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Ergonomics Analysis of Classroom Furniture

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Abstract

One of the University Campus in Semarang city provides two types of class facilities: regular classes and creative classes. The first type is equipped with traditional non-adjustable chairs with desks arranged facing the front of the room, while the second types are equipped with movable whiteboard desks, adjustable wheeled chairs, and interactive whiteboards. Both types of rooms are facilitated with a whiteboard and standard projector. In the creative class, the tables and chairs are easily moved to support the learning process. For the students, to be in a sitting position in long hours in the class using the furniture that doesn't fit properly, can result in poor posture and even problems with the musculoskeletal system This study discusses the design of both classes based on anthropometric and ergonomic related to the furniture and the layout. Students' comfort during the learning process and social interaction were captured using a questionnaire. Preferences and perceptions about the comfort of the classroom were analysis to determine opportunities for improvement that can enhance the learning environment.

Keywords: Classroom environment, ergonomics, furniture, regular classes.

1. INTRODUCTION

In today's educational landscape, the design of classroom environments plays an important role in student's learning experiences. The critical component of this environment is the design of classroom furniture, which directly influences students' comfort, posture, and overall educational experience [1][2] (Haque et al., 2014; Widiastuti et al., 2020). Students spend a significant portion of their academic journey seated in classrooms, making it essential to prioritize the ergonomic aspects of classroom furniture and create a learning environment that promotes effectiveness and student well-being. Ergonomics in educational environments, often referred to human factors engineering as a multidisciplinary field that emphasizes the optimization of human well-being and system performance in the design of products and surroundings [3] (Kroemer & Grandjean, 2001). The ergonomics aspects can contribute to comfort and conducive learning process and students' needs [4].

Well classroom design which includes the furniture and layout have an effect on students' comfort, concentration, and overall learning experience [5]. (Lippman & Bulanda, 2011). It also positively affects student engagement, participation, and academic performance, with the physical surroundings significantly influencing

the overall learning experience. In contrary, Ill-designed furniture impact to discomfort, shortened attention spans, and musculoskeletal issues among students, potentially hindering their educational progress. Applying anthropometrics which contain of human body measure, is fundamental in classroom design [6] (Pheasant & Haslegrave, 2005). Furniture tailored to various body sizes and shapes can prevent discomfort and health problems associated with prolonged sitting.

One of University at Semarang city equipped by are two types of classrooms: creative and regular one. The creative classrooms furnished by adjustable and movable chairs and desks; the regular classrooms filled out with wood folding chairs with desk. In regular classrooms, traditional non-adjustable chairs typically arranged to facilitate a frontal teaching style. On the other hand, creative classrooms equipped with movable whiteboard desks, adjustable wheeled chairs, interactive whiteboards, and projectors, enabling dynamic and interactive learning settings. Furthermore, these creative classrooms allow for the flexible rearrangement of tables and chairs to encourage group interactions and collaborative learning experiences.

This study aims to investigate students' response related to ergonomic aspects and human factors associated with classroom furniture, room layout, and facilities in regular and creative classrooms. Through a comprehensive questionnaire survey, the study intends to identify prevalent issues students face regarding classroom furniture and the learning environment in these settings. It also aims to reveal student preferences and perceptions concerning classroom comfort, identifying areas for enhancement to enrich the overall learning environment. Research objectives encompass a two-pronged approach: analyzing classroom furniture and layout ergonomics in regular and creative classrooms using anthropometry data and human factors; and evaluating student comfort and preferences within these classroom settings.

2. LITERATURE

The study evaluates the comfortability and musculoskeletal disorders associated with classroom furniture, highlights the importance of ergonomic design to reduce discomfort and prevent musculoskeletal issues among students [7] (Agyapong & Glalah, 2021), other study tries to determine the mismatches in dimensions can lead to discomfort and musculoskeletal pain, particularly in the neck, shoulders, and elbows at library furniture [8] (Alozie, Yel, & Uyal, 2020). The effect of classroom seating layout also discussed to analyses different desk layouts and their impact on student participation and assessment performance [9][10] (Rogers, 2020; Pranata & Angraini, 2023).

Similar research was conducted at University in Bangladeshn [1] (Haque et al., 2014), the researchers assessed the potential mismatch between the dimensions of classroom furniture and the anthropometric characteristics of 500 university

students. The primary types of furniture examined were desk-and-chair sets and chairs with mounted desktops. The research with case study at university in Turkey, trying to find out about the student dissatisfaction related to existing classroom furniture, environmental factors, and comprehensive approach to propose new furniture dimensions [11] (Utku et al., 2021).

