Progress in Engineering Application and Technology Vol. 3 No. 1 (2022) 786-796

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Design Improvement of Laboratory Chair Used at Universiti Tun Hussein Onn Malaysia, Pagoh Campus Based on Ergonomic Factors

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DOI: https://doi.org/10.30880/peat.2022.03.01.078
Received 17 January 2022; Accepted 11 April 2022; Available online 25 June 2022

Abstract: This study looks on laboratory seating designs that were based on ergonomic principles. Ergonomics is the study of fitting a product to its users or a job to its workers. This research is being conducted at the Campus Pagoh of Universiti Tun Hussein Onn Malaysia. The main objective of this project was to improve the chair design in the laboratory. The project's insistence came from users' poor posture when using the laboratory's seats which can lead to health issues such as back pain and spinal misalignment. Kinovea software was implemented to measure the user's posture in this study. The Rapid Body Assessment (REBA) tool was used to examine each measurement of various body part posture in order to determine the risk level of the laboratory's chair.The existing laboratory seating received a REBA score of 8, indicating a high risk that requires investigate and implement change. This project also conducted an online survey, which revealed that 89.00 % of 42 respondents experienced difficulties using the laboratory's seats. The proposed design includes desirable characteristics such as an adjustable backrest lumbar support, and footrest ring. The suggested seat design received a REBA score of 5, which is significantly lower than the current design's REBA score. It was illustrating by Catia software to take the angle posture from the model so that the major differences in ergonomic factors between the current and proposed designs can be compared.

Keywords: Ergonomic, SOLIDWORKS, REBA

1. Introduction

Ergonomics are just as important in the laboratory as in the workplace, warehouse, or other facilities. It significantly impacts productivity, job attitude, fitness, focus, and posture [1]. Therefore, a high quality, comfortable and well-designed laboratory chair is essential when considering lab furnishings. However, the injury caused by the potential non-ergonomics lab chair is underestimated, where a bad posture and rigid working positions can result in severe muscular and skeletal injury. The improper chair design is one of the causes of incorrect sitting positions, resulting in poor posture,

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fatigue, severe psychological stress, and serious impacts on student performance. Currently, many stools are being used in the laboratory. Nevertheless, the proper type of stools with a supportive back is not being provided, which essential to be considered together with seating options that are more conducive to spinal support [2]. Correctly adjusted laboratory ergonomic chairs can make a significant difference [3]. Students can avoid bending or leaning over to a work area since the seat is higher and allows for closer positioning while keeping the proper pelvic angle, allowing for work with less fatigue and fewer health-related issues [4].Implementing an ergonomic laboratory chair should be considered a worthy investment when it increases productivity and benefits students' health. Therefore, this project will focus on redesigning a laboratory chair that meets the ergonomic factor standard, which contributes to good posture and, as a result increased focuses and stamina over extended periods of seated task work. In addition, the durability and strength of the redesign chair also will be considered.

REBA has been selected as an ergonomic assessment tool that will determine the risk factors due to it most suitable for the works that need to be conducted by using the chair in the laboratory. To evaluate the risk level of the laboratory chair, the Rapid Body Assessment (REBA) analyses the current laboratory user posture, with the focus on the effect of seat design on user posture. Kinovea software is also used to determine the user's corresponding posture angle [5].The obtained data from the online survey shows the demand of users for a feature in ergonomic laboratory chair design. Catia software used to perform an ergonomic analysis of the chair and analyse the model when sit on proposed laboratory seat. The proposed laboratory seat design by used SOLIDWORKS software.

2. Methodology

2.1 Flowchart of Methodology

Figure 1 shows the methodology flowchart of this research.

