A Study On Anthropometric and Ergonomic Design Of Furniture in the Laboratory of Arts Education

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Abstract: *This study examines the comfort level of furniture in Arts Education laboratory. It was conducted to investigate the relationship between furniture comfort and the students achievement. This research use mix method model (qualitative and Quantitative design), study using anthropometrics and ergonomics theory to analyse the data. How anthropometrics and ergonomics dimensions vary between students is the main problems in this study. The findings of the study states that the ergonomics and anthropometrics dimension among the students has a value of X (mean) under 395-490 mm Standard International (recommendation: Dreyfuss , 1959, Nurmianto , Eko.1991). With a standard deviation of 1.96, the 2.5 percentile and 97.5 percentile are still in the normal range 34.7-45.7 cm (Data Table 4.7 and Table 4.8: Force student-dimensional anthropometrics 2012-2013). Furniture Design in Arts Education Studio has not considered the use of body dimension for the students using it. Therefore the students might experience discomfort while doing lab work using the existing furniture (2.5 percentile), and hence the furniture should be adjustable. Center of gravity or moment of gravity during lab hours of students sitting and resting on the buttocks of normal working area is in the range of 34.7-45.7 cm. While students standing on the feet resting with angular motion and freedom of movement is in the range 72.5-89.8 (Data Table 4.2 - Table 4.5: Data Ergonomics Student from 2012 to 2013) in accordance with the recommendation CG Drury in the 'Journal of Applied Ergonomics' Vol.13, p.135 which is in the comfortable level. In contrast, furniture discomfort in Arts Education Studio has no significant effect on student achievement. It might be influential in the event of injury to the wrist (tenosynovitis), or incidents that are categorized as epycondylitis, peritendinitis and carpal tunnel syndrome, which will affect student's work caused by muscle pain, thereby reducing student achievement.*

Keywords: *Anthropometric, Ergonomic, Furniture, Laboratory*

1. Preliminary

Supriyanto (2010, P.124) in a study entitled "Factors Affecting the Ability of Constructive Drawing in Students in Arts Education Program" mentioned that one of the factors that affect a student's ability to draw constructive is the completeness and condition of facilities and infrastructure. Data from the study's findings stated that 29 % of the 102 students expressed there are very few facilities and infrastructure, 19 % said enough, and the remaining 52 % stated mediocre. This finding does not necessarily show students receive the infrastructure as it is. Some of the attributes that determine the infrastructure variables are: completeness, comfort (ergonomic), size (anthropometry), functions, feasibility, etc. