

Empathising and Defining the Strategy Development Process Adoption of Industrial 4.0 in SMEs

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ABSTRACT

The advent of Industry 4.0 has become an integral part of the manufacturing industry, playing a crucial role in boosting competitiveness and enhancing productivity within companies. Small and Medium Enterprises (SMEs), which contribute significantly to the national economy, must inevitably embrace the adoption of Industry 4.0 technology. However, the implementation of this technology at the SME faces numerous obstacles. To address these challenges and facilitate the transformation to Industry 4.0 in SMEs, this research aims to construct a comprehensive adoption strategy. Currently in its preliminary stage, the strategy development process primarily involves identifying stakeholders, their needs, and the goals they aim to achieve. Design thinking, specifically the empathize and define phase, is employed as the methodological approach. The information utilized in this study originates from systematic literature reviews conducted using PRISMA. The analysis of the gathered data has identified several stakeholders, including government entities, IT experts, management personnel, and employees. However, for the purpose of creating user personas, the focus is narrowed down to management and employees. User personas are instrumental in understanding the goals and potential obstacles faced by these individuals. The culmination of this stage is the formulation of a problem statement, which will be further refined in subsequent phases of the design thinking process.

Keywords:
Industry 4.0; strategy adoption; SMEs; design thinking.

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1. INTRODUCTION

Digitalization in the manufacturing industry offers numerous advantages in today's industrial era [1]. By leveraging a combination of cutting-edge technologies such as the Industrial Internet of Things (IIoT), Internet of Things (IoT), Cyber-Physical Systems (CPS), and Big Data Analytics, operational processes can be executed with ease and flexibility [2]. At the economic, automation, and digitalization fronts, Industry 4.0 technology plays a pivotal role in boosting productivity and operational efficiency [1]. The integration of digital technology and Industry 4.0 principles into production systems presents companies with opportunities to enhance operations and develop novel products and services [3].

At the managerial level, cross-departmental vertical integration facilitates the seamless flow of information and communication, resulting in accelerated dissemination and improved problem-solving capabilities. Furthermore, it enhances organizational flexibility and problem-solving capacity [1]. In addition to increasing productivity and efficiency, Industry 4.0 technologies also yield positive environmental impacts. For instance, the implementation of a dashboard feature system enables operators to proactively monitor and maintain optimal temperatures, leading to energy savings. This, in turn, contributes to a reduction in resource consumption and emissions, positively impacting the environment. Moreover, this system aids in preventing downtime by facilitating predictive maintenance activities. Consequently, efficiency and capacity are amplified, while human labor and associated costs are reduced [4].

Small and Medium Enterprises (SMEs) serve as the cornerstone of the manufacturing industry [5]. These enterprises play a significant role in the economic and social sectors, consistently contributing to innovation and competitiveness [6]. Remarkably, SMEs account for over 90% of a country's GDP [7], earning them the title of "engines of growth" as they actively fulfill crucial needs related to economic development and employment within communities [7]. A key advantage of SMEs lies in their agility when it comes to adopting new technologies and catering to niche markets. In contrast, larger companies tend to excel in efficiency but often lag in embracing innovation due to their inherent complexities [5], [7]. As a result, SMEs must remain adaptable to technological and market changes in order to stay competitive [8].

For instance, in India, SMEs have compelling reasons to implement Industry 4.0 technologies, particularly cloud computing. By leveraging cloud computing, these enterprises can achieve cost savings, ensure data security, and significantly reduce processing time, thanks to the accessibility of data from various locations and at any time. Moreover, the adoption of cloud computing enables SMEs to avoid hefty infrastructure investments, thereby alleviating capital expenditure burdens [9].