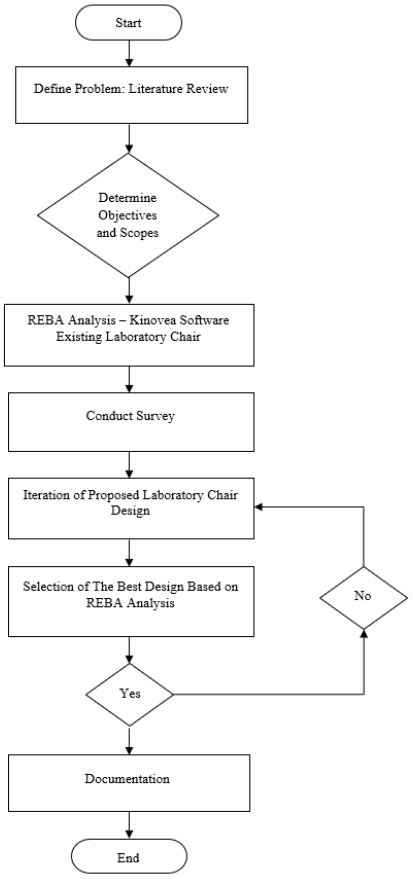


Figure 1: Flowchart of Methodology

2.2 Kinovea Software

Kinovea software is a great assessment tool that analyses the physical movement of a video while also giving precise measurement and annotation. In order to complete the ergonomics assessment task in this study, accurate and precise measurement of the user's posture is vital. After sees the interface of Kinovea software, select to file and insert the selected video into the Kinovea software. After that, the analysing of the video has been started. There is provided some effective features that can help to analysis of any physical movement that displayed in the video. The analysis that done by Kinovea software will very helpful for getting best result for the REBA analysis. In this study, the result obtains from the angle that displays at the part that has been selected at the position and the angle will automatically generate the angle. Figure 2 shows the one of example has been taken from the result.

Figure 2: Angle that generate at selected part of position

2.3 Rapid Entire Body Assessment

Rapid Entire Body Assessment (REBA) has been chosen as an ergonomics assessment tool for this ergonomic analysis design of the proposed laboratory chair. The development of REBA assessment is aimed to develop a postural analysis system that sensitive to musculoskeletal risks in various tasks. Each of body parts is given score according to the guideline which can refer in Figure 3 which consists three table to evaluate score that obtain from the Kinovea result. The REBA assessment method can be divided into two groups: Group A and Group B. The Group A scoring focuses on the neck, trunk, and leg body part, while Group B included arm and wrist evaluation. The scoring of the REBA tool is started from Group A and after that followed by Group B. The guideline of REBA scoring has different step for both groups which Step 1 until 6 is for scoring Group A while Step 7 until 12 is scoring for Group B. Table 1 below illustrates the guideline of overall REBA scoring.

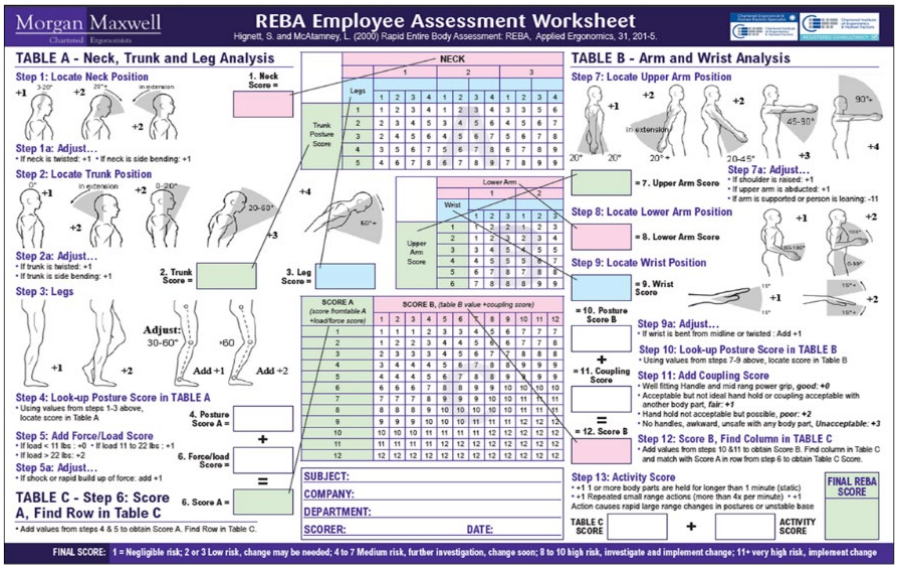


Figure 3: REBA Employee Assessment Worksheet

Table 1: Guideline of overall REBA scoring

Score	Level of MSD risk
1	Negligible risk, no action required
2-3	Low risk, change may be needed
4-7	Medium risk, further investigation, change soon
8-10	High risk, investigate and implement change
More than 11	Very high risk, implement change now

