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# Design of Custom Storage Rack Based on the Principles of 5S Practices

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**Abstract**

University storage rooms play a crucial role in ensuring the safe and efficient storage of essential items, supporting seamless academic and research operations. This study focuses on addressing storage challenges faced by the Final Year Project Committee (JKPSM) at Universiti Tun Hussein Onn Malaysia (UTHM) Pagoh branch campus, particularly in managing poster stands. The current storage method by stacking poster stands in cardboard boxes, results in disorganization, increased risk of damage, and time-consuming retrieval processes. These issues exemplify common storage inefficiencies in academic institutions. To resolve these challenges, a custom-designed storage rack was proposed, adhering to the 5S principles (sort, set in order, shine, standardize, sustain) to optimize space utilization and improve organization. Data was gathered through interviews and observations before and after implementing the storage rack, with findings translated into statistical insights using a 5S checklist. The design process incorporated the Pugh method to evaluate alternatives and SolidWorks CAD software to create a 3D prototype model. The proposed storage solution significantly improved the organization, efficiency, and safety of poster stand management, as perceived by end users. The findings underscore the value of a 5S-based storage rack in reducing waste, enhancing quality, and facilitating better performance in academic and research storage operations.

## 1. Introduction

The storage room managed by the Final Year Project Committee (JKPSM) at UTHM Pagoh branch campus faces significant challenges due to disorganized and inefficient storage practices. Currently, poster stands, which are essential for academic presentations and research activities, are stored haphazardly in cardboard boxes. This disorganization leads to inefficiencies, potential damage, and difficulty in retrieval, resulting in wasted time and increased risk of losing or damaging these critical resources. To address these issues, this project proposes the design and implementation of a custom poster stand rack based on the principles of 5S practices— Seiri ((Sort), Seiton (Set in Order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain). These principles, rooted in Japan's Toyota Production System, have been widely adopted across industries to improve workplace efficiency, safety, and productivity [1, 2, 7, 8].

The 5S methodology provides a systematic approach to organizing workspaces, reducing waste, and fostering a culture of continuous improvement [3, 9, 10]. By applying these principles, the project aims to create a custom poster stand rack that optimizes space utilization, enhances organization, and ensures the accessibility of poster stands. The proposed rack will provide a dedicated and systematic storage solution, reducing the time spent searching for poster stands, minimizing the risk of damage, and improving overall workflow efficiency. Studies emphasize the importance of visual management and systematic organization in storage areas, particularly for items like poster stands. Research has shown that implementing 5S practices can significantly reduce search time [4], enhance floor space utilization [5], and improve overall operational efficiency [6]. This project aligns with these findings, aiming to create a practical, cost-effective solution that supports the academic and research activities of the JKPSM committee. By designing a custom poster stand rack, the project not only addresses the immediate storage challenges but also promotes long-term sustainability and efficiency within the JKPSM storage room. The ultimate goal is to transform the storage room into a well-organized and efficient space, ensuring that poster stands and other essential materials are stored safely, accessed easily, and maintained systematically.

## 2. Materials and Methods

The research project was conducted in the storage room designated for the JKPSM (Jawatankuasa Project Sarjana Muda) committee members at UTHM Pagoh branch campus of Universiti Tun Hussein Onn Malaysia (UTHM), located on the third floor of block B. The study employed a combination of primary and secondary data collection methods to gather comprehensive insights. Primary data was collected through structured interviews and direct observations, which provided detailed information about the storage room's current disorganization and user preferences for the custom storage rack design. The interview protocol was validated by an expert panel to ensure its reliability, and participants included JKPSM committee members and staff familiar with the storage room operations. Secondary data was obtained through literature reviews and 5S implementation frameworks, which informed the design and evaluation process. Data analysis involved semi-qualitative methods, with the Pugh method used to compare and select the most suitable storage rack design based on 5S principles. Additionally, SolidWorks software was utilized for 3D modeling and stress analysis, ensuring the structural integrity and practicality of the proposed prototype. This comprehensive approach ensured the design was both functional and aligned with the goals of improving storage organization and efficiency.

