PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 6 No. 2 (2025) 298-306
https://publisher.uthm.edu.my/periodicals/index.php/peat

Improving Storage Organization Through 5S Practices in a Welding Workshop

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DOI: https://doi.org/10.30880/peat.2025.06.02.033

Article Info

Received: 26 June 2025
Accepted: 11 august 2025
Available online: 30 October 2025

Keywords

5S practices, conceptual design, storage organizer, welding tools, workshop

Abstract

University storage spaces are crucial for keeping tools and materials safe, organized, and easily accessible, especially in workshops where efficiency and safety are essential. However, challenges such as tool misplacement and disorganized workspace often hinder operational efficiency. This study explores the potential of 5S practices (Sort, Set in order, Shine, Standardize, and Sustain) to optimize storage organization in a welding workshop at Universiti Tun Hussein Onn Malaysia (UTHM). The research study aims to enhance storage organization and tool retrieval accessibility through the implementation of 5S practices. Additionally, the study involved designing a conceptual model for a welding tools storage organizer based on 5S principles. Genba observations in the workshop storeroom and structured interviews with users served as primary data collection methods, while descriptive analysis employed for data analysis. This study successfully delivered a practical implementation of 5S practices and a systematic design solution to enhance storage organization and tool retrieval accessibility in the welding workshop environment.

1. Introduction

In industrial and university settings, the efficiency and organization of storage spaces are crucial for achieving operational excellence. In a welding workshop of university environment, well-organized storage organization is essential for maintaining productivity and safety. However, many workshops struggle with disorganized workspaces, misplaced tools, and inefficient storage systems. These problems not only reduce operational efficiency but also cause significant safety risks, leading to potential accidents and injuries. In this context, implementing 5S practices (Sort, Set in order, Shine, Standardize, Sustain) can significantly improve storage organization, ensuring that tools and materials are systematically arranged, easy to locate, and safely stored.

The 5S practices, originating from lean manufacturing principles, focus on creating a clean, organized, and efficient workplace, which is crucial for quality welding operations. By adopting 5S practices, welding workshops can minimize searching time for tools, reduce the likelihood of equipment damage, and promote a safer working environment [1,2]. Specifically, the 5S principle of sort involves removing unnecessary items, keeping only essential tools and materials, therefore freeing up valuable workspace. Set in order principle focuses on arranging tools and materials in an accessible manner, often using tagging and labelling systems to streamline workflow. The principle of shine emphasizes maintaining a clean workspace, which helps identify issues of equipment maintenance. Standardize involves providing consistent procedures for organizing and maintaining the workspace, ensuring that these practices are followed regularly. Finally, sustain principle ensures the long-term success of 5S implementation by nurturing a culture of continuous improvement.

An initial study through observations specified that the current storage organization in a welding workshop facility at Universiti Tun Hussein Onn Malaysia (UTHM) Pagoh branch campus is unorganized and leading to frequent misplacement of tools and materials. Therefore, this study aims to improve tools storage organization by applying 5S principles in a storage room of welding workshop. In addition, a conceptual design for a welding tool storage organizer has been proposed to ensure efficient storage and easy retrieval. For this purpose, this study gathered primary data through Genba observations in the welding workshop storeroom, structured interviews with users, and employing descriptive method for data analysis.

To improve operating efficiency and safety outside of the current setting, 5S has also been effectively implemented in other industrial facilities and university workshops. Research has shown that 5S is effective in promoting discipline and cleanliness in UTHM machining workshops and lean healthcare facilities. Furthermore, numerous tool organizer designs, including pegboards, shadow boards, and foam inserts, have grown in popularity in industrial settings as a way to increase tool availability, reduce search time, and improve visibility. This study improves these basics by including user input and engineering simulation to assess the suggested design.

2. Methodology

This section describes a systematic methodology used in this study, providing a comprehensive explanation of the research methods and processes. The methodology encompasses the research design, which outlines the approach and structure of the study. This is followed by a description of the data collection and analysis methods, including the tools and processes involved in gathering and analysing the data. The section then explains the interview scoring method and presents the conceptual design for a welding tools storage organizer.