2.4 SOLIDWORKS Software

Solidworks software is a well-known engineering design software and widely used by engineer and designer SOLIDWORKS is a solid modelling CAD and computer-aided engineering (CAE) programme that is commonly used to create three-dimensional (3D) modelling designs. Dassault Systemes released this programme in 1995. Advanced capabilities of Solidworks programme can be used to design an assembly part, analyse a model with difference parameters, simulate a design part based on difference conditions, and so on. SOLIDWORKS software is used extensively in this study to sketch the design of the laboratory ergonomic seat with proper dimensions in 3D.

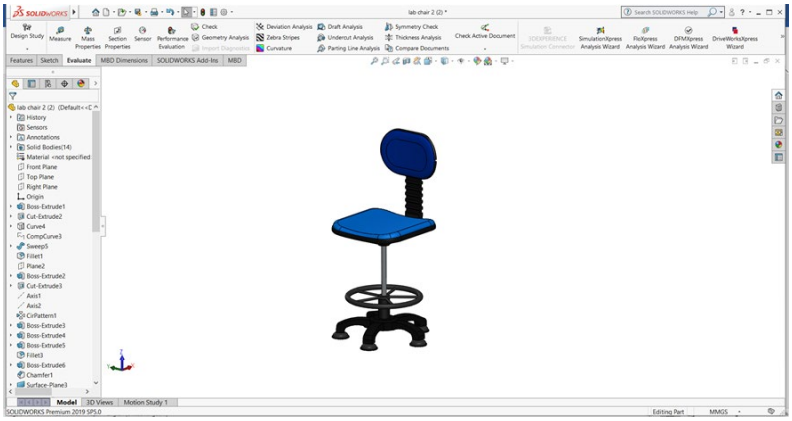


Figure 4: Interface of SOLIDWORKS software

2.4 Catia Software

The product being designed in the Part Design workbench may be evaluated directly for user fit using ergonomic criteria. On this study, the design already designed at SOLDWORKS so that the design just open in a new file. Then, the Ergonomics Design & Analysis workbench contains these capabilities, which are divided into four sections: Human Builder, Human Activity Analysis, Human Posture Analysis, and Human Measurements Editor. The interface of Catia software which first must select the Ergonomic Design & Analysis and go for Human Builder to set the software to ergonomic analysis mode [6]. Figure 5 shows that the manikin has been inserted in the design of seat to obtain the result of REBA score on the proposed seat design.

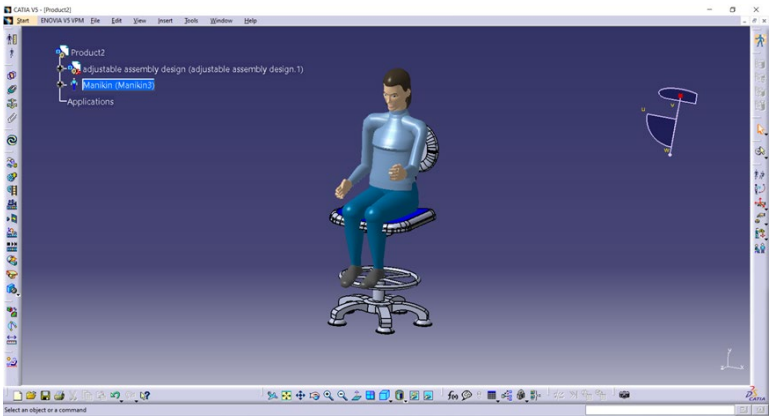


Figure 5: The manikin inserted in the design

3. Data Analysis and Result

3.1 Analysis of Survey

42 respondents from the survey that has been distributed to student Universiti using social media in order to obtain unbias opinion and standpoint regarding to current laboratory's seat design. The overall analysis of the user's experience with the laboratory seat is shown in Figure 6. It is obvious that the number of users have difficulties using laboratory seats. These results indicate that a laboratory seat should be redesigned based on ergonomics factor.

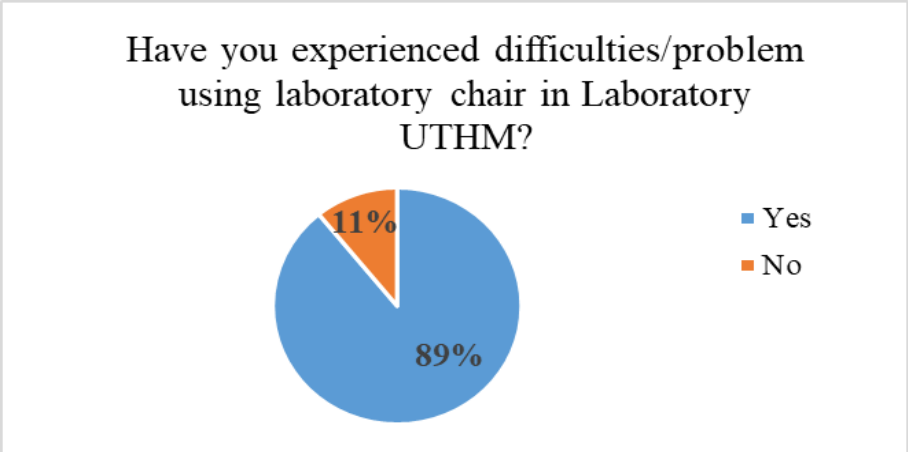


Figure 6: User's experience of laboratory seat

The overall results concerning the factor of an uncomfortable laboratory seat is demonstrated in Figure 7. There is 29.00 % for without backrest on the current chair design and 25.00 % of the users unsatisfied with small seat pan. Others factor of uncomfortable experience included the height of the chair is not suitable, the table used designed fix height and not stable.

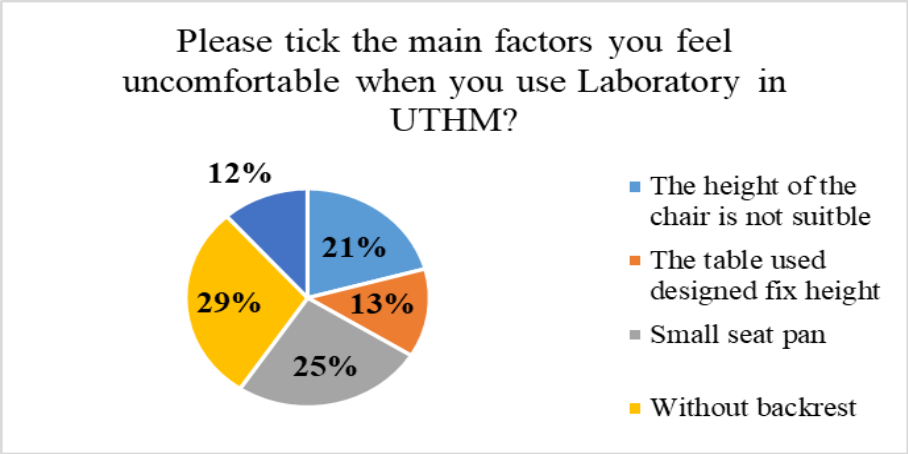


Figure 7: Analysis of uncomfortable factors

The analysis of desired seat features is shown in Figure 8. The number of respondents preferred adjustable seat height and backrest support. Additional desirable seat features included a foot ring, a five-star seat base, and an armrest.

