Journal of Information Systems and Informatics
Vol. 5, No. 3, September 2023 e-ISSN: **2656-4882** p-ISSN: **2656-5935**
DOI: 10.51519/journalisi.v5i3.535 Published By DRPM-UBD

Material Requirement Planning Information System: Prototype And Lead Time Analysis

Mikhael Billy Tanaga[1], Raymond Sunardi Oetama[2,*]

[1,2]Information System Departement , Universitas Multimedia Nusantara, Tangerang, Indonesia
Email: [1]mikhael.billy@student.umn.ac.id, [2]raymond@umn.ac.id

Abstract

In the pharmaceutical manufacturing industry, efficient and accurate production processes ensure quality products and meet customer demands. However, many companies still rely on manual systems, such as Microsoft Excel, which can lead to challenges and inefficiencies. The problems identified include a lack of integration between product data and manufacturing documents, error-prone manual data entry, document mix-ups, and time-consuming processes. The study aimed to design and implement a web-based material requirement planning system to address the challenges of a manual manufacturing system in a pharmaceutical company. The objectives were to improve integration, streamline production processes, and reduce lead time for enhanced operational efficiency. The study employed a prototyping approach to design and develop a web-based material requirement planning system. User feedback and requirements guided iterative design cycles, while User Acceptance Testing evaluated system performance and usability. The impact on operational efficiency was assessed by measuring lead time before and after implementation. The implemented web-based material requirement planning system successfully resolved integration issues, reduced manual data entry errors, and minimized document mix-ups within the pharmaceutical manufacturing company. User Acceptance Testing achieved a 100% average percentage. The lead time was improved from 207-251 minutes to 122-159 minutes, demonstrating enhanced operational efficiency.

Keywords: Material requirement planning, Reporting, Scheduling, User Acceptance Testing, Web Application.

1. INTRODUCTION

The rapid advancement of technology necessitates individuals to adapt to the changes it brings. These changes result from technological progress occurring globally, including in the business sector. Technological developments in the business sector encompass software applications that assist companies in organizing and managing their operations [1]. One such application is Enterprise Resource Planning (ERP), which aids in managing and coordinating business processes [2]. The concept of ERP dates back to the 1960s when it was initially known as Inventory Control Packages [3]. These packages were developed to automate inventory control and represented the first generation of centralized

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

computing systems. The emergence of Inventory Control Packages paved the way for the development of subsequent generations of centralized systems, including Material Requirement Planning (MRP), which became a central component of these systems [4]. The MRP system serves the purpose of planning production needs based on the master production schedule. The MRP II system emerged as the third generation of centralized computing systems, expanding upon the functionalities of the previous MRP system [5]. MRP II incorporated additional functions such as finance, project management, human resources, and engineering [6]. Its primary objective is to provide crucial information support for business activities, particularly procurement, and production [7]. Implementing an MRP system in a manufacturing company offers several benefits, including the availability of a master production schedule, bill of materials, manufacturing orders, and capacity planning [8]. These benefits ensure the availability of raw materials and production components when needed, optimize warehouse stocks, and increase efficiency in manufacturing operations.

Material Requirement Planning is an inventory management method that facilitates scheduling production processes and allocating required raw materials [9]. It is considered a second-generation centralized computing system and a precursor to ERP systems. MRP aims to automate the control of demand-dependent inventory by ensuring the timely allocation of raw materials based on information from the master production schedule, bill of materials, and production cycle [10]. This System is crucial in optimizing production efficiency and minimizing manufacturing errors, such as inaccurate stock levels or material shortages.

Several previous studies have attempted to devise solutions for addressing MRP challenges. One study created a web-based information system using PHP, primarily focusing on mitigating issues related to raw material shortages [11]. Another study conducted within the military aircraft industry in India placed greater emphasis on material selection through the utilization of the AHP algorithm [12]. Furthermore, earlier research also concentrated on time reduction within material requirement planning. Some studies aimed to uncover instances of time wastage [13, 14], while another study developed mathematical models to assess profitability [15]. In this context, the objective was to design and implement a web-based MRP system to tackle the limitations of a manual manufacturing setup in a pharmaceutical company. The developed System was a website, distinct from addressing raw material shortages. Instead, it aimed to replace an outdated Excel-based system, concurrently diminishing lead time.

