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AN ASSESSMENT OF STUDENTS' UNDERSTANDING ON ANTHROPOMETRY AND ERGONOMIC IN SHELTER DESIGN EXECUTION

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Abstract

Anthropometry and ergonomic are the basic knowledge of design in the process of creating a functional and innovative humanistic products. The purpose of this study was to assess the understanding of the aspects of anthropometry and ergonomic as a fundamental knowledge of design among the first year UKM architecture students. This measure was administrated with 23 students (9 males, 14 females) on their final design project for KKSB 1116 (Architectural Design 1) course. Measurements were conducted through comparison of their understanding on both the basic knowledge of theory and its application in their shelter design. Results indicated that there were significant differences in pre- and post-test of their understanding regardless of their former educational background. Series of interventions in the learning processes boosted the level of understanding of the students. At the end of the design project, all students generally showed a high level of understanding in both aspects and achieved the course's outcomes (COs).

Keywords: Anthropometry, Ergonomic, Experiential learning, Design project, Shelter.

1. Introduction

Programme of Bachelor Science of Architecture (Part I) at Universiti Kebangsaan Malaysia (UKM) as three-year programme consists of six semesters. The first two semesters are allocated for the foundation year by emphasising on the design fundamental knowledge. As a freshman of

architecture student, the design basic knowledge is a vital tool for empowerment of design ability to produce an innovative functional design. Anthropometry and ergonomic are among of the design fundamental knowledge which are introduced and learned during the first year.

Anthropometry is the study of the human body's size and proportion. The establishment of the human anthropometric data is a crucial process for the product and spatial design development, whereas, ergonomic refers to the study on how the product can be designed comfortably, safely, and effectively according to the human anthropometric data [1, 2]. All functional designs need to be adjusted to the specific user anthropometric to maximize the usability and minimize the negative effects on the user. Certainly, these two basic knowledge need to be exposed at the foundation level, as they begin to deal with human in the design of spatial environment.

Problem-based learning (PBL) is a common practice in the architectural pedagogy or better known as a design project. During the first semester, the students are required to complete three major design projects for the KKSB 1116 course (Architectural Design 1). The expected course outcomes (CO) are: 1) Student to be able to produce creative, innovative, and portray originality in design; 2) Student to be able to understand and apply an anthropometry and ergonomic in the design. As the final design project, the student is required to design a shelter for a mountain hiker, which corresponds to the CO.

An active learning environment through several interventions is applied in the execution of this design project. The interventions include self-experience, series of lectures, design development, craft-making, and design evaluation. All these interventions are expected to enhance the understanding and application of the anthropometry and ergonomic in design. This study was aimed to assess the students' understanding of both the basic knowledge (anthropometry and ergonomic) in theory and its application in their shelter design.

2. Execution of Final Design Project

Final design project task is to produce a shelter in full-scale (1:1) for a mountain hiker (Fig. 1). It carries 50% of the overall marks. The task needs to be completed in the duration of five weeks. The shelter is designed for only one user. The design must be innovative, with consideration of lightweight materials, small product packaging, and ease to assemble. Most importantly, the design must be ergonomic.

An execution framework for the final design project is strategically planned based on the experiential learning theory [3]. Several active interventions promote an active learning environment for the students at every phase of the framework. Figure 2 shows a summary of the execution framework for the deliverable of the final design project.

First, as the introduction phase, the task and considerations of this project were explained during the presentation of project brief by the studio master. The brief also included the design requirements and expectations for this project. Then, students were exposed to the real experience as a mountain hiker at Gunung Angsi, Negeri Sembilan. By this exposure, students were expected to be sensitive

to the nature of activities, its challenges, and limitations as a hiker in the mountainous surrounding. The students were also expected to be inspired by the nature for the concept and idea development, then translated to the apparatus model. Nevertheless, at this stage, the input knowledge of anthropometry and ergonomic were not yet introduced.

Fig. 1. Example of student's work of shelter.