### 2.1 Data Analysis Method

The Pugh method and SolidWorks analysis were employed to evaluate and optimize the custom storage rack design. The Pugh method systematically compared three design alternatives (Design 1, Design 2, and Design 3) against 5S-based criteria (Sort, Set in Order, Shine, Standardize, and Sustain), using a + (better), - (worse), or S (same) scoring system. The highest-scoring design was selected as the optimal solution for the project. SolidWorks analysis complemented this by creating a 3D model of the design and conducting stress, displacement, and strain simulations under operational loads. The results confirmed the design's structural integrity, with maximum stress below the material's yield strength and minimal displacement, ensuring the prototype was practical and durable for real-world use. Together, these methods provided a comprehensive, data-driven approach to selecting and validating the optimal storage rack design.

### 2.2 Evaluation of Existing Storage Room Organization Before Implementing 5S Practices

The evaluation of the existing storage room organization and poster stand storage before implementing 5S practices involved a comprehensive assessment through observations, walk-throughs, and structured interviews. A detailed checklist based on the 5S principles (Sort, Set in Order, Shine, Standardize, and Sustain) was developed and used to systematically evaluate the storage room's disorganized state, including issues such as haphazard stacking of poster stands, lack of designated storage areas, and poor visual clarity. Structured interviews were conducted with lecturers and staff to gather semi-qualitative feedback on the storage room's condition and preferences for custom storage rack designs. The interview questions were developed in collaboration with the supervisor and validated by an expert panel to ensure clarity and relevance. Participants were asked to rate their satisfaction with the current storage conditions and provide feedback on three proposed storage rack designs, which were evaluated using criteria aligned with the 5S principles. The Pugh method was employed to analyze and rank the design alternatives, ensuring the selected design optimized space utilization, safety, and adherence to 5S principles. This evaluation provided critical insights into the storage room's inefficiencies and informed the development of a tailored storage solution

### 2.3 Main components of prototype fabrication

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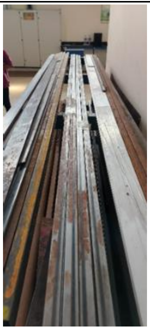
The fabrication of the prototype requires the utilization of different components as shown in Table 1, each chosen for its distinct attributes and role in the overall design and performance

***Table 1***: Prototype material

| Component | Function | Figure |
|---|---|---|
| Mild Steel Square Hollow | Serves as the framework of the rack via welding techniques. |  |
| Plywood | Acts as the structure of the rack and the upper sloth frame to keep the poster stands apart while being stored. |  |
| Heavy Duty Castors | Supports a load of up to 250kg and facilitates the movement of the rack. |  |
| Wallpaper Sticker | Envelops the whole rack structure, offering a visually pleasing appearance. |  |

## 2.4 Tools and Equipment for Fabrication Process

The fabrication of the prototype involves the use of various tools and equipment, as shown in Table 2, each selected for its specific function in cutting, shaping, welding, and assembling the custom storage rack, ensuring precision, durability, and adherence to 5S principles.

***Table 2*: Tools and equipment used in fabrication process**

| Tool/Equipment | Function | Figure |
|---|---|---|
| Metal Cutting Circular Saw | Trims steel bars to specified lengths. |  |
| Handheld Electric Jigsaw | Shapes plywood into specified designs and makes sloths. |  |
| Cordless Hand Drill | Creates holes in plywood while assembling. |  |
| Measuring Tape & Ruler | Measures dimensions and marks dimensions for cutting and assembly. |  |
| TIG Welding Machine | Used for welding metal parts to assemble the frame of the storage rack. |  |
| Hand Grinder | Smooths welded metal surfaces and removes sharp edges. |  |
| Sandpaper | Smooths wooden surfaces and edges. |   |
| Steel Paint & Brush | Used for coating the metal frame to protect it from rust and improve appearance. |   |
| Wallpaper Stickers | Used to cover the plywood surfaces for a visually pleasing appearance. |  |
| Cutter Knife | Cuts wallpaper stickers to fit the plywood surfaces. |  |
| Screws | Joins plywood and metal frame together. |  |