2. METHODS

PT Mecosin Indonesia is chosen as the case study. This Company, a leading pharmaceutical company in Indonesia, faces challenges with its non-integrated

p-ISSN: 2656-5935 http://journal-isi.org/index.php/isi e-ISSN: 2656-4882

management systems. To address these challenges, the Company has decided to design a web-based MRP system for Material Requirement Planning. The System aims to integrate data, facilitate the creation of bills of materials and manufacturing orders, and provide a dashboard for production status monitoring. The initial step involves developing a prototype of the web-based MRP system.

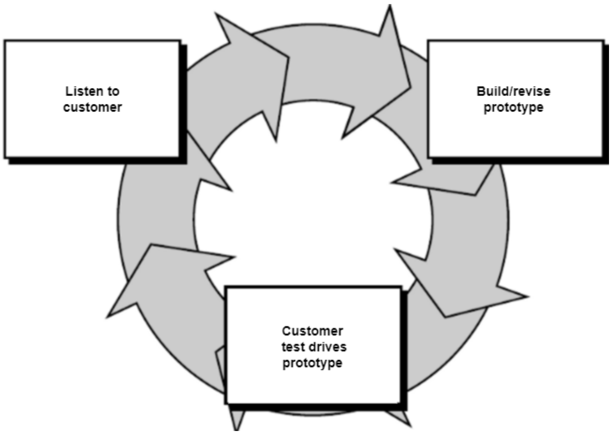


Figure 1. Prototype Method [16]

The System Development Life Cycle prototype method is shown in Figure 1. This method was selected to ensure full control over the system development process. The prototype model offers flexibility in modifying [17] and adapting system requirements and functions as the prototype evolves [18]. It is a suitable approach for The Company, which lacks experience implementing an ERP system. The Company can maximize flexibility throughout development by utilizing the prototype method. They can evaluate the prototype system and make necessary adjustments before finalizing it, ensuring it meets their requirements. This iterative approach allows for ongoing modifications to requirements and functions during development while testing the prototype's response to these changes. The prototyping method consists of three main stages. Firstly, in the "Listen to customer" stage, the focus is gathering information about the user's desires and needs for the System. It involves analyzing requirements, identifying problems, and understanding all requirements.

Secondly, in the "Build/Revise prototype" stage, the emphasis is on designing and creating a prototype system based on the user's provided requirements. The prototype is designed by using UML. UML is visualized through the representation of diagrams that include various types, such as use case diagrams [19]. The system design process continues until the prototype system is formed, which will then be evaluated. The MRP system prototype is developed using PHP as the main programming language, utilizing the CodeIgniter framework and

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

MySQL. Finally, in the "Customer test drives prototype" stage, the aim is to evaluate the created prototype system from the previous stage using User Acceptance Test and Lead Time Analysis. User Acceptance Testing provides the benefit of confirming the functionality of the System [20].

Assessment is performed through Lead Time Analysis. Lead Time Analysis, a technique in supply chain management, examines the duration a product or material requires to transition from order placement to customer delivery, encompassing the complete span between these two junctures. Different manufacturing control levels influence lead times and play a vital role in establishing control parameters, such as lead time offsets, within Material Requirements Planning (MRP) systems [21]. Integrating technology and automation tools is closely intertwined with Lead Time Analysis, as it significantly reduces lead times [22]. In this research, lead time is defined as the cumulative duration of stages comprising Receiving a Production Order (RPO), Generating a New Bill of Material (NBM), Inputting Bill of Material Components (BMC), Creating a Manufacturing Order (CMO), Preparation, and Production, measured in minutes. So the formula to calculate Lead time is shown in formula (1).

$$Lead\ Time = t_{RPO} + t_{NBM} + t_{BMC} + t_{CMO} + t_{Preparation} + t_{Production} \quad (1)$$

The System captures precise timestamps for significant events during the manufacturing process, such as receiving a production order, generating a new bill of material, inputting a bill of material components, creating a manufacturing order, initiating the preparation phase, and completing production. These timestamps are organized chronologically, forming a coherent sequence of events depicting the manufacturing process for a particular order. Lead time for each process is computed by subtracting the event creation timestamp from its completion or status update timestamp, revealing the specific process duration. By aggregating individual process lead times, the System calculates the comprehensive lead time for the entire manufacturing order, representing the total span from order creation to completion.

3. RESULT AND DISCUSSION

3.1 Listen to Customer

Figure 2 depicts the swim lane diagram of the Company's business process involving three departments: Sales, Warehouse, and Manufacturing. The process begins with the generation of production requests from Sales or Warehouse. Sales assess product availability and either proceed with order fulfillment or request production from Warehouse. A warehouse can also initiate production requests when stock levels reach the predefined minimum. Manufacturing creates a bill of

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

material (BOM) for each request, generates manufacturing orders, and forwards them to Warehouse. The Warehouse verifies raw material availability. If available, Manufacturing proceeds with production; otherwise, Warehouse initiates the fulfillment process.

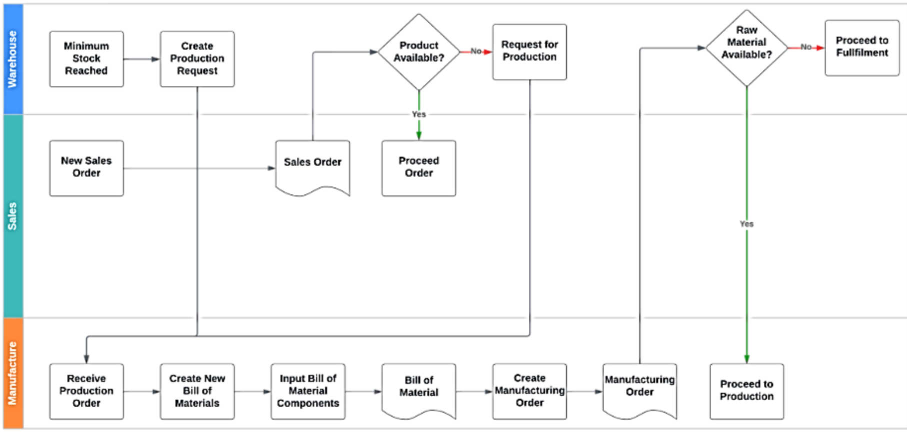


Figure 2. Business Process for Manufacturing Department

User requirements are crucial in software development as they define the necessary functions of the software to meet user needs. These requirements are categorized into functional and non-functional requirements. Functional requirements describe the specific features and functionalities the software should possess, addressing user tasks and behaviors. On the other hand, non-functional requirements focus on the software's qualities, such as performance, security, usability, and reliability. Developers can ensure that the software meets user expectations and performs effectively by identifying and addressing functional and non-functional requirements. These are the user requirement based on the problems and solutions provided for the Company.

The System's functional requirements are: The Production Manager manages product category data, product unit data, product data, header bill of materials, bill of materials components, manufacturing orders, and user data. The Production Staff also manages header bills of materials, bills of materials components, and manufacturing orders. Both the Production Manager and Production Staff can view the production activity status. Regarding non-functional requirements, the System is designed to run smoothly on the Google Chrome web browser, used during User Acceptance Testing, and requires internet connectivity. The System can effectively manage unit data, product categories, and products. It is also capable of handling bills of materials and manufacturing orders. The System provides a dashboard to display production activity status. User data management, including usernames and passwords, is the responsibility of the Production

p-ISSN: 2656-5935 http://journal-isi.org/index.php/isi e-ISSN: 2656-4882

Manager. The System accesses the MySQL database through phpMyAdmin, which the System utilizes.

3.2 Build/Revise Prototype

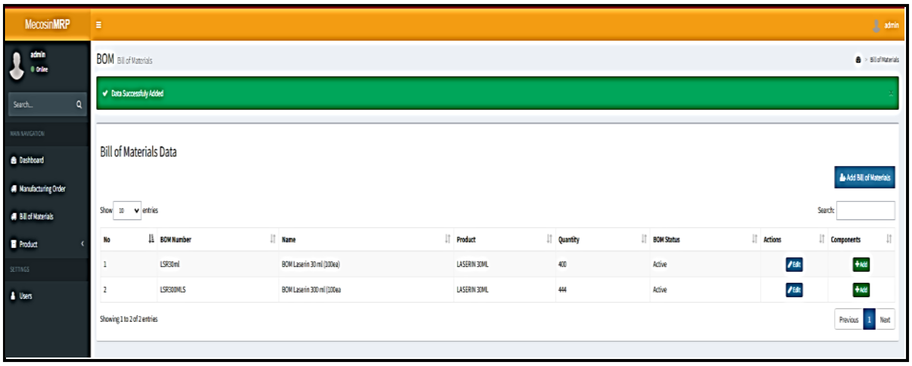
Use case diagram use in understanding of the system designed for the manufacturing activities. The diagram includes two actors: the production staff and the production manager. The production staff is the factory employee who has access to create bills of materials and manufacturing orders based on the existing orders. Production orders will be received by the manufacturing department and handled by the production staff, creating a bill of materials and manufacturing orders. The production manager plays a significant role in monitoring and controlling production activities and the performance of the production staff. Use case diagram as shown in Figure 3.

Figure 3. Use Case Diagram of The Proposed System

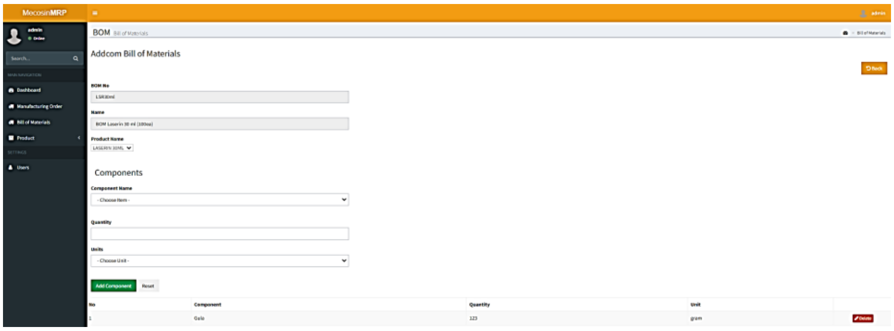
Additionally, the production manager has access rights to manage product data (categories, units, etc.) and user data accessing the System. Both production staff and managers have access rights to view the status of production activities. There are two types of features. The first one marked by the grey eclipse is the default

p-ISSN: 2656-5935 http://journal-isi.org/index.php/isi e-ISSN: 2656-4882

feature because it is a mandatory feature required to support the special features marked by the orange eclipse.



(a)



(b)

Figure 4. Bill of Material consists of (a) Header Page, (b) Component Page

Figure 4 depicts the Bill of Material. Firstly, Figure 4(a) showcases the interface of the bill of material header page. On this page, users can view the header data from the bill of material and perform actions such as adding and editing the bill of material header information. Users can also access the bill of material component page from this page by clicking the add button on the last column. Figure 4(b) displays the page for the bill of materials' components. Users can view the component data of the selected bill of materials. Users also have the option to add and delete existing components. Multiple input fields include a component name from raw material, quantity needed per component, and the unit used.