Several companies and researchers also give a guideline in designing chair, as can be seen in Figure 1:

		Measurement
Seat Height	A	Popliteal height + Shoe allowance
Seat Depth	B	Buttock-popliteal length - Clearance allowance
Seat Width	C	Hip breadth, sitting + Clothing allowance
Backrest Height	D	None
Backrest Width	E	Waist breadth
Backrest Lumbar	F	None
Armrest Height	G	Elbow rest height
Armrest Length	H	None
Distance Between Armrests	I	Hip breadth, sitting + Clothing allowance

Figure 1 Chair design reference [12]

3. METHODS

The research steps described in Figure 1 below:

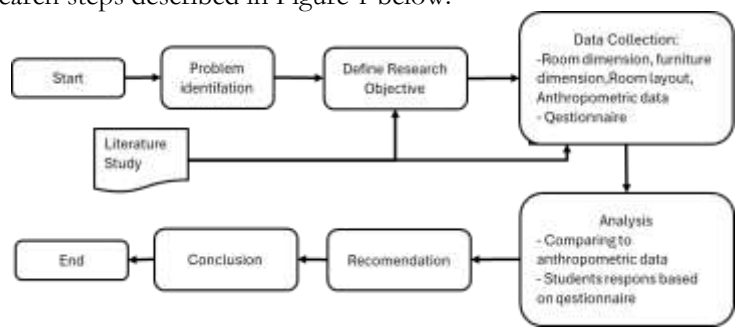

Figure 2 Research flow chart

Participants of this study are student at the University, who has experienced learning process in both type of classroom. Data collection will primarily rely on a structured questionnaire. The questionnaire will feature Likert-scale questions to assess students' perceptions of comfort, ergonomic aspects, and satisfaction with classroom furniture and environment. Additionally, demographic

questions will collect information on participants' gender, and class type.

The Likert scale questionnaire was distributed using to WhatsApp group of students, accompanied by clear instructions for completion. Anthropometric measurements, including height, weight, limb lengths, and other relevant dimensions, were taken using standard tools and techniques [13] (Sinaga & Setiawan, 2020). The collected data consist of questionnaire responses, dimension of furniture and anthropometric data. The analysis includes Cronbach alpha to determine the reliability of questionnaire, and validity test for questionnaires result.

4. RESULTS AND DISCUSSION

4.1 Classroom and Facility

Each classroom has a different furniture type, as can be seen in Figure 2. The class has 2 Air Conditioning to regulate room temperature, one projector, and additional TV monitor at creative classroom.

Regular classroom Creative classroom

Figure 2 Chair and Desk at regular and creative classroom

The capacity of a regular classroom is about 45 students, while creative classrooms can hanlde 30 students. The layout of chair and desk can be seen in Figure 3 below:

(a) (b)

Figure 3. Classroom layout (a) Regular (b)creative

4.2 Questionnaire Result

Research participants filled out a questionnaire consisting of 24 questions, questions about creative and regular classroom comfort. They assess the conformity of their behavior to the statement from strongly disagree to strongly agree. The following table (Table 1), presents the results from 55 participants:

Table 1. Questionnaire Result

No	Variable	Regular Classroom		Creative Classroom	
		Mean	Std.Dev	Mean	Std.Dev
1.	The furniture in the classroom designed to maximize the use of space	4.23	0.81	4.37	0.84
2.	Air circulation in the classroom is sufficient.	4.35	0.83	4.38	0.844
3.	The whiteboard is visible from all areas of the classroom.	4.31	0.83	4.35	0.68
4.	The space between the table and chairs sufficient for leg movement	4.08	1.22	4.31	0.83
5.	Does the space between rows of desks allow for student movement without disturbing others?	4.19	1.05	4.46	0.85
6.	The layout of tables and chairs support students sit comfortably without excessive distractions	4.14	1.03	4.37	0.84
7.	The seating position facilitate access to materials and interaction with friends	4.21	1.05	4.37	0.84
8.	Classrooms are designed to maximize natural light	4.33	0.96	4.38	0.84
9.	Artificial lighting sufficient for reading and working?	4.42	0.85	4.31	0.83
10.	The light evenly distributed throughout the classroom?	4.40	0.98	4.31	0.83