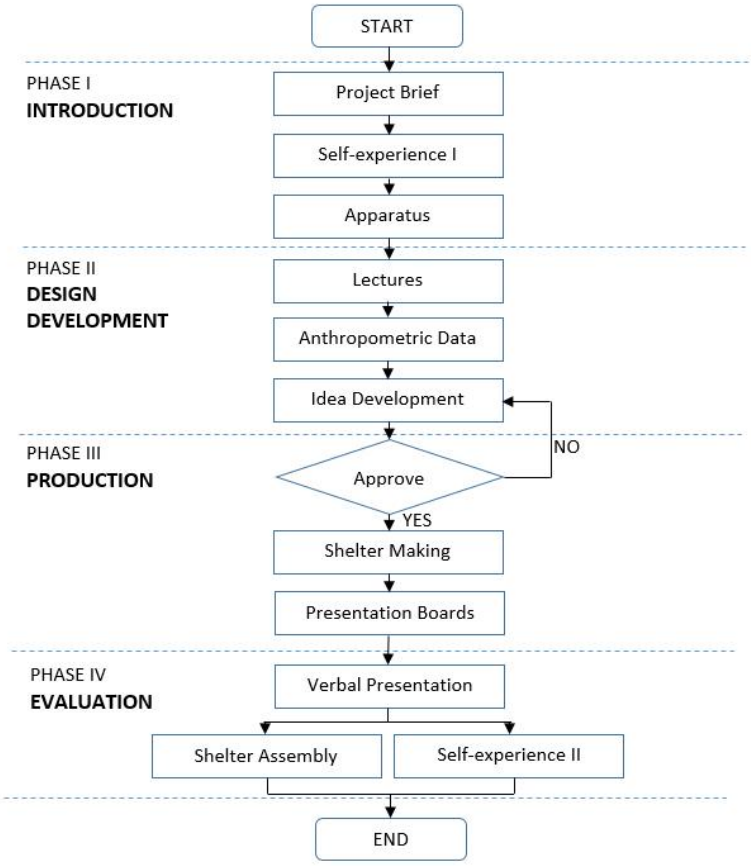

Fig. 2. Summary of execution framework for final design project.

In the second phase, the students were already involved in the design development of the shelter. An apparatus model developed at the earlier phase was used as the idea generator for the shelter design. The students produced several ideas via mock-up models and sketches, and finalised the shelter design through series of critique sessions. In this stage, the students need to incorporate their understanding of anthropometry and ergonomic. Beforehand, series of lectures were conducted for the input knowledge of anthropometry and ergonomic. Then, the students established an anthropometric data of their own based on the proposed activities included in the shelter design. Figure 3 shows an example of the establishment of anthropometric data by a student.

Later in the next phase of shelter production, the execution involved the active actions of craft-making such as cutting, sewing, and welding which required high-intensity of efforts and energy. Then, trial shelter assembly was conducted to detect and minimise design flaws. The students were also required to produce the presentation drawing boards for this design project. The drawing of human figures based on the anthropometric data was requested to display their understanding of anthropometry and ergonomic as shown in Fig. 4.

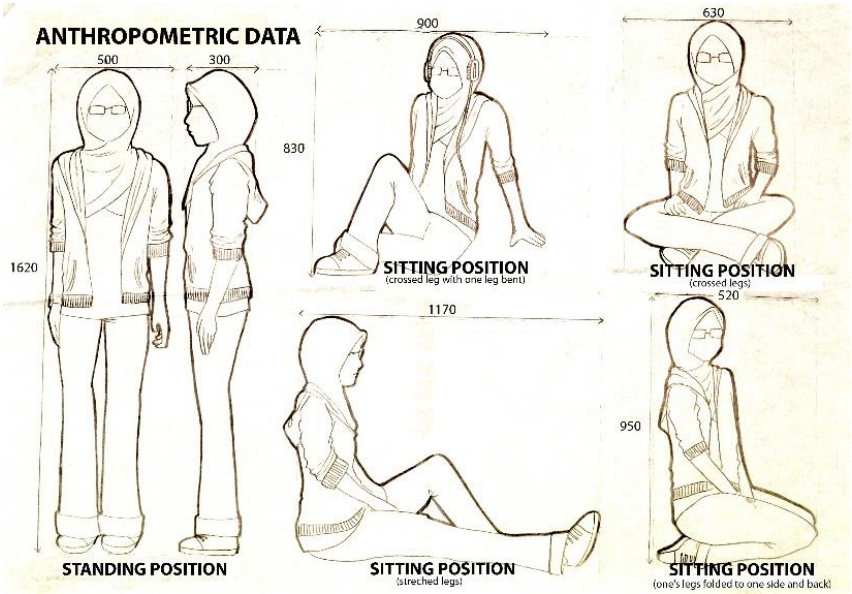

Fig. 3. Establishment of the anthropometric data based on proposed activities for the shelter.

Finally, two stages of evaluation were conducted in the evaluation phase. In the first evaluation, the students were required to verbally present their works based on the final presentation drawing boards. For the second stage, the evaluation was done on the shelter assembly in the real environment at Sungai Chilling, Selangor as shown in Fig. 5. The students also embraced their understanding through self-experience activities by staying overnight in their own shelter. Therefore, the students were expected to fully understand the anthropometry and ergonomic knowledge, and to meet the course outcomes (COs).

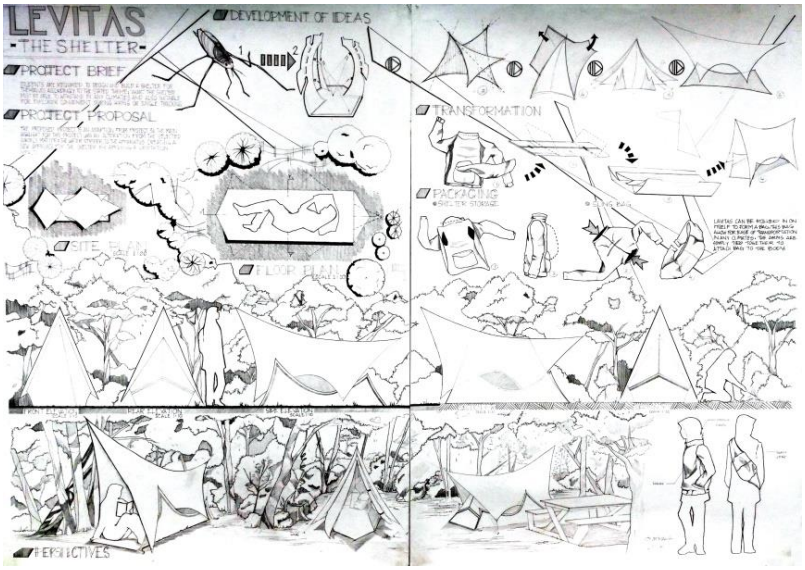

Fig. 4. Example of presentation drawing boards by a student.

Fig. 5. Self-experience activities by staying overnight in their own shelter at Sungai Chilling, Selangor.

3. Assessing the Student's Understanding

Experiential learning processes involving creativity, innovation, and problem-based learning are incorporated in the curricula of programmes of architecture, product design, and engineering. [4]. The experiential learning includes critical thinking, decision making, and problem solving on how to apply the knowledge learned and how to incorporate suitable skills for the design project task to be completed. Therefore, the students are actively engaged with the design project task, by developing learning strategies as they perceive the importance and the value of knowledge.

The understanding of one's particular learning material can be observed at every phase of design project execution. The interventions at every phase such as the establishment of anthropometric data, shelter making, and self-experience are

designed to empower the students' understanding and the application of the fundamental knowledge in their designs. Active learning environment via intervention encourages the student to gain knowledge by experiential learning [5].

Former education background of the student also influences the performance of their understanding of this particular subject. Generally, the novice students have no or less knowledge as they have never been exposed before. On the other hand, this subject is not new for the experienced students (e.g., diploma holder from polytechnic) as they are already familiarised with the subject during their previous study. Thus, an evaluation of the students' understanding needs to be done in order to improve the students' performance in the future.

4. Methodology

Twenty three students took part in this assessment. In general, the investigation of students' understanding of anthropometry and ergonomic was designed to correspond to the execution framework of the final design project as shown in Fig. 2. The data collection were performed after the students completed all of the interventions in every phase (Fig. 6). The comparative analyses were performed on students' understanding based on knowledge acceptance in every phase.