## 2.5 Prototype Building process

The fabrication process of the custom storage rack prototype as shown in Figure 1 involved several key steps to ensure a functional and durable design. The process began with the preparation of materials, including mild steel square hollow tubes for the frame, plywood for the body and top frame, heavy-duty castors for mobility, and wallpaper stickers for aesthetic finishing. The metal rods were cut to specified lengths using a metal-cutting circular saw, ensuring precise dimensions for the frame. The plywood was then shaped using a handheld electric jigsaw, with the body cut to fit the frame and the top frame designed with 200 square sloth holes (8.5cm x 8.5cm each) to hold the poster stands securely. Pilot holes were drilled at each corner of the sloth holes to facilitate accurate cutting, and the jigsaw was used to create the slots, ensuring smooth edges and proper alignment. The assembly of the prototype involved welding the metal frame using TIG welding techniques, ensuring strong and precise joints, and attaching heavy-duty castors to the base for mobility. The plywood components, including the body and top frame, were then attached to the metal frame using screws, with careful alignment and finishing to ensure a smooth surface. After assembly, the welded metal surfaces were cleaned and smoothed using a hand grinder, while the plywood edges were sanded to remove splinters and rough spots. The final steps included applying a protective coating of steel paint to the metal frame and covering the plywood surfaces with wallpaper stickers for a visually appealing finish. This comprehensive fabrication process resulted in a complete prototype that was both structurally sound and aesthetically pleasing, ready for testing and evaluation.

