

Gundala Small Medium Enterprise Production Planning and Inventory Control System

Fadhilah Athhar Fauzi Avicenna¹, Zuraidin MohdSafar^{1*}

¹Faculty of Computer Science and Information Technology,
University Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA

DOI: <https://doi.org/10.30880/aitcs.2024.05.01.025>

Received 24 June 2023; Accepted 18 May 2024; Available online 30 August 2024

Abstract: Manufacturing Resource Planning (MRP) and inventory control are the cores for Small-Medium Enterprise (SME) to works efficiently in keeping records for inventory and plannings for production efficiently. The system involved in every aspect and procedure regarding inventory control which coexist alongside manufacturing sector to achieve the most effective approach. A web-based Production Planning and Inventory Control (PPIC) system was developed to maximize the availability of the system for usage which provides more flexibility and less limitation for task executions. The prototype method is used to deliver this system for its compatible method. Identifying the issue statement, objectives, system requirements, building the system interface, and constructing the database are all part of the system construction procedures. The system developed in PHP and MySQL under Visual Studio Code. The system is intended to improve the entire operation effectiveness of PPIC and expected to be maintained and enhanced in the long term.

Keywords: MRP, PPIC, SME, Web Based System

1. Introduction

A known small and medium-sized enterprise (SME), PT Gundala is an established producer of sensors that gather data via IoT integration. The business has grown and prospered significantly throughout the years. However, PT Gundala has difficulties in the areas of production planning and inventory control in order to keep its competitive advantage and maintain its pace of expansion. The firm now records and manages these important areas of its operations using manual methods using Microsoft Word and Excel. By creating a web-based Production, Planning, and Inventory Control (PPIC) system for PT Gundala, this thesis seeks to overcome these difficulties [1].

There are various issues with PT Gundala's reliance on manual procedures and fragmented software programmes like Microsoft Word and Excel for production planning and inventory control. Lack of a Material Requirements Planning (MRP) system, which causes inefficiencies and restrictions in the PPIC procedures, is one of the primary issues. This thesis suggests that a web based PPIC system be created in order to address the problems PT Gundala is now facing. Production planning and inventory management procedures will be combined in the system to provide an organised, automated, and real-time platform.

*Corresponding author: zuraidin@uthm.edu.my

| This is an open access article under the CC BY-NC-SA 4.0 license.

2. Literature Review

2.1 Manufacturing Resource Planning

Manufacturing Resource Planning, commonly known as MRP II in modern production planning. It is an advanced version of the original MRP I system that accounts for new variables like as demand forecasting, master scheduling, capacity planning, and so on. It was spearheaded by Oliver Wight in 1983. Inventory management that does not use computerized systems and methods tend to face more difficulties within Small and medium-sized enterprises (Sme) [2].

2.2 Web Based Production Planning and Inventory Control System

An online platform that integrates production planning and inventory management procedures is referred to as a web-based Production, Planning, Inventory management (PPIC) system. It makes use of the capabilities of web technology to better decision-making, collaborate more effectively, and expedite processes in industrial contexts. The goal on web based PPIC systems is to examine the amount of information already available about the creation, application, and advantages of such systems.

2.3 Systems Comparison Table

The three existing systems were studied and compared to the featured proposed system. It consist of the modules of production planning and inventory control system along with some additional features in which existing systems has to offer. The results of the comparison is displayed on Table 1.

Table 1: Systems' Comparison

| Feature/System | Katana | SAP | Odoo | Proposed System |
|-------------------------------------------------|---------------|---------------|---------------|------------------------|
| Inventory Control | Available | Available | Available | Available |
| Work Order Creation | Not Available | Not Available | Not Available | Available |
| Production Scheduling | Available | Available | Available | Available |
| Capacity Planning | Available | Available | Available | Available |
| Bills of Material (BOM) | Available | Available | Available | Available |
| Tailored Solution Development | No | No | No | Yes |
| Scalability and Futureproofing | No | No | No | Yes |
| User Authentication and Access Control | Not Available | Not Available | Not Available | Available |
| User-Friendly Interface and Intuitive Usability | No | No | No | Yes |

Table 1: Systems' Comparison (cont.)

| | | | | |
|----------------------------------------|-----|-----|-----|-----|
| On-Premises Deployment and Integration | Yes | Yes | Yes | Yes |
|----------------------------------------|-----|-----|-----|-----|

3. Methodology

The phases in SDLC comes with a variety of models design such as Waterfall model, Incremental Model, V-Model, Agile Model, Spiral Model, and Big Bang Model which comes with different specific usage as well as the advantages and disadvantages of the model [3]. In this project, Prototype Model approach is chosen as it suits the situation and condition of the project development.

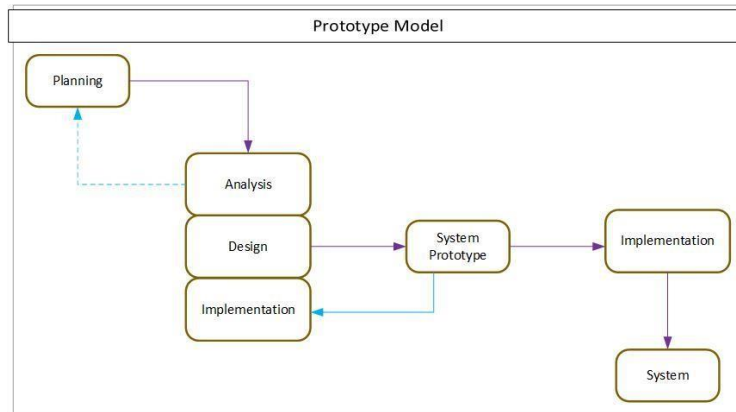


Figure 1: Prototype Model [4]

Table 2: System Development Workflow

| Phase | Activity | Description |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Planning | <ul style="list-style-type: none"> Identifying the issue Requirement analysis Plan the project schedule | <ul style="list-style-type: none"> Gantt Chart Proposal |
| Design | <ul style="list-style-type: none"> Identifying the issue Requirement analysis Plan the project schedule | <ul style="list-style-type: none"> ERD Use case diagram Activity diagram Classes design |
| Implementation | <ul style="list-style-type: none"> Coding | <ul style="list-style-type: none"> Functional outcome |
| Testing | <ul style="list-style-type: none"> Checking the usability of the system | <ul style="list-style-type: none"> Functional outcome |
| Maintenance | <ul style="list-style-type: none"> Error checking | <ul style="list-style-type: none"> Fixing the flaw of the system |

4. Results and Discussion

4.1 System Analysis and Design

System analysis and design involve with the planning of information system development by outlining in detail what a system ought to perform and how its components should be implemented and function. The system's Unified Modelling Language (UML) has been defined, which includes use-case diagrams, sequence diagrams, activity diagrams, classes diagrams, and the database design, which is an Entity Relationship Diagram.

