
Industrial Engineering Integrated Practicum Framework Design Based on ERP

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ABSTRACT

The use of Enterprise Resource Planning (ERP) in company management is becoming increasingly important. This creates a high demand for graduates with knowledge and skills in the field of ERP. Industrial Engineering is the right program of study to meet these needs, and an integrated practicum course can be an effective means of teaching ERP-related skills to students. This paper provides a general overview of the current design of integrated practicum curriculum and ERP learning and proposes an innovative framework for integrated practicum courses in the industrial engineering study program by implementing ERP technology. Waterfall model is the process used to design and develop the framework in this research. The waterfall model is used which operates sequentially starting from requirements analysis, system design, implementation and testing. Testing is conducted by teaching assistants to assess whether the ERP modules can be implemented in specific practicum scenarios and align with the practicum's objectives. From the results of user acceptance testing, an average score of 4.5 was obtained. This means that the proposed framework was accepted in terms of suitability with the practicum subsystem, increasing understanding of integrated business processes in the company, and increase the ability to process data and teamwork. With these results, this framework can help industrial engineering study programs in designing standard integrated practicum course curricula and increase students' experience in using ERP with practicum case studies. So that the proposed framework can later provide industrial engineering graduates with experience regarding ERP in companies.

Keywords:

Enterprise Resource Planning (ERP); ERP learning framework; industrial engineering; integrated practicum

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1. Introduction

The modern business landscape's complexity necessitates companies to upgrade their information technology infrastructure to integrate all assets efficiently. Information Technology (IT) implementation is pivotal for success and competitiveness in a rapidly evolving digital environment. More and more companies are accelerating the application of information technology with the aim of making it easier to run company operations and speed up appropriate decision making (Constantiou & Kallinikos, 2015). Key IT aspects such as data analytics, cloud computing, and automation play vital roles in streamlining processes, enhancing efficiency, facilitating decision-making, and fostering communication and collaboration (Qosasi et al., 2019). Hence, companies must prioritize the development of their information systems to thrive amidst fierce competition.

Enterprise Resource Planning (ERP) has become the primary solution for businesses today. ERP can provide a comprehensive way to manage a company's resources. ERP has the capability to unify all processes across functional areas, departments, and company locations. System integration allows real-time data integration from different systems, thus eliminating discrepancies in processes between functions, departments, or locations. By implementing ERP, companies will be greatly helped in carrying out their operational activities because data can be exchanged easily between departments. Apart from that, companies can also store transaction data that has been carried out in

a structured manner, making it easier to make decisions. With speed and accuracy in decision making, companies will be better able to compete (Elgohary, 2019). Some commonly used ERP software by companies include SAP, Odoo (OpenERP), Oracle, JD Edwards, PeopleSoft, etc (Putra et al., 2021).

In order to achieve Indonesia's goal of becoming one of the world's top 10 economies by 2030, the Ministry of Industry is encouraging not only large industries but also small and medium-sized enterprises (SMEs) to capitalize on opportunities in the era of Industry 4.0. One of their efforts is by implementing digital systems for processing SME data using ERP. The ERP market in Indonesia is projected to experience a CAGR of 7.01% during the forecast period of 2022-2028. This market growth is driven by the presence of numerous domestic companies and global leaders (Inkwood, 2022). In addition, it is also because ERP provides complete business needs and is supported by internet technology and its increasingly rapid devices (Kenge & Khan, 2020). Therefore, it is important for Indonesian workers to possess the necessary skills and knowledge about ERP, both in business processes and information technology.

The Industrial Engineering Study Program can play a role in meeting these competency needs. Graduates of Industrial Engineering are responsible for designing, implementing, and enhancing systems and processes in various industries, including manufacturing, healthcare, and logistics (Kosky et al., 2021). Understanding and being able to use ERP systems are considered crucial as they enable industrial engineering graduates to better manage and optimize business processes, which can lead to increased efficiency and productivity.

According to Curbano et al., there are several industrial engineering competencies needed in the world of work, such as establish work and safety standards, perform production planning, scheduling and control function, design and implement quality assurance system, prepare logistics plan, draw up facilities design and layout, develop efficient information systems, and conduct research and development (Curbano et al., 2018). Some of these competencies are in line with ERP learning, especially those related to supply chain management (Khan et al., 2020; Qureshi, 2022) and the ability to design information system (Neubert et al., 2004) such as performing production planning, scheduling and control functions, prepare logistics plans, and develop efficient information systems.

In Indonesia, there is an institution known as the Badan Kerjasama Penyelenggara Pendidikan Tinggi Teknik Industri (BKSTI). According to the official website (BKSTI, 2021), this organization was founded with the aim of strengthening and enhancing the quality and relevance of higher education in Industrial Engineering in Indonesia. Its functions involve addressing and resolving various issues that arise in the implementation of higher education in Industrial Engineering, while also serving as a platform for collaboration among its members in exchanging information and conducting activities related to education, research, and community service. Additionally, BKSTI plays a role as a partner for the Directorate General of Higher Education and other relevant stakeholders in the sector of higher education in Industrial Engineering in Indonesia.

In the core curriculum composition of the BKSTI, there is a mandatory course for the Industrial Engineering Study Program called "Integrated Practicum". This practicum has a weight of 2 credits. This practicum utilizes the same product or object as a connector between each subsystem, where the output from one subsystem becomes the input for another subsystem (BKSTI, 2022). At least three different practicum subsystems must be integrated in the Integrated Practicum, which include:

- a. Work System Design and Ergonomics
- b. Production System Design
- c. Cost Estimation and Analysis

In this integrated practicum, students engage with these different subsystems, allowing them to understand how they interact and influence each other within a practical context.

This practicum is used as an object for ERP learning because the activities carried out in this practicum involve all the competencies mentioned by Curbano et al., (2018) above. By implementing ERP software in the integrated practicum, it can establish better connections between the subsystems involved in the integrated practicum. Additionally, it can assist students, assistants, and professors in easily monitoring and maintaining practicum data, promoting a more integrated practicum experience. The utilization of ERP in this practicum would also offer students a new experience by simulating the flow of data within a company, which can be valuable for their future endeavors.

However, there are currently no specific guidelines for implementing integrated practicum. There are differences in how to carry out integrated practicum at various universities. So that in addition to providing experience for

students regarding the use of ERP software, the proposed framework can also provide the same initial view in designing the curriculum for Integrated Practicum courses in industrial engineering study programs.

2. Theoretical Background

2.1 Industrial Engineering

In general, industrial engineering is a field of science related to planning, designing, developing, repairing, implementing, installing, and evaluating the performance of complex processes or systems that involve the integration of people, equipment, technology, and information (Marin-Garcia et al., 2011). Primary attention in industrial engineering focuses on industrial systems, especially in the manufacturing sector, where it has been proven over the years that the contribution of industrial engineering is critical to its success (Musharavati, 2013).

According to Industrial and System Engineers (IISE), like other engineering sciences, industrial engineering is also required to understand basic sciences such as calculus, physics, statistics and probability. This basic knowledge becomes the foundation for expanding his understanding of the 12 areas of industrial engineering knowledge which are also known as the Industrial Engineering Body of Knowledge, as shown in Figure 1.



Fig. 1 IISE Body of Knowledge

2.2 Integrated Practicum

According to the definition from BKSTI (2022), Integrated Practicum requires students to understand the concepts, theories, and design techniques before conducting the laboratory. This laboratory uses the same product or object as a binder between each subsystem, where the output of one subsystem will be the input for the other subsystem. At least three different laboratory subsystems must be integrated in Integrated Laboratory, which include Work Design and Ergonomics, Production System Design, and Estimation and Cost Analysis. Integrated practicum is designed as a learning factory that is important in engineering education. With learning factory learning, students will develop practical skills and professionalism because the learning process simulates real-world conditions (Martawijaya, 2012)

2.3 Enterprise Resource Planning (ERP)

Enterprise Resource Planning (ERP) is a software suite that includes various modules, such as human resources, inventory, purchasing, sales, finance, and manufacturing, which provides cross-organizational information integration through integrated business processes. These packages can be customized to meet the specific needs of the organization. In the 1990s, ERP systems became the standard replacement for legacy systems in large companies, especially multinational corporations (Parr & Shanks, 2000; Willcocks & Sykes, 2003).

The development of ERP systems has followed the pace of evolution of computer systems. In the 1960s, inventory control packages were introduced to meet customer demand and automate inventory management. In the 1970s, companies began to realize the importance of managing large inventories, so Material Requirements Planning (MRP) systems emerged to manage the manufacturing process. In the 1980s, MRP evolved into MRP II with the addition of modules for project management, finance, sales analysis, distribution management, human resources, and engineering to improve efficiency. Then, in the 1990s, ERP vendors started adding more functions into the main

modules, forming the next generation of ERP known as ERP II. ERP II includes not only applications, but also business strategies for users (Kumar & van Hilleberg, 2000)

There are several market leaders in developing and implementing ERP systems such as SAP, Oracle, Microsoft, Sage, etc., these vendors typically require high costs for comprehensive business solutions. This situation presents difficulties for small to medium-sized enterprises in adopting ERP systems (Ganesh et al., 2016). OpenERP (Odoo) emerged as one of the enterprise resource planning systems. Since its launch in 2005, Odoo has rapidly developed and has become a leader in the business community, catering to both small and large-scale enterprises (Jindal & Singh Dhinda, 2013). Odoo offers several advantages such as cost-effectiveness, flexibility, complete ownership, quality assurance, and ease of upgrading (Ganesh et al., 2016).

To help Industrial Engineering students understand company business processes, Odoo is very helpful, especially for institutions that are constrained by costs. The modules provided by Odoo are also sufficient for learning material related to industrial engineering. Each module in an ERP software serves specific functions and business processes. Additionally, data is essential for the smooth execution of business processes within each ERP module. Here is an explanation of the ERP modules:

a. Purchase

The Purchase module in Odoo serves as a powerful tool for businesses to manage their procurement processes efficiently. This module facilitates the end-to-end management of purchasing activities, from the creation of purchase orders and supplier selection to invoicing and payment. The Purchase module also supports vendor management, allowing businesses to maintain detailed supplier profiles, monitor performance, and negotiate favorable terms. With features such as automated procurement suggestions based on inventory levels, businesses can optimize their stock levels and minimize stockouts. Furthermore, the module enables efficient collaboration between different departments involved in the procurement process. Firdaus et al (2019) have implemented a purchase module at an institution for purchase management. The data required for the purchase module is vendor and product / raw materials. The purchase module business process is also explained in this research (Firdaus et al., 2019).

This is very closely related to logistics management which is studied in industrial engineering. By knowing the procurement process, students will better understand the terms in the procurement process such as vendor, procurement schedule, lead time, receipt, and the process of making purchase orders in the company.

b. Inventory

The Inventory module is a robust and versatile tool designed to empower businesses in managing their stock efficiently. This module provides a comprehensive solution for inventory control, allowing users to track stock levels, monitor product movements, and optimize warehouse operations. Businesses can organize their products into categories, set reordering rules, and utilize multiple warehouses with ease. The real-time visibility into stock levels facilitates effective demand forecasting and ensures timely replenishment. The integration with other modules, such as Sales and Purchase, enables seamless coordination between different departments, ensuring that inventory levels align with customer demands and procurement needs. Inventory optimization is very important to study in industrial engineering to minimize storage costs. An example of implementing an inventory module for warehouse management is carried out by Sulaksono et al (2023).

c. Manufacturing

The manufacturing module requires several essential data points, including master product details, Bill of Materials (BOM), work orders, and routing information. The module also features the Master Production Schedule (MPS), aiding in planning and scheduling production activities to meet demand while optimizing resources. MPS proves highly beneficial for manufacturing and production companies, enabling efficient process management (Odoo, 2022). In industrial engineering programs studying production management is very important with the aim of optimizing the use of resources and to meet demand in a timely manner.

d. Sales

With the Sales module, users can generate professional quotations, track sales orders, manage product catalogs, and monitor inventory levels in real-time. The integration with other Odoo modules such as Inventory and Accounting ensures a cohesive workflow from sales to fulfillment and invoicing. To run the sales process, data on products in inventory, including quantity and selling price, is required, as well as customer data. Several studies have also used sales modules for companies and SMEs (Adhi Prasnowo et al., 2019; Gantira Mira et al., 2017; Panduwiyasa et al., 2022).

e. Surveys

The surveys module is designed to create and manage surveys and questionnaires. It enables the collection of feedback, opinions, and insights from various stakeholders, including customers, employees, partners, potential buyers, and more. The Surveys module serves as a reliable tool for conducting research, gathering data, and making informed decisions based on received responses. This module proves highly valuable in the stages of product development and design (Odoo, 2022).

f. Accounting

The Odoo Accounting module is a comprehensive accounting application that streamlines various accounting processes and improves overall productivity. It offers a range of features, including AI-powered invoice recognition, synchronization with bank accounts, and smart matching suggestions. The module is designed to provide real-time data availability, allowing managers to make informed decisions based on accurate and timely information.

The Odoo Accounting module is fully integrated with other Odoo apps, such as CRM, eCommerce, and inventory management, ensuring seamless data flow and reducing manual data entry. This integration allows businesses to save time and gain transparency in their accounting processes, ultimately leading to more efficient and accurate financial management (Odoo, 2022).

3. Literature Review

There are several fields that underlie ERP development such as information technology, computer science, information science, mathematics, and system theory. Its success largely depends on the application of modern management principles. When implemented carefully, ERP systems have the potential to support effective decision-making for businesses (Lu, 2020). More than just enabling competitiveness in the current era, ERP systems also help organizations achieve their strategic goals, including educational institutions (Liu & Zhiwen, 2019). Hence, it can be considered that ERP systems, as a tool, are becoming a must in management, engineering, and business studies in academic environments. The importance of ERP systems can be understood from the fact that its approach is based on practical learning that is strongly related to basic and specific understanding. By utilizing ERP systems as a teaching tool in higher education, users can experience firsthand its benefits and understand its relevance (Shatat & Burtamani, 2019)

Several studies have been conducted to improve ERP capabilities. The researchers proposed various methods that are expected to be effective for transferring knowledge about ERP. Several studies have made software adjustments to support the learning process. For example, integrating ERP with university e-learning (Schwade & Schubert, 2016) and integrating ERP with Business Analytics (Cadersaib et al., 2022). Some studies have focused on delivery methods such as game simulations (Charland et al., 2015; Faisal et al., 2019; Hwang & Cruthirds, 2017; Jheengut et al., 2021; Pakinee & Puritat, 2021), case studies (Alharbi, 2021; Bresfelean et al., 2021), and project-based (Bąkała & Sankowski, 2015; Gerogiannis & Fitsilis, 2006). These studies have been conducted in various fields of study, but none have examined the field of industrial engineering.

The case studies used in these studies have often been fictional or simulations, some of which only illustrate data flow (Faisal et al., 2019; Pakinee & Puritat, 2021; Paulet & Dick, 2019). Additionally, some studies have employed case studies from academic articles that do not showcase real-world material flow (Alharbi, 2021). These methods do not provide experience with real objects to learn ERP.

In the integrated practicum of Industrial Engineering, students directly engage in practical activities encompassing designing, processing manufacture, and even sales stages. With tangible objects to work on, students learn to input data into the ERP software database correctly and simulate scenarios when dealing with multiple orders. The business processes followed mirror standard ERP practices, aiming to provide experiential learning that closely resembles real-world company conditions. This hands-on approach allows students to gain a comprehensive understanding of how ERP systems are applied in real business settings.

ERP implementation methods in integrated practicum need to be considered. Integrated practicum is made as a simulation of working in a company, so it has the character of a real company but with a simpler level of complexity. Many methods can be applied in the development of ERP systems in companies such as waterfall method, rapid prototyping, agile, and some adjust to company conditions. (Nagpal et al., 2015). Since the integrated practicum is likened to a small company with non-complex problems, a traditional development approach is sufficient, namely using the waterfall method. The waterfall model operates sequentially with no concurrent phases.

This implies that each phase must be completed before the next phase can begin. This model is characterized by its simplicity and ease of understanding (Theisen et al., 2017). A visual depiction of the Waterfall model is shown in Figure 2.

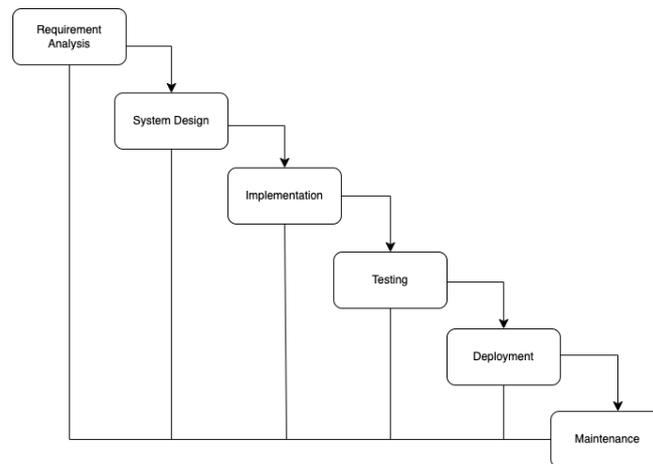


Fig. 2 Waterfall Model

4. Methodology

The research is conducted in the Industrial Engineering Study Program at Universitas Gadjah Mada (UGM). The subject of the research is the integrated practicum within the undergraduate Industrial Engineering program at UGM. In UGM, the integrated practicum consists of several practicums spread across multiple semesters. The ERP software used in this research is an open-source software called Odoo. The development of the framework was carried out through several stages following the waterfall model depicted in Figure 3. The following subsections provide explanations for each stage:

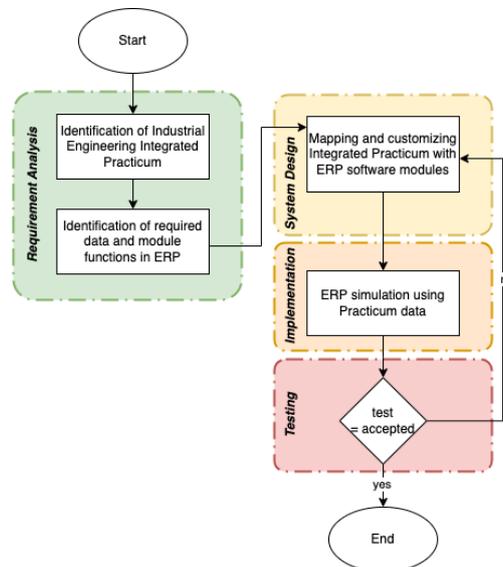


Fig. 3 Research Methodology

4.1 Identification of integrated industrial engineering practicum

The methods used at this stage are observation and interviews. Observations were carried out by directly observing the ongoing practicum, while interviews were carried out to obtain information from the practicum assistant. Several documents are also used as sources of information, such as practicum modules, the curriculum of the Industrial Engineering Study Program at UGM, and the BKSTI 2022 curriculum.

4.2 Identify the required data and the function of the modules in the ERP

ERP software consists of various modules, each dedicated exclusively to specific aspects of business processes. These modules cover areas such as product development, planning, sales or marketing, procurement, finance, and

more. Companies can utilize ERP software to oversee back-office activities and responsibilities, encompassing supply chain management, distribution process management, pricing, configuration, project planning, enhancing financial data accuracy, automating employee lifecycles, accounting, reducing repetitive tasks, assessing business needs, and effective human resources management and payroll (Alsharari, 2022).

In this research, several ERP modules are employed to facilitate the integrated practicum within the field of Industrial Engineering. These modules include sales, purchase, inventory, manufacturing, surveys, quality, and accounting. Each module serves a specific purpose and contributes to the seamless execution of various stages within the integrated practicum, providing students with a practical experience of how ERP systems are utilized across different business functions.

4.3 Mapping and adjusting the Integrated Practicum with ERP software modules

In this phase, a mapping is conducted between the integrated practicum and the existing modules within the ERP system. The mapping process is based on the input and output data of the integrated practicum and the functions of the ERP modules. The results of this mapping will be discussed in the results section. In this stage, a Data Flow Diagram (DFD) is used to describe the flow of data between the practicum and ERP software.

The Data Flow Diagram (DFD) is one of the oldest structured tools available to support system analysis and design. This simple diagram aids analysts in understanding the system and conveying information about the system to users (Gane & Sarson, 1977; Hatley & Pirbhai, 1987; Yourdon & Constantine, 1979). The Data Flow Diagram uses a set of limited symbols to depict data:

- Square boxes symbolize external entities that function as sources or destinations of information outside the system.
- Circles or rounded rectangles represent activities, signifying data transformations.
- Arrows illustrate the flow of information from one activity or source to another activity or destination.
- Rectangles without one side symbolize information storage.

4.4 ERP simulation using Practicum data

After the design was finished, simulations were conducted with practicum assistants to see the suitability of the flow and data. This stage is done with focus group discussion (FGD) to get the same view of the framework design.

4.5 User Acceptance Testing (UAT)

User Acceptance Testing (UAT) is a software testing phase conducted by end-users to ensure that the software meets their requirements and expectations. The goal of UAT is to ensure that the software can be easily and effectively used by end-users. UAT also aims to identify any bugs and issues that may exist in the software. End-users will test the software using realistic usage scenarios.

UAT is carried out to test whether the ERP software can be effectively applied for the purposes of integrated practicum. Teaching assistants and the supervising faculty members are enlisted as users and respondents for this stage. The assistants are provided with explanations and instructions to navigate and operate the application. Subsequently, testing is conducted to ensure that the software functions properly and aligns with the practical requirements.

5. Results

In broad terms, the integrated practicum is divided into four steps, which are engineering/industrial design, shop floor, assembling floor, supply and demand, and accounting. These four steps must be conducted sequentially to provide students with an understanding of the business process flow in a company. Figure 4 is outline of flow of Industrial Engineering Integrated Practicum. In essence, this integrated practicum is designed to provide students with a hands-on experience that mirrors real-world business processes, spanning from product design to sales. Consequently, the concept of a sequentially related practicum, starting from the initial stage and progressing to the final stage, is crucial for imparting a comprehensive understanding of the business processes within a company to the students.

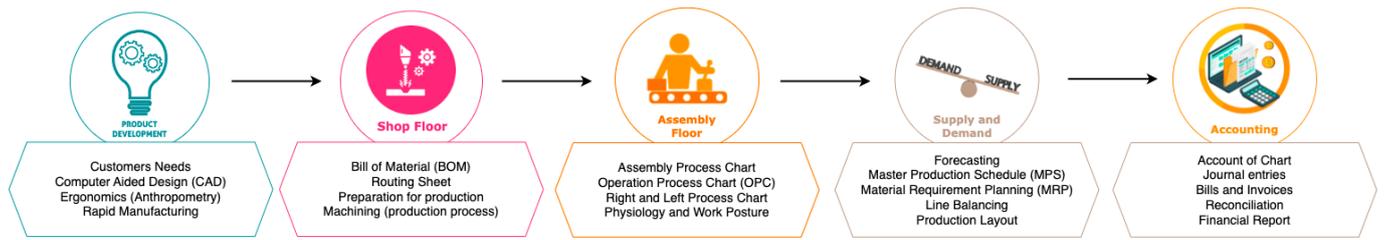


Fig. 4 Outline of Flow of Industrial Engineering Integrated Practicum

The concept engineering/industrial design phase can also be referred to as the product development stage. In this phase, students learn how to identify customer needs within the constraints of the predefined product theme of the practicum. Based on customer need data, students grasp how to transform these requirements into a product design. This stage also incorporates material related to ergonomics, particularly anthropometrics, enabling students to design products that cater to user comfort. Furthermore, students learn to convert their product designs into prototypes by leveraging modern technology.

Subsequently, the next stage is the shop floor. In this phase, students delve into the production system related to workstations and the processing of raw materials into product components, based on designs created in the previous stage. Students understand how to execute various process sequences for each part, commencing with the preparation of required equipment, machining, standard work time calculation, and the creation of work-related documents like routing sheets, and bills of materials (BOM).