However, the truth remains that numerous SMEs continue to encounter difficulties when attempting to adopt and implement technology, particularly in the context of Industry 4.0. In Indonesia, a majority of still continue to utilize information technology, specifically social networking platforms, to engage and communicate with their consumer base [10]. They unprepared to embrace the principles of Industry 4.0 [11]. The automotive SME sector, 56% of companies are operating at a novice level of technological adoption, while others exhibit no intention to transition to Industry 4.0 [12]. A survey encompassing 502 manufacturing industries unveiled that a staggering 86% of these companies rely on ICT technology. Furthermore, the level of awareness regarding the significance of Industry 4.0 among SMEs stands at a mere 5.46%, in stark contrast to the 36.17% observed among larger companies [13]. Considering the indispensable role played by SMEs in the economy, it becomes imperative for them to effectively leverage technology to sustain operations and compete. However, a multitude of challenges and barriers hinder their adoption of technology, particularly in the realm of Industry 4.0. These challenges encompass deficient workforce skills [1], [14], steep investment costs and pronounced risks of failure [3], limited comprehension and concern regarding strategic and managerial aspects [15], inadequate infrastructure [9], a scarcity of experts [8], insufficient governmental support in the form of capital assistance or incentives, ambiguous regulations [16], [17], security risks associated with data sharing [1], [18]. In light of these challenges and obstacles faced by SMEs, it is crucial to adopt an appropriate method or approach that facilitates the integration of Industry 4.0 technology. This research aims to develop a strategy for the implementation of Industry 4.0 technology, utilizing a design thinking approach with a specific emphasis on the empathize and define phases.

A literature review was conducted to identify previous research on the implementation framework of Industry 4.0. Using the keywords "framework" AND "adoption" AND "industry 4.0" AND "sme" in the Scopus database, 9 papers were selected for comparison. One of the papers discussed a framework for measuring technology maturity [19]. Perea also created a comprehensive framework with a focus on oil and gas-based SMEs [20]. Mohammadiyan's framework aimed to address social, environmental, and quality issues in the context of transitioning towards Industry 5.0, primarily oriented towards both profit and non-profit organizations in preparing future SMEs [21]. A framework also has been built to study the impact of Industry 4.0 technology on circular economy in SMEs within the European Union [22], while Wong emphasized governmental investigations on capability, institutional support, advantages, and market factors to measure readiness for Industry 4.0 implementation in SMEs. Another focus in another framework is about on a sociotechnical perspective that analyzed the relationship between technology implementation and organizational changes [23]. Meanwhile, another framework focuses on the training and re-skilling process to build a strong workforce for Industry 4.0 implementation [24] and a study that examines several existing frameworks to see how a framework can be flexible

and sustainable to help SMEs implement Industry 4.0, but this research is still at the stage of comparing different frameworks [25]. These studies have revealed clear knowledge gaps in how to effectively and sustainably apply Industry 4.0 in manufacturing SMEs, highlighting the need for a holistic framework to help SMEs overcome the challenges they face in adopting Industry 4.0.

2. METHOD

This research commences with a systematic literature review that serves as a valuable source of information for applying the design thinking approach to the implementation of Industry 4.0 technology in SMEs. The literature study follows the PRISMA method, as depicted in Figure 1, using the keywords "implementation" AND "industry 4.0" OR "technology" AND "SMEs." A total of 39 articles from the filtered database were utilized, focusing on the topic of implementing Industry 4.0 technology in SMEs. Subsequently, an analysis was conducted employing the design thinking approach during the empathize and define stages. The design thinking approach in this study draws inspiration from Kenny's thought process [26]. Design thinking is an approach employed to identify, comprehend, and cater to the interests of potential customers or users throughout the product or service design process. Its objective is to foster observation and empathy with the target user [27]. The stages outlined in Table 1 provide a summary of the approach adopted during the empathize and define phases in design thinking. The forthcoming section provides a detailed description of the execution of these two phases. However, it is important to acknowledge that this study has limitations regarding government users and IT experts, owing to the scarcity of information available in the literature. Hence, further discussion on these aspects is not feasible.

1. Phase 1 Emphatise

During this phase, the primary objective is to cultivate a deep and empathetic comprehension of user requirements and challenges. Several activities are carried out at this initial stage, with the majority of information collected for later stages in the design process. The understanding developed encompasses various aspects: identifying the user's concerns and focal points, comprehending how users perceive the implementation of technology in their business, identifying the specific needs that must be addressed, and recognizing the issues involved in adopting Industry 4.0 technology within their companies. In each step of the empathy process employed in this study, the ultimate goal is to foster empathy with every stakeholder involved, as an integral part of the design thinking approach.