2.1 Data Collection and Analysis Methods

The research study encompasses the storage and accessibility of welding tools in a storage room of a welding technology workshop at UTHM Pagoh branch campus. The welding tools, used for shielded metal arc welding (SMAW), gas metal arc welding (GMAW), and gas tungsten arc welding (GTAW) operations in the workshop, include electrodes, fillers, surface cleaning tools, and cutting tools. The implementation process for this research study is structured into three main phases: pre-5S (before implementing 5S practices), post-5S (after implementing 5S practices), and the conceptual design of tools storage.

In this research study, semi-quantitative research design has been employed to collect primary data. This approach combines elements of both quantitative and qualitative data collection, using numerical data alongside descriptive or categorical data. In specific, Genba observations (on-site walk-throughs) and structured interviews (formalized face-to-face question-and-answer sessions) were utilized as data collection instruments for both pre-5S and post-5S phases of this research study. The Genba observations were conducted using an observation checklist based on a 5S audit checklist adapted from previous studies [1,3-6]. Table 1 summarizes the data collection and analysis methods.

Table 1 *Data collection and analysis methods*

Research Study Phases	Research Design Approaches	Data Collection		Data Analysis	
		Methods	Instrument / Procedure	Methods	Instrument / Procedure
Pre-5S	Semi-quantitative	Genba observation	5S audit checklist	Descriptive statistic	Numerical counts (Frequencies)
Post-5S	Semi-quantitative	Structured interview	Interview protocol questions form	Descriptive statistic and Scoring method	Frequencies and Mean scores
Conceptual design of tools storage	Engineering & simulation-based design	Computer aided design (CAD)	SolidWorks software	Finite element analysis (FEA)	SolidWorks software

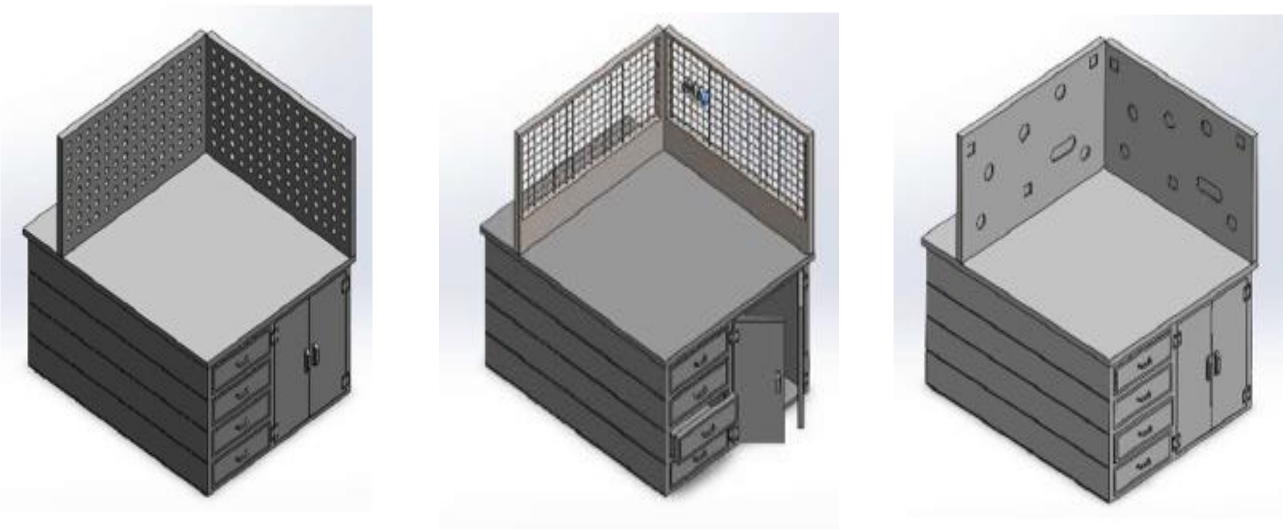
Additionally, two rounds of structured interview sessions were conducted using the validated interview protocol questions for the first round (pre-5S) and the second round (post-5S), to collect and record both quantitative and qualitative data. The data gathered through the 5S audit checklist were analysed using descriptive statistics, such as numerical counts or frequencies. Meanwhile, data obtained from the interview sessions from five interviewees, which consists of head of workshop, two assistant engineers of the welding workshop, lecturer, and student, were analysed using descriptive statistics by means of a scoring method, focusing on frequencies and mean scores.

