

THE IMPLEMENTATION OF ENTERPRISE RESOURCE PLANNING DURING THE PRODUCT DESIGN PROCESS THROUGH THE PROCESS OF DESIGN THINKING

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Abstract

The implementation of Enterprise Resource Planning (ERP) systems in the product design phase plays a crucial role in modern industries. The product design phase with the design thinking approach produces an innovative product that meets user requirements. The product design process, which begins with capturing user requirements and culminating in a thorough specification of a finished product, requires extensive data and expertise. Iterative product design processes contribute to the complexity of the data that must be managed within an organization. This study involved the implementation of an Enterprise Resource Planning (ERP) software named Odoo within the product design process using a design thinking methodology. By examining the student practicum activities in automotive design, starting from the user survey phase and going all the way to the component design details, a comprehensive ERP system was developed. This system is capable of seamlessly integrating all the data throughout the entire process. Based on the outcomes of testing and assessment, it can be concluded that the modules in Odoo software can be effectively integrated into the product design process. Effective processes in integrating ERP into product design phases can improve production quality and efficiency as well as facilitate greater flexibility and innovation. Implementing ERP throughout the product design phase results in a seamless flow of information, enhanced inventory control, and overall productivity enhancement. This ultimately leads to operational efficiency, competitive advantage, and high user satisfaction in the industry.

Keywords: Enterprise Resource Planning (ERP), Product Design Process, Design Thinking

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INTRODUCTION

Enterprises must enhance the quality of information to integrate all of their assets using the most recent information technology, as the competition in the contemporary business world becomes more intricate. Information technology (IT) is becoming more than just a supporting element; rather, it is a critical component in deciding a company's success. In today's fast-paced and more digital business climate, an organization's ability to operate successfully and competitively depends on the use of IT within the organization. IT aids businesses in decision-making, process automation and streamlining, efficiency improvement, communication, teamwork, etc. [1]. Consequently, businesses should concentrate on improving their information systems.

Enterprise Resource Planning (ERP) is a prominent solution in modern times that offers a complete approach to managing a company's

resources. ERP possesses the capacity to integrate and streamline all the operations spanning various functional domains, departments, and geographical sites within the organization. System integration enables the seamless integration of real-time data from several systems, thereby avoiding discrepancies in processes across functions, departments, or locations. This requires meticulous planning and coordination to ensure seamless real-time data access and to avoid discrepancies in operations. Additionally, the lack of comprehensive user understanding and operational knowledge of ERP systems often results from insufficient education and training, leading to inefficient implementation. Ensuring that employees are adequately trained and familiar with ERP operations is crucial for the system's success[2]. stated that ERP systems are specifically designed to offer significant advantages to organizations, such as enhanced operational

effectiveness, superior decision-making capabilities, and enhanced employee collaboration and communication. ERP systems also offer corporate information and analytical functionalities [3]. The adoption of ERP systems by enterprises, particularly in Indonesia, has witnessed substantial expansion owing to the proliferation of both domestic and international companies in the country [4]. Companies commonly utilize ERP software, such as SAP, Odoo (OpenERP), Oracle, JD Edwards, and PeopleSoft [5].

In the age of Industry 4.0, organizations must consistently innovate and swiftly adapt to evolving markets and technologies. Design thinking has been demonstrated as a successful tool for managing innovation processes. It is a methodology that focuses on the needs of users and combines a deep understanding of those needs with a series of iterative procedures to create unique solutions. The steps in design thinking include empathizing, defining, ideating, prototyping, and testing. Each of these stages plays a crucial role in the development of pertinent and efficient goods that meet users' expectations. The design thinking method has also been shown to promote sustainability-focused innovation [6].

However, the application of design thinking is not limited to the development of ideas and solutions. The significance of data management as a consequence of design thinking has been frequently disregarded. The company's valuable asset is the data produced from each stage of design thinking, such as user insights, feedback, and test results. A structured and integrated database is used to manage and store these data, which allows for the analysis, reuse, and accessibility of data for future initiatives.