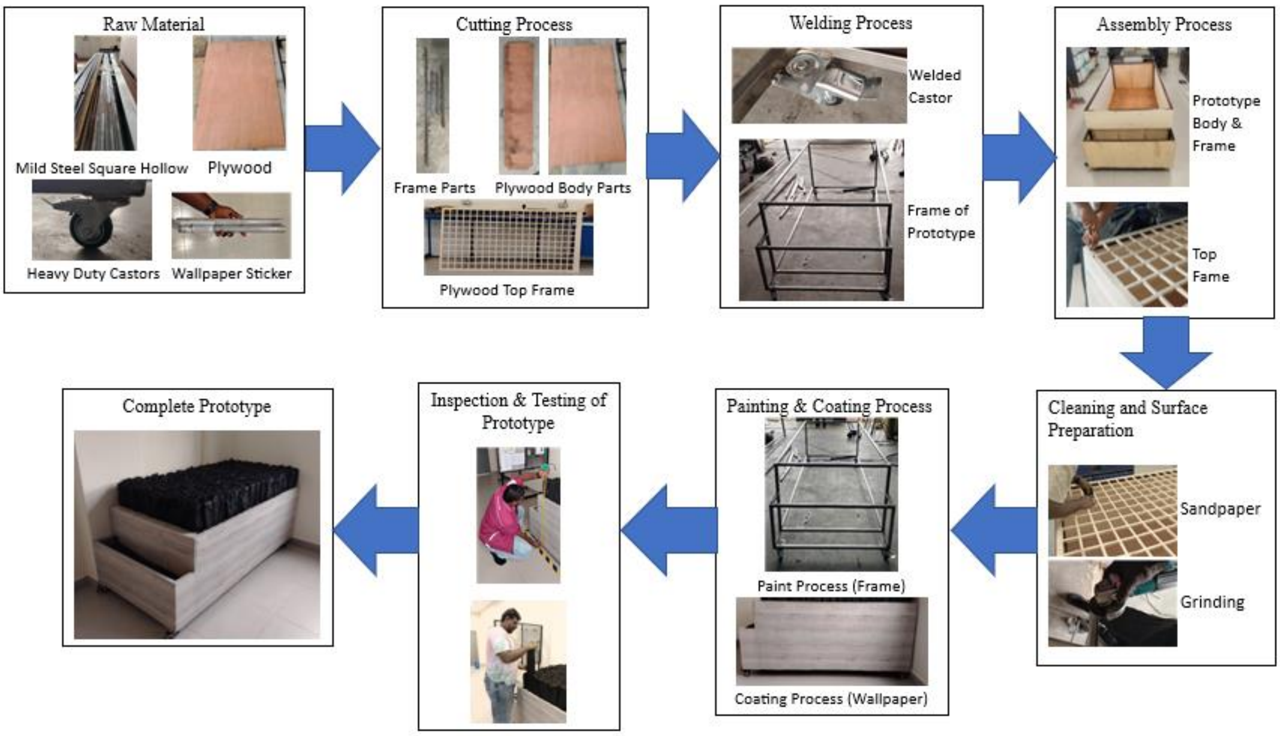



***Fig. 1***: Prototype building process

## 2.6 Inspection and testing of a prototype model

The inspection and testing of the prototype model involved a systematic approach to evaluate its functionality and alignment with 5S principles. The process began with a visual and dimensional quality inspection, where the prototype was examined for defects such as dents, scratches, misalignment, and surface finish issues. Measurements were taken to ensure the dimensions matched the design specifications, with any discrepancies noted. Next, storage and retrieval accessibility testing were conducted to assess the efficiency of the storage rack. Retrieval times for poster stands were measured both before (average time: 17.37 seconds) and after (average time: 9.37 seconds) the prototype's implementation, with timing data recorded using a stopwatch. The testing involved placing the prototype in the storage room, simulating real-world retrieval scenarios, and comparing the time taken to retrieve poster stands from the new system versus the previous disorganized setup. This method allowed for a clear evaluation of the prototype's impact on storage efficiency and accessibility.

### 2.7 Evaluation of Storage Room Organization and Prototype Performance After Implementing 5S Practices

The evaluation of the storage room organization and prototype performance after implementing 5S practices involved a systematic approach to assess the effectiveness of the custom poster stand rack and the overall improvements in the storage room. Observations and walk-throughs were conducted using a detailed checklist aligned with the 5S principles (Sort, Set in Order, Shine, Standardize, and Sustain) to evaluate key aspects such as organization, cleanliness, accessibility, and safety. The checklist, validated by the supervisor, ensured a thorough and consistent assessment of the storage room's transformation. Structured interviews were conducted with lecturers and staff to gather semi-qualitative feedback on the storage room's condition and the prototype's performance. The interview questions, developed in collaboration with the supervisor and validated by an expert panel, focused on the impact of 5S practices and user satisfaction with the new storage rack. Participants provided feedback on the prototype's functionality, ease of use, and adherence to 5S principles, which was documented and analyzed. Additionally, user satisfaction was measured through a combination of structured interviews and checklist ratings, ensuring a comprehensive evaluation of the prototype's performance. This structured approach confirmed the successful implementation of 5S practices, highlighting significant improvements in storage organization, efficiency, and user satisfaction

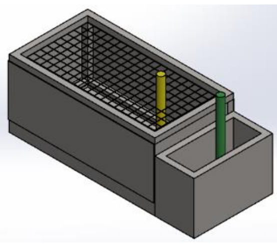
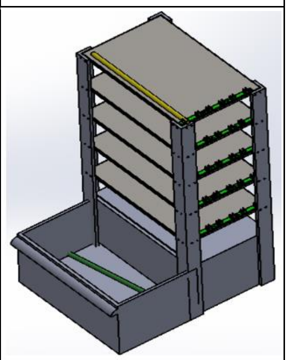
## 3. Results and Discussion