After all parts are manufactured, and other supporting components are available, the next stage is the assembling floor. In this phase, students learn to assemble the previously produced components or parts into a complete product. During the assembly process, students analyse the assembly process, calculate the required time, create left and right-hand assembly guides, develop an assembly chart, and develop an operation process chart (OPC).

The subsequent stage involves learning how to manage the production system when dealing with demand and supply. During this phase, students acquire knowledge related to mass production activities based on demand. The topics covered in this stage include demand forecasting, master production schedule creation, understanding master requirement planning, line balancing, and designing the layout of production floor facilities.

Finally, the last stage is accounting. Through accounting, students can apply their accounting knowledge to analyse the financial performance of a company. They can utilize their IT skills to develop and implement efficient accounting solutions. Additionally, their accounting knowledge and skills can be beneficial for employment across various industries, such as manufacturing, services, trade, or managing their own business finances.

Each step consists of a series of practicum modules that represent integrated practicum subsystems. Details of the practicum modules for each step can be seen in Figure 5. Each module is color-coded to identify its subsystem. Green represents work system design and ergonomics, blue represents production system design, and yellow represents cost estimation and analysis. The integrated practicum series is designed to have a total duration of 5400 minutes or equivalent to 2 credit hours in accordance with the BKSTI curriculum requirements.

To ensure that each part proceeds sequentially and smoothly, a product or object that can serve as a link between the sections is necessary. The theme of the product used in the integrated practicum is a critical component that must be accurately determined to function as a connector between the practicum subsystems. At the very least, the criteria for the chosen product should meet the requirements which can be seen in Table 1.

Table 1. Product Theme Criteria

No	Criteria	Description
1	WIDE SCOPES OF STUDY	It involves various disciplines within the field of Industrial Engineering.
2	SUFFICIENT DEPTH OF STUDY	The complexity of the problem is met.
3	PRODUCT VARIETY	It is available in the market and caters to multiple user segments.
4	SUSTAINABILITY	The product will continue to evolve in line with user needs, trends, and technology.

These criteria ensure that the chosen product is well-suited to connect and integrate the different aspects of the practicum seamlessly.

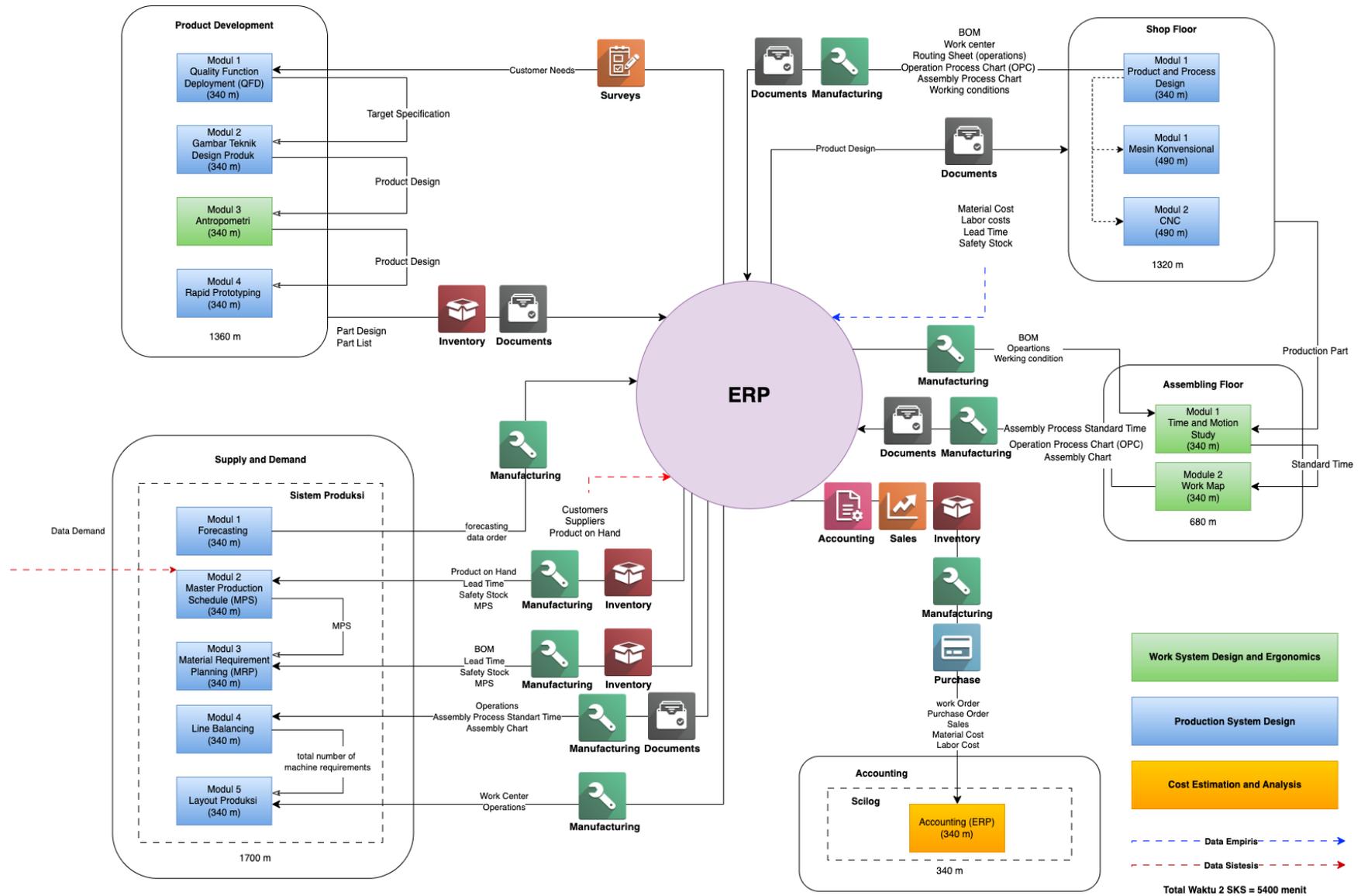


Fig. 5 Data Flow Diagram (DFD) of Integrated Practicum

5.1 Engineering/Industrial Design (Product Development)

In the engineering/industrial design (product development) stage, there are four modules that need to be presented to the students. This stage is the initiation phase based on customer needs, with the products being developed in line with the predefined theme. The time allocation for this part is 1360 minutes, with each module being given a time allocation of 340 minutes for its entire sequence, including pre-test, content delivery, in-class/lab activities, and post-test.

First, students learn to identify core problems in both the internal and external market. From these problems, students formulate opportunities. Opportunities are values that are variable and uncertain, so it's essential to identify each opportunity and turn it into a mission statement. In this module, students learn to use a tool called Quality Function Deployment (QFD) to transform customer needs into product specifications. This module is named "Quality Function Development (QFD)" and can be categorized under the production system design subsystem.

When capturing customer needs, the Odoo module for surveys can be utilized with its questionnaire creation feature. Students can create questions to gather information about customer needs, using various types of question formats that are available for selection. As explained by Nissi, M (2021), users can design different types of surveys, ranging from simple ones with a few questions to complex surveys with multiple questions and a variety of question types. Additionally, students can determine who can participate in the survey and how the survey will be distributed (Nissi, 2021).

Next, from the obtained specifications, in the technical drawing module, students perform measurements and sketching to refine the design. To enhance the design, this section includes a module on anthropometry, which falls under the Work Design and Ergonomics subsystem. With the anthropometry module, students can adjust the product's dimensions by considering human body measurements. However, this module can be tailored to fit the predefined theme. For instance, if the product theme is learning chairs, this module would be highly beneficial for determining the right dimensions for customers. Otherwise, it could be placed in the assembling floor section for workstation design purposes. Additionally, the rapid prototyping module can be taught to enhance students' skills in utilizing modern technical equipment.

The output from this section will yield a parts list and the design of product components. This data is crucial for the subsequent stages of the practicum. In Odoo, component data can be stored in the master product. Figure 6 displays the form for saving master product data.