2.2 Interview Scoring Method

The scoring methods were used to examine qualitative and quantitative data obtained during structured interviews. In this research study, this approach involved assigning numerical values to five interviewees based on established criteria, which facilitated comparison and understanding. The scores were then evaluated using descriptive statistics, with an emphasis on frequencies and mean scores, to detect patterns and assess the effectiveness of 5S implementation. This technique provides a formal method for assessing changes in workplace organizations before and after 5S practices were implemented.

2.3 Conceptual Design of Welding Tools Storage Organizer

In this study, three initial freehand sketches for a conceptual design of a board-based and modular storage organizer for welding tools have been proposed and created: pegboard rack-based tools organizer (Design 1), metal netting board rack-based tools organizer (Design 2), and shadow board rack-based tools organizer (Design 3). Each design option embodies 5S principles as illustrated in Figure 1. Using SolidWorks software, these sketches have been developed into detailed computer-aided-design (CAD) drawing and three-dimensional (3D) models to determine suitable materials for load simulation and structural analysis through finite element analysis (FEA) method. The design aims to create an efficient, user-friendly, and organized storage solution with various configurations and features.



(a) (b) (c)

Fig. 1 *Design options for welding tools storage organizer (a); Pegboard rack-based tools organizer (Design 1); (b) Metal netting board rack-based tools organizer (Design 2); (c) Shadow board rack-based tools organizer (Design 3)*

3. Results and Discussion

The final evaluation assesses the overall organization of the storage room and the proposed conceptual design for the tool storage organizer. This includes gathering user perceptions and feedback on the organizer's practicality and usability to ensure it meets end-user needs. Necessary adjustments are then made to optimize the design and improve its effectiveness.

3.1 Evaluation of Tool Storage Condition through Genba Observation in the Pre-5S

The Genba observation results of the existing tool storage condition in the storeroom at the welding workshop, using the 5S audit checklist, revealed significant areas for improvement. The phase of sort principle identified numerous unnecessary items cluttering the space, leading to inefficiencies. During the principle of set in order assessment, it was clear that tools and materials lacked proper labeling and designated storage locations, causing delays in retrieval. The principles of shine evaluation showed that the storeroom was not being cleaned regularly, with dust and debris accumulating, potentially affecting equipment performance. The principle of standardize step highlighted the absence of consistent procedures for maintaining organization and cleanliness. Lastly, the principle of sustain review indicated a need for better adherence to established protocols and standards, requiring further commitment to uphold the 5S principles continuously. Table 2 summarizes the findings of the Genba observation based on the reflection of the 5S principles. The examples of disorganized storage conditions in the existing tool storage before 5S implementation are shown in Figure 2.

Table 2 *Findings of Genba observation on the tool storage condition in the pre-5S*

No	Findings of Genba Observation
1	Unnecessary items are kept
2	Disorganized tools and accessories
3	Untidy workspace
4	Lack of use of tagging and labelling for designated place
5	Lack of evidence such as guidelines and standard towards continuous improvement practices

(a) (b) (c)

Fig. 2 *Tool storage condition before 5S implementation (a) Untidy workspace; (b) Lack of use of tagging and labelling for designated place; (c) Disorganized tools and accessories*

3.2 Evaluation of Tool Storage Condition through Structured Interview in the Pre-5S

A structured interview session was conducted with five key respondents as highlighted in Section 2.1. There were selected because they frequently use the welding storeroom and have a practical understanding of current storage problems. The questions aimed to assess the current state of tool accessibility, labelling system, cleanliness, space utilisation and standard operating procedures prior to implementing the 5S principles. The data collected was examined using descriptive statistics in terms of mean score. Table 3 shows the summary of key findings.