This study presents the results and discussions on improving the storage room organization and developing a custom storage rack prototype based on 5S practices. The process began with the validation of the structured interview protocol, which was reviewed and approved by an expert panel to ensure clarity and alignment with project objectives. Three design alternatives (Design A, B, and C) were evaluated using the Pugh method, with Design A (vertical storage) selected as the optimal solution due to its simplicity, high storage capacity, and alignment with 5S principles. The selected design was further analyzed using SolidWorks simulations, which confirmed its structural integrity through stress, displacement, and strain analyses. Inspection and testing results showed a 46% improvement in retrieval times, highlighting the prototype's effectiveness in enhancing storage and accessibility. Post-implementation evaluations demonstrated significant improvements in storage organization, cleanliness, and operational efficiency. The study concludes that the prototype successfully improved efficiency, reduced clutter, and fostered a more organized and sustainable storage environment.

### 3.1 Design alternatives, specifications and features

Table 3 outlines three design options (Design A, Design B, and Design C) for the custom storage rack, each with unique specifications and features, such as vertical or horizontal storage, clip systems, and heavy-duty castors for mobility, ensuring organized and efficient storage of poster stands.

***Table 3***: Design alternative

| Design Option | Specifications | Features | Figure |
|---|---|---|---|
| **Design A** | - Vertical storage with slots and clips<br>- Supports 200 poster stands<br>- Heavy-duty castors for mobility | - Slots with clips to hold poster stands<br>- Additional space for damaged stands<br>- Easy to move |  |
| **Design B** | - Horizontal storage with drawers and clips<br>- Supports 40 poster stands<br>- Heavy-duty castors for mobility | - Drawers with clips for organized storage<br>- Additional space for damaged stands<br>- Compact design |  |

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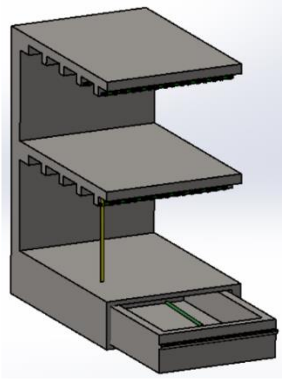
| Design Option | Specifications | Features | Figure |
|---|---|---|---|
| **Design C** | - Combination of vertical and horizontal storage with drawers and clips<br>- Supports 200 poster stands<br>- Heavy-duty castors for mobility | - Vertical and horizontal slots with clips<br>- Additional space for damaged stands<br>- Modular design |  |

## 3.2 Evaluation Results of The Existing Storage Room Organization and Poster Stand Storage Before Implementing 5S Practices

The evaluation of the existing storage room organization and poster stand storage before implementing 5S practices. Observations and walk-throughs revealed a highly disorganized and neglected storage environment, characterized by scattered final year student reports, disarrayed teaching files, and a cluttered meeting table. Dust-covered surfaces, untidy tables piled with dismantled equipment, and unlabelled poster stands stored in their original packaging boxes further contributed to inefficiencies and increased risk of damage. Structured interviews with users reinforced these findings, with respondents rating the issues between 4 (Agree) and 4.5 (Between Agree and Very Agree). Key concerns included the lack of designated storage areas, poor visual clarity, and the absence of standardized guidelines, which collectively hindered productivity and safety. Users overwhelmingly favoured Design 1 (vertical storage) for the custom storage rack, citing its simplicity, cost-effectiveness, space optimization, and ease of maintenance as key advantages. These results highlighted the critical need for systematic improvements to create a well-organized, efficient, and safe storage environment.