p-ISSN: 2656-5935 http://journal-isi.org/index.php/isi e-ISSN: 2656-4882

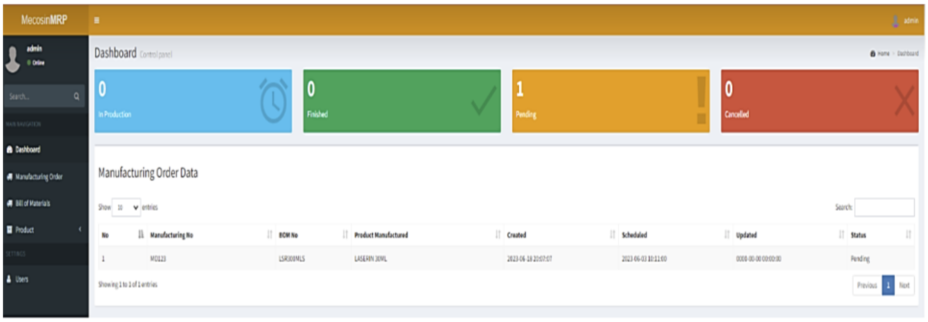


Figure 5. Dashboard of Manufacturing Orders

Figure 5 depicts the System's dashboard of Manufacturing Orders. Users can access a manufacturing order table on this page, accompanied by a tally of manufacturing orders categorized by their respective statuses. Additionally, users can employ filters to pinpoint manufacturing orders associated with particular statuses. This dashboard also shows the timestamp for created and updated times essential for lead time calculations from creating the manufacturing order process. As mentioned above, the lead time is calculated from a series of processes, including Receiving a Production Order, Generating a New Bill of Material, Inputting a Bill of Material Components, Creating a Manufacturing Order, Preparation, and Production. In each process, the lead time is determined by calculating the duration between the time of creation and the moment when the status is updated to indicate completion. With the implementation of the new System, lead time data is directly extracted from the System, streamlining the process. In contrast, the previous Excel-based System did not provide visibility into time data. Consequently, calculating lead time in the earlier System required manual notation.

3.3 Customer Test Drive Prototype

User acceptance level score for each feature given by each tester. Not all features achieved a perfect score in terms of user acceptance. The "Edit Bill of Material Header" feature received a lower score due to employees' unfamiliarity with the System and its functionality, confusion, and increased time required for comprehension. Similarly, the "Add Bill of Material Component" and "Add Manufacturing Order" features also fell short of a perfect score due to challenges adapting to the system-based method and associating components with manufacturing orders. Initially, the "Edit Manufacturing Order" feature had an expected imperfection, but terminology-related concerns have been addressed. Overall, the average user acceptance score received was 92.8%. The results of user acceptance level score is shown Table 1.

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

Table 1. Quantitative User Acceptance Test

Features	Acceptance Level					Total
	Disagree	**Disagree**	**Doubtful**	**Agree**	**Strongly Agree**	
Add Bill of Material Header					2	100%
Edit Bill of Material Header				1	1	90%
Add Bill of Material Component				1	1	90%
Delete Bill of Material Component					2	100%
Add Manufacturing Orders				1	1	90%
Edit Manufacturing Orders				2		80%
Access Dashboard					2	100%
Average						92.8%.

Table 2. Comparison of Business Process Time Taken Before and After System (in minutes)

Business Process	Before System				After System			
	Redundancy	Time Taken			Redundancy	Time Taken		
		Min	Avg	Max		Min	Avg	Max
Receive Production Order	12	18	19	21	0	4	5	7
Create a New Bill of Material	12	18	21	24	0	9	10	10
Input Bill of Material Components	16	25	28	30	0	6	8	11
Create Manufacturing Order	13	18	19	23	0	1	3	4
Preparation	19	34	42	49	0	12	19	27
Production	22	94	100	104	0	90	96	100
Lead Time		207	229	251		122	141	159

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

Upon completing system design and user acceptance testing, it is now necessary to assess whether the System effectively enhances the efficiency of the production system. Table 2 demonstrates that the total time taken for each business process varies, including the time dedicated to redundancy within those processes. Employees previously had to engage in manual tasks to ensure data redundancy, such as creating duplicate copies of documents for each process. Additionally, they had to list extra components for component redundancy using Excel, which consumed additional time. Although the System was not specifically designed for redundancy purposes, it reduces the total time required for each business process by minimizing redundancy time. Overall, the System significantly removed redundancy and improved efficiency and time savings across the business processes. The implementation of the System has resulted in a decrease in lead time for business processes. The lead time has reduced from 207-251 minutes before the System to 122-159 minutes after the System.

The results demonstrate the System's positive impact on process efficiency and time optimization. By addressing redundancy and streamlining processes, the System improved productivity and reduced lead times, benefiting the production system's overall performance. It underscores the significance of utilizing technology-driven solutions to drive operational improvements and enhance business outcomes. By decreasing lead time, companies can respond to customer demands more swiftly. It enables faster product delivery, catering to customers seeking immediate products or services. Companies capable of expedited product delivery enhance their potential to seize market opportunities more effectively.

4. CONCLUSION

A web-based material requirement planning system was designed to improve the Company's manufacturing activities. The web-based material requirement planning system was designed using the prototyping method. The System was developed using PHP programming language with CodeIgniter framework and Bootstrap. The system design utilized Microsoft Visual Studio Code and XAMPP tools. It includes features such as an integrated database for managing bills of materials and manufacturing orders. By inputting product data into the System, employees no longer need to manually type each component, reducing the occurrence of typographical errors. The System was evaluated through User Acceptance Testing (UAT) conducted by two individuals: the Production Manager (Mr. Wahyu) and the Production Staff (Mr. James). The results of the UAT showed an average of 92.8% from both individual tests. The System has effectively demonstrated its ability to enhance the efficiency of the total lead time required for product manufacturing and remove redundancy. The lead time has experienced a decrease, going from a previous range of 207-251 minutes to 122-159 minutes after the implementation of the System.

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

ACKNOWLEDGMENT

The financial and facility support provided by Universitas Multimedia Nusantara is greatly appreciated, as it has been instrumental in ensuring the successful completion of this research.

REFERENCES

[1] G. Tsaramirsis *et al.*, "A modern approach towards an industry 4.0 model: From driving technologies to management," *J. Sensors*, vol. 2022, pp. 1–18, 2022.
[2] P. Yosevine, R. S. Oetama, J. Setiawan, and E. Princes, "Enterprise Resource Planning (ERP) Evaluation and Implementation: A Case Study," *J. Multidiscip. Issues*, vol. 1, no. 1, pp. 49–66, 2021, doi: 10.53748/jmis.v1i1.10.
[3] I. Jackson, J. Tolujevs, and Z. Kegenbekov, "Review of inventory control models: a classification based on methods of obtaining optimal control parameters," *Transp. Telecommun.*, vol. 21, no. 3, pp. 191–202, 2020.
[4] O. El Hairech and A. Lyhyaoui, "The New Generation of ERP in the Era of Artificial Intelligence and Industry 4.0," in *International Conference on Advanced Intelligent Systems for Sustainable Development*, 2020, pp. 1086–1094.
[5] M. N. Salur and W. K. Kattar, "The impact of enterprise resource planning (ERP) on the audit in the context of emerging technologies," *Ekon. Maliye İşletme Derg.*, vol. 4, no. 2, pp. 115–123, 2021.
[6] M. Al-Amin, T. Hossain, J. Islam, and S. K. Biwas, "History, Features, Challenges, and Critical Success Factors of Enterprise Resource Planning (ERP) in The Era of Industry 4.0," *Eur. Sci. Journal, ESJ*, vol. 19, no. 6, p. 31, 2023.
[7] A. Faccia and P. Petratos, "Blockchain, enterprise resource planning (ERP) and accounting information systems (AIS): Research on e-procurement and system integration," *Appl. Sci.*, vol. 11, no. 15, p. 6792, 2021.
[8] J. K. F. Sitanggang and I. Muda, "The Conversion Cycle: Review of Material Requirements Planning (MRP)," in *ICSST 2021: Proceedings of the 1st International Conference on Social, Science, and Technology, ICSST 2021, 25 November 2021, Tangerang, Indonesia*, 2022, p. 151.
[9] V. A. Budiono, L. Gozali, and I. W. Sukania, "Production and Capacity Planning as well as Inventory and Distribution Control in Snack Packaging Companies Using Open Source ERP Simulation," in *2023 19th IEEE International Colloquium on Signal Processing & Its Applications (CSPA)*, 2023, pp. 64–69.
[10] J. B. Munyaka and V. S. S. Yadavalli, "Inventory management concepts and implementations: a systematic review," *South African J. Ind. Eng.*, vol. 33, no. 2, pp. 15–36, 2022.