The first comparison was to assess the understanding performance of pre-existing knowledge between two matched-pairs of students. Basically, almost all students were freshmen, and could be acknowledged as novices to this research subject. However, there were nine students who were diploma holders in architecture or interior design. They were considered as experts on this research subject. Therefore, the comparison was made between a group of novice students (Matriculation/STPM) and a group of expert students (Diploma). To match with nine students from the expert group for this exercise, nine students from novice group were randomly selected from the total of 14 students. Two measurements of pre-test (taken at introduction phase) and post-test (taken at evaluation phase) were conducted for both groups.

The second comparison was to assess the understanding performance of the students based on the interventions introduced in every phase of the design project execution. Four repeated interval measurements were taken after completion of every intervention of every phase (Fig. 6). The interval were: 1) Introduction Phase; 2) Design Development Phase; 3) Production Phase, and 4) Evaluation Phase.

A set of questionnaires were used in this study as a research tool. The questionnaires were designed based on the students' understanding on anthropometry and ergonomic through the intervention experiences. The questionnaire contained four questions with an ordinal scale of 1 to 9 based on students' understanding of the research subject. Scale 1 indicated the lowest understanding and scale 9 indicated the highest understanding. Half of the questions focused on their knowledge understanding and the other half focused on their experiential learning. Examples of questions are attached in Appendix A. The students were given the same questionnaires after they completed each phase as mentioned above. Data were analysed using a statistical tool, SPSS, and supported by qualitative methods such as interview sessions with the students as well as observation throughout the data collection.

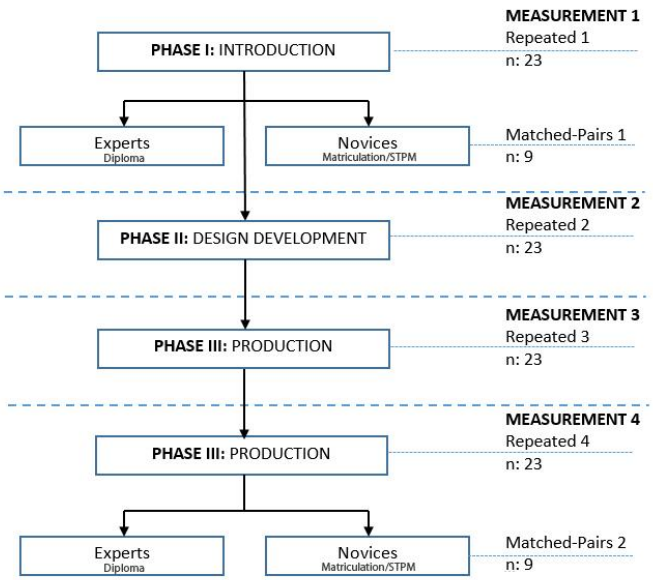

Fig. 6. Research design framework for data collection.

5. Results and Discussion

In assessing the students' understanding of the theory and application of anthropometry and ergonomic, collected data were analysed by using Wilcoxon Signed-Rank Test in SPSS. This test is very suitable for the ordinal scale data assessment in gauging the level of understanding for a group of respondents [6]. As mentioned earlier, first comparison exercise was made between two groups of students; expert and novice groups. Measurements were taken twice; at the introduction phase as pre-understanding assessment and post-understanding assessment.

There was a significant difference in the understanding performance of these two matched-pairs groups at the introduction phase ($T = 45.00$, $p < .05$). No input lecture on anthropometry and ergonomic was given during this phase. The students with previous education background of diploma showed familiarization to this research subject. The difference in pre-understanding can be clearly noticed in Fig. 7, which the median for the expert students was 32 whereas for the novice students was only 12.

However, after several interventions, both groups seemed to be similar in their post-understanding performance ($T = 25.00$, $p > .05$), which was measured at last phase, the evaluation phase. This can be confirmed by the Blox Plot in Fig. 8. The median for both groups were 33 and 31, respectively. It can also be seen that even there were students from both groups achieved the maximum score of 36 for understanding in anthropometry and ergonomic. From this results, it can be concluded that all students, regardless of previous educational background, were able to achieve a good understanding through all interventions that have been designed for them in this final project. Table 1 shows the summary of the results.