4.2 Unified Modelling Language (UML)

The Unified Modelling Language (UML) is extremely important in web-based Production Planning and Inventory Control (PPIC) or Material Requirements Planning (MRP) systems. UML provides a standardised syntax and collection of diagrams for modelling and visualising system components, interactions, and behaviours. Stakeholders participating in the creation of PPIC or MRP systems can use UML to efficiently communicate and comprehend system requirements, design decisions, and overall system structure. Use case diagrams, class diagrams, sequence diagrams, and activity diagrams are examples of UML diagrams that enable for the explicit description of functionality, data flows, and process workflows. These diagrams assist in detecting system bottlenecks, maintaining correct inventory management, optimising production planning, and promoting effective stakeholder cooperation. Furthermore, by providing a visual blueprint that acts as a reference throughout the development and maintenance phases, UML supports the flexibility, reusability, and maintainability of PPIC or MRP systems. It is a powerful approach for modelling and documenting an MRP system's functional requirements, allowing designers and developers to efficiently capture business processes and system functionality[5].

4.2.1 Use Case Diagram

The Use Case Diagram depicts the interactions between two actors, "Admin" and "User," in a web-based system. The "Admin" actor has broader system access and permissions. They can access use cases such as Login, Inventory Management, Inventory Monitoring, Bills of Material, Work Order, Master Production Schedule, Organizational Structure, Pricebook, and Logout. Additionally, the Admin can manage user accounts through the User Management use case. On the other hand, the "User" actor has more limited functionalities. They can access use cases such as Login, Registration, and Logout. The diagram provides a visual representation of the roles and permissions of each actor, giving an overview of the system's functionalities and the distinct actions available to Admin and User.

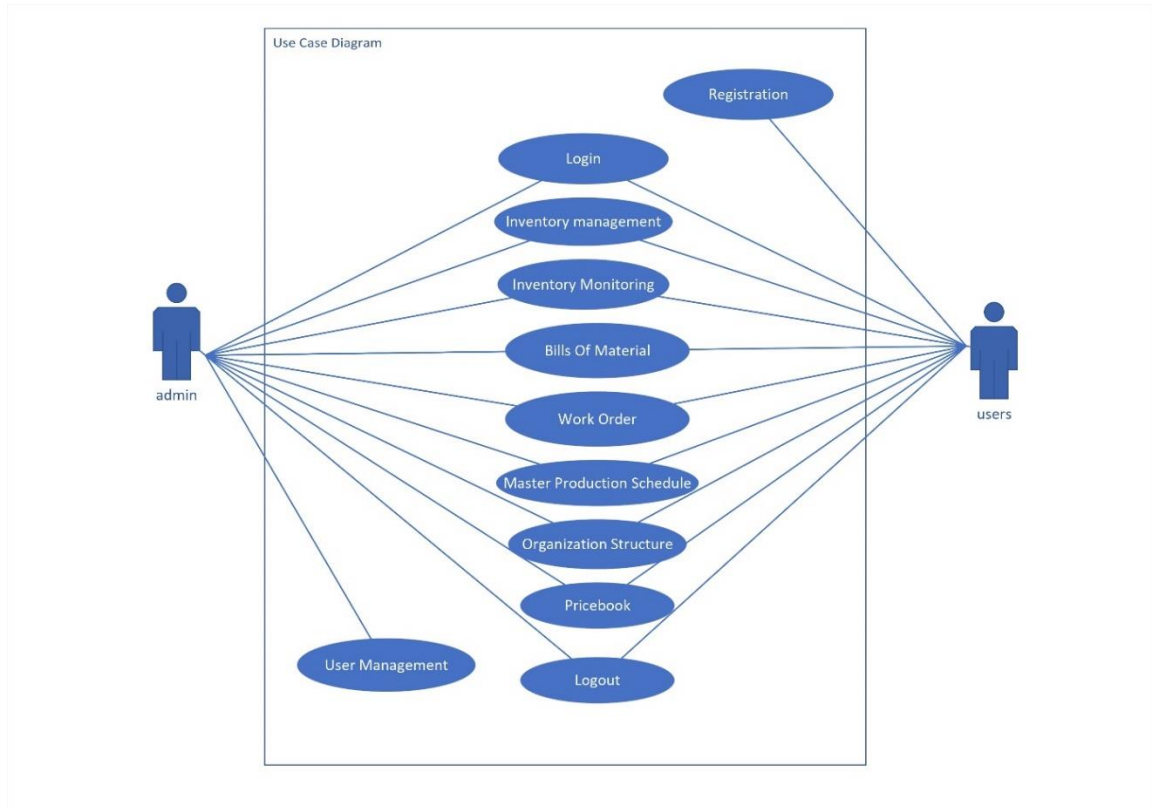


Figure 2: Use Case Diagram

4.2.2 Class Diagram

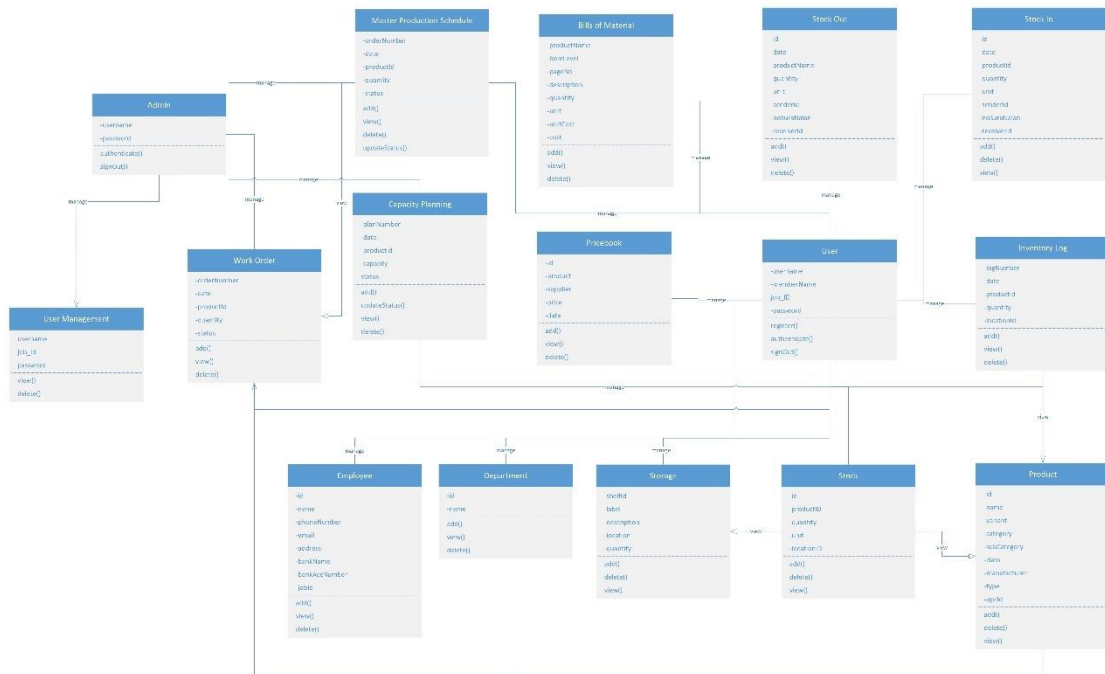


Figure 3: Class Diagram

4.2.3 Activity Diagram

Activity diagrams are helpful in identifying bottlenecks and inefficiencies by showing the sequential and parallel activities involved in the MRP process. The system caters to two distinct sections: Users and Administrators. Both parties require login credentials, except for Users who need to register if they do not have an account yet. The diagram showcases the various modules and functionalities available to Users and Administrators.

Starting with the User section, after logging in or registering, Users can access the Stakeholders module. This module allows Users to input and view data related to customers and suppliers. Users can enter customer information, view existing customer data, add new suppliers, or browse through supplier details. Moving on to the Inventory Management module, both Users and Administrators have access. This module comprises three main components: Stock, Product, and Storage. Users can view stock details, search for products, and check storage availability. Administrators, in addition to these functionalities, can also modify or delete product entries, update stock information, and block user access if necessary. Another module accessible by both parties is the Inventory Monitoring module. Here, Users and Administrators can view, and input data related to the inventory. This includes maintaining a price book for products, entering incoming and outgoing stock details in the Stock In and Stock Out pages, and reviewing the Inventory Log for comprehensive inventory information. The Organizational Structure module allows Users and Administrators to manage departments and employees within the system. Users can input new department details and view existing department records. Similarly, Users can add new employees and browse through employee information. Administrators have the added authority to modify or delete department and employee records.

Lastly, the Production Planning and Control module is available to both Users and Administrators. Here, they can input and display work orders for production planning purposes. Users can create new work orders, view their own work orders, and update their status. Administrators could modify or delete work orders and change the status of various data entries, such as Capacity Planning and Master Production Schedule (MPS).

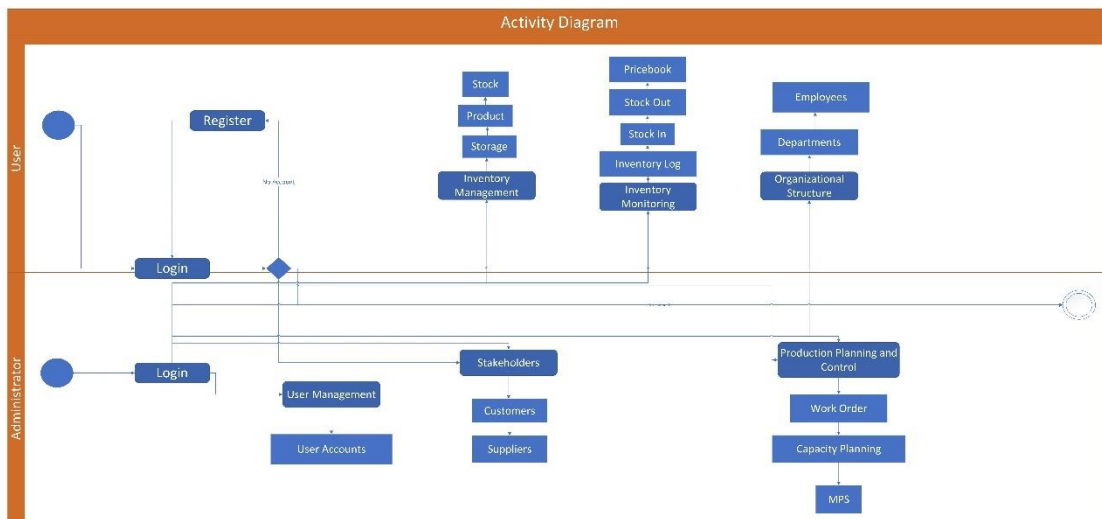


Figure 4: Activity Diagram

4.3 Entity Relationship Diagram (ERD)

Entity Relationship Diagrams are essential for the creation of a web-based system since they allow for a more accurate effort projection on how a web system will be built with the addition of the back-end element of the application utilising various methodologies [6].