The screenshot shows the Odoo Product Template form for a product named 'Car'. The interface includes a navigation bar at the top with tabs for Inventory, Overview, Operations, Products, Reporting, and Configuration. The main header shows 'Products / [202300001-CARS] Car' and a 'New' button. Below the header, there are several key metrics: 1,153.00 Units On Hand, 1,153.00 Units Forecasted, In: 0, Out: 0, Min: 0.00, Max: 0.00, 1 Bill Of Materials, 0.00 Units Sold, and 1 Schedules. The product name 'Car' is displayed with a star icon and a small image of a car. There are checkboxes for 'Can be Sold' (checked) and 'Can be Purchased'. The form is divided into tabs: General Information, Sales, Inventory, and Accounting. The General Information tab is active, showing fields for Product Type (Storable Product), Invoicing Policy (Ordered quantities), Unit of Measure (Units), Purchase UoM (Units), Sales Price (Rp200,000.00), Customer Taxes (11%), Cost (Rp75,836.53 per Units), Product Category (All), Internal Reference (202300001-CARS), Barcode (202300001-CARS), and Product Tags. An INTERNAL NOTES section is also present at the bottom.

Fig. 6 Form Product Template

5.2 Shop Floor

In the shop floor stage, students learn to transform raw materials into semi-finished products. They gain knowledge in using both conventional machines and Computer Numerical Control (CNC) machines to create their products based on the part list information and the design output from the product development stage. This section consists of three modules: Product and Process Design, Conventional Machines, and Computer Numerical Control (CNC). The total time required for these three modules is 1320 minutes.

The Product and Process Design module is allocated a total of 340 minutes. In this module, the instructor explains topics related to the workstations to be used, the bill of materials (BOM), routing sheet, assembly process chart, and operation process chart (OPC). This material needs to be covered before engaging in machining activities so that students have the necessary knowledge about what and how to carry out the production process.

After receiving the necessary materials, students proceed with production using both conventional and CNC machines. These two modules (conventional machines and CNC) can be conducted concurrently since they are related to the production process. It's possible that CNC machines may be utilized at specific points in the manufacturing process of part production. The time allocated for these two modules is 980 minutes, meaning that students must complete all part production activities within this time frame. This proposed concept is similar to that carried out by Iqbal and Fitriadi (2023) who designed industrial engineering design practicum 1 at Universitas Muhammadiyah Surakarta (Iqbal & Fitriadi, 2023).

There are several outputs in this practicum, the first is the BOM. Examples of BOM table can be seen in Table 2

Table 2. BOM Table

No.	Kode	Nama	Quantity	Keterangan
1	A	WIPADS CAR	801	Assembled
2	A1	Body	806	Assembled
3	A2	Chassis	806	Assembled
4	A1.1	Right Frame	806	Assembled
5	A1.2	Left Frame	806	Assembled
6	A1.3	Screw	12090	Purchased
7	A1.4	Engine Hood	806	Manufactured
8	A1.5	Roof Panel	806	Manufactured
9	A1.6	Back Bumper	806	Manufactured
10	A1.7	Front Bumper	806	Manufactured
11	A1.8	DeckLid	806	Manufactured
12	A2.1	Back Axle	806	Manufactured
13	A2.2	Gardan	806	Manufactured
14	A2.3	Left Back Wheel	806	Manufactured
15	A2.4	Underframe	806	Manufactured
16	A2.5	Right Steering Hub	806	Manufactured
17	A2.6	Right Front Wheel	806	Manufactured
18	A2.7	Right Front Axle	806	Manufactured
19	A2.8	Right Back Wheel	806	Manufactured
20	A2.9	Pull Rod	806	Manufactured
21	A2.10	Left Steering Hub	806	Manufactured
22	A2.11	Left Front Wheel	806	Manufactured
23	A2.12	Left Front Axle	806	Manufactured
24	A2.13	Screw	12090	Purchased
25	A2.14	Button Latch	3224	Purchased
26	A1.1.1	Right Body	806	Manufactured
27	A1.1.2	Right Door	806	Manufactured
28	A1.1.3	Right Hinge	806	Purchased
29	A1.1.4	Right Top Latch	1612	Purchased
30	A1.1.5	Screw	4030	Purchased
31	A1.2.1	Left Body	806	Manufactured
32	A1.2.2	Left Door	806	Manufactured
33	A1.2.3	Left Hinge	806	Purchased
34	A1.2.4	Left Top Latch	3224	Purchased
35	A1.2.5	Screw	4030	Purchased

and BOM tree images can be seen in Figure 7.

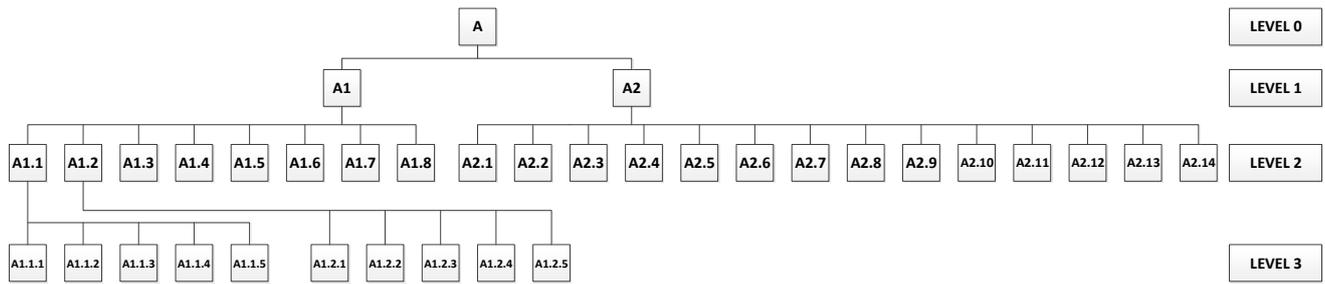


Fig. 7 BOM Tree

The BOM data is stored in the ERP database through the Manufacturing application by navigating to the Products menu, selecting the Bill of Material sub-menu, and clicking the New button. Then, choose the product for which you want to set up the BOM. Figure 6 displays the BOM page for the chassis component. It is crucial to specify all the components in the BOM, including those that are produced, and identify the materials that make up these components.

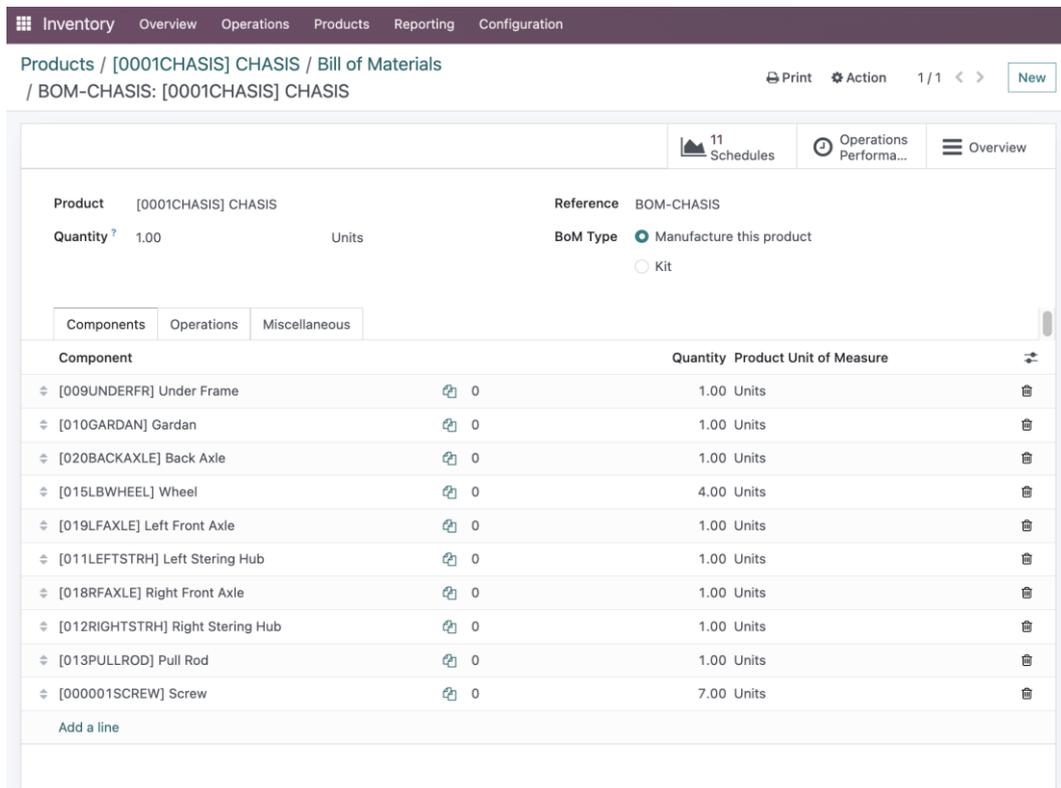


Fig. 8 BOM Chassis

The next output is the routing sheet. Routing sheet data is valuable for calculating the cost of production and for the subsequent stages of the practicum. This data can be stored in the Odoo database. However, before saving the routing sheet, the identification of workstations needs to be carried out. In this case study, several workstations are used, such as the band saw, scroll saw, surface planer, drilling, CNC, and others, as per the production requirements. The case study employs primary materials like PVC and wood, so these machines are suitable. Subsequently, data for these workstations can be saved in the work center master data in the ERP software. The work center form's appearance can be seen in Figure 9.