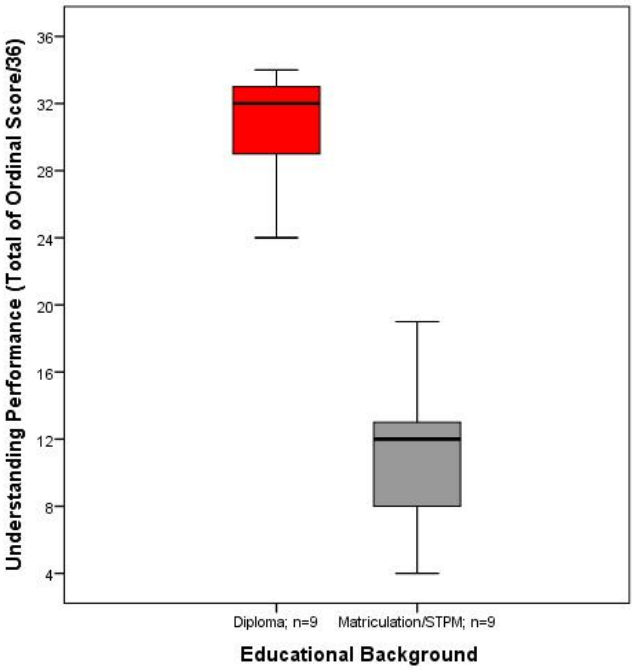

Fig. 7. Understanding performance of two matched-pairs of students at pre-understanding (introduction) phase.

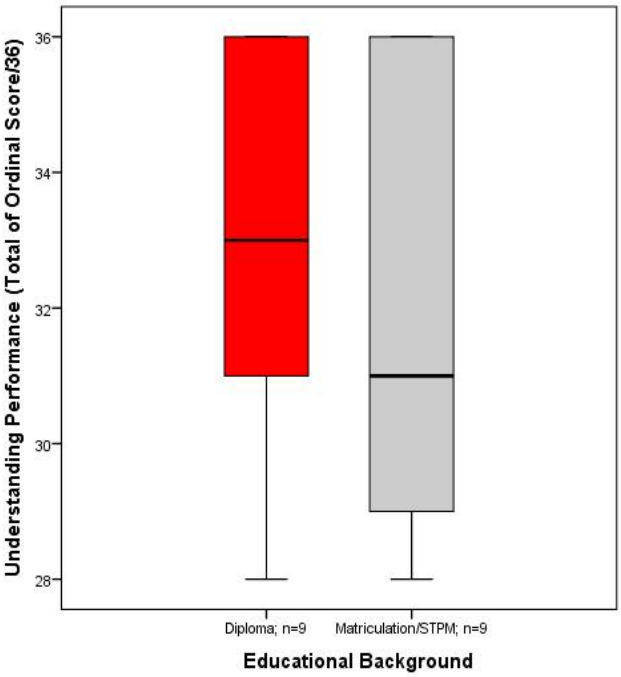

Fig. 8. Understanding performance of two matched-pairs of students at post-understanding (evaluation) phase.

Table 1. Summary of results for pre- and post-understanding.

Phase Test	Group	*N*	Sum of Rank	Sig.(2-tailed)	Median	Mean	Std.Deviation
Pre-Understanding **Introduction Phase**	Expert	9	45.00	0.007	32	30.44	3.283
	Novice	9			12	11.11	5.622
Post-Understanding **Evaluation Phase**	Expert	9	25.00	0.766	33	32.56	3.245
	Novice	9			31	31.89	3.371

Repeated measurements in the form of design intervention were taken periodically from all the students to assess their understanding after completion of every phase. The intervention's effectiveness can been determined by this exercise. At the introduction phase, the students' performance were measured by identifying their pre-existing knowledge on this particular subject. In Fig. 9, score range of pre-existing knowledge from all students was very broad, shown by the standard deviation of 9.8 and median of 21 (Table 2). There was a student with a very low understanding, and a student with a very high knowledge on this subject.