11.	There are some problems with glare, reflections, or shadows from light sources	3.90	1.24	3.77	1.35
12.	The tables and chairs support body posture for long periods of sitting	3.59	1.42	4.38	0.84
13.	Backrest give a sufficient support to prevent from fatigue	3.87	1.22	4.37	0.84
14.	The table has the right height for comfortable sitting	4.13	1.14	4.29	0.82
15.	The table provides enough legroom underneath	4.09	1.02	4.33	0.83
16.	The table is spacious enough for books and equipment.	3.15	1.63	4.33	0.83
17.	The table is comfortable for using laptop	3.50	1.51	4.38	0.84
18.	There is a problem with furniture noise (creaking)	3.90	1.24	3.63	1.44
19.	Classroom storage is well designed to organize personal items	4.13	1.14	4.25	0.95
20.	There are sufficient power outlets available for electronic charging purposes.	3.67	1.46	4.42	0.85
21.	Technology tools such as projectors or interactive screens are easy to reach and use.	4.73	0.82	4.75	0.95
22.	The color of the classroom paint creates a comfortable learning atmosphere	4.69	0.96	4.81	0.79
23.	AC temperature creates a comfortable learning atmosphere	4.65	0.97	4.79	0.80
24.	You are satisfied with the position of the door?	4.65	1.08	4.75	0.95

With a Cronbach alpha value of 0.901, the questionnaire is reliable, and the data collected can be used for further analysis. Following a validity test, the result showed that not all variables were valid. For both types of classroom variable 11 (there are some problems with glare, reflections, or shadows from light) analyze further. The questionnaire of regular classroom showed that question 3, 9, and 18 won't proceed in next analysis; while for creative classroom, question 4, 15,16,17, and 24 will not proceed. Validity test result showed in the following table (Table 2):

Table 2. Validity Test Result for Reguler Classroom

Variable	Regular Classroom		Creative Classroom	
	Validity test	Decision	Validity test	Decision
Var1	0.341	Valid	0.304	Valid
Var2	0.274	Valid	0.282	Valid
Var3	0,193	Invalid	0.286	Valid
Var4	0.519	Valid	0,249	Invalid
Var5	0.343	Valid	0.343	Valid
Var6	0.501	Valid	0.328	Valid
Var7	0.582	Valid	0.407	Valid
Var8	0.515	Valid	0.360	Valid
Var9	00,241	Invalid	0.395	Valid
Var10	0.364	Valid	0.289	Valid
Var11	0,186	Invalid	0,15	Invalid
Var12	0.483	Valid	0.411	Valid
Var13	0.491	Valid	0.412	Valid
Var14	0.415	Valid	0.302	Valid
Var15	0.458	Valid	0,255	Invalid
Var16	0.524	Valid	0,245	Invalid
Var17	0.319	Valid	0,161	Invalid
Var18	0,045	Invalid	0.286	Valid
Var19	0.431	Valid	0.453	Valid
Var20	0.620	Valid	0.320	Valid
Var21	0.395	Valid	0.331	Valid
Var22	0.515	Valid	0.333	Valid
Var23	0.277	Valid	0.280	Valid
Var24	0.385	Valid	0,257	Invalid

For further analysis, all the variables that were not valid, removed from the analysis. The results showed that comfort level of students in creative classrooms reached 87,4%, while the comfort level in regular classrooms was around 82,3%. Comparison of regular and creative class responses, describe in the following Figure (Fig. 1):

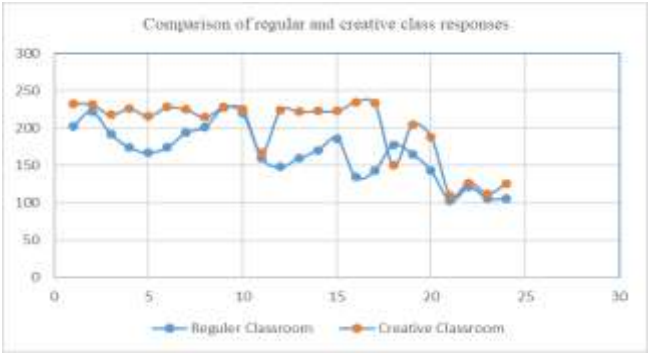

Figure 4. Comparison of regular and creative class responses

Based on the questionnaire distributed, an evaluation of the existing questions has been carried out. The goal is to identify questions with the lowest level of satisfaction, so that it can focus on the most critical problems faced by the majority of students and specific recommendations for improvement can be made for each class while comparing strengths and weaknesses between classes. Questions with the lowest level of satisfaction should be prioritized, because this will be the focus of improvement efforts. In this way, solutions can be offered that are more effective and have a positive impact on students and the learning process in each class.