The screenshot shows the SAP Work Center configuration interface. At the top, there are navigation tabs: Manufacturing, Overview, Operations, Planning, Products, Reporting, and Configuration. The current view is 'Work Centers / Scroll Saw'. On the right, there are performance indicators: 0.00% OEE, 0.00 Hours Lost, 0.00 Minutes Load, and 0% Performance. The main form contains the following fields:

- Work Center Name:** Scroll Saw
- Code:** SCW
- Tag:** (empty)
- Working Hours:** Standard 40 hours/week
- Alternative Workcenters:** (empty)
- General Information** and **Specific Capacities** tabs are visible.
- PRODUCTION INFORMATION:**
 - Time Efficiency: 100.00 %
 - Capacity: 1.00
 - OEE Target: 90.00 %
- COSTING INFORMATION:**
 - Cost per hour: 2,000.00 per workcenter
 - 25,000.00 per employee
 - Setup Time: 00:25 minutes
 - Cleanup Time: 00:00 minutes
- OPERATIONS:** Requires Log In
- DESCRIPTION:** Description of the work center...

Fig. 9 Form Work Center

In the form shown in Figure 14, there are several fields that need to be filled out, such as cost per hour, working hours, and so on. Students can research literature to obtain the required information to fill in these fields. As for setup time and clean-up time, students can directly measure these times during the production process.

Once all the work centers are saved, the next step is to save the routing sheet data. Figure 10 is an example of a manual routing sheet for one of the components.

LEMBAR RENCANA PROSES											
Nama	: WIPADS CAR	Hal ke	: 7/21		File	Gambar :					
No Part	: 7	Material	: PVC Foam								
Nama Part	: Back Bumper	Ukuran	Panjang							: 220 mm	
Dibuat oleh	: Kelompok 22		Lebar							: 10 mm	
Tanggal	: 21 September 2021		Tinggi							: 80 mm	
No Proses	Uraian Operasi	Stasiun Kerja	Set Up		Spindle Speed (rpm)	Feed Rate (mm/s)	Waktu Set Up (s)	Waktu Proses (s)	Waktu Total (s)		
1	Membuat sketsa garisdengan ukuran 220 mm dan 80 mm	Kerja Bangku	Pensil	Mistar			19	85	104		
2	Memotong bahan baku sesuai ukuran yang ditentukan	Cross Cut	Mata Gergaji	Mistar	3650	73	13	19	32		
3	Menghaluskan benda untuk melakukan fillet	Belt and Disc Sander	Amplas		2850	14,3	12	90	102		

Fig. 10 Routing Sheet

The routing sheet data has previously been provided by the instructor in the Product and Process Design module. Students only need to complete the setup time, process time, and other columns that they can gather during production. This routing sheet data can be saved in the ERP database. The page for operations can be seen in Figure 11.

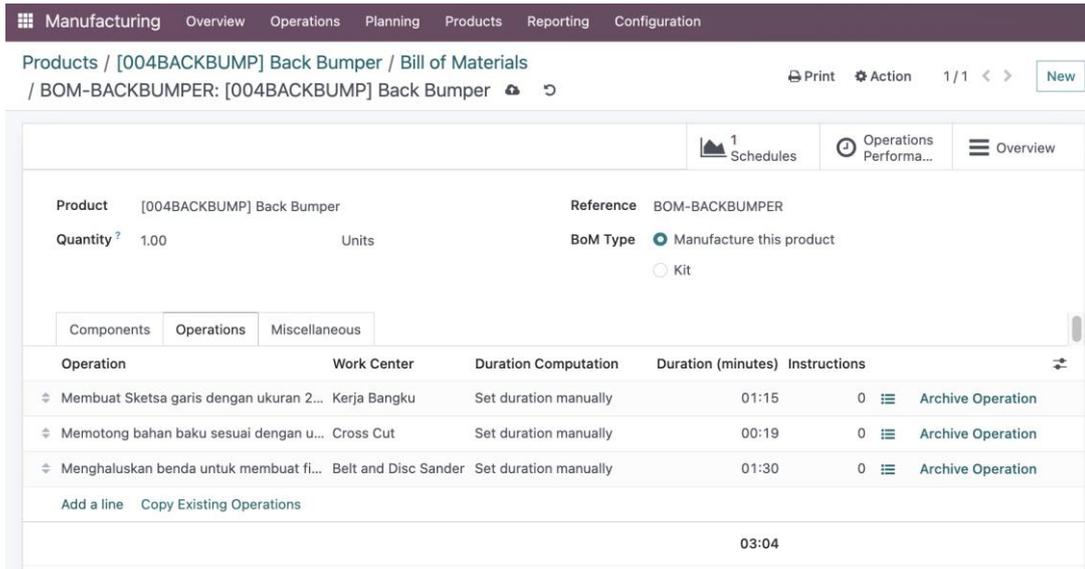


Fig. 11 Operations Odoo

5.3 Assembling Floor

The Assembling Floor section consists of three modules, each with an equal time allocation of 340 minutes, totalling 1020 minutes. These modules include Time and Motion Study, Work Posture, and Physiology and Biomechanics. However, only the Time and Motion Study module can be integrated with ERP software. The other modules may require separate case studies or exercises provided by the instructor.

The Time and Motion Study module requires materials such as the parts produced and the BOM data created in the previous practicum. In this module, students learn to measure work times and analyze the assembly process movements using tools like the right-handed and left-handed process charts. The output from this module can provide additional data for the Assembly Line work center and the sequence of assembly operations for the product. For example, the assembly process for the chassis component may require an assembly sequence as shown in Figure 12.

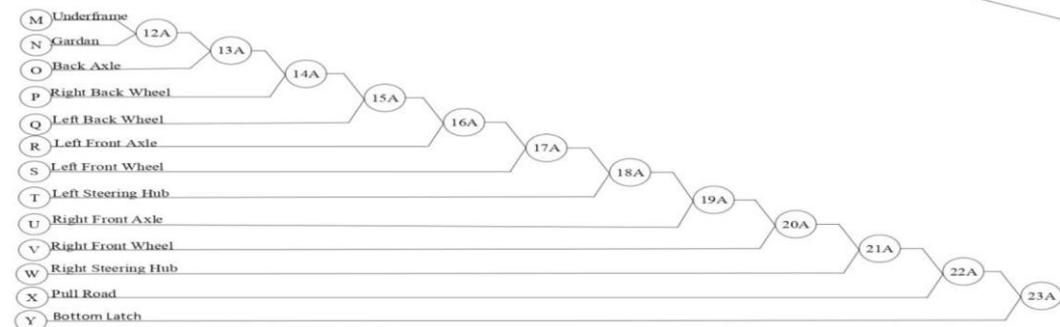


Fig. 12 Assembly Process Chart Chassis

The time for each assembly process is determined through indirect time motion study calculations, resulting in assembly times that can be documented in the OPC.

From this data, students can add master operations to the ERP for the assembly process. The steps for doing so are the same as those used to access the page shown in Figure 16. An example of the assembly operations for the chassis component can be seen in Figure 13.