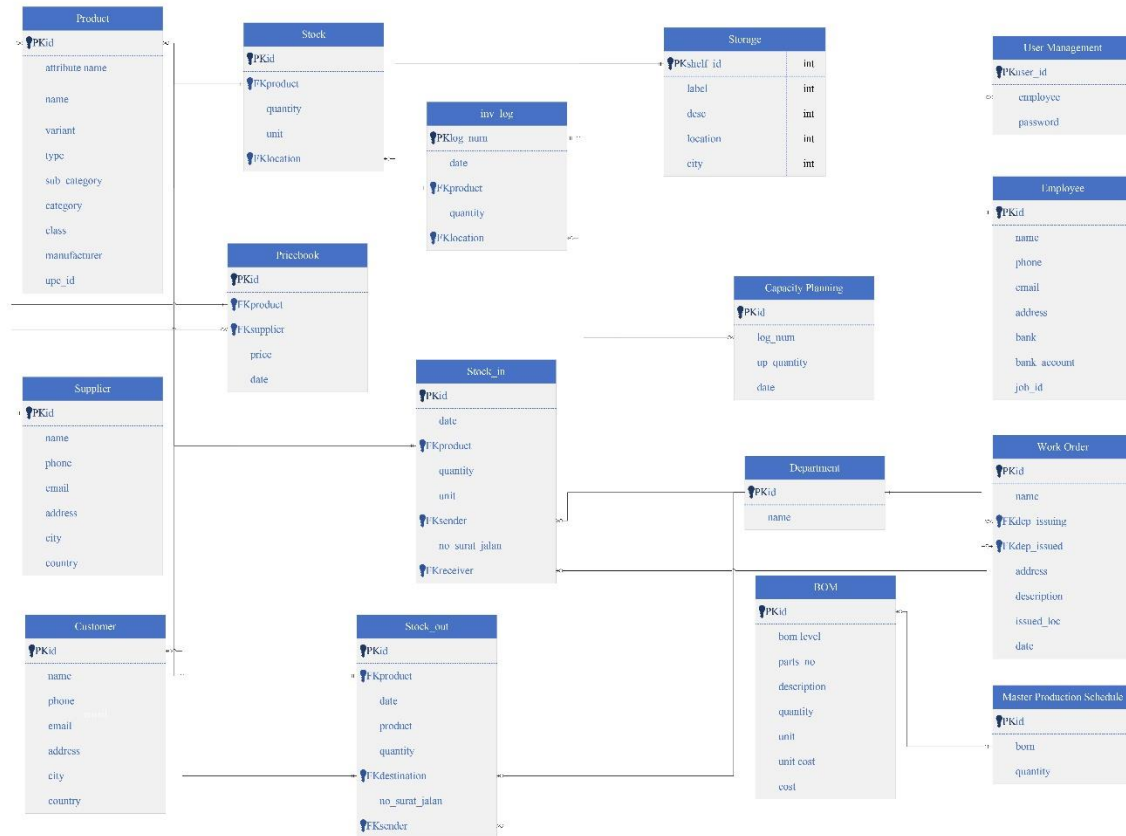


Figure 5: Entity Relationship Diagram (ERD)

4.3.1 Functional Requirement

For Gundala Ltd., the analysis of requirements would show user needs, hardware specifications, functional and non-functional requirements, user demands, alongside software for production planning and inventory control. Functional and non-functional needs are shown in Tables 3 and 4.

Table 3: Functional requirement analysis

| No. | Module | Description |
|-----|----------------------------|---------------------------------------------------------------------------------------------------------------|
| 1 | Registration and login | Functions to register and authenticate user to access the system |
| 2 | Inventory Management | Input and store data regarding product, stock, and storage as well as to display the records. |
| 3 | Stock Monitoring | Keep track on the ongoing stocks and incoming stocks |
| 4 | Pricebook | Keep track on product price and date it is made |
| 5. | Work Order | Record work orders for production planning purpose |
| 6. | Master Production Schedule | Monitor the works on production whether it is in progress or completed |
| 7. | Bills of Material | Record the material requirement for production and overview the total price related to the materials involved |
| 8. | Capacity Planning | Record capacity plans and overview whether the plans are still approved or pending |
| 9. | Inventory Log | Records the inventory flows and time for any changes being made |

Table 3: Functional requirement analysis (cont.)

| | | |
|-----|-----------------|-------------------------------------------------------|
| 10. | User Management | Management setting for admin to control user accounts |
|-----|-----------------|-------------------------------------------------------|

4.3.2 Non-Functional Requirements

Table 4: Non-functional requirement analysis

| No. | Requirements | Variable Value |
|-----|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Performance | <ul style="list-style-type: none"> The system needs to be always accessible. Any web browser should be able to access the system. |
| 2 | Operational | <ul style="list-style-type: none"> The programme needs to be simple to use. The system needs to be simple to upgrade and maintain. |
| 3 | Security | <ul style="list-style-type: none"> Users can only access the system if they have a valid ID and password. |

4.10 Implementation and Testing

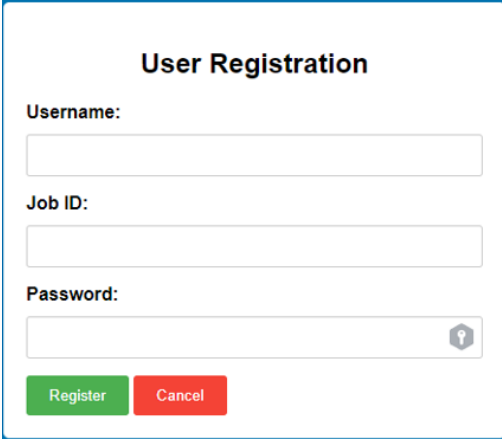
The conclusion should summarize the main findings of the study, and restate the key points inferred from trends observed and discussed regarding the data. Some suggestions should be included to encourage the continuation of the current research.

4.10.1 Manufacturing Resource Planning

The following section will go through the modules that were implemented in this system. These include user identification and access control, inventory management, inventory tracking, bills of material, work orders, capacity planning, and master production scheduling. For each module, the program's partial code will be discussed in its own section.

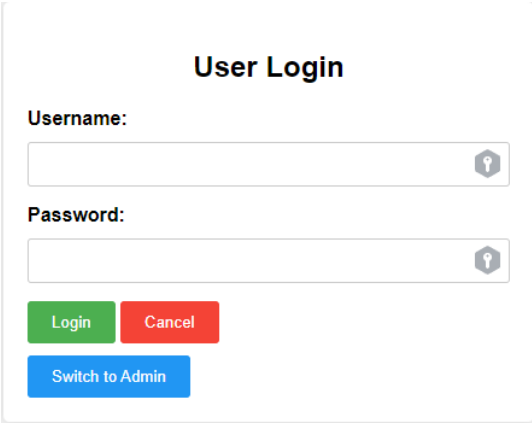
4.10.1 User Identification and Access Control module

There are two types of users which are User and Admin, User needs to register their username, job ID, and password to the database as in Figure 7 to setup an account to login to the system whereas the admin can login to the system right away with the username and password as in Figure 8. The main difference between the two is that Admin has access to the user management which is displayed on the navigation bar while it is unavailable on the user navigation bar interface as displayed on Figure 9 and Figure 10. The user management allows Administrator to oversee user accounts along with the details such as the job ID, username, and password as well as authority to remove the account to block access to the system as shown in Figure 11.