Table 3 *Interview results in relation to storage condition in the pre-5S*

Observation *(Scale 1: Very Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Very Agree)*	Respondents (R)					Mean
	R1	R2	R3	R4	R5	
Unnecessary items are kept	3	3	3	3	5	**3.4**
Disorganized tools and accessories	3	3	3	3	5	**3.4**
Untidy workspace	3	3	3	2	5	**3.2**
Lack of use of tagging and labelling for designated place	3	3	2	3	2	**2.6**
Lack evidence of guidelines & standard towards continuous improvement	2	3	3	3	5	**3.2**

The results of the structured interviews have many significant difficulties were found in the current welding workshop storage room. One of the most significant issues was the presence of unnecessary tools, which received a mean score of 3.4 perceived by respondents. This indicated that the storage room contained a lot of outdated or unused materials, indicating a weak implementation of the "Sort" principle. This indicated that the storage organization has a lot of old or unnecessary tools.

Similarly, the disorganized arrangement of tools and parts, which had a score of 3.4, indicated a lack of comprehensive planning for organizing the equipment, limiting accessibility and efficiency that reflected the principle of "Set in Order". The overall untidiness of the workstations, with a score of 3.2, reflected weaknesses in cleaning and maintenance, both of which are fundamental elements of the "Shine" principle.

Meanwhile, the lack of marking and labelling, which received the lowest rating of 2.6. Although, this revealed a low level of disagreement for lack visual management, however there was a respondent's feedback (R5) with score 5 that aligned with "Standardize" principle, making it difficult for users to identify and return things to the correct place. In addition, the lack of clear guidelines and procedures, scoring 3.2 that reflects the principle of "Sustain", implied a lack of standard procedures or efforts towards continuous improvement. Overall, these findings highlighted the need to use systematic methods such as the implementation of 5S to improve workshop storage organisation, cleanliness and functional efficiency.

3.3 Evaluation of User Preferences for Conceptual Design of Tool Storage Organizer through Structured Interview in the Pre-5S

The structured interviews conducted prior to implementing the 5S significantly assessed user preferences for three design options of welding tool storage organizer. As shown in Table 4, the Design 2 emerged as the top choice, earning a perfect score of 15 with a consistent score of 3 in each category, reflecting strong user approval across all criteria. Design 1 received moderate support with a total score of 10, scoring 2 in each category. In contrast, Design 3 was not favored at all, receiving a score of 0 across the board. These results clearly indicate that Design 2 best met user expectations and was the most suitable design for further development.

This is strongly driven by the types of tools commonly seen in welding workshops, such as pliers, screwdrivers and clamps, which are best stored under a hanging system for easy access and visibility. Design 2, with its metal mesh board and hooks, allows these instruments to be stored in the open and quickly reached without having to bend or dig into closed compartments, which is an ergonomic feature popular with regular users. While Design 1 (peg board rack) provides a similar idea for hanging, it is less adaptable to tools of different weights and sizes. Design 3 (shadow board rack) was selected as not ideal because it has a pre-set layout that does not allow for flexibility with moving and rearranging tools. Design 2 optimally balances usability, user comfort and 5S compatibility, making it the most viable option for workshop applications.

Table 4 *User preferences of design for welding tool storage organizer in the pre-5S*

	Design 1	Design 2	Design 3
Sort	2	3	0
Set in Order	2	3	0
Shine	2	3	0
Standardize	2	3	0
Sustain	2	3	0
Total	**10**	**15**	**0**

3.4 Structural Analysis Result

The results of structural analysis were presented by means of stress, strain and displacement analysis using finite element analysis (FEA) method. The von Mises stress pattern under a vertical distributed load of 500 N/m^2, which represents the weight of mostly stored hand tools such as wrenches, pliers and screwdrivers for Design 2The maximum measured stress is approximately 68.56 MPa, and the minimum is 0.00 MPa (Appendix A). Since the cabinet is constructed of ordinary carbon steel with a typical yield strength of 250 MPa, the structure is well below the safety limit and will not be permanently deformed. This means that the storage organizer is not at risk of permanent deformation under the current loading conditions.

Meanwhile, the strain analysis for Design 2 (Appendix B) shows how much the cabinet material stretches or deforms under load. which shows the extent to which the storage material deforms or stretches under load. For ease of understanding, the findings are color-coded so that the red area represents a small amount of strain, and the blue area shows little or no strain. The simulation shows that the largest strain is small, approximately 1.2773×10^{-7}. The structure does not easily deform under load because most of the cabinet remains in the blue zone. The maximum strains are primarily on top mesh panel and on a few of the joints of the drawer, as would be expected since these are locations that see direct forces. But the stresses are so small that it doesn't affect the storage organizer's function. Overall, there are no obvious signs of deformation, and the structure maintains its own stress rather efficiently.

