues to hold a competitive advantage in the global manufacturing sector. [3] As the government forces manufacturers to adopt Industry 4.0, those who are already observing the standards face obstacles.

2.2 Challenges of Industry 4.0 during the Implementation Process

Even though Industry 4.0 would generate economic advantages, there remain challenges to its adoption. Several dimensions, including scientific, economic, social, political, and technical aspects, contribute to the challenges faced by organizations. [4] Barriers to adoption include financial concerns, such as the fear of investment costs outweighing potential growth, and the lack of financing for maintenance.

Management also faces challenges related to time constraints, as the transition to Industry 4.0 is a labor-intensive process, requiring significant time and investment. Human resource development is another concern, as the shift towards Industry 4.0 necessitates new skills, and there is a potential shortage of suitably trained employees. As automation replaces manual labor, psychological risks surface that have an impact on occupational safety and health. [4] The cloud-based or web-based infrastructure of Industry 4.0 raises concerns about cybersecurity, privacy, and data security. One of the biggest challenges in information management is transforming massive amounts of generated data into meaningful information.

A certain impact exists for small and medium-sized enterprises (SMEs), which encounter challenges like developing a feasible Industry 4.0 strategy, financial limitations, inadequate standardization, and lack of IT skills. Industry 4.0 adoption varies depending on the size of the company; larger companies can afford to allocate more resources toward addressing technical, financial, and human resource challenges than SMEs. Contributions of the paper include addressing IoT/Industry 4.0 practices currently in use, identifying implementation barriers, and suggesting an IoT framework to support Industry 4.0 in a particular SME case study, all with an emphasis on Malaysian SMEs. [5] Although there is no appropriate framework for Industry 4.0 in the Malaysian context, the study attempts to close knowledge gaps about obstacles to successful implementation.

3. Methodology/Framework

The study's approach is essential to understanding the complex IoT deployment environment in small and medium-sized businesses (SMEs). This study was carried out using a qualitative method through online interviews and a focus group. The qualitative method provides insights into research objectives through primary data and helps to improve the ideas or hypotheses of a new framework's implementation [5]. This section outlines the painstaking procedures used in the selection of participants, the shift to online interviews that was required due to the COVID-19 epidemic, and the comprehensive method of developing the framework and doing thematic analysis.

3.1 Participant Selection and Qualitative Approach

The research used a qualitative approach, including focus groups and online interviews. Based on their prior expertise in the company, five participants were chosen to represent different jobs in three SMEs.. Details of the participant sample are outlined in Table 1.

Table 1: Participant Sample

Participant	Department	Company	Current Position	Years of Experience
1	Operation	A	Plant/Operation Manager	28
2	Maintenance	A	Head of Maintenance	20
3	Operation	A	Innovation Manager	19
4	IT/Development	A	Project Manager/Software Developer	14
5	Automation	A	Robotics Manager	11

3.2 Online Interview Process

Face-to-face interviews were substituted with 30- to 45-minute online Zoom sessions because of the COVID-19 epidemic. Two volunteers in a pilot test made sure the questions were suitable, clear, and relevant. For data reliability, leading suggestion avoidance, consistent questioning, and structured interviewing approaches were used. According to James and Busher [6], having a limited budget and not being able to conduct interviews in different places, online interviews can give great opportunities to researchers.

3.3 Thematic Analysis and Framework Development

Thematic analysis was used in NVivo Version 12 to find patterns and themes in the two stages of interview data collection. In the second stage, six experts in Industry 4.0 and IoT participated in a Zoom-hosted focus group. Participants' responses were meticulously analyzed in order to create the IoT framework. Company names were kept hidden in order to preserve confidentiality. Figure 1 visually illustrates the research methodology, offering a concise overview of the study design and procedures.

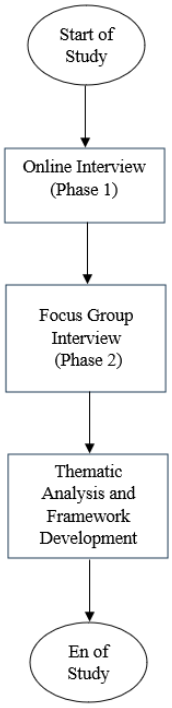

Figure 1 : Flowchart Illustrate the Methodology

4. Result

4.1. Perceptions about IoT and Industry 4.0

When queried about their understanding of IoT, most participants described it as a "communication and interaction method between machines and humans." They expressed the notion that IoT involves programming devices to execute specific actions remotely and facilitating information exchange across interconnected machines via the internet. Participant 1 emphasized the programming aspect, while Participant 2 focused on information exchange. Participant 3 highlighted the value companies derive from interconnected devices, and Participant 4 simply characterized IoT as "anything connected to the internet." Participant 5 underscored the remote management and monitoring facets of IoT. Regarding Industry 4.0, the majority of participants perceived it as encompassing automation and the integration of various technologies, including big data, IoT devices, and real-time communication. Notably, Participant 2 presented a distinctive view, defining Industry 4.0 as a "digital link between a server and local networks that provides real-time data."