Handling data during product development phase can be challenging, and it is common to encounter numerous issues. Different stakeholders, such as designers, engineers, and marketers, may have conflicting priorities, leading to discrepancies in the interpretation and use of design data. This misalignment can result in inconsistent design requirements and goals. Additionally, the accuracy of data collected during user research or market analysis is often overestimated; incomplete, biased, or outdated data can lead to designs that do not meet actual user needs. The complexity of managing large volumes of design data—from CAD files and technical specifications to user feedback—can cause inefficiencies and errors, making it challenging to maintain a coherent and accurate design process.

Communication gaps between teams can further exacerbate these issues, as inconsistent or siloed data management practices lead to misunderstandings and deviations from the expected design outcomes.

Recent advancements in ERP technology have significantly impacted product design, enhancing innovation and efficiency in the process. Modern ERP systems incorporate advanced analytics [7], artificial intelligence [8], and machine learning [9] to offer deeper insights and predictive capabilities [10], which are crucial during design thinking phases. These advancements facilitate real-time data analysis and decision-making, ensuring that product designs are not only innovative, but also aligned with market demands and operational capabilities. The integration of ERP systems with IoT and cloud technologies [11] further enables seamless data flow and collaboration across departments, ensuring that design iterations are informed by the latest data and trends.

Integration of the ERP system into the design ideation phase of the product design process offers substantial advantages. ERP ensures that the data collected and analyzed during the design thinking phase are accessible and utilized proficiently by a variety of departments within the company, such as production, marketing, and management. It not only enhances operational efficiency but also expedites marketing time and enables organizations to promptly adapt to evolving market trends and customer demands.

In both the manufacturing and service industries, Indonesia faces certain obstacles when implementing an ERP system [12]. Human resources are a primary obstacle, as users lack a comprehensive view of how to operate an ERP system. The absence of education and training in the operational knowledge and use of the system is the root cause of this lack of comprehension, which results in an inefficient ERP implementation [13]. According to [14], the implementation of an appropriate ERP system can facilitate the achievement of strategic objectives, effective decision-making, and competitiveness. ERP implementation's success is contingent upon numerous critical factors, including the efficient administration of its operational performance with ERP [15].

Consequently, ERP systems are extensively employed in the study of management, engineering, computing, and business management at universities in the field of education. Students can experience a substantial positive effect on their preparation for the workforce by employing the ERP system as teaching assistance [16][17]. Previous

experiments have explored the integration of ERP with business analytics [18], the use of ERP in game simulations [19][20][21][22][23] and the teaching of ERP through case studies [24][25].

Several studies have examined the implementation of ERP in medium-sized to large enterprises [26][27], the factors that contribute to its success [28], and obstacles that impede the implementation of ERPs in enterprises [29].

Another major challenge is aligning the ERP system with the organization's strategic objectives and operational performance. The rapid pace of technological advancements and market changes necessitates the continuous innovation and adaptation of ERP systems. Integrating ERP with methodologies such as design thinking, which emphasizes user needs and iterative development processes, adds to complexity. Effective data management strategies are required to handle the valuable data generated during design thinking stages, ensuring accessibility and reuse for future initiatives.

There have been few studies on the integration of ERP into the product design process. Therefore, *this study examines the use of ERP in data management during the product design process in organizations that employ design thinking*. Hence, this study is anticipated to offer a more profound understanding of how organizations can enhance innovation processes and gain a competitive edge by implementing efficient and organized data management.

METHODS

There are two variants of ERP systems: proprietary and open source. SAP is one of the most popular commercial ERP software packages [30]. Nevertheless, SAP licensing is expensive, and instructors must complete training and pass certification examinations in order to use it. Conversely, open-source ERP does not require licensing fees. However, certain ERP vendors exclusively provide cloud-based or on-premise services, whereas others provide both. Users can install applications on their computers and customize or modify programs with on-premises services. Some vendors offer enterprise features in addition to the fundamental features of the community version, which can be used to access additional modules at a cost [31].