## 3.3 Pugh Method Analysis for Selecting Design Options of Poster Stand Storage Rack

Table 4 outlines the Pugh method analysis used to select the optimal design for the custom storage rack. Three design alternatives which are Design A (vertical storage), Design B (horizontal storage with drawers), and Design C (combination of vertical and horizontal storage) were evaluated against 5S-based criteria of Sort (C-1S), Set in Order (C-2S), Shine (C-3S), Standardize (C-4S), and Sustain (C-5S). Each design was scored using a + (better), - (worse), or S (same) rating relative to a baseline. Design A scored the highest overall, excelling in Set in Order and Shine, and was selected for its simplicity, high storage capacity, and alignment with 5S principles. The Pugh method provided a systematic, data-driven approach to design selection, ensuring the chosen solution optimized storage organization, efficiency, and user satisfaction. The evaluation of design alternatives using the Pugh method, as shown in the table 4, highlights the performance of three designs (Design A, Design B, and Design C) based on the 5S principles

**Table 4** *Pugh method table for custom poster stand storage rack*

| Criterion | Design A | Design B | Design C |
|---|---|---|---|
| **C-1S (Sort)** | 3 | 1 | 1 |
| **C-2S (Set in Order)** | 4 | 0 | 1 |
| **C-3S (Shine)** | 4 | 0 | 2 |
| **C-4S (Standardize)** | 3 | 1 | 1 |
| **C-5S (Sustain)** | 3 | 1 | 2 |

| | | | |
|---|---|---|---|
| **Total Score** | 17 | 3 | 7 |

## 3.4 Engineering Drawing

The engineering drawing for the complete prototype, as shown in the Figure 2, was created using SolidWorks 3D modeling, detailing the dimensions and structural components of the custom storage rack to ensure precision and adherence to design specifications.

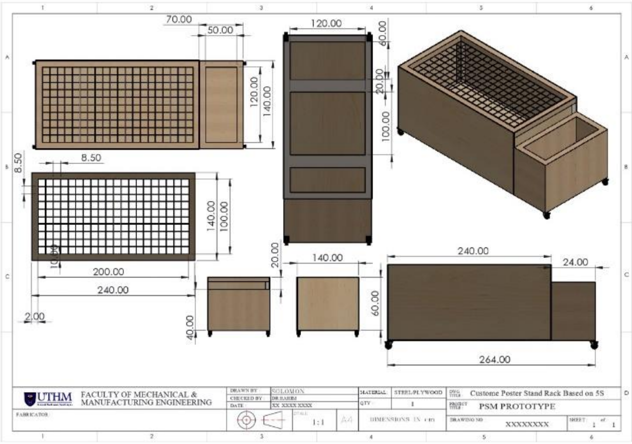
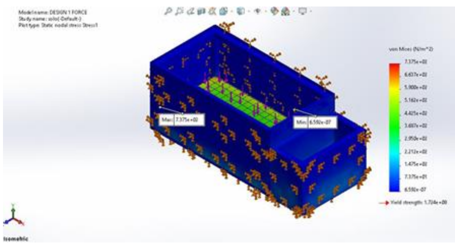
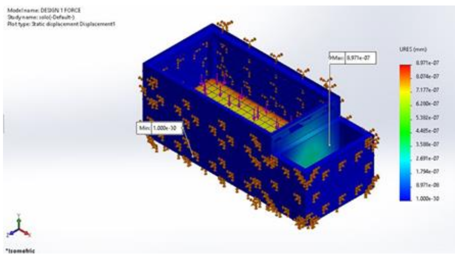



***Fig. 2***: Prototype design

## 3.5 Design analysis using SolidWorks software

Table 5 presents the results of structural analyses conducted using SolidWorks, including stress, displacement, and strain analyses, with the maximum stress well below the material's yield strength, minimal deflection ensuring stability, and low overall strain, confirming the design's structural integrity and safety under operational conditions.