4.2. Current Status and Practices of the IoT and Industry 4.0

The survey revealed that most participants indicated their companies are either in the early stages of discussing or have taken limited steps toward implementing IoT/Industry 4.0. Participants 2 and 3 mentioned their departments are still in the discussion stage and have no plans for implementation, with Participant 3 expressing skepticism due to perceived lateness. Regarding employee preparation, participants 1, 3, and 5 believe top management has actively taken steps, including hiring experts and providing training. However, Participant 2 reported a lack of plans for employee preparation, while Participant 4 stressed the importance of practical training on actual machines. Concerning top management's interest in learning about IoT/Industry 4.0, the majority of participants stated active involvement and regular meetings. Yet, Participant 2's company is not currently planning to explore these technologies, and Participant 3 mentioned discussions about the company's transformation. In terms of technology spending from 2017 to 2021, most participants reported expenditures ranging from MYR 250,000 to MYR 1,400,000. Notably, Participant 2 mentioned spending MYR 1,400,000 on

unused devices, while Participant 4 saw immediate benefits from a MYR 1,000,000 investment in new machinery. Participant 5 spent MYR250,000 on a high-frequency welding machine, not specifically on IoT or Industry 4.0 technology. Overall, participants had varied experiences with technology investments, with some reaping benefits and others facing underutilized devices.

4.3. Barriers to the Implementation of the IoT and Industry 4.0

Participants identified common barriers to implementing IoT/Industry 4.0, including staff education and training, budget constraints, and financial management challenges. Participants 1 and 2 emphasized the need for employee training, while Participant 3 highlighted funding issues, and Participant 4 mentioned a lack of experience among workers. Participant 5 stressed securing budgets for implementation and maintenance as a primary barrier. Regarding company policies, most participants viewed their company's stance on IoT/Industry 4.0 positively or with room for improvement. However, Participant 2 expressed dissatisfaction, citing a lack of clear guidelines that could negatively impact the company. Participant 5 was concerned about the absence of IoT/Industry 4.0 in their company's policy, fearing potential harm to the company's goal of becoming a leading automotive vendor. In terms of problem resolution, most participants reported that management is supportive and actively working to address IoT/Industry 4.0 issues. Participant 2 faced administrative issues, while Participant 5 indicated their company has yet to implement IoT/Industry 4.0. Participant 4 described using a "predictive path method" to analyze machine data and promptly resolve issues. Regarding challenges faced, participants commonly cited funding and a shortage of skilled staff. Solutions included seeking government assistance, initiating small-scale implementations, and providing employee training. Participant 3 addressed device connection issues by installing a high-performance IT network, while Participant 5 faced additional challenges related to COVID-19, material supply, and precise planning, requiring focused attention from SMEs.

4.4. IoT Implementation Framework

The focus group reported that the company is implementing IoT and robotic technology to enhance operations but faces challenges due to a lack of skills. Centralized servers and a central operations room are in place, allowing real-time data viewing. The company aims to achieve Industry 4.0. Participants noted the company follows Lean production and standard processes but faces challenges. They plan to integrate IoT to address Lean system issues. The current protocol system, influenced by Perodua, is manual and time-consuming. The company successfully implemented IoT in two production line machines, improving efficiency. They emphasize the potential of IoT for better planning and suggest adopting more IoT technologies. The focus group mentioned adopting the ISO/TS standard for the automotive industry as a framework for technology implementation. The standard provides a systematic information flow based on operational data. The group believes the current framework can be adapted for Industry 4.0 or IoT with modifications. The existing framework has shown positive results and is cost-effective. The proposed framework for smoother IoT implementation involves ordering from suppliers, material flow through stages, and real-time information sharing. IoT integration aims to enhance accuracy, communication, and speed. Implementing the technological framework/IoT is expected to positively impact SMEs' performance, improving internal communication, reducing errors, and enhancing product quality. It can make the company a reliable player in the market and provide customization opportunities for a competitive edge globally. The proposed framework is based on the study results, emphasizing the positive impact on SMEs' performances.