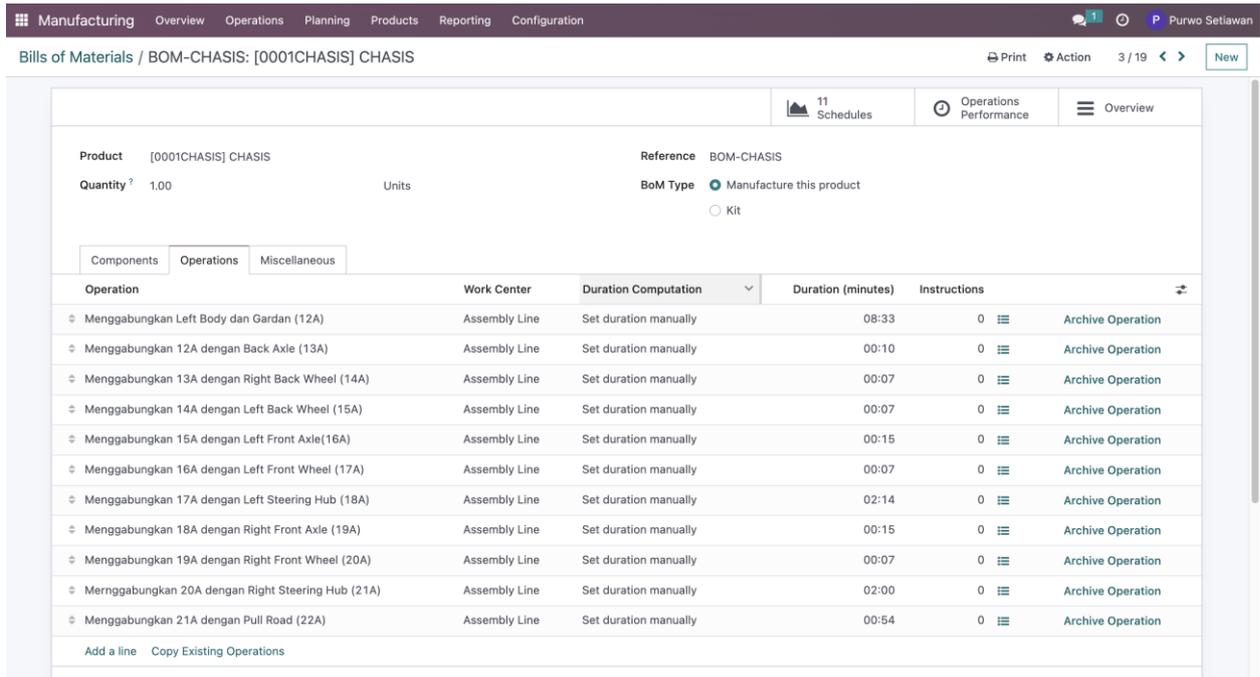


Fig. 13 Operations Chassis

5.4 Demand and Supply

There are five modules in the Demand and Supply section: forecasting, master production schedule (MPS), material requirement planning (MRP), line balancing, and production layout. The time allocation for running these modules is 1360 minutes. To execute this section, it is necessary to include some synthesized data in the ERP, such as customer data, vendor data, product on hand, safety stock, and lead time. Table 3 provides an explanation of these data elements.

Table 3. Synthesis Data

Data	Description
customers	Data customers contain information about customers, including their names, addresses, contacts, and purchase details. This data is used for managing customer relationships, such as sales, marketing, and customer service. Customer data in Odoo can be accessed through the Sales application.
Vendors	Data vendors contain information about suppliers, including their names, addresses, contacts, and purchase-related information. Vendor data is used for managing relationships with suppliers, such as purchasing, negotiations, and payments. You can access vendor data in Odoo through the Purchase application. This information is essential for effective procurement and supply chain management. To create vendor data in Odoo using the Purchase application, you can follow these steps
Product on hand	The "product on hand" data is used to identify the quantity of products currently available in the warehouse. Here is how to input the "product on hand" quantity for each product.
Safety stock	Safety stock, or minimum quantity in Odoo, refers to the stock kept in storage to prepare for unforeseen demand or disruptions in the supply chain. Maintaining safety stock helps businesses prevent stockouts and potential loss of sales.
Lead time	In Odoo, lead time refers to the time needed to replenish inventory, whether it's production time or purchasing time.

The first module to be executed is the forecasting module. In this module, students will be provided with knowledge about various forecasting methods. Subsequently, students will learn to create forecasts for upcoming periods using historical demand data provided by the instructor. This module will produce a monthly demand forecast for the future.

The forecasted data is then utilized to create a Master Production Schedule (MPS). In this phase, students can manually create it using Excel and can also utilize the MPS feature in the ERP software. In the "Forecast Demand" column, students can use the output from the forecasting module conducted earlier.

Next is the Material Requirement Planning (MRP) module. Essentially, ERP is an advancement of MRP that is automated using information technology. Therefore, with the practicum data available, in this module, students can simulate the MRP process using ERP. From the MPS page, you can view the component requirements in terms of quantity and timing based on BOM data, lead time, and the availability of raw materials and components. Figure 14 depicts the component requirements with the inputted forecast data.

	Oct 19	Oct 20	Oct 21	Oct 22	Oct 23	Oct 24	Oct 25	Oct 26	Oct 27	Oct 28	Oct 29	Oct 30	Oct 31
[202300001-CARS] Car by Units	1,153.00	1,045.00	937.00	829.00	721.00	721.00	613.00	613.00	505.00	319.00	211.00	211.00	103.00
- Actual / Forecasted Demand	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 0	0.00 / 10	0.00 / 0	0.00 / 10	0.00 / 18	0.00 / 10	0.00 / 0	0.00 / 10	0.00 / 10
+ Actual / Suggested Replenishment REPLENISH	0 ≤...≤ 1000	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 5
= Forecasted Stock	⊗ 0	1,045.00	937.00	829.00	721.00	721.00	613.00	613.00	505.00	319.00	211.00	103.00	0.00
[0001CHASIS] CHASIS by Units	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Actual / Forecasted Demand	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0
- Indirect Demand Forecast	0.00	0.00	0.00	0.00	0.00	5.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00
+ Actual / Suggested Replenishment REPLENISH	0 ≤...≤ 1000	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 5	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 10
= Forecasted Stock	⊗ 0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
[009UNDERFR] Under Frame by Units	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Actual / Forecasted Demand	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0
- Indirect Demand Forecast	0.00	0.00	0.00	0.00	5.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00
+ Actual / Suggested Replenishment REPLENISH	0 ≤...≤ 1000	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 5	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 10	0.00 / 10
= Forecasted Stock	⊗ 0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
[020BACKAXLE] Back Axle by Units	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Actual / Forecasted Demand	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0	0.00 / 0

Fig. 14 Material needs

From this data, users can create component procurement requests. Replenishment can be done one by one for each component or collectively for all needed components. Procurement is carried out by generating manufacturing orders for products that are manufactured and through request purchase orders for products that are purchased. Of course, the ordering process takes into account both the manufacturing lead time and the vendor delivery lead time. This way, students gain a better understanding of the interdepartmental relationships, where MRP can trigger material procurement according to the required quantity and lead time.

Subsequently, in the line balancing module, students learn to determine the ideal number of workstations. Data from the assembly process chart, work centers, and time-related information such as takt time, lead time, nect time, and cycle time can be extracted from previous practicums through ERP software. With this data, students can utilize other software tools to design a Flexible Line Balancing system. The method used in this module is the same as that used by Isnaini et al (2022) to regulate line balancing in a tofu factory (Isnaini et al., 2022).

The last module is the production layout module. The goal of this module is for students to determine a fabrication layout while considering demand data, workstation transfers (routing sheets), and transfer costs. The routing sheet data is crucial in this module for calculating the transfer costs between workstations. In general, the steps for configuring the production layout can be seen in Figure 15. All calculations are performed with the assistance of Excel software. Then, to determine the appropriate layout, students can use other software tools such as Quantitative System (QS) or similar applications. This method is the same as that used by Nugroho et al (2012) to minimize the distance that materials are moved on the production floor using QS software (Nugroho et al., 2012).

