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Improving Classroom Chairs for Student Comfort and Health: An Ergonomic Approach

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Abstract:
This research addresses the critical issue of discomfort and health challenges experienced by students due to non-ergonomic chairs in university classrooms. Students spend a significant portion of their day in classrooms, leading to discomfort and potential health issues stemming from improper chair design. This study identifies problems with existing tablet armchairs. By analysing data from 64 university students and conducting RULA assessments, discomfort areas and posture issues were identified. Anthropometric measurements from the students aided in developing a more ergonomic chair design. The study's methodology involves subjective evaluations, interviews, RULA assessments, and anthropometric measurements. It concludes in designing and developing an improved tablet armchair, addressing the identified issues. The newly designed chair dimensions align with anthropometric measurements to enhance student comfort and well-being. The study underscores the significance of ergonomics in product design, specifically in educational settings, to minimize musculoskeletal risks and enhance user comfort. This research presents a foundational step towards implementing ergonomic solutions in educational environments for better student well-being and comfort.
Keywords: Anthropometry; Sitting posture; RULA; Furniture design; Risk assessment; Comfort

1. INTRODUCTION

In educational institutions, students typically spend around one-fourth of the day (6 hours) in class, partaking in teaching and learning (T&L) activities like writing, reading, and listening to lectures (1). When participating in T&L, students often sit for prolonged amounts of time, which can be uncomfortable and unhealthy depending on their posture and chair suitability. Using a chair that is improperly designed can cause several problems, including psychological stress that has an adverse effect on a student's capacity to learn (2), back pain, neck pain, arm, shoulder, and muscle paralysis (3).

The chairs being utilized by students in classrooms presently have backrests that are constructed of rigid plastic material. This is causing discomfort and inconvenience to the students as these chairs are less ergonomic and do not provide adequate support to their backs. The lack of support can lead to fatigue, back pain, and other related issues, which could ultimately affect their overall performance in class. Students feel uneasy in this environment, especially during protracted T&L sessions. According to past studies, the seats currently in the classroom do not entirely support the most recent necessities (4,5). Furthermore, the poor back support of non-ergonomic chairs exacerbates musculoskeletal disorders that affect internal muscles. According to Rahman (6), the pain experienced by musculoskeletal disorder patients demotivates them and makes it more difficult for them to move around and carry out everyday tasks.

RULA stands for Rapid Upper Limb Assessment, and it is a method used to assess the risk factors associated with musculoskeletal disorders (MSDs) in relation to the design and use of workspaces, including school furniture (7,8). RULA is often applied in ergonomics to evaluate the ergonomic suitability of a task or workstation. In the context of school furniture design, RULA can be used to assess whether the design of desks, chairs, and other classroom furniture promotes proper posture and minimises the risk of musculoskeletal strain for students (9). The assessment involves observing and analysing different aspects of the workstation, such as the user's posture, the furniture's arrangement, and the repetitive nature of tasks. By using RULA, designers can identify potential ergonomic issues and make adjustments to improve the overall design of school furniture, ensuring that it supports the well-being and comfort of students, reduces the risk of discomfort or injury, and promotes a conducive learning environment (10).

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Ergonomic considerations and anthropometric data are crucial when designing a chair, particularly for students. Most chairs in lecture halls and classrooms were not designed ergonomically, which impacts a person's unusual posture. The physical stress and muscular reaction in the back and neck are exacerbated by this circumstance, making it harder to focus on finding a better position (11–13). Numerous studies have revealed that physical problems in the classroom are directly related to one's sitting posture and are led by an imbalance in the anthropometric measures of the students relative to their ages (14–16).

In design, all products, including consumer products, clothes, and living and working environments, should be adjusted to user anthropometry to reduce adverse health impacts. Anthropometry, or the study of human body measurement, is utilised in engineering to guarantee that products are as valuable and capable as possible. Incorporating anthropometric data in the early idea stage can reduce the requirement for subsequent size and form alterations, which can be costly (17,18). Understanding the links between the body and the designed product is also necessary to apply anthropometry knowledge properly. Anthropometric data is vital for the designer in setting dimensions for a new product design. This data consists of human body size and shape (19). The data on the human body size and shape is carefully measured and collected in detail to get the best reading of the human body. This measurement is vital to get human compatibility with the products to be produced. Examples of anthropometric design applications include furniture design (20), automotive design (13,21), as well as product design (22).

This study aims to investigate the problem with the existing tablet armchair design and develop a new ergonomic and comfortable tablet armchair. Tablet armchairs are commonly used furniture in university settings, probably because they can be movable and reconfigurable.

2. METHODOLOGY

The study adopted a quantitative research approach, utilising survey, and the Rapid Upper Limb Assessment (RULA) to thoroughly examine and enhance the design of tablet armchairs in educational settings. Following the survey, the RULA method was applied to objectively assess the seated postures of students during classroom activities, validating and complementing quantitative findings. Anthropometric measurements were collected from a subset of students to inform the redesign of the tablet armchair, capturing quantitative data on body dimensions. The redesign phase incorporated insights from survey and RULA assessments, addressing identified issues and aligning the new design with ergonomic principles. This process aimed to ensure that modifications resulted in improved ergonomic conditions for students during lectures, emphasising a comprehensive and user-centred approach to armchair redesign.

2.1 Questionnaire

To acquire more lucid data for this study, the researcher opted for survey (23,24). The study population included undergraduate students in east coast university in Malaysia. The research sampling used purposive random sampling to those who are currently using tablet armchair in their lectures during research time. There were 64 respondents who met the inclusion of this study. The questionnaire given comprised three sections: a) Demography, b) Problem Evaluation, and c) Seat Design Specification.

2.2 RULA Assessment

RULA analysis is used in this study to record information on the user's sitting position on the existing tablet armchair. Golchha et al. state that RULA is a method to evaluate and study the connection between occupational risk factors and upper limb disorders (25). The biomechanical and postural demands of job tasks on the neck, trunk, and upper extremities are considered (26). RULA is intended to be a quick, simple, and affordable tool that does not require expensive equipment. Data was collected by observing the student using the tablet armchair (Figure 1).

Figure 1. Respondent's posture for RULA assessment.

The RULA scoresheet was marked according to the posture situation during observation. The final RULA score was calculated and referred to the RULA action level for further interpretation, as shown in Table 1 (27).

Table 1. RULA levels and indications.

Final Score	Action Level	Indications
1 or 2	1	Posture is acceptable if not maintained
3 or 4	2	Further investigation is needed. May need changes.
5 or 6	3	Further investigation and changes needed soon.
7 or more	4	Investigation and changes required immediately.

2.3 Anthropometry Data Measurement

Anthropometry is the measurement of the human body according to physical characteristics. These anthropometric data measurements are needed to design an adjustable, more ergonomic tablet armchair according to a person's physical form. According to Dessalew *et al. (*28), anthropometric considerations are important in improving a person's efficiency. Anthropometric data is important in designing products that suit the user.

In this study, anthropometric data was collected from the subset of the students who used the tablet armchair in the lecture room. Measurement tools used in this research are the anthropometer kit and measurement tape. The measurement consists of 11 measured dimensions that have been collected from 10 females and 14 males. Figure 2 shows the dimensions measured in this study (number 1 to number 11).

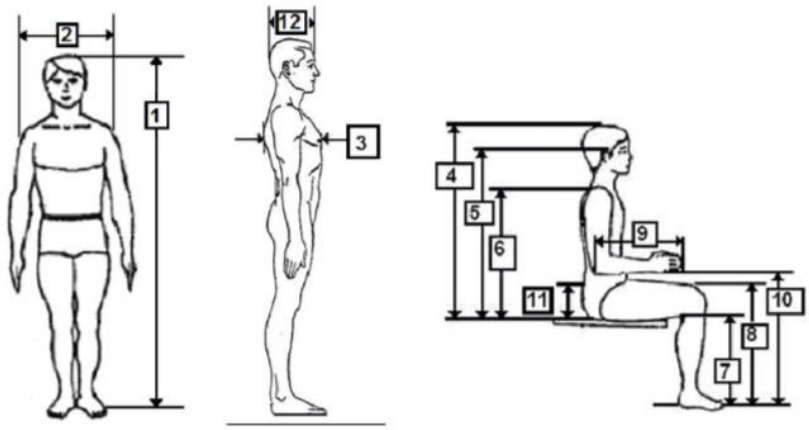

Figure 2. Anthropometry dimension measurement.

2.4 Design Process

The design process is the development of the chair, from sketches to prototypes. According to Haapalainen and Lindman, the design process starts from creating idea, sketches, mock-ups, and prototypes (29). Idea sketch is a phase for collecting product or furniture design ideas. An idea sketch is formed based on the characteristics identified by the researcher. It is obtained from the respondents and then applied as a drawing to make it clearer and easier to understand. According to Gryaditskaya *et al*. (30) an idea sketch that goes through the process of adding, reducing, improving, and adding value will be further explained with more careful drawings. This process will be able to show the planned design idea. The design idea will be incorporating anthropometric data and addressing RULA and quantitative analysis outcomes.

3. RESULTS AND DISCUSSION

3.1 Survey

The demographic data collected by the respondents in the first section is depicted in Table 2. The results show that most of the respondents were Malay females aged 21 to 23 years old. More than half of the respondents reported using their right hand.