When selecting an ERP system, it is crucial to consider factors other than licensing costs. One of these factors is the complexity of server installation, as certain ERP systems, including SAP, ERP Next, and Adempiere, have challenging implementation processes. Additionally, the ERP configuration should be sufficiently straightforward to accommodate the

necessary modules and case study requirements without being overly complex [32].

The ERP software used in this research was the Odoo Enterprise 16 educational version [33]. We gathered data on student activities at the Laboratory of Product Design and Development, Department of Mechanical and Industrial Engineering, Gadjah Mada University. Car products with a reduced scale and materials composed of wood and aluminum are examples of products employed.

Students are capable of developing innovative products through the application of design thinking techniques, which enable them to represent the general process of product development in the industry. The discipline of product design and development is a component of the body of knowledge in engineering [34].

Some important steps must be taken in the process of integrating Odoo into the product design phase. In general, the stages undertaken in this study are Determined Required Data, ERP Setup, Module Selection and Customization, Data Migration, Testing and Evaluation (Figure 1).

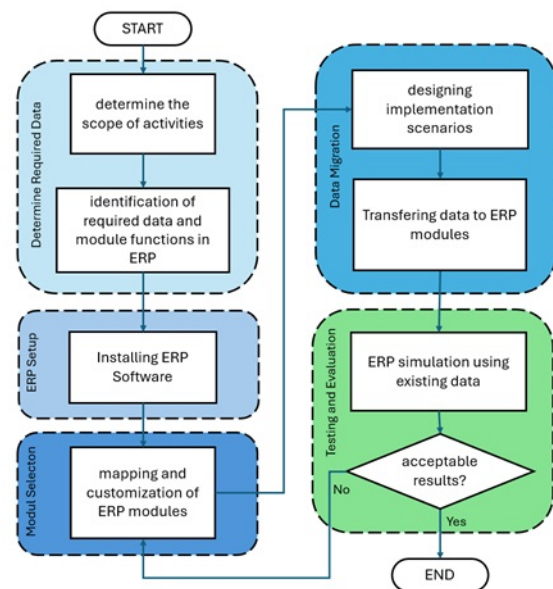


Figure 1. Method for integrating Odoo into the Product Design Process

The first step was to determine the required amount of data. This phase begins by determining the activity linkup in the product designer where the ERP is implemented. In this study, the product design steps were selected using the design-thinking approach. The required data, such as product specifications, design parameters, material information, and

manufacturing processes, are identified and collected. To understand the features, data requirements, and necessary parameters, it is also necessary to study the ERP software modules that will be utilized.

The procedure for installing ERP software is as follows. Odoo software was used in this study. This stage includes setting up the system and determining the type of user and their role. This phase includes setting up the system and determining the type of user and its role.

The next step is the selection of Odoo modules that are relevant to the scope of the activity specified previously. Mapping was conducted between the phases of product design, the data used, and the modules provided by Odoo. In this study, the modules chosen were Surveys, Documents, Discuss, Knowledge, and Inventory. The modules were modified to meet these requirements. Modifications are made by adjusting the document templates, simplifying the workflow, and updating entries in the inventory management and Bills of Materials (BOM).

Data migration is the next step. At this stage, a process scenario is compiled, starting from the initial process to the final process while entering the data obtained in the previous step. The entered data can be either fixed or variable data with variable values.

System testing was then conducted to verify whether the customized system could work as expected. The tests included a functional testing process on all modules and features, as well as conducting user input testing.

Finally, an evaluation is conducted to measure the performance and effectiveness of the system. Users provide feedback regarding difficulties in use or other aspects that need to be corrected or improved, which can be reevaluated from the mapping or module selection process in the ERP software.

IMPLEMENTATION

Each module of the Odoo software is associated with distinct business functions and processes. In the production process of a product, Odoo software offers a variety of modules such as sales, purchase, inventory, manufacturing, surveys, quality, and accounting modules. Not all modules are required during the product design phase. The front page of Odoo is shown in Figure 2.

Empathizing is the initial phase of design thinking founded on product design, with the objective of acquiring and comprehending users' needs. Interviews, surveys, and observations

were implemented during this phase to ascertain user requirements. The Surveys module on Odoo can be implemented during this phase.

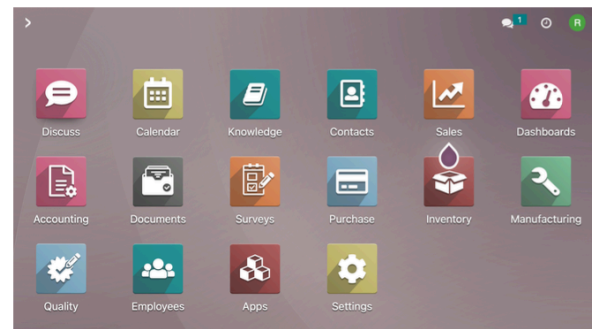


Figure 2. Odoo Front Page View of Modules

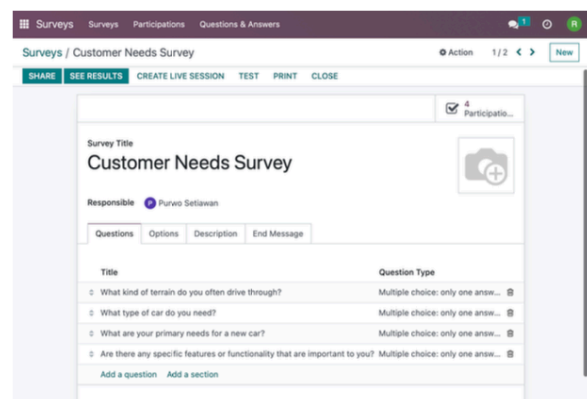


Figure 3. View on Survey module

The purpose of the Surveys module is to streamline the creation and implementation of questionnaires and surveys. It allows us to collect feedback, opinions, and insights from a diverse array of stakeholders such as customers, employees, partners, and potential purchasers. The organization can customize this module to meet its requirements. A diverse array of surveys can be developed from basic surveys with a limited number of questions to intricate surveys with numerous questions and a variety of question categories. It can also ascertain the eligibility of the respondents and the method of survey distribution. A page view of the survey creation process is illustrated in Figure 3. The survey results are presented in the form of data and graphs in Figure 4.

Based on the findings of this survey, we can proceed to the subsequent phase of design thinking, which is define. The objective of this phase is to identify issues by analyzing data from the previous phase. The process of identifying problems is human oriented.

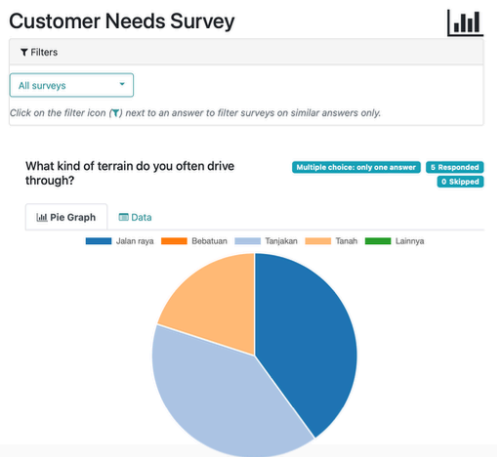


Figure 4. View on the Survey Result page

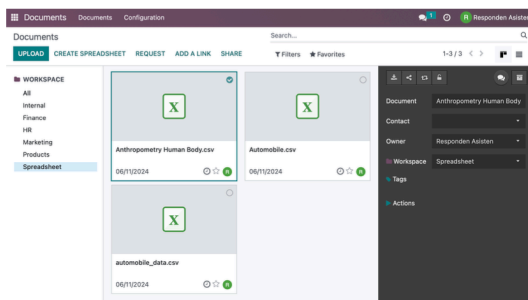


Figure 5. View on the Documents module to store spreadsheet data.

Therefore, ergonomics-related materials, such as anthropometry, can be included at this stage. With the availability of anthropometric materials, the product can be analyzed according to the comfort measurements of the human body because the product developed requires anthropometric measurement analysis. The

applicable module in Odoo is the Documents module, which may be used to store the existing anthropometric spreadsheet data (Figure 5). Alternatively, a new survey using the Surveys module can be conducted to obtain up-to-date data.

At this point, we can use the House of Quality (HoQ) as a tool to obtain design specifications. The HoQ is capable of converting qualitative need statements into quantitative ones. Furthermore, product benchmarking can be utilized to identify several conflicting design variables, enabling a comprehensive evaluation of different designs at this point. The utilization of HoQ or comparable tools can be documented in the Knowledge module on Odoo (Figure 6), enabling all members of the design team to comprehend the tools employed.

Following the creation of the design specification, the subsequent step in the design thinking process is 'Ideate'. During this stage, the process generates numerous innovative ideas or solutions for problem-solving. Tools such as mind mapping and brainstorming can be used for both narrative and visual tasks such as sketching and 3D modeling. The Discuss module on the Odoo facilitates the recording and organization of the conversation process or brainstorming activities (Figure 7). The outcomes of the inventive design concepts can be stored in the Documents module (Figure 8).

The subsequent stages in the design thinking process are 'Prototype' and 'Test'. During this phase, several instruments can be utilized, such as a CNC machine or a 3D printer, to create a prototype of the product. The required documentation consisted of a Computer-Aided Design (CAD) drawing and a G-Code files for the machine's processing.

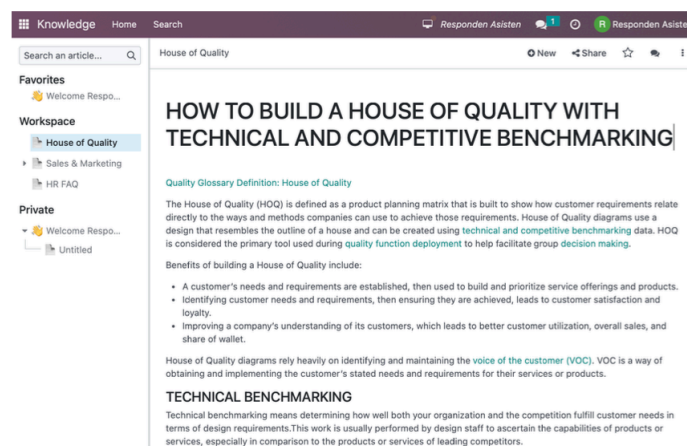


Figure 6. View on the Knowledge module

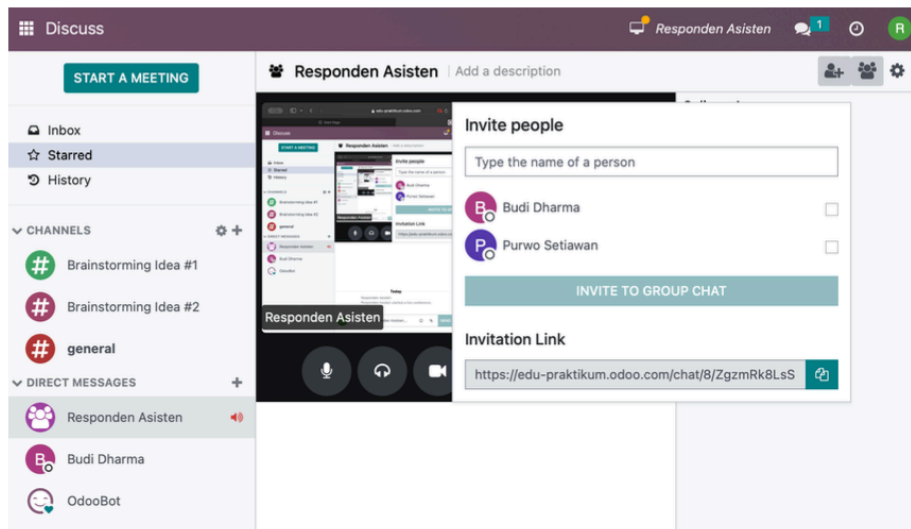


Figure 7. View on the Discuss module

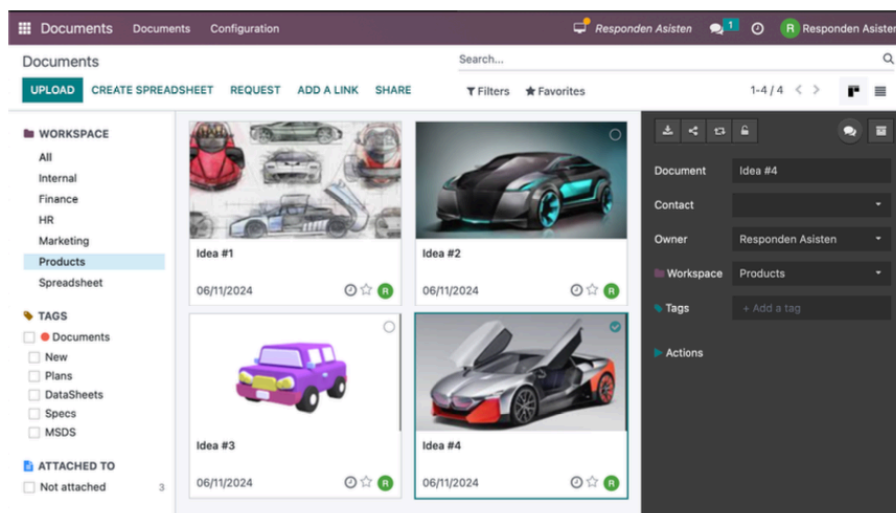


Figure 8. View on the Documents module for storing design data.

The product testing procedure may involve either computer simulation testing or actual product testing by the consumer. If a user satisfaction survey of the tested prototype is necessary, all documentation can be saved in either the Documents module or the Surveys module.

To establish a connection between the product design and production phases, once a product design has been confirmed to be suitable for mass production, specific information regarding the product's components can be inputted into the Inventory module on Odoo. The Inventory module is utilized to facilitate inventory management in the warehouse, encompassing tasks such as delivery, receiving, and preparation of materials for manufacturing. The product design will reveal the requirements for the

components and Bill of Material (BOM) of the product, which will then be entered as the product master data entry in the inventory module (Figure 9). The essential data required to complete the product master include Product Name, Product Description, Product Category, Product Price, Product Code, Unit of Measure, Stock, and Barcode.

Based on the above description, it can be inferred that ERP software is capable of effectively managing all the data during the design phase of a product based on design thinking. Figure 10 depicts a schematic representation of the complete design thinking phase involved in designing a product, as well as the role of the ERP modules in the Odoo software in effectively managing the current data.

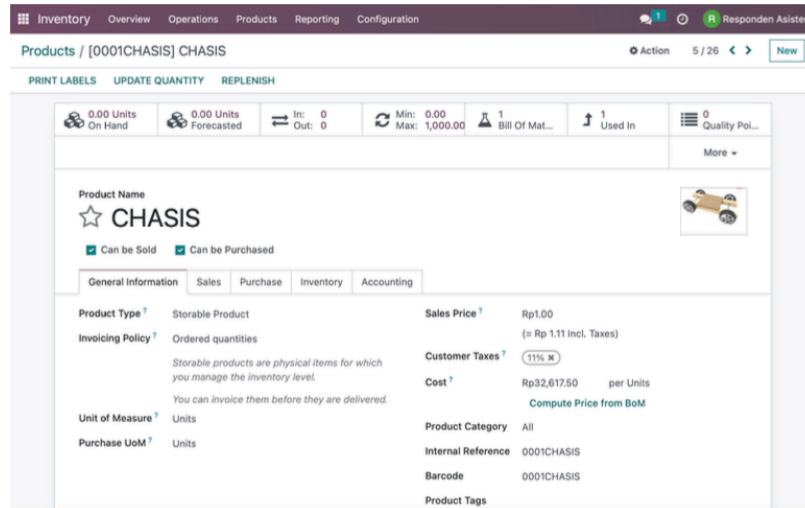


Figure 9. View of the Inventory module to store component detail data of the product

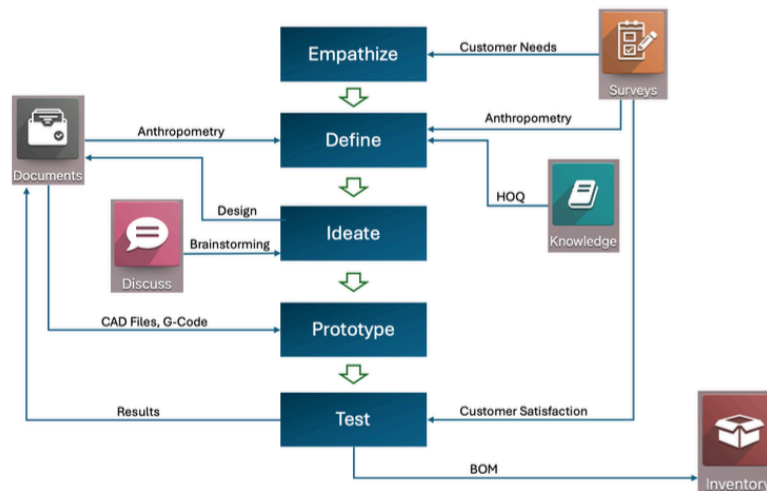


Figure 10. Schematic Diagram of Odoo Modules Implementations in Product Development

The ERP system underwent testing using User Acceptance Test (UAT). Fifteen stakeholders were used, all of whom had used ERP software. There were 10 statements given to the respondents. Respondents were asked to provide their level of acceptance on a scale of one to five. Based on the results, it is evident that the average level of agreement is 4.5, indicating that the system had a high level of acceptance among its user

DISCUSSIONS

In some cases, companies have successfully bridged the ERP and their product design processes. One example is the Volkswagen Group Company. The company utilizes ERP to streamline its new product development process as it seeks to transition to electric vehicles [35]. The company focuses on

improving supply chain efficiency and production, which has changed significantly for new vehicle products. The traditional automotive value chain involves various activities including inbound logistics, product design, final delivery, and services. However, the automotive industry is shifting towards a flexible service model, with vehicles becoming electric, connected, and autonomous.

Another example is the shoe maker company Nike. This company uses ERP to manage its extensive product portfolio [36]. ERP is used to capture and understand user preferences and streamline the design-to-manufacturing process. This ERP integration allowed Nike to produce more personalized products, such as custom footwear, while maintaining efficient production and inventory management. The ERP system helped in

forecasting demand accurately, while design thinking ensured that customer preferences were at the forefront of product development.

Nevertheless, these companies utilize costly and intricate ERP software and technology. Considering that ERP integration and product development processes have proven successful for large companies, the challenge is how small- and medium-sized companies may effectively leverage the benefits of ERP for their own businesses.

In this study, we demonstrated how to manage the data or information generated in a product design process using open-source ERP software. The advantages of using this software are as follows: First, micro- and small-medium enterprises, which run the Indonesian economy, will have a low entry barrier to using ERP tools. It is free to use and customize. Moreover, comparable software typically includes modules and a data entry workflow. Second, organizational units can manage and share data securely. They can monitor or track any updates in real-time fashion. This ERP tool integrates the data collected during the product design lifecycle into a comprehensive view. Third, small and medium-sized enterprises may experience business process automation similar to that of larger enterprises. Hence, these enterprises can efficiently manage their resources.