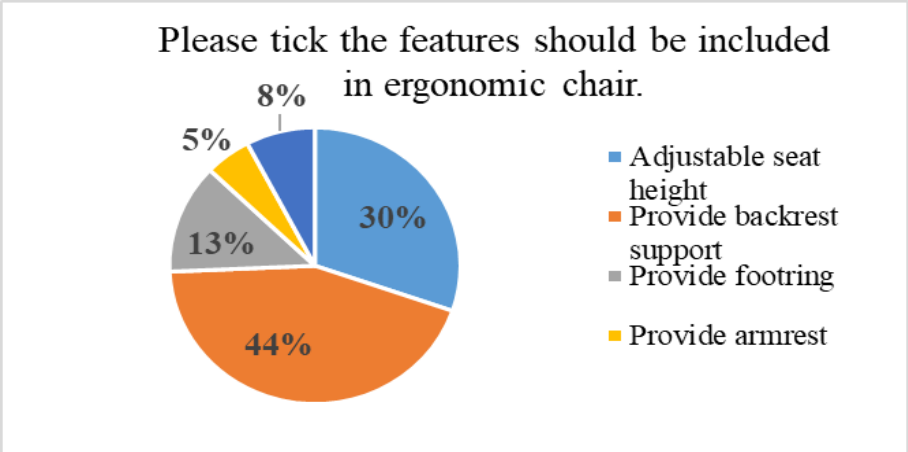


Figure 8: Analysis of desired seat feature

4.2 REBA score on Existing Laboratory Seat

The analysis of the existing laboratory's user posture is accomplished by REBA where the analysis focused on the effect of the seat design on user's posture. Kinovea software is used to measure corresponding posture angle. Figure 9 shows the analysis of REBA with the angle description of the body posture for (a) neck, (b) trunk and (c) leg. Table 2 shows the analysis of REBA assessment for neck, trunk and leg.

(a) (b) (c)

Figure 9: Neck, trunk and leg analysis for REBA

Table 2: REBA scoring for neck, trunk and leg

Body Part	Score
Neck	2
Trunk	4
Legs	3
Posture Score A (Table A)	7
Force/Load score	0
Score A (Posture Score A + Force/Load force	7
Upper Arm	3
Lower Arm	1
Wrist Position	1
Posture Score B (Table B)	3
Coupling Score	0
Score B (Posture Score B + Coupling Score)	3
Activity Score	1
Table C Score	7
REBA Score (Table C Score + Activity Score)	8

Table 3 summaries the overall score based on the analysis different body parts postures, each of the body parts positions score is obtained according to the REBA assessment worksheet. From the Table 3, it can be summarized that the overall REBA score is 8. The risk level for the existing is hig risk and need to investigate and implant change soon.

Table 3: REBA score of existing laboratory seat

Analysis	Description	Score
Neck	**76.6°**	**2**
Trunk	**51.7°**	**4**
Leg	**62°**	**3**

4.3 Proposed Design

The obtained data from the online survey shows the demand of users for a feature in ergonomic laboratory chair design. Figure 10 demonstrate the proposed laboratory seat design by used SOLIDWORK software. The proposed laboratory seat design is done by referring the outcome of REBA on the existing laboratory seat design and the conducted survey. The existing laboratory seat design is modified by changing the ergonomic dimension and adding several useful features based on ergonomic factors and features that the users needed from the survey. The features included adjustable seat height, backrest support lumbar, foot ring, seat tilt and five-star base with damping rubber.

Figure 10: The proposed laboratory seat design

4.3.1 The Adjustable seat height

The most important feature of an ergonomic chair is the ability to adjust the seat height. ideal adjustable seat height is designed in the range of 365mm to 500mm, according to the Department of Occupational Safety and Health Ministry of Human Resources Malaysia (DOSH). The seat height can be adjusted by the users dependent on their body height. The new design used a gas lift adjustable height

in the design to assist any users with different height where they can adjust the chair since the table is fixed height.

4.3.2 Adjustable backrest support

The backrest design of the proposed design able to recline independently of the seat, and it is acceptable to sit upright or recline slightly in the chair as the backrest is designed for reclined seating. The backrest design also adjustable height that can move vertically up and down so that can be adjust easily with the user's body height range. This can be fully support human's inward part of spine.