In addition, the static displacement results for Design 2 (Appendix C) by the colour shows how much different parts of the storage organizer move when loaded; the blue area is the area of minimal or no movement, and the red area is the maximum movement. The simulation found that the maximum movement was about 9.950×10^{-5} mm, which is very small, and the minimum was essentially zero. The highest displacement was at the top rim of the mesh panel, as expected since this is the position furthest from the base where the storage rests. Overall, the storage organizer remained very stable and barely moved at all in its current state. Since the cabinet is made of plain carbon steel, which is strong and rigid, this small displacement is a good sign that the design is holding up well without bending or flexing in any noticeable way. This is a reassuring result, especially for a structure intended to support tools or equipment.

However, the fact remains that the simulations were carried out under ideal conditions. The calculations are based on static loads and homogeneous material properties only, which may not be as accurate as in a real workshop environment. In practice, storage organizers may be subject to dynamic loading such as vibration, impact and cyclic use, as well as environmental factors such as humidity, corrosion and wear. This constraint states that although the design is excellent in simulation, there will be a need for further validation through physical prototypes and dynamic testing to confirm reliability and long-term durability.

3.5 Evaluation of Tool Storage Condition through Observation in the Post-5S

As illustrated in Figure 6, the workspace has been reorganized for greater efficiency after implementing 5S practices based on the finding of walk-through observation. For examples, labeled shelving holds equipment neatly, workbenches are clean, and the new arrangement of rack-shelving improves accessibility. The storage space environment is now more orderly, functional, and secure.

Fig. 6 *Tool storage condition after 5S implementation*

3.6 Evaluation of Tool Storage Condition through Structured Interview in the Post-5S

After implementing 5S practices in the welding workshop's storage area, five users, the same individuals interviewed in the pre-5S phase, were interviewed again. The interview session focused on finding the critical factors such as tool organization, labeling, tidiness, storage requirements, and maintenance procedures. The feedback obtained from the end users was overwhelmingly positive, with most aspects receiving important scores. The mean rating score based on the interview session as highlighted in Table 5 indicates that the storage spaces became more systematic, tidy and safe, with improved visibility of tools. The development of clear standards and guidelines is widely accepted as a sign of an effective standardization initiative. Although regular inspections and maintenance received relatively low ratings, overall performance was good. These findings indicate that the 5S strategy has a significant beneficial influence on storage organization, leading to increased productivity and cleanliness in the workplace.

Table 5 *Interview results in relation to storage condition in the post-5S*

Observation *(Scale 1: Very Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Very Agree)*	**Respondents (R)**					**Mean**
	R1	**R2**	**R3**	**R4**	**R5**	
Organized tools, equipment, and accessories facilitate easy differentiation	4	5	5	5	5	**4.8**
The presence of designated places and storage solutions, such as tagging and labelling, enables systematic arrangement and storage	5	5	5	5	5	**5.0**
The storage setup is organized, tidy, and safe, providing clear visibility for locating welding tools	5	5	5	5	5	**5.0**
Extensive establishment of storage guidelines, standards or methods for organizing the welding tools	5	5	5	5	5	**5.0**
Clear evidence that regular checks and maintenance are being performed on the storage system	4	5	5	4	5	**4.8**

3.7 Evaluation of User Preferences for Conceptual Design of Tool Storage Organizer through Structured Interview in the Post-5S

The selected design option of Design 2 as a welding tool storage organizer, was then evaluated by the same users as in the pre-5S phase to obtain their perceptions and feedback, so that the design can be proceed for use in supporting the implementation of 5S practices. Specifically, the evaluation has been done for consistency with the 5S principles, which are essential for keeping the workstation clean, organized, and effective. Table 6 shows the overall user feedback on the selected design option (Design 2) in the post-5S.

Table 6 *Users feedback on the selected design option (Design 2) as a welding tool storage organizer*

5S Principles	Respondents (R)					Mean
	R1	R2	R3	R4	R5	
Sort	5	5	5	4	4	**4.6**
Set in Order	5	5	5	5	5	**5.0**
Shine	5	5	5	5	5	**5.0**
Standardize	4	5	5	5	5	**4.8**
Sustain	4	5	5	5	4	**4.6**

Indeed, the condition of the welding tool storage area was assessed using a structured interview based on the 5S principles. Each category was rated on a scale from 1 (strongly disagree) to 5 (strongly agree). Overall, the mean rating score that represents the user feedback indicated a strong level of satisfaction with the proposed storage design. Specifically, by means of sort principle, the users felt that the space was well-organized, with clutter removed and essential tools clearly separated from unnecessary ones. In terms of set in order principle, the tool organizer was described as practical and easy to use, making it easy to find and return tools that significantly improved workflow. The shine principle stood out for the clean and tidy appearance of the area, supported by visual cues that made it easy to keep items tidy. For the principle of standardize, the system was praised for its consistent layout and clear guidelines, which helped make setup easy to follow and maintain. Finally, under sustain principle, regular updates, reviews, and visual reminders were seen to help keep the system running smoothly over time. Overall, the results show that the design not only supports the 5S principles but also helps create a more efficient, organized, and user-friendly workspace.

3.8 Discussion of Main Findings

The overall findings clearly demonstrate that the implementation of 5S practices in the welding workshop's storage room successfully met the objectives of the study. Optimizing the floor space and improving organization was achieved through the effective use of the Sort and Set in Order principles, creating a more structured, accessible, and efficient workspace. Meanwhile, improving the cleanliness and improve the labelling and tagging system was achieved by introducing regular cleaning routines and using color-coded labels and durable tags, which helped improve visual organization, security, and tool tracking. Additionally, a 3D conceptual design for a modular welding tool organizer was developed using SolidWorks as a systematic and practical solution, and its structural integrity was validated through FEA.

4. Conclusion

This research study has successfully identified and addressed key areas for improving storage organization within the storeroom of the welding workshop. The Genba observations, utilizing the 5S audit checklist, revealed significant issues with unorganized storage. By implementing the 5S principles, the workshop achieved a more organized, clean, and efficient storage environment. In addition, the project focused on proposing a conceptual design for a modular storage organizer, ensuring efficient storage and retrieval accessibility, which was validated through FEA and user feedback. In conclusion, the results of this research study emphasize the importance of systematic organization and continuous adherence to 5S practices in optimizing storage solutions.

Acknowledgement

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through Tier 1 (Vot H222).

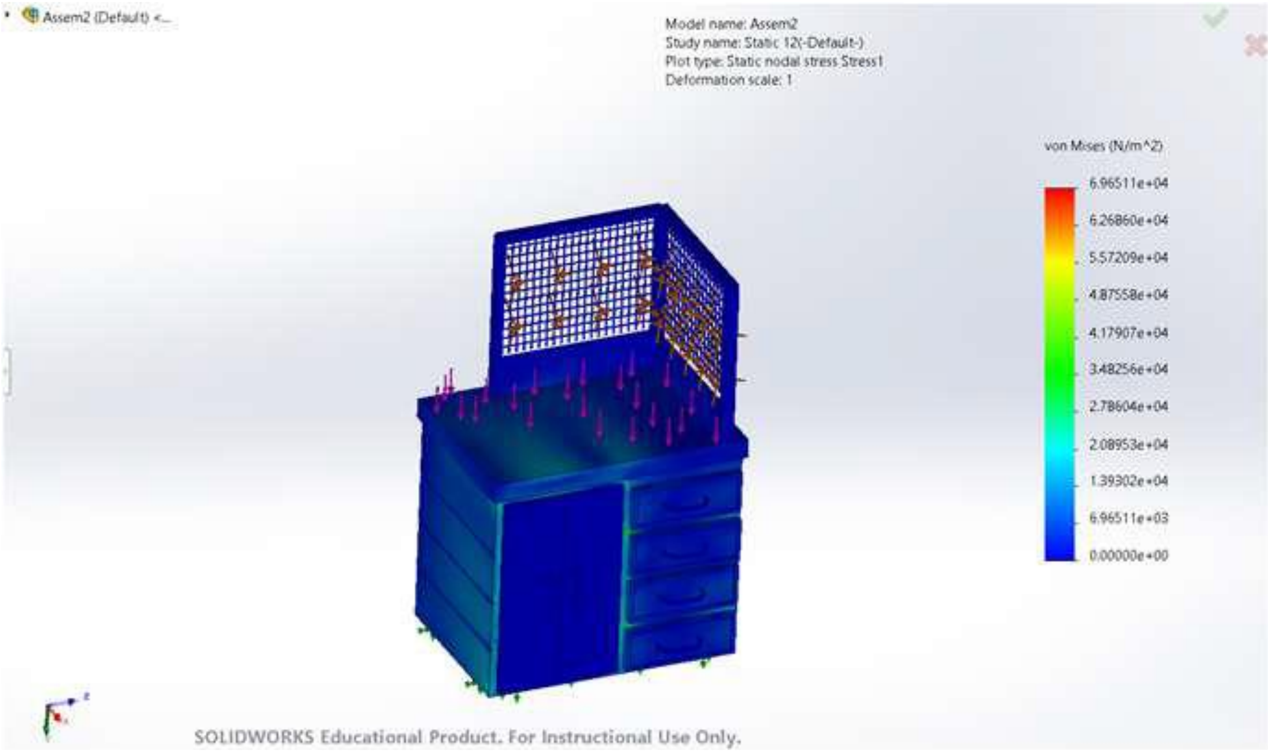
Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