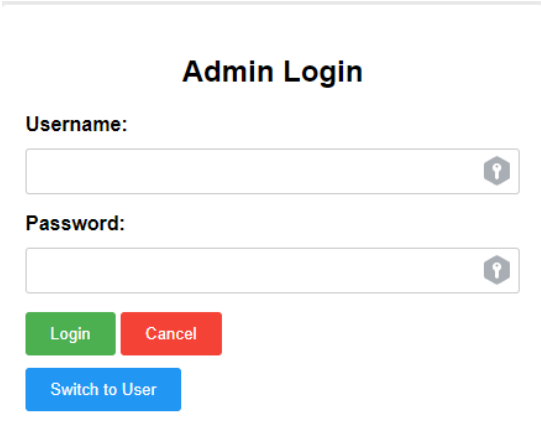
The registration form is titled "User Registration". It contains three input fields: "Username:", "Job ID:", and "Password:". The "Password:" field has a toggle icon on the right. Below the fields are two buttons: "Register" (green) and "Cancel" (red).

Figure 6: Registration form for user



The login form is titled "User Login". It contains two input fields: "Username:" and "Password:", both with toggle icons on the right. Below the fields are three buttons: "Login" (green), "Cancel" (red), and "Switch to Admin" (blue).

Figure 7: login form for user



The login form is titled "Admin Login". It contains two input fields: "Username:" and "Password:", both with toggle icons on the right. Below the fields are three buttons: "Login" (green), "Cancel" (red), and "Switch to User" (blue).

Figure 8: login form for admin



Figure 9: navigation bar for Admin



Figure 10: Interface of Navigation bar for User

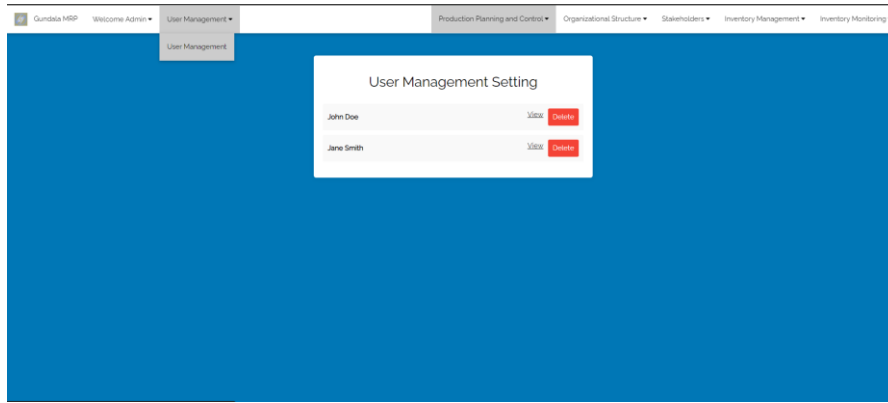


Figure 11: User management setting for admin

4.10.2 Inventory Management

Inventory Management consist of Product, Stock, and Storage functions whereas they will display the list from the database respectively. Figure 12 is the input form for the data to be stored into the database and displayed on the list while Figure 13 shows the existing data of the product that have been created. As for the Stock and Storage, they are the procedure and functionality are similar to Product except that Stock required existing Product ID and Shelf Location to be able to input the data.

Add New Product

ID:

Name:

Variant:

Type:

Sub Category:

Category:

Class:

Manufacturer:

UPC ID:

Figure 12: Input product form

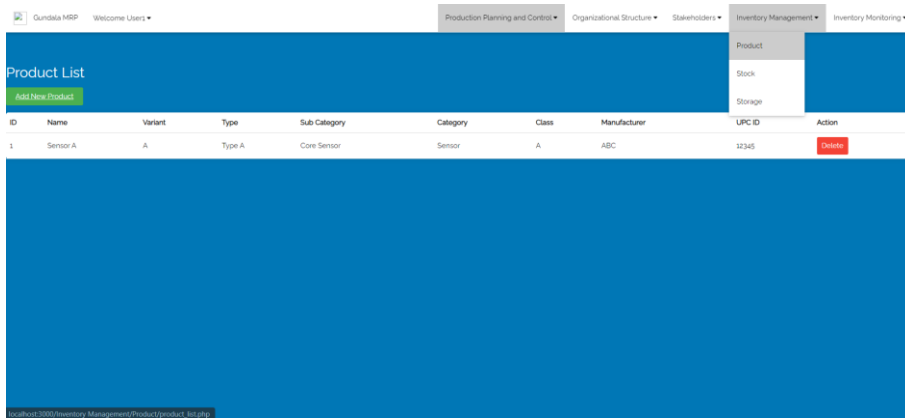


Figure 13: Product Interface



Figure 14: Stock List Interface

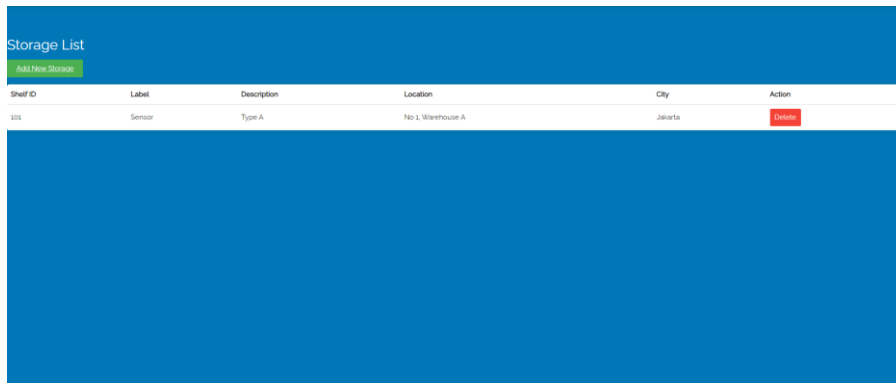


Figure 15: Interface of Storage

4.10.3 Inventory Monitoring

Inventory Monitoring also consist of 3 functions such as Inventory Log, Stock in and out with the list displayed on each function via the database. Figure 16 illustrates the interface of inventory log where it records the product price and location of the product. Stock In and Stock Out will records the stocks of products on where its heading, who are receiving them, etc as shown in Figure 17 and Figure 18.