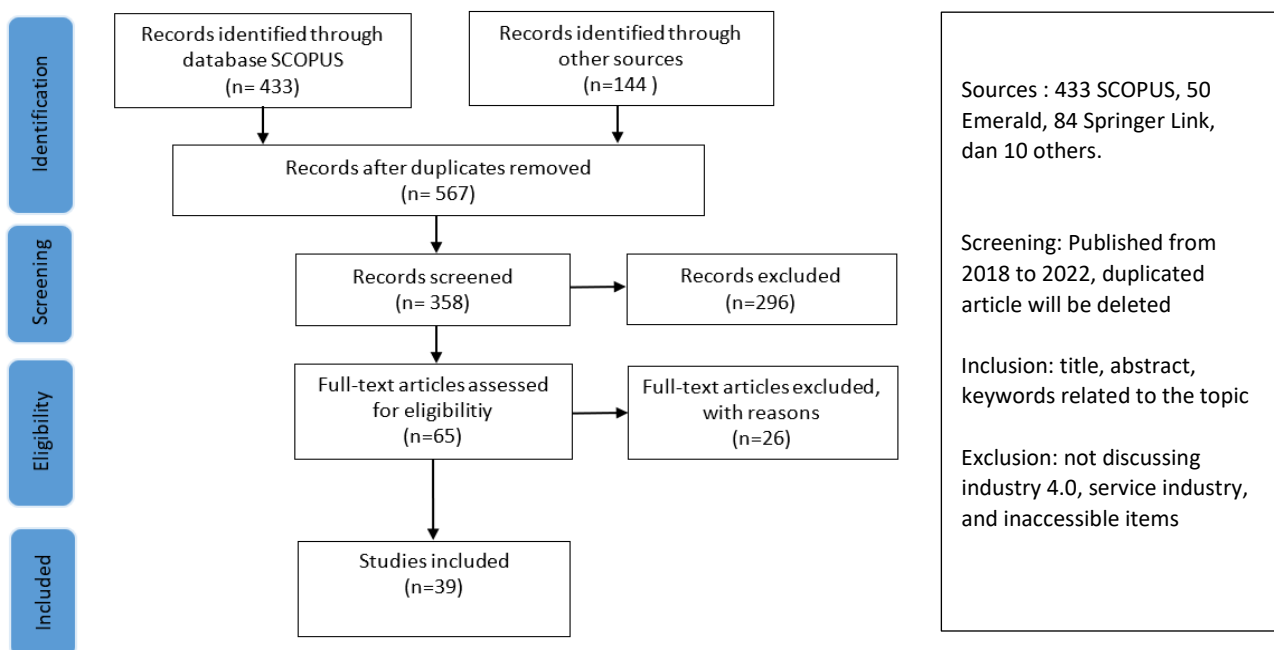


Figure 1 - PRISMA

a. Stakeholder Mapping

The process of stakeholder mapping was derived from the findings of a literature review, taking into account several key factors: (i) identifying the various stakeholders who may be impacted by the adoption of Industry 4.0 technology in SMEs, (ii) determining the specific types of technology that will influence their work, and (iii) understanding the roles that stakeholders will play in relation to the adoption of Industry 4.0 technology.

b. Personal interviews

In the process of conducting individual interviews, adjustments were made as the information source relied on literature rather than direct interactions with informants. Instead, the author sought answers to specific questions from systematic literature sources. These questions encompassed various aspects: (i) the advantages of implementing Industry 4.0 technology for SMEs, (ii) the impact of technology on each stakeholder, (iii) the response of SMEs towards technology, (iv) the obstacles that impede adoption, (v) the support required to facilitate adoption, (vi) the motivations driving SMEs to adopt Industry 4.0 technology, and (vii) the approaches employed by technical SMEs in adopting Industry 4.0 technology.

2. Phase 2 Define

The define phase, which is the second stage of the design thinking process, involves the definition of the problem at hand. During this phase, all the discoveries and insights gathered from the empathize phase are gathered and analyzed. This allows for the interpretation and reframing of user needs, as well as the construction of data. Subsequently, these findings are mapped into a visual model [28].

Table 1 - Stages of Design Thinking, Empathize Phase and Define Phase

Phase	Activity	Stakeholder	Goal	N	Method
Phase 1 Empathies	Stakeholder mapping	Employees Manager Government Technology expert	To identify stakeholder roles	39	Literature study
	Individual interview	Employees Manager Government Technology expert	To understanding of needs and considerations from various perspectives stakeholders Identify obstacles and supports for SMEs in implementing industrial technology 4.0	39	Literature study
Phase 2 Define	Reflections from phase 1		To identify emerging patterns To identify the outline of the problem that needs to be fixed To compile stakeholder needs in phase 1	39	Development of problem statements User persona development

3. RESULT AND DISCUSSION

3.1. Result

In this stage, the researcher will present the outcomes of the two design thinking phases: the empathize phase and the define phase (refer to Table 1).