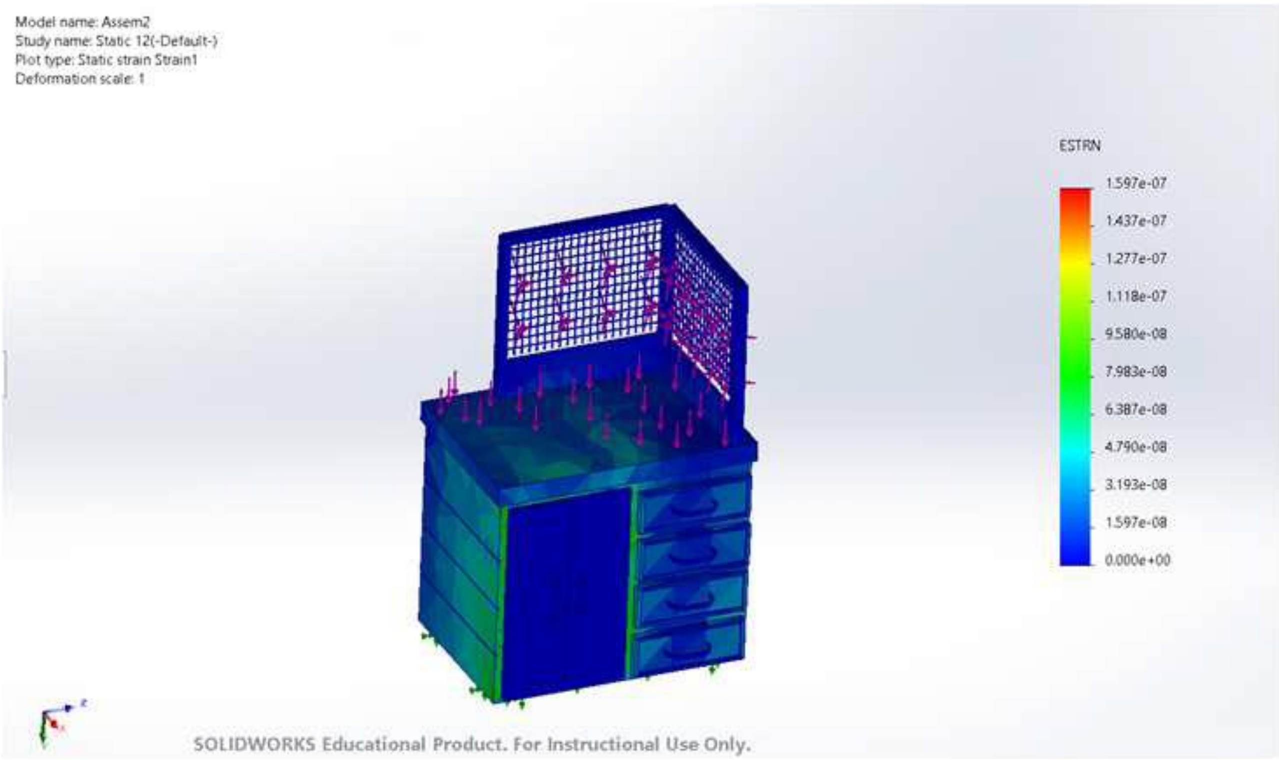
Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Nurul Nabilah Abd Halim, Rahim Jamian; **data collection:** Nurul Nabilah Abd Halim; **analysis and interpretation of results:** Nurul Nabilah Abd Halim, Rahim Jamian; **draft manuscript preparation:** Nurul Nabilah Abd Halim, Rahim Jamian. All authors reviewed the results and approved the final version of the manuscript.