Figure 16: Inventory Log Interface

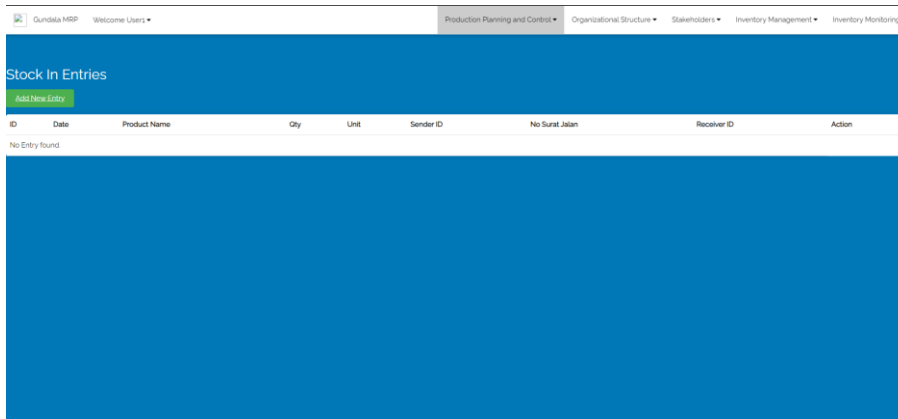


Figure 17: Stock In Entries

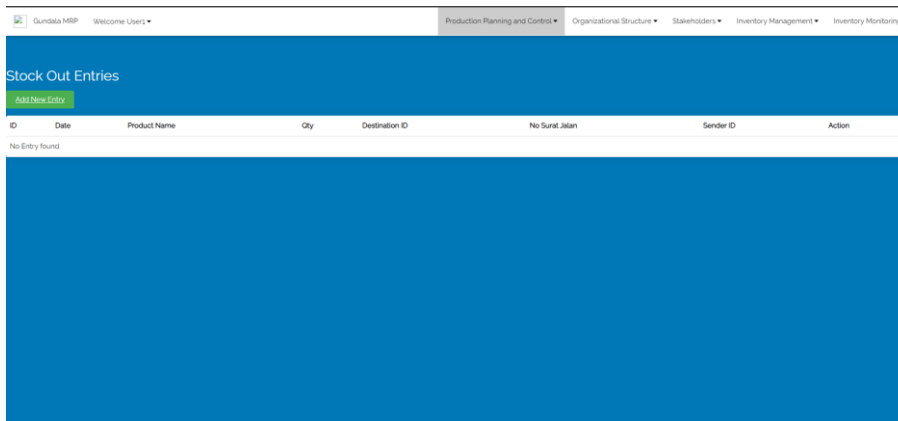


Figure 18: Stock Out Entries

4.10.4 Bills of Material (BoM) module

BoM module is where user can add the requirement of a product to be manufactured, user can add a new product BoM and input the form to be displayed in a list as shown on Figure 19 which then will be displayed on the main page of the BoM as well as displaying the calculated numbers of the total of unit cost and cost in the background for each product registered via the form to the system.

BoM Form

Product Name:

BoM Level:

Parts No:

Description:

Quantity:

Unit:

Unit Cost:

Cost:

Figure 19: Bills of Material input form

| Bills of Material - Infrared Sensor | | | | | | | |
|-------------------------------------|----------|---------------|----------|-------|-----------|---------------|---------------------------------------|
| BoM Level | Parts No | Description | Quantity | Unit | Unit Cost | Cost | Action |
| 1 | ABC123 | Description 1 | 10 | Piece | 5.00 | 50.00 | <input type="button" value="Delete"/> |
| 2 | XYZ456 | Description 2 | 15 | Piece | 7.50 | 112.50 | <input type="button" value="Delete"/> |
| Total Unit Cost: | | | | | | 162.50 | |
| Total Cost: | | | | | | 812.50 | |

Figure 20: Interface of bills of material (BoM) function

4.10.5 Work Orders module

Work Orders module works as a status to display ongoing and accomplished work orders in a list. Figure 21 shows the interface of work orders list where each order numbers from the form Figure 22 which will appeared upon user clicking the button of “add A new Work Order”.

| Work Orders | | | | | | |
|--------------|------------|------------|----------|-------------|---------------------------------------|--|
| Order Number | Date | Product ID | Quantity | Status | Action | |
| WO-001 | 2023-05-01 | IR-001 | 300 | Completed | <input type="button" value="Delete"/> | |
| WO-002 | 2023-05-05 | LED-001 | 200 | In Progress | <input type="button" value="Delete"/> | |
| WO-003 | 2023-05-10 | PCB-001 | 50 | Planned | <input type="button" value="Delete"/> | |

Figure 21: Interface of Work Orders function

Figure 22: Work orders input form

4.10.6 Capacity Planning module

The system provides a record for the capacity plans with the status whether it is pending or approved for the next step along with the remove function to drop any rejected plan. Figure 23 shows the list of registered plans from user perspective while Figure 24 displays the admin side where admin can approve or delete the plan. It is set to ‘Pending’ upon the form submission by default.

| Plan Number | Date | Product ID | Capacity | Status | Action |
|-------------|------------|------------|----------|----------|--------|
| CP-001 | 2023-05-01 | IR-001 | 500 | Approved | Delete |
| CP-002 | 2023-05-05 | LED-001 | 1000 | Pending | Delete |
| CP-003 | 2023-05-10 | PCB-001 | 300 | Approved | Delete |

Figure 23: Capacity Planning interface

Figure 24: Data input form for capacity planning module

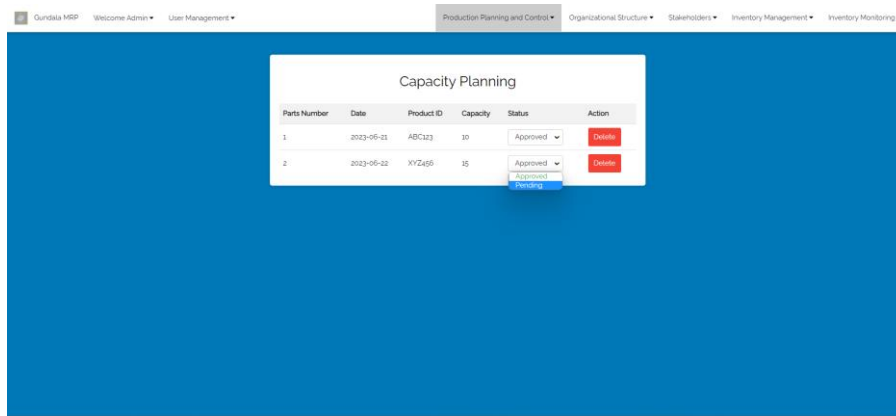


Figure 25: Admin decision making interface for capacity planning module

4.10.7 Master Production Scheduling (MPS)

MPS is integrated with Work Order module to help users to keep on track with the production scheduling. It has similar interface and functions as Capacity Planning module where users will submit a form for a work order and the status will be set 'In Progress' as shown on Figure 26 and only admin can set it to 'Completed' status' as shown on Figure 27.