***Table 5***: SolidWorks analysis result

| Type of Analysis | Figure of Analysis | Analysis of Design |
|---|---|---|
| Stress Analysis |  | The maximum stress is significantly below the yield strength of the material (1.724e+08 $N/m^2$), indicating that the structure is well within the safe operational limits. |
| Displacement Analysis |  | The results indicate minimal deflection, ensuring structural stability during use. |

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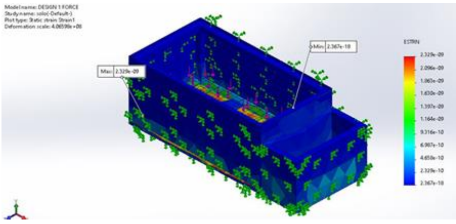
| | | |
|---|---|---|
| Strain Analysis |  | The maximum strain of 2.329e-9, concentrated in high-stress regions but significantly low overall, reflecting good material performance. |

## 3.6 Inspection And Testing Results

The inspection and testing results of the custom storage rack prototype. A visual and dimensional quality inspection revealed minor issues, such as uneven wallpaper application and slight misalignments in plywood edges, with dimensional variations of 0.5 to 1 cm from specifications. Despite these, the prototype met functional requirements. Storage and retrieval accessibility testing demonstrated significant improvements, with average retrieval times reduced from 17.37 seconds (before implementation) to 9.37 seconds (after implementation), reflecting a 46% increase in efficiency. This improvement was attributed to the organized storage system, which eliminated the need to search through disorganized packaging boxes and allowed for quick identification and retrieval of poster stands. The testing confirmed the prototype's effectiveness in enhancing storage organization and accessibility, aligning with the 5S principles of efficiency and orderliness.

## 3.7 Evaluation of Storage Room Organization and Prototype Performance After Implementing 5S Practices

This subsection outlines the storage room organization and prototype performance after implementing 5S practices. Observations and walk-throughs revealed significant improvements, with the previously chaotic storage area now neat, organized, and efficient. Custom poster stands were introduced, allowing for clear differentiation between functional and maintenance-needed stands, simplifying retrieval processes. The room was thoroughly cleaned, with designated safe zones marked by zebra tape and a red tagging area created for future-use items. Reports and documents were systematically sorted by year and alphabetically, while tables and equipment were properly arranged, minimizing clutter and risk of damage. Structured interviews confirmed high user satisfaction, with respondents praising the enhanced functionality, accessibility, and professional atmosphere of the storage room. Expert panel evaluations further validated the prototype's success, highlighting its role in improving cleanliness, organization, and operational efficiency. Overall, the implementation of the custom storage rack and 5S practices transformed the storage environment into a well-organized, user-friendly, and sustainable space.

## 3.8 Discussion of Main Findings

The study successfully developed a custom storage rack prototype based on 5S principles, significantly improving storage organization, operational efficiency, and user satisfaction. The design process focused on clarity, effectiveness, and compliance with 5S methodologies, with vertical storage identified as the most efficient configuration for maximizing storage capacity and minimizing floor space usage. A three-dimensional (3D) model created in SolidWorks confirmed the design's structural integrity, with stress and strain analyses showing minimal displacement and load demands well below the material's yield strength. The Pugh method was used to systematically evaluate design alternatives, with the selected prototype excelling in 5S alignment, simplicity, and cost-effectiveness. While the chosen design demonstrated high practicality, opportunities for incorporating features from other designs were identified for future enhancements. The prototype's implementation led to a 46% improvement in retrieval times, highlighting its effectiveness in creating a more organized and efficient storage environment.

# 4. Conclusion

The study successfully designed and implemented a custom storage rack prototype based on 5S principles to address the disorganization in the JKPSM storage room at UTHM Pagoh. The Pugh method was used to evaluate three design alternatives, with Design A (vertical storage) selected as the optimal solution due to its simplicity, high storage capacity, and alignment with 5S principles. SolidWorks analysis confirmed the design's structural integrity, ensuring it could safely support the required load. Testing revealed a 46% improvement in retrieval times, demonstrating the prototype's effectiveness in enhancing storage efficiency and accessibility. Post-implementation evaluations showed significant improvements in organization, cleanliness, and operational efficiency. The project highlights the importance of systematic design and 5S practices in creating sustainable, efficient, and user-friendly storage solutions. Recommendations for future improvements include adding safety features, ergonomic enhancements, and modular components to further optimize the design.

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