After the exposure to the theory of anthropometry and ergonomic, and its application to their design, the students started to develop and increase their understanding in this subject. At this phase (design development), the students were required to establish their own anthropometric data, which was needed for their shelter design and making. The score was drastically increased from the previous measurement. The differences in understanding the performance of students between Design Development Phase and Introduction Phase of students were very significant ($T = 9.50$, $p < .05$). At this stage, all students were already embraced the understanding of this knowledge except for one student (outlier, represented by closed circle in Fig. 9). It can be assumed that this student has different learning styles [7]. This particular student was unable to grasp the understanding through theoretical approach but excelled in the intervention of practical or shelter making, which was noticeable in the subsequent phase.

The results of comparison between the phases of Production and Design Development indicated that there was no significant difference in the understanding performance among the students. The Wilcoxon T confirmed the above statement with $T = 67.00$, $p > .05$ (0.354). The median score of the performance of understanding of both phases was almost similar, with 30 and 31, respectively. The students achieved high scores in their understanding. The active learning activities through the interventions during both phases improved the understanding level from the theoretical sessions to the application sessions. The students also embraced the understanding by applying the knowledge to their own shelter design which was taught in the previous phase. The active learning process involved activities such as sewing, welding, and craft making. The interactions among the students enhanced the motivation to increase their understanding [8, 9]. In conclusion, both interventions are needed for future programmes.

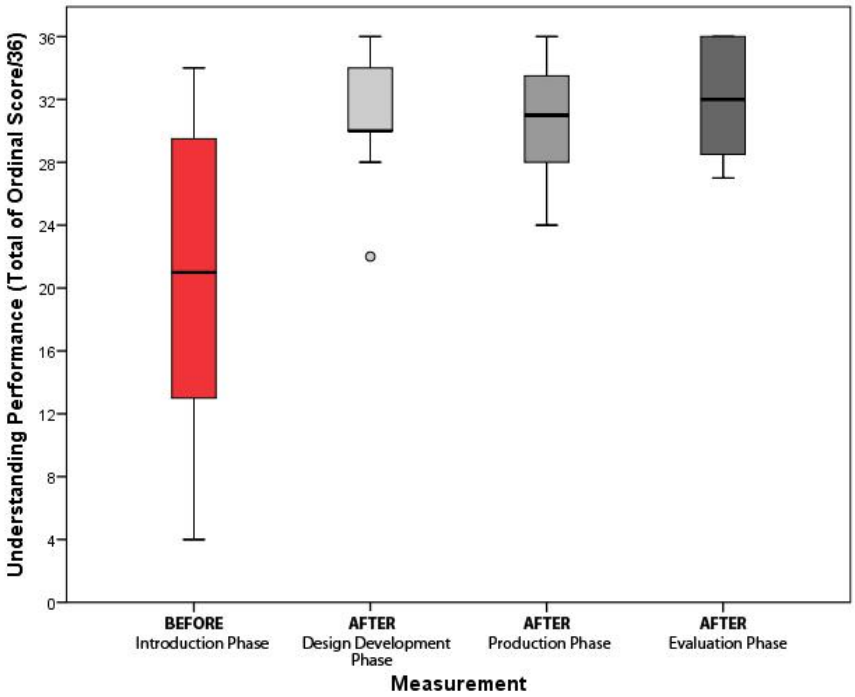

Fig. 9. Understanding performance of anthropometry and ergonomic at every phase in the execution of final project.

Besides that, the boost of the understanding performance also related to the self-motivation which influenced self-efficacy and performance goal of the students [10-12]. However, at the final phase, the performance of the students' understanding on anthropometry and ergonomic showed significant differences to compare with the previous phase, Production Phase (T = 20.00, $p < .05$ (0.002)). The relevance of this subject to be included in the design process can be justified by the students themselves, especially when they experienced the overnight stay in their own shelter. This experience further enhanced their understanding of the importance of this knowledge for application in the humanistic design. It also created an awareness to provide a good, ergonomic, and comfortable design for the end user. Summary of the results are shown in Tables 2 and 3. The Spearman Rho rank-order correlation coefficient test also demonstrated the existence of a significant correlation (r = 0.795, p = 0.000) between the understanding level and the experience throughout the project execution.