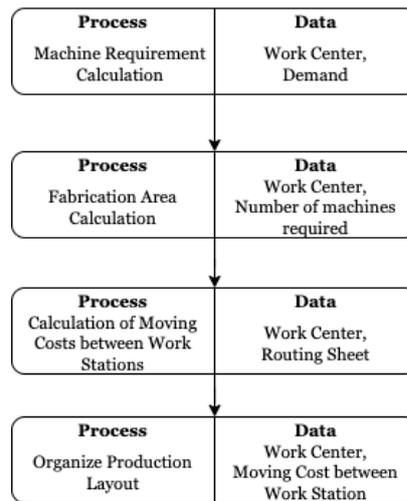


Fig. 15 Steps for Production Layout Module

5.5 Accounting

In the accounting section, there is only one module, which is "accounting," with a time allocation of 340 minutes. In this module, students learn about the accounting module in Odoo for the operational needs of a company. Before undertaking this practicum, it is expected that students have taken courses in management accounting or introductory economics. The focus of the accounting module practicum is to learn the accounting cycle using ERP software and create well-structured financial reports.

Odoo accounting effectively automates the reporting system by seamlessly integrating transaction data between accounts receivable and accounts payable accounting systems through automated journal entries. Odoo demonstrates commendable reporting capabilities, making it a suitable candidate for enhancement as an ERP system tailored for smart SMEs (Gusev et al., 2021). This is suitable as student study material.

First, students will learn about opening balances. The purpose of opening balances in accounting is to represent a company's financial position at the beginning of a new accounting period. It is the account balance, which can be related to bank accounts, customer accounts, or supplier accounts, at the start of a fiscal or accounting period.

The next topic is about creating a new account, where students learn how to generate a new Chart of Accounts (CoA). A CoA is a list of accounts used to record financial transactions in Odoo accounting. The CoA typically includes account codes, account names, and account types.

Next, students learn to create journals. Journals are a critical component in Odoo accounting. They are used for recording financial transactions, generating financial reports, and analyzing the financial performance of a company.

Subsequently, students learn about the financial implications of purchase and sales transactions. In this phase, students create invoices and bills for transactions that have occurred. Afterward, students are introduced to the concept of reconciliation. They learn what reconciliation means and the steps involved in the ERP software for reconciliation. Reconciliation is an important process for ensuring that financial records accurately reflect the company's actual financial position. It involves matching transactions in the software with real-world financial statements or bank records to confirm their accuracy and completeness.

Finally, students can make financial reports such as general ledger, loss and profit report, and balance sheet. In general, the material taught in this module is as done by Demilda et al., (2022) who implemented the accounting module in a shop and Terminanto & Hidayanto, (2017) who implemented and configuring the Odoo accounting module in a Small and Medium Businesses.

5.6 User Acceptance Testing

In this study, UAT is provided to end-users, specifically the lab assistants in their final semester. Lab assistants in the final semester were chosen as respondents because they have already gone through various integrated practicums. Therefore, it is expected that the respondents already have comprehensive knowledge of integrated practicums.

Before filling out the questionnaire, respondents will be briefed on the integrated practicum framework mentioned above. Subsequently, respondents will be given a simulation or the opportunity to try using the Odoo software to simulate each case study in the practicum module.

There were fifteen respondents, all of whom had used ERP software. Of the five respondents, only two had never experienced an integrated practicum because according to him the practicums that had been carried out had not been integrated with one another.

There were 10 statements given to respondents. Respondents were asked to provide their level of agreement on a scale of one to five. The results of the questionnaire recapitulation can be seen in Table 2. In these results it can be seen that the average obtained is equal to 4.5, which means that all statements have been approved.

Table 2. Recapitulation of questionnaire results

No	Statement	Grade (1-5)
1	Integrated Practicum is a practicum that uses the same product or object as a binding element between each subsystem, where the output from one subsystem becomes the input for another subsystem. At least three different practicum subsystems must be integrated in Integrated Practicum, including: 1) Work System Design and Ergonomics, 2) Production System Design, 3) Cost Estimation and Analysis. Based on this definition, do you agree that the proposed framework consists of the three mentioned practicum subsystems?	4.6
2	Do you agree that the proposed framework has an object that can bind the mentioned subsystems?	4.5
3	Do you agree that the practicum time allocation in the proposed framework is appropriate?	4.1
4	Do you agree that the implementation of ERP in the proposed framework can be easily used?	4.0
5	Do you agree that the proposed framework can help in understanding the interconnections between Integrated Practicum modules?	4.8
6	Do you agree that the proposed framework can better assist students in understanding the business processes in a company?	4.6
7	Do you agree that the practicum framework offered will provide graduates with the ability to design integrated systems that meet company standards?	4.6
8	Do you agree that the proposed framework will provide the ability to analyze and interpret data to support industrial engineering decision-making processes?	4.7
9	Do you agree that the proposed framework can provide the ability to apply methods, skills, and modern technical equipment required in industrial engineering practice?	4.6
10	Do you agree that the proposed framework can provide the ability to work in a team?	4.5

In terms of completeness of subsystem components and interrelationships between subsystems, the proposed framework can link between practicum subsystems with an above-average level of agreement. The proposed framework is also considered to be able to assist students in understanding the interrelationships and flow of integrated practicum and understanding business processes according to those in companies in general. The expected graduate outcomes in this course also received more than average scores, namely in terms of the ability to design system integration, analyze and interpret data, use modern skills and techniques and be able to work in teams. However, there are two points that have low scores, namely points three and four related to time allocation and ease of use. This is because the shop floor section requires more production time so it is necessary to do trials with a number of existing students with machine usage skills that may be below average. In addition, the level of convenience is also felt to be lacking because respondents have only done one simulation with limited time. So that respondents feel unfamiliar.

6. Discussions

This research proposes an integrated practicum framework based on ERP system. The goal is to provide students, especially industrial engineering students, with knowledge of business processes and ERP system functionality. In addition, the proposed framework can also be used as the same initial view to design an integrated practicum course curriculum in industrial engineering study programs.

The framework is designed using a DFD that shows the interrelated data flows between practicums. Each practicum is connected by data stored in the ERP system. However, in order for the practicum to be well integrated, the objects used need to be considered by meeting several criteria such as WIDE SCOPE OF STUDY: involving various disciplines in Industrial Engineering, SUFFICIENT DEPTH OF STUDY: indicating that the problem's complexity meets the requirements, PRODUCT VARIETY: being multi-segment user-oriented in the market, and SUSTAINABILITY: meaning the product will continually evolve to meet user needs, trends, and technology advancements. The practicum process is also made sequentially according to the flow in the company as follows: product development → shop floor → assembling floor → supply and demand → accounting. This sequence ensures that the data used in the practicum can be seamlessly integrated from the initial stage to the final stage. ERP software is leveraged to enhance the connectivity of data flow between the subsystems, making the entire process more streamlined and efficient.

The UAT results obtained show an approval level score equal to 4.5, which means that the proposed framework is accepted in terms of completeness of subsystems, subsystem linkages, business processes, ability to design integrated systems, process data, interpret data, use modern tools, and teamwork. However, there are still things that need to be considered, namely related to time allocation and ease of use. It is necessary to do a lot of training by assistants and lecturers to overcome this.

This research is currently in the design phase, based on the understanding of the integrated practicum according to BKSTI, standard ERP business processes, and the curriculum of the Industrial Engineering Program at Universitas Gadjah Mada. It is expected that further research will be conducted to evaluate the proposed framework, taking into account the outcomes of students after completing the integrated practicum and the perspectives of industrial engineering programs at other universities or institutions.

7. Conclusion

By implementing ERP software in the integrated practicum, students gain a clear understanding of the purpose of the data generated during the practicum. Students can also utilize the available data to make decisions during the practicum. Furthermore, using ERP software allows students to learn standard business processes used by real companies, as ERP software is designed for actual business needs. This provides students with practical knowledge and experience that can be applied in a real-world business setting. In addition, the proposed framework can also be the same initial view for industrial engineering study programs in designing curriculum, especially integrated practicum courses.

Acknowledgments. I would like to thank all practicum assistants in the Industrial Engineering Study Program at Gadjah Mada University for their cooperation in becoming a source of information and respondents in testing the framework.

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