1. Empathize phase

During the stakeholder mapping activity, various stakeholders involved in the adoption of Industry 4.0 technology in SMEs were identified, including the government, IT experts, managerial departments, and employees (see Figure 2). The government plays a crucial role in establishing regulations, security systems, and incentive programs. IT experts are responsible for the technical implementation of technology, encompassing infrastructure, standards, capacity and quality, as well as the design and maintenance processes. SME employees are important stakeholders as they will operate the technology. Their engagement is influenced by their skills, expertise, and perceptions of technology acceptance. The managerial department represents a vital stakeholder group, as it is responsible for the decision-making process. When deciding to adopt technology, managers need to determine the appropriate strategy. Their decision-making process is influenced by a clear understanding of the importance of technology implementation for the company. The awareness, commitment, corporate culture, and considerations related to investment and costs also play a significant role for managers in this context.

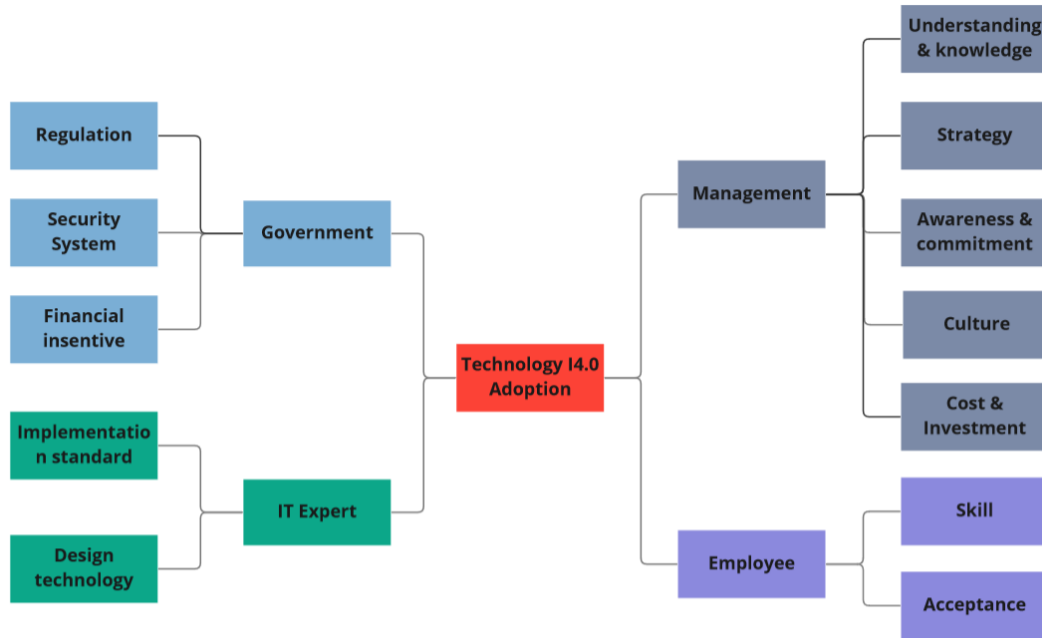


Figure 2 – Stakeholder Mapping

The subsequent step in the empathize phase involves conducting individual interviews with a personalized approach, as illustrated in Figure 3. For this research, a technical adjustment was made by preparing a set of predetermined questions that will extract information from relevant literature sources. The outcomes of this activity will be further elaborated upon in the define phase, providing more comprehensive insights.



Figure 3 – Personal Identification

2. Define phase

Stakeholder mapping activities are valuable for researchers to identify the key stakeholders involved in the adoption of Industry 4.0 technology in SMEs. In the define phase, the identified stakeholders, namely management and

employees, are further characterized as user personas. Each user persona possesses their own unique perspectives, goals, and needs, as outlined in Table 2. The management user persona has a distinct perspective, goal, and set of needs. Their perspective includes recognizing a new problem and seeking revenue enhancement. Their goals revolve around achieving ease of use, minimizing maintenance costs, enhancing the value chain, promoting flexibility, ensuring a positive impact on the environment, avoiding adverse societal consequences, simplifying the managerial system, and capitalizing on new opportunities.

On the other hand, the employee user persona also possesses their own point of view, goal, and needs. They perceive that the equipment is challenging to operate and therefore desire easy operation and reduced errors. Their needs include a safe working environment, decreased defective products, easy monitoring, timely warnings for errors, clear usage instructions, and ultimately an increase in productivity.