To determine the questions that have the minimum level of satisfaction based on the questionnaire in Tables 1, the dissatisfaction score (DS) is evaluated. In this study, it is assumed that the most important indicator of dissatisfaction is assigning 1 point to questions in the questionnaire with a dissatisfaction scale of 1 to 5, where 1 indicates the highest level of dissatisfaction.

The 5 questions with the highest DS scores are selected in Table 1 for Regular Classroom. The problems selected are as follows:

1. The tables and chairs support body posture for long periods of sitting (Q12)
2. There are sufficient power outlets available for electronic charging purposes (Q20)
3. Backrest give a sufficient support to prevent from fatigue (Q13)
4. The space between the table and chairs sufficient for leg movement (Q4)
5. Classroom storage is well designed to organize personal items (Q19)

The 5 questions with the highest DS scores are selected in Table 1 for Creative Classroom. The problems selected are as follows:

6. There is a problem with furniture noise (creaking) (Q18)
7. Classroom storage is well designed to organize personal items (Q19)
8. The table has the right height for comfortable sitting (Q14)
9. The space between the table and chairs sufficient for leg movement (Q4)
10. The light evenly distributed throughout the classroom (Q10)

4.3. Recommendation

Based on the results of the dissatisfaction score (DS) assessment, it can be concluded that most of the problems in regular classrooms are related to the comfort and functionality of the furniture, especially tables and chairs. The five questions with the highest DS scores indicated the greatest dissatisfaction with aspects such tables and chairs support body posture for long period, backrest support, space between the table and chairs, storage to organize personal items, and availability of power outlets for electronic charging.

Recommendation for dimensions of chairs is (1) seat height is 44.07 cm, (2)

seat depth 39.88cm, (3) seat width is 78-95cm, (4) backrest width 43 cm, and (4) armrest height 24.65 cm. Dimensions of desk height is 69 cm, the width of desk is 100cm.

Physical comfort is very important for students in regular classrooms. Desks and chairs that do not support proper posture can cause fatigue and even long-term health problems. The use of ergonomically designed desks and chairs, which provide lumbar support and adjustable features, can help reduce the risk of musculoskeletal problems associated with poor sitting posture, and improve student comfort. The availability of sufficient power outlets is also important because the use of electronic devices such as laptops/ tablet/ iphone has become an important part of the teaching and learning process. In addition, limited desk space not only disturbs students' comfort but can also interfere with their focus on the assigned tasks. By providing adequate space, students can more comfortably organize material and work more efficiently.

On the other hand, the dissatisfaction score (DS) results for the creative classroom show that the main problems are related to the physical environment and classroom ergonomics. The most prominent issues include storage design, appropriate table height for comfortable seating, and enough space between the table and chairs to move around, and light distribution throughout the classroom.

This shows the need for improvements in ergonomic interior design and better spatial planning to create a supportive learning environment. Several things can be done, such as using better furniture materials and designs that reduce incidents. Next, lighting adjustments need to be made to eliminate glare, reflections and shadows that can interfere with learning comfort. Even though the satisfaction quite good (> 80%) for both type of classroom. Not only comfort of chairs and desk, but space also to put stuff (laptop, gadget, book, etc.) is important.

4. CONCLUSION

The focus of this research is to comprehensively understand the ergonomic and human factors that influence student comfort and well-being in regular and creative classes for university students. It was found that students tend to feel more comfortable in creative classroom environments compared to regul ar classrooms, which may be due to differences in furniture and room layout. Ergonomic analysis highlighted the need to correct identified problems, such as discomfort during long periods of sitting in regular classes, and physical and ergonomic interference in creative classes. The proposed improvements include classroom ecosystems, spatial layout adjustments, and facility improvements to increase student comfort and productivity. Therefore, this research underlines the importance of paying attention to ergonomic aspects and students' needs in designing learning

environments. As a follow-up study, research could focus on implementing and testing specific interventions or design modifications based on identified problems. Additionally, longitudinal studies can be conducted to assess the effectiveness and long-term prospects of implemented interventions on student well-being and learning outcomes.

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