4.4.1. IoT Preparation (Phase1)

In this stage, the organization is required to assess its preparedness for implementing IoT, utilizing the 5M model (man, machine, material, method, and money) within the framework of SQDCM (safety, quality, delivery, cost, and morale). The assessment involves evaluating accessibility, commitment of management and staff, staff responsiveness, manpower levels, customer satisfaction, operational enhancements, process agility, waste reduction, issue identification, efficiency, data consistency, accurate data parameters, clarity and value of data, as well as breakdowns. This evaluation

aids in pinpointing areas of concern and determining the organization's readiness for IoT implementation.

4.4.2. Planning and Implementation (Phase2)

In this stage, the organization is required to strategize and execute the IoT system. The planning process should derive from evaluating results on a smaller scale and must pinpoint crucial issues, bridging the readiness gap. The organization should gauge the readiness of the 5M factors for IoT implementation assessment. The implementation phase should prioritize precision in machine/setting, suitability for IoT, technology availability, developability, material availability, quality, thickness, measurement accuracy, adherence to standard operating procedures (SOPs), and consideration of display options such as tablets and mobile devices. Moreover, the implementation process should also account for the graphical user interface (GUI) designed for data collection and analysis.

4.4.3. Evaluation and Improvement (Phase3)

In this stage, the organization is tasked with assessing the outcomes of implementation and pinpointing areas that require enhancement. The evaluation process involves scrutinizing customer feedback, production performance, waste management, manual reporting, damage control, product rejection rates, profit and loss reports, quality standards, and feedback from the workforce. The assessment should center on the disparities between the planned and actual outcomes, as well as considerations of muri (overburden), mura (unevenness), muda (waste), and the level of support from management. Additionally, the organization must evaluate potential failure points, the proficiency of maintenance specialists, installation and connection processes, and the performance of sensors. The success of the implementation is affirmed by the realization of new value in the system.

5. Discussion

The research indicates a nuanced understanding of IoT and Industry 4.0 among SMEs in Malaysia, contrary to previous studies [70,73]. Although many SMEs are in early stages of IoT and Industry 4.0 adoption, proactive steps by top management, including hiring experts and training initiatives, are evident. Despite financial challenges, SMEs have invested significantly in technology upgrades, ranging from MYR 250,000 to MYR 1,400,000 between 2017 and 2021 [45]. However, experiences with technology vary, and uncertainties persist regarding the financial benefits of implementing IoT in Industry 4.0, as noted by Koch et al. [49].

Challenges in implementation span education, training, budgeting, and a lack of worker experience, aligning with the dimensions of Industry 4.0 [43]. Funding and skilled staff availability emerge as major barriers, prompting SMEs to seek government assistance and prioritize employee training [56]. The study provides a nuanced view of IoT and Industry 4.0 implementation, showcasing successes alongside challenges in integrating advanced technologies.SMEs pragmatically adopt the ISO/TS standard, originally designed for the automotive industry, as an IoT implementation framework. This standard not only acts as a guide for best practices but also serves as a crucial communication conduit [38].

The proposed three-phase IoT implementation framework is based on a pragmatic approach to Industry 4.0 in SMEs. In the preparation phase, readiness factors (5M - manpower, knowledge, skills, understanding, and processes) are identified and addressed. The implementation phase involves machine and material preparation, GUI development, data collection, analysis, and overall planning and execution. The final phase emphasizes evaluation based on customer feedback, production performance, waste levels, profit and loss reports, etc., followed by iterative improvements.

In conclusion, the framework provides practical guidance for SMEs to assess, plan, implement, and enhance their IoT systems. By leveraging this framework, organizations can navigate challenges associated with IoT and Industry 4.0, optimizing operations, improving profitability, and enhancing customer satisfaction in a rapidly evolving technological landscape.

5. Conclusion

In summary, this study explores the implementation of Industry 4.0 and IoT among SMEs in Malaysia. While SMEs exhibit a general understanding and progress in adopting IoT, challenges like education gaps and budget constraints persist. [8,9] The proposed IoT framework, emphasizing effective management, shows promise in overcoming these challenges and enabling remote monitoring. [7,10] Recommendations include expanding IoT applications, modifying the framework for Industry 4.0 compatibility, and addressing challenges through strategic measures. Despite contributions, study limitations highlight the need for further research with a larger, more diverse sample. This research not only aids Malaysian SMEs in enhancing competitiveness but also contributes valuable insights to the broader field, emphasizing the ongoing need for exploration and innovation in Industry 4.0 and IoT implementation.

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