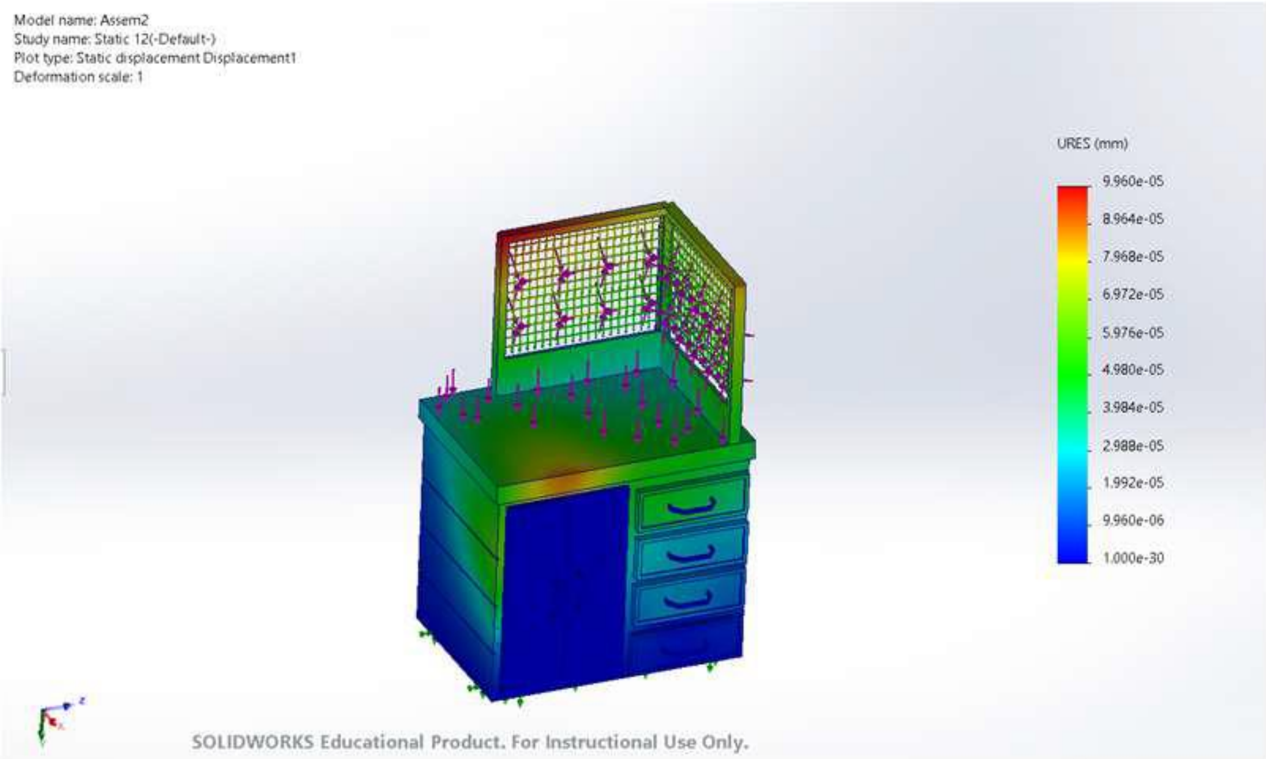
Appendix A: Stress analysis



Appendix B: Strain analysis



Appendix C: Displacement analysis



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