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

[11] N. Hasanati, E. Permatasari, N. Nurhasanah, and S. Hidayat, "Implementation of material requirement planning (MRP) on raw material order planning system for garment industry," in *IOP Conference Series: Materials Science and Engineering*, 2019, vol. 528, no. 1, p. 12064.

[12] J. Saravanan and J. J. Thakkar, "An integrated approach for lead time reduction of military aircraft major overhaul: A case of ABC Company," *Int. J. Qual. Reliab. Manag.*, vol. 35, no. 1, pp. 2–33, 2018, doi: 10.1108/IJQRM-07-2015-0102.

[13] G. Rajesh, "Implementation of a Lean Model in Manufacturing Industry," *Int. J. Ind. Eng.*, vol. 2, no. 1, pp. 10–14, 2015, doi: 10.14445/23499362/ijie-v2i2p103.

[14] A. Palange and P. Dhatrak, "Lean manufacturing a vital tool to enhance productivity in manufacturing," *Mater. Today Proc.*, vol. 46, pp. 729–736, 2021.

[15] N. M. Modak and P. Kelle, "Managing a dual-channel supply chain under price and delivery-time dependent stochastic demand," *Eur. J. Oper. Res.*, vol. 272, no. 1, pp. 147–161, 2019, doi: 10.1016/j.ejor.2018.05.067.

[16] A. L. Hananto, B. Priyatna, and A. Haris, "Application of prototype method on student monitoring system based on WEB," *Buana Inf. Technol. Comput. Sci. (BIT CS)*, vol. 1, no. 1, pp. 1–4, 2020.

[17] M. Meloni *et al.*, "Engineering origami: A comprehensive review of recent applications, design methods, and tools," *Adv. Sci.*, vol. 8, no. 13, p. 2000636, 2021.

[18] D. A. N. Wulandari, A. A. H. Bahar, M. G. Arfananda, and H. Apriyani, "Prototyping Model In Information System Development Of Al-Ruhamaa'Bogor Yatim Center Foundation," *J. Pilar Nusa Mandiri*, vol. 17, no. 2, pp. 127–136, 2021.

[19] J. Wiratama and F. A. T. Tobing, "Analysis and Design of an Web-Based Ticketing Service Helpdesk at Food and Packaging Machinery Company," *Ultim. InfoSys J. Ilmu Sist. Inf.*, vol. 13, no. 1, pp. 19–28, 2022, doi: 10.31937/si.v13i1.2656.

[20] Z. Ajab Mohideen, A. Sheikh, and K. Kaur, "Developing an open source mobile app in library services: the case of a national university in Malaysia," *Digit. Libr. Perspect.*, vol. 38, no. 3, pp. 283–300, 2022.

[21] M. A. Sellitto, "Lead-time, inventory, and safety stock calculation in job-shop manufacturing," *Acta Polytech.*, vol. 58, no. 6, pp. 395–401, 2018.

[22] S. H. Arnob, R. I. Atik, M. A. Ahmed, and S. M. Hassan, "Lead Time Optimization of RMG Sector Supply Chain in," *Supply Chain Insid. ISSN 2617-7420*, vol. 04, no. 01, pp. 5–11, 2020.