Table 2 – User Persona

User	Point of View	Goal	Needs
Management	A new problem arose	Revenue enhancement	Ease of use, low maintenance costs, increase value chain, flexible, positive impact on the environment, does not create contra in society, easier in managerial system, can bring up new opportunities
Employee	The equipment is difficult to operate	Easy operation and reduce errors	Safe, decrease defect product, easy to monitoring, warnings if errors occur, clear usage flow, increasing productivity

As mentioned earlier, government users and IT experts are not discussed or analyzed in the literature as the focus is primarily on the perspective of business owners. Therefore, the user personas discussed in this study are limited to management users and employees. Once the user personas have been identified, the subsequent step involves identifying the problems through the problem statement stages. There are five key problem areas identified, including flexibility, finance, socio-cultural factors, value propositions, and technology devices. These problem statements are summarized in Table 3.

These aspect and problem statements revolve around various considerations related to a user persona and their needs. Flexibility; the strategy must be used flexibly, easy to understand, and to implement. This aspect highlights the importance of a strategy being adaptable and user-friendly. The user persona desires a strategy that can be adjusted according to changing circumstances. It should also be easily comprehensible and implementable by the individuals or teams involved. Financial; strategy does not incur high costs and must be commensurate with the results. The financial aspect emphasizes the user persona's concern regarding cost-effectiveness. They seek a strategy that provides satisfactory results while keeping expenses at a reasonable level. This implies that the strategy should offer a good return on investment and not burden the user with excessive financial implications. Socio-cultural; strategy does not cause pro and contra in society. The socio-cultural aspect highlights the user persona's desire for a strategy that avoids creating polarizing opinions or controversies within society. They value harmony and seek a strategy that aligns with the broader social and cultural norms without causing any significant conflicts or divisions. Value propositions; strategy can address external barriers related to regulations and security risks. This aspect points out the user persona's need for a strategy that can effectively overcome external barriers such as regulatory compliance and security risks. The strategy should be capable of addressing these challenges and providing solutions that enable smooth operations within the relevant legal and security frameworks. Keys to success; the strategy must accommodate so that the company's management remains committed to continuously adopting technology. This aspect emphasizes the user persona's recognition of the importance of technology adoption for the success of their organization. They seek a strategy that can accommodate the needs and preferences of the company's management, ensuring their commitment to embracing and integrating technology continuously. Technology device; strategy can be used in selecting devices that are safe and do not cause new problems. The technology device aspect highlights the user persona's concern for the selection of safe and problem-free devices. They desire a strategy that provides guidance or criteria for choosing technology devices that do not introduce new risks or issues. It implies the need for a strategy that ensures the compatibility, reliability, and safety of the chosen devices.

Overall, these aspect and problem statements reflect the user persona's desire for a flexible, cost-effective, culturally compatible, regulatory-compliant, technology-embracing strategy that facilitates safe device selection. Meeting these requirements would address the persona's concerns and enhance their overall user experience.

Table 3 – Problem Statements

Aspect	Problem Statements
Flexibility	The strategy must be used flexibly, easy to understand and to implement
Financial	Strategy does not incur high costs and must be commensurate with the results
Socio-cultural	Strategy does not cause pro and contra in society
Value propositions	Strategy can address external barriers related to regulations and security risks
Keys to success	The strategy must accommodate so that the company's management remains committed to continuously adopting technology
Technology device	Strategy can be used in selecting devices that are safe and do not cause new problems

3.2. Discussion

In the second phase, problem statements that need to be addressed for each aspect regarding the strategy being developed have been identified. The strategy must be used flexibly, easy to understand, and easy to implement. Flexibility is crucial for the successful implementation of Industry 4.0. The strategy should allow organizations to adapt and adjust their processes and operations according to their specific needs and circumstances. It should be easy to understand and implement, ensuring a smooth and efficient transition to Industry 4.0 technologies. Since existing frameworks are often difficult to implement for SMEs, especially those that only focus on assessing the readiness of organizations for Industry 4.0 [29]. Moreover, methods and tools to support companies in moving towards Industry 4.0 are still scarce [30], particularly for SMEs where most tools, frameworks, and models oriented towards SMEs fall short of going beyond providing the current readiness status of organizations for Industry 4.0 [31]. Therefore, this research can provide companies with new insights on steps and tools to facilitate the implementation of Industry 4.0 principles and technologies in the future to enhance their operational performance.