The students' understanding in anthropometry and ergonomic achieved an excellent level as exhibited in their design works. This can be supported by the excellent final project marks, where 13 students obtained excellent marks (A and A-), six students with good marks (B+), three students with B grade, and only one student obtained a B- (Fig. 10). Thus, it can be concluded that the students have achieved the second course outcome (CO); i.e. to be able to apply an understanding of anthropometry and ergonomic in their design. At the end of the final project, all the students can be presumed to attain a similar level of understanding regardless of their former educational background. Pedagogical

approach of problem-based learning by introducing a series of interventions remarkably enhanced the understanding performance of the students.

Table 2. Summary of descriptive results of every phase.

Phase Test	*N*	Median	Mean	Std.Deviation
Introduction Phase (Pre-Understanding)	23	21	20.83	9.833
Design Development Phase	23	30	31.26	3.306
Production Phase	23	31	31.00	3.261
Evaluation Phase (Post-Understanding)	23	32	32.43	2.921

Table 3. Summary of Wilcoxon-T results.

Phase Test	*N*	Sum of Rank	Sig.(2-tailed)
Design Development Phase – Introduction Phase	23	9.50	0.000
Production Phase - Design Development Phase	23	67.00	0.354
Evaluation Phase – Production Phase	23	20.00	0.002

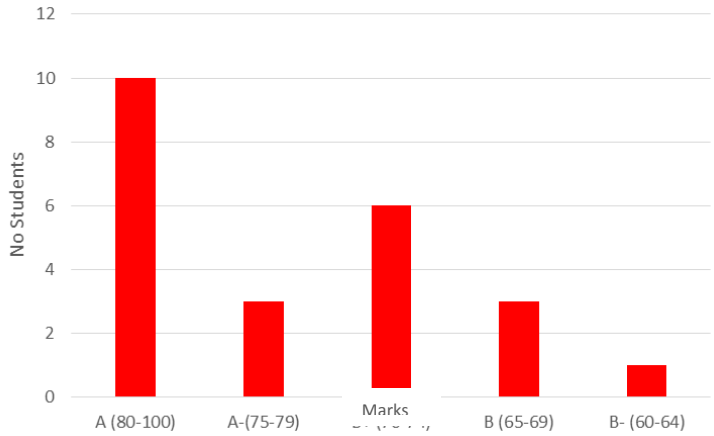

Fig. 10. Final marks for the design project.

5. Conclusions

An investigation has been made in assessing the performance of students in understanding the anthropometry and ergonomic. The first assessment was conducted on pre- and post-test using the technique of two matched-pairs based on the students' former educational background. Significant differences can be

detected at both of the performance phases. At evaluation phase (post-test), all students obtained a good and similar performance level of understanding regardless of the pre-existing knowledge.

The second assessment was conducted with four repeated measurements at every intervention in the final project learning processes. The results indicated significant differences after the students were introduced to the knowledge of anthropometry and ergonomic. The differences also could be noticed when the students underwent a self-experience exercise, and deeper understanding was gained in both phases. In between phases, the differences were not significant, however, the level of understanding were increased. The pedagogical approach of experiential learning in this project was proven to be appropriate in improving the students' understanding.

Acknowledgement

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Appendix A

Example of Questionnaire

LEVEL/PHASE: Please tick (√) your answer in the box provided.

Pre-Understanding		Intervention I		Intervention II		Post-Understanding	

Score:

1	2	3	4	5	6	7	8	9
Highly Disagree	Very Disagree	Disagree	Partly Disagree	No Sure	Partly Agree	Agree	Very Agree	Highly Agree

Please circle your answer based on score above.

No	Item	Score								
1	At this level, I have understood with anthropometry and ergonomic.	1	2	3	4	5	6	7	8	9
2	At this level, I have understood how to apply an anthropometry and ergonomic in design.	1	2	3	4	5	6	7	8	9
3	I understand that anthropometry and ergonomic is important for humanistic design.	1	2	3	4	5	6	7	8	9
4	I understand that by applying anthropometry and ergonomic efficiently in design, the product will work comfortably, safely, and efficiently.	1	2	3	4	5	6	7	8	9