The results from the second section of the subjective evaluation, which focuses on the problem evaluation of the existing tablet armchair, are shown in Figure 3. The figure shows the percentage of pain or discomfort experienced by users according to different body areas. According to the evaluation conducted, it is apparent that a substantial number of respondents reported experiencing varying degrees of discomfort in their neck, shoulders, and back areas. The discomfort experienced in these areas may range from mild to severe and may be attributed to factors such as poor posture and prolonged sitting. 31.7% of the respondents reported experiencing discomfort in their waist area, while the wrist and hip areas were also identified as other common areas of discomfort, with 20.6% and 14.3%, respectively. These findings

suggest that discomfort in the aforementioned areas is common among the respondents. It is imperative to identify the root cause of the discomfort and take necessary precautions to mitigate the problem.

Table 2. Respondents' demographic descriptive analysis.

Information		Total	Percentage (%)
Gender	Male	17	26.6
	Female	47	73.4
Ethnic	Malay	54	84.4
	Chinese	2	3.1
	Indian	2	3.1
	Others	6	9.4
Age	18-20	4	6.3
	21-23	36	56.3
	24-26	24	37.5
Dominant hand	Right	58	90.6
	Left	6	9.4

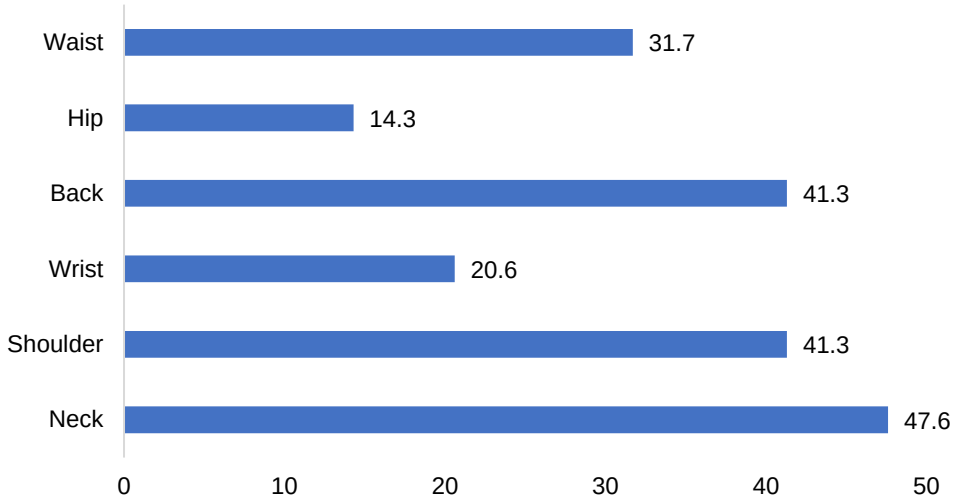

Figure 3. Problem evaluation analysis.

The third section of the subjective evaluation report illustrates the chair parts favoured by the respondents, as shown in Figure 4. It refers to which aspects of the tablet armchair must be emphasised to improve sitting comfort. The respondents' preferences signify a clear inclination toward specific components of the tablet armchair. The overwhelming emphasis on the backrest, constituting 58% of the preferences, underscores its paramount importance in redesigning. This high percentage suggests that the respondents strongly believe that improvements to the backrest are crucial for enhancing sitting comfort in the chair.

The lower emphasis on the tablet, seat, felt pads, legs, and side rails (ranging from 1% to 27%) suggests that while these elements are recognised, they might not be the primary areas that require attention for enhancing sitting comfort, according to the respondents' perspectives. Conversely, minimal emphasis was placed on the front and back rails. This data indicates that respondents did not consider these components as essential areas for improvement in the tablet armchair's design.

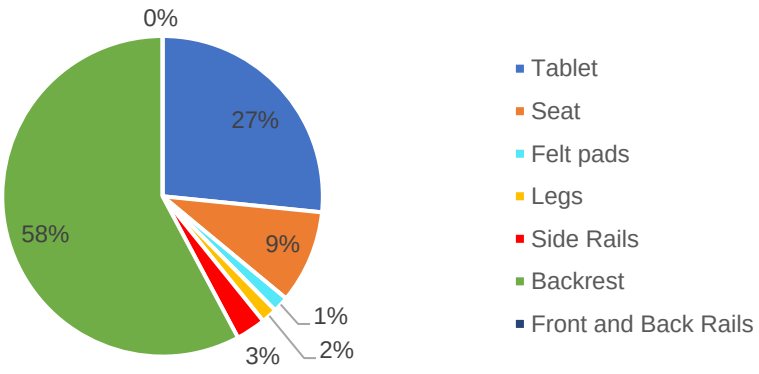

Figure 4. Tablet armchair parts analysis.

3.2 RULA Assessment

From the RULA score calculation, the final score was 5 showing further investigation and changes need to be done soon on the posture involved. The students or individuals in this situation will likely experience minimal strain or discomfort related to their upper limb posture, and there is no immediate need for significant ergonomic adjustments (31). However, continuing periodic assessments and monitoring for any changes in the sitting position is essential to maintain this low-risk posture over time.

3.3 Anthropometry Data Integration

The anthropometrics results are tabulated as shown in Table 3 for male and female data. Using Excel software, anthropometric data were summarised into mean, standard deviation (SD), and 5th and 95th percentile values. Table 4 shows the detailed size of the new tablet armchair using the anthropometrics data value as a calculation. The calculated measurement will be incorporated into the new chair design.

The anthropometric results from Table 3 are used as a benchmark for the new tablet arm dimensions. As mentioned by Kahya (32), the author suggests using anthropometric and ergonomic principles to evaluate the mismatch between anthropometric measurements and design dimensions.

Table 3. Anthropometry data collection.

No	Anthropometry data	Male				Female			
		5%	95%	Mean	SD	5%	95%	Mean	SD
1	Height	163.6	173.6	174.6	5.1	147	165	167	3.1
2	Popliteal height	39.2	46.8	44	2.3	33	38.1	41.4	1.6
3	Shoulder height	63	72	71	2.1	58	68	71	2
4	Elbow rest height	21.6	24.4	26.4	1.9	15	13.2	19	1.9
5	Popliteal-buttock length	44.1	53.8	56.2	3.1	43.5	51	53.2	2.6
6	Hip breadth	34.2	40.8	37.1	1.9	33	45	47	4
7	Chest depth	32.2	40.8	43	1.8	33.2	41.1	40.1	3.8
8	Thigh thickness	14.1	15	16.2	1.7	14.5	16.5	17	1.4
9	Elbow length	23	28.7	29.3	1.5	21.9	25	27.2	1.3
10	Upper arm length	37	38.1	40	2.3	28.3	31.2	35.4	1.8
11	Lower arm length	25	29.5	31.2	2.1	22.2	25.3	28	1.2

Table 4. New lecture's chair dimension.

No	Lecture's Chair Dimension	Anthropometric Measurement	Value (mm)
1	Chair height	Popliteal height + Sitting shoulder height	1158.0
2	Chair seat height	Popliteal height + Shoes soles thickness	368.1
3	Chair seat breadth	Hip breadth + Clothing thickness	481.0
4	Chair seat back height	Sitting shoulder height	720.0
5	Distance of table edge to chair seat back	Chest depth	411.0
6	Table length	Lower arm length + Elbow length	582.0

3.4 Design Process

A series of sketches had been developed to generate the characteristics of the new tablet armchair design. The sketch process includes ideation, development, and final design, as depicted in Figure 5.

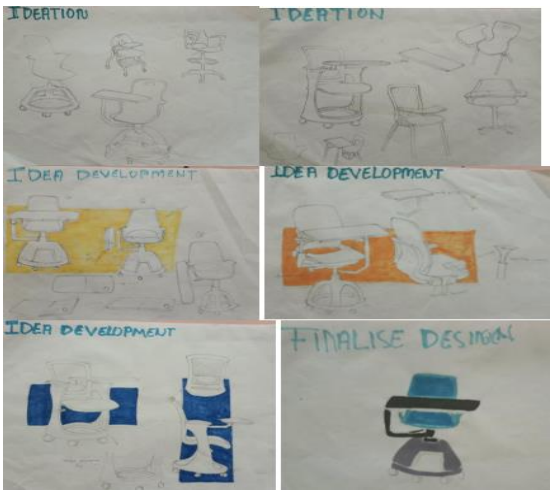

Figure 5. Sketches process.

After the series of sketches had been developed, a 3D model was constructed using 3D modelling software. This 3D model was created to accurately depict the chair design throughout the product development process. The developed 3D model of the chair design can be seen in Figure 6.

Figure 6. 3D model of final design.

The new tablet armchair design was improved from seat, seatback, and table criteria to comply with the subjective evaluation and interview results.

4. CONCLUSION

This study was able to achieve its objectives which are to investigate the problem of the existing chair and to develop a new ergonomically chair design. By utilizing anthropometric data, this study can offer fresh perspectives on the design of tablet armchairs for lecture halls. Using this technique, the user can comfortably fit in the lecture hall with specifically constructed chairs. In anthropometry, body dimension information is needed to calculate the tablet armchair design dimension. The measured body proportions will be adjusted to the chair's design as indicated in the design development. In conclusion, the results of this study can raise awareness of the value of ergonomics in daily life and the need to incorporate them into all product designs. This improvement can manage musculoskeletal risk factors and increase users' comfort. However, further investigation must be done to ensure the research can be applied in all aspects.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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