However, the implementation and deployment of ERP tools within small and medium-sized enterprises remains challenging. Digital transformation requires the use of people, processes, technologies, and data. Manual data entry can result in errors, incomplete, or inaccurate data. Integration with other systems, such as sensing data from IoT sensors and other original data sources, is necessary through application programming interfaces (APIs). Odoo lacks such features. Moreover, we must deploy standard operating procedures to ensure that all organizational units follow the same workflow for data management. To ensure a single source of authentic data, we avoided replicating or inputting data multiple times.

Another technical drawback is that the database's rigid structure makes the empathizing phase difficult. The input from customers or stakeholders is normally highly variable, and sometimes cannot fit the designed structure. Additional information necessitates additional data fields, which creates inconsistencies compared to older stored data.

Odoo is usually deployed as a Software-as-a-Service (SaaS). Financially, the use of SaaS incurs monthly or yearly costs, including software hosting and human resource operating the software. This may become an obstacle to

adoption for small- and medium-sized enterprises. Without proper planning and regular use, it is unsustainable.

To overcome those issues, we propose the following acquisition strategy as follows:

- 1) Prioritize transformation at the stage that creates the highest value. In the design thinking paradigm, the empathizing process is the most important stage. It contains who the users are and what they need. The subsequent iterations of the product design process require information from this empathizing process. The organization must also assess the necessary expenses. The cloud-based and on-premise deployments have different cost structures. Once the ERP reaches a certain level of maturity in this process, the enterprise can proceed to the next phase of implementation. Hence, implementation and deployment will gradually occur.
- 2) The use of ERP software is obligatory. Internal training and support are necessary to prevent unwanted outcomes. This software employs a user-centered paradigm in both product design and use. Proper distribution of procedures and manual use is crucial.
- 3) The risks to security and privacy can be reduced by implementing security policies and best practices.

The practical implications of this research findings suggest that businesses, particularly small and medium-sized enterprises (SMEs), can leverage open-source ERP software such as Odoo to enhance their product design and development processes. By integrating ERP into the design thinking phase, companies can streamline operations, manage data more securely, and efficiently allocate resources, leading to improved product outcomes. For instance, SMEs can achieve similar levels of business process automation as larger enterprises, allowing them to compete more effectively in the market. However, the successful application of ERP requires careful planning and strategic implementation.

Businesses should focus on transforming the stages of product development that offer the most value, such as the empathizing phase in design thinking, to ensure that ERP implementation aligns with users' needs and business goals. Internal training and support are crucial to prevent errors and ensure that the system is used effectively. Additionally, addressing potential security and privacy risks through robust policies and best practices can help mitigate the vulnerabilities associated with ERP adoption.

Moreover, companies can apply these findings by gradually implementing ERP systems, starting with cloud-based or on-premise deployments, depending on their cost structure and operational needs. This approach ensures that ERP integration is sustainable and can grow with the company.

CONCLUSION

ERP software offers various modules for product design, including sales, purchase, inventory, manufacturing, surveys, quality, and accounting. Odoo is an open-source ERP software that can effectively manage data during the design thinking phase of a product. It is suitable for small and medium-sized enterprises, offering low entry barriers, secure data management, and efficient resource management. However, implementation and deployment can be challenging due to manual data entry, integration with other systems, and the rigid structure of the database. To overcome these issues, a strategic acquisition strategy is proposed: prioritize transformation at the stage that creates the most value, ensure internal training and support, and reduce security and privacy risks by implementing security policies and best practices.

There is still more research on the application of ERP in product development processes. How integrating ERP in product life cycle management (PLM) relates to product innovation and development efficiency, as well as the impact on cost management and profitability throughout the product life cycle, is the most potential research field in ERP integration in the product development process. Both areas of research offer significant potential for advancing understanding and improving practices in product development and management.

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