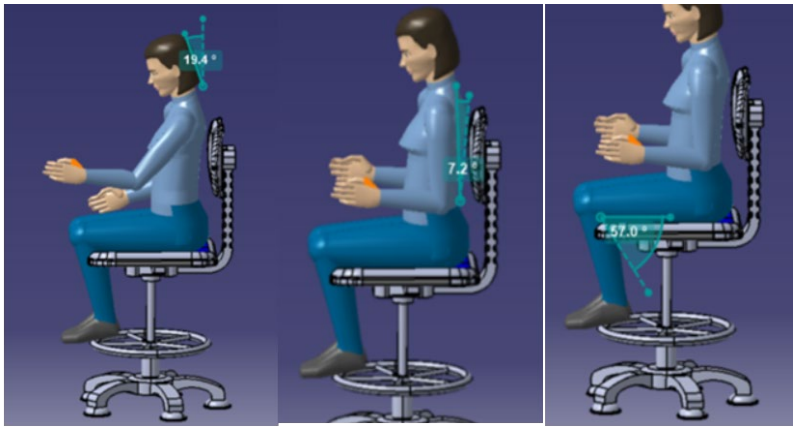
4.3.3 Footrest ring

The footrest ring is also an essential element in this study because most laboratory chairs are higher than other standard chairs, and their feet cannot touch the floor to support their feet. Related to this problem, footrest able to overwhelmed it by provide a support for foot on the proposed laboratory seat design. The footrest is designed 70mm away from the floor.

4.3.4 Five-star base

This feature has been selected by respondents to increase the stability and absorb more human weight by the base. On other hand, the seat base is broader so it giving the chair more stability and firmness where it is also supported by damping rubber at the foot of the chair.

4.4 REBA score on Proposed Laboratory Seat



Catia software used to perform an ergonomic analysis of the chair and analyse the model when sit on proposed laboratory seat. Kinovea software is also used to determine the model corresponding posture angle. One model that use manikin from Catia use the same chosen sample's height chosen to demonstrate the proper seating position when using the laboratory seating. Figure 11 shows the analysis of REBA with the angle description of the body posture for (a) neck, (b) trunk and (c) leg. Table 4 shows the analysis of REBA assessment for neck, trunk and leg.

Table 4: REBA scoring for neck, trunk and leg

Analysis	Description	Score
Neck	19.4°	1
Trunk	7.2°	3
Leg	57°	2

Table 5 summaries the overall score based on the analysis different body parts postures, each of the body parts positions score is obtained according to the REBA assessment worksheet. From the Table 5,

it can be summarized that the overall REBA score is 5. The risk level for the existing is medium risk and need further discussion and change soon.

Table 5: REBA score of proposed laboratory seat

Body Part	Score
Neck	1
Trunk	3
Legs	2
Posture Score A (Table A)	4
Force/Load score	0
[redacted]	
Upper Arm	3
Lower Arm	1
Wrist Position	1
Posture Score B (Table B)	3
Coupling Score	0
[redacted]	
Activity Score	1
Table C Score	4
[redacted]	

4.5 Comparison between Existing and Proposed Design

Initially, the REBA score for the current design was 8, indicating that it is a high-risk design that requires more research and adjustment as soon as possible. Fix seat height, fix seat position, no backrest design, and not stable have all been identified as issues that contribute to the high REBA score. On response to these issues, users are more likely to adopt poor posture and feel very uncomfortable while sitting in a laboratory chair. Significant improvements are included in the proposed design to improve the seated experience. To generate a new design, SOLIDWORKS software is used. The proposed design obtained a REBA score of 5, which indicates a medium risk level. This represents an improvement over the existing design's REBA score.

4. Conclusion

In conclusion, the objectives of this study have been successfully achieved. This objective is accomplished by the use of SOLIDWORKS software and the analysis of a questionnaire. The ergonomic concept and detail criteria or desirable feature of chair design were the subject of the redesign of laboratory seating, which was based on a survey. As a result, the new design takes into account all of the features. After the redesign of laboratory seating is complete, the REBA score is successfully reduced to 5 which indicated medium risk. This shows the significant improvement of seating posture.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for the continuous support.

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