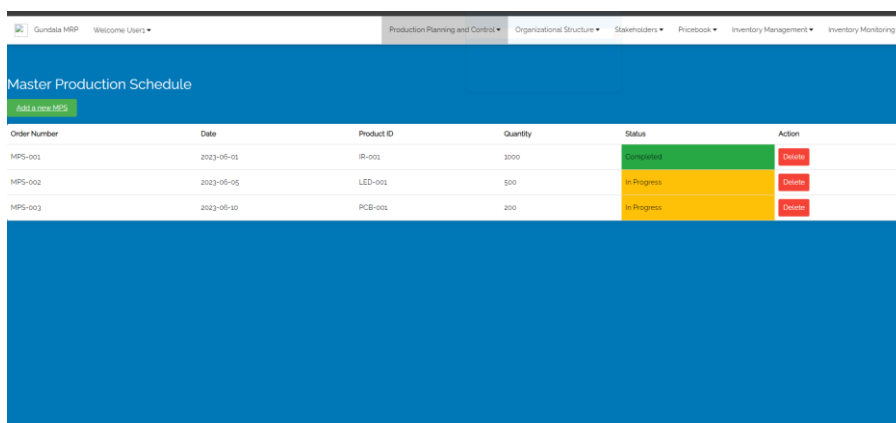


Figure 26: MPS interface

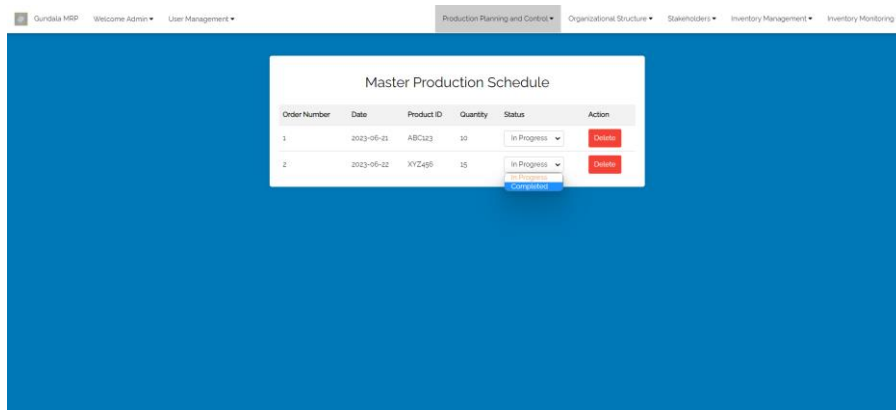


Figure 27: Admin MPS decision making interface

4.12 Testing

Developers will try to ascertain whether their programming and code satisfy the demands of the client throughout the testing phase. Even though it is difficult to fix every fault that may be found during

testing, the results of this stage can be utilised to lower the overall number of defects in the software. A testing process is required to make sure the system delivers the anticipated outcome. The test case, the expected result, and the actual output make up its three components.

Table 5: Functionality test result

| Function | Test Plan | Expected Outcome | Actual Result |
|----------------------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------|
| User Identification and Access Control | System can only be access if user register itself and admin can remove or create user account | Admin can manage user accounts and both parties can access the system through login page | Pass |
| Inventory Management | The system allows input of product, stock, and storage data which will be displayed in the system | User can add or remove the information within the system as well as viewing the stored information | Pass |
| Inventory Monitoring | System records the inventory in a log as well as any incoming or outgoing stocks and price book | User can keep track of items from going in and out and records of the prices of products | Pass |
| Bills of Material (BoM) | Record on materials required for an assembly or product along with its cost | User able to input BoM data into the system and it able to calculate the total parts and cost required to produce an item | Pass |
| Work Orders | The system allows creation of work orders for production purposes | User able to create work orders in the system and view it for future reference | Pass |
| Capacity Planning | Scheduled production based on BoM for manufacturing | User able to refer BoM data and plan the production of specific module or product | Pass |
| Master Production Scheduling (MPS) | Scheduled production based on BoM for manufacturing | User able to refer BoM data and plan the production of specific module or product | Pass |

4.3.2 User Acceptance Test

User Acceptance Testing (UAT) is the phase in which users or clients test the built system to assess its acceptability. They are used to collect information and insights from respondents in order to answer particular research questions or test hypotheses. The response rate and quality of information obtained will be determined by the subject matter of the study and the criteria that have been established[7]. In this example, the web based PPIC system or MRP was discussed, and respondents understood what was requested in the questionnaires. The testing included 20 participants, and the findings were reviewed and graphed. Respondents are asked to fill out a survey form to gauge their acceptability and satisfaction with the produced system. Figure 23 depicts user interface UAT, whereas Figure 24 depicts system functionalities UAT.