In the financial aspect, the strategy should not incur high costs and must be commensurate with the results, which is a major concern for organizations, especially SMEs, considering the high investment required for implementing Industry 4.0 [32]. The strategy should be designed in a way that minimizes costs and maximizes return on investment [33]. It should provide a clear cost-benefit analysis, ensuring that the financial implications of adopting new technologies are justified by the expected outcomes. Industry 4.0 is the result of complex interactions and coordination between technical and social aspects in the pursuit of digital transformation of production processes [34]. Also, the built strategy should not cause pros and cons in society. The implementation of Industry 4.0 technologies can have social implications, such as changes in employment patterns or potential disruptions to traditional industries [35]. The strategy should address these socio-cultural aspects and aim to minimize any negative impacts [36]. It should consider factors such as job displacement and the need to retrain or enhance the skills of the workforce to ensure a smooth transition that benefits both the organization and society as a whole. The strategy should address external barriers related to regulations and security risks. Industry 4.0 involves the integration of physical and digital systems, which can introduce new regulatory and security challenges [37]. The strategy should address these external barriers by ensuring compliance with relevant regulations and implementing robust security measures. It should provide a clear value proposition that assures stakeholders about the mitigation of risks and the protection of sensitive data.

The strategy should accommodate the company's management to remain committed to continuous technology adoption. This aligns with Hariyani's [38] argument that the successful implementation of Industry 4.0 requires strong commitment and support from the company's management. The strategy should address the key factors that can help maintain this commitment, such as fostering a culture of innovation, providing adequate training and support, and showcasing tangible benefits and outcomes. By accommodating the needs and concerns of the management, the strategy can ensure sustained focus on technology adoption [39].

In the technology devices aspect, the strategy should assist in selecting devices that are safe and do not introduce new problems. The selection of appropriate technology devices is crucial for the successful implementation of Industry 4.0 [40]. The strategy should provide guidance in choosing devices that are reliable, secure, and compatible with existing systems [41]. It will help organizations avoid potential pitfalls, such as investing in devices that introduce new compatibility issues or security vulnerabilities [42]. By addressing these aspects and problem statements, the framework component can provide organizations with a structured approach to adopting Industry 4.0, ensuring flexibility, cost-effectiveness, social acceptance, regulatory compliance, management commitment, and appropriate technology device selection.

4. CONCLUSION

Overall, the aim of this research is to present how the design thinking process can be used to develop an implementation strategy for Industry 4.0 technology for SMEs. The stages used in this method are limited to empathy and define. A literature study was conducted to gather information supporting the research topic, using the PRISMA method and reviewing a total of 39 literature sources. In the first phase (empathy), user identification was conducted, consisting of government officials, IT experts, managers, and employees. However, the users considered were the managers and employees, and they were included in the user persona to be discussed in the second phase (define). Prior to the second phase, in the empathy phase, observations and understanding were carried out regarding the experiences, challenges, and needs of the users involved in the problem to be solved. The goal of these activities was to provide the researcher with insights into the desired features and functions that should be included in the strategy to address the constraints faced by SMEs in the implementation of Industry 4.0 technology. Some of the questions asked were: what causes dissatisfaction in the implementation of Industry 4.0, what causes sadness, and what causes happiness when adopting Industry 4.0. After answering these questions, a focused and clearly defined problem statement was formulated. This problem statement describes the problem to be solved and guides the team in finding relevant solutions. Problem formulation was done through the user persona. The identified problem statements include: flexibility aspect, the strategy should be used flexibly, easy to understand, and implement; financial aspect, the strategy should consider the financial factors for SMEs; socio-cultural aspect, the strategy should not create controversies in society; value proposition aspect, the strategy should address external challenges related to regulations and security risks; keys to success aspect, the strategy should accommodate the commitment of the company's management to continuously adopt technology; and technology aspect, the strategy should accommodate the selection of safe devices that do not create new problems.

Through these activities, the Define phase in Design Thinking helps the team in focusing on the problem to be solved, understanding user needs, and establishing a strong foundation for the development of relevant and user-oriented solutions. However, there are limitations in this research, namely that it only uses the first phase (empathy) and the second phase (define). Another limitation is that the information used does not include primary data obtained directly from SMEs. These limitations can be addressed in future research.

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