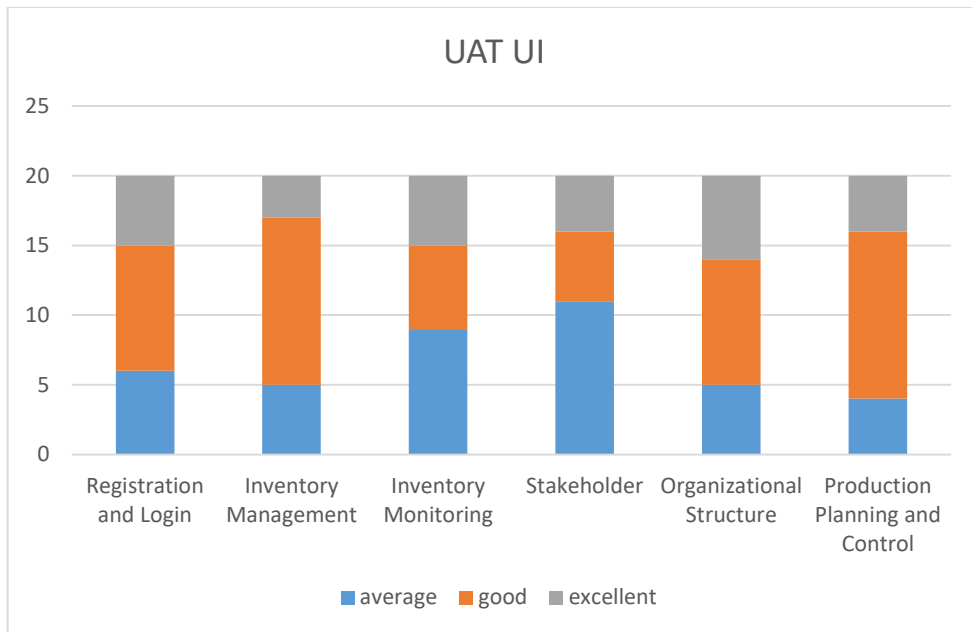


Figure 25: UAT results for User Interface

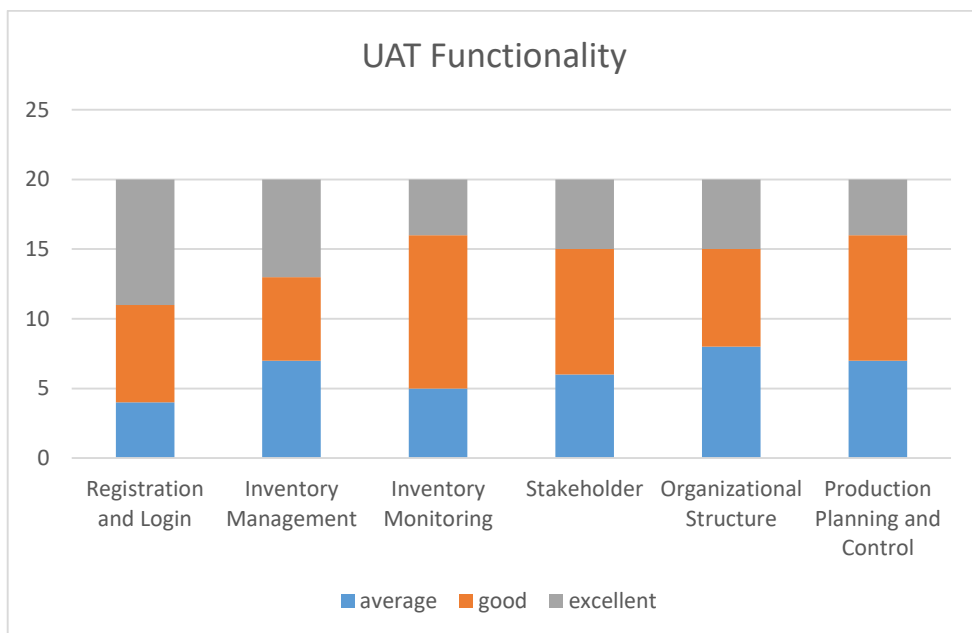


Figure 26: UAT results for Functionality

5. Conclusion

In summary, the advantages of this PPIC system encompass improved production planning, enhanced inventory management, accurate bills of material management, effective capacity planning, streamlined master production scheduling, user-friendly registration and login, and efficient user management by the admin. These advantages contribute to increased operational efficiency, cost savings, improved customer satisfaction, and better decision-making for the organization.

5.1 System Advantages

The PPIC system provides a centralised platform for effective production planning. It enables users to generate and manage work orders, track their progress, and allocate resources effectively. The system offers real-time tracking and monitoring of the inventory levels. The BOM module allows users to produce and maintain precise bills of materials for each product. It ensures precise record-keeping of components and their amounts necessary for manufacturing. The PPIC system aids in capacity planning by analysing historical data, production requirements, and available resources. This increases production, decreases lead times, and increases customer satisfaction. The MPS capability provides efficient production scheduling and on-time order fulfilment.

5.2 System Disadvantages

The system still lacks features that resemble a complete MRP system especially on the sales and procurement, manufacturing sector and in-depth features of the inventory control. This system could not function as a complete system for actual business standard. Aside from that, this features still offer some working basic modules as a web based PPIC system.

5.3 Recommendations

As for recommendation, it is best to seek suggestions from experienced developer on developing and maintaining MRP system. Apart from that, existing company feedback would come in handy in the making of a better system from their business requirement. More features could be implemented such as a complete production system where it can generate its own work order and automation in certain modules where it will increase the effectiveness of the overall performance and efficiency of the system for business purposes. Inventory records could be more flexible, and any incoming or outgoing stocks could be enhanced in terms of automating the data input in several ways. In a nutshell, this system has a lot of room for expansion and enhancements.

Acknowledgment

The author would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support.

References

- [1] A. S. Girsang and A. Purwanto, "Controlling system for stock raw material for production planning and inventory control in a pharmacy company," *International Review of Mechanical Engineering*, vol. 11, no. 11, pp. 855–861, Nov. 2017, doi: 10.15866/ireme.v11i11.12330.
- [2] E. Olusanya, *Research on the Impact of Inventory Management and Control of Cash Flow on the Liquidity of Organisations: A Study of Selected Small and Medium Scale Enterprises*, vol. 1. 2016. doi: 10.60392/EOE-16-5-21-01.
- [3] N. Dwivedi, D. Katiyar, and G. Goel, "A Comparative Study of Various Software Development Life Cycle (SDLC) Models," *International Journal of Research in Engineering, Science and Management*, vol. 5, no. 3, pp. 141–144, Mar. 2022, [Online]. Available: <https://journal.ijresm.com/index.php/ijresm/article/view/1881>
- [4] D. Purnomo, "Model Prototyping pada Pengembangan Sistem Informasi," *Jurnal Informatika Merdeka Pasuruan*, vol. 2, no. 2, 2017, doi: 10.37438/jimp.v2i2.67.

- [5] R. J. Najy, "MRP(Material Requirement Planning) Applications In Industry-A REVIEW," Jan. 2020.
- [6] W. Muchaendepi, C. Mbohwa, T. Hamandishe, and J. Kanyepe, "Inventory Management and Performance of SMEs in the Manufacturing Sector of Harare," *Procedia Manuf*, vol. 33, pp. 454–461, 2019, doi: <https://doi.org/10.1016/j.promfg.2019.04.056>.
- [7] M. S. Afolayan and O. A. Oniyinde, "Interviews and Questionnaires as Legal Research Instruments," 2019, doi: 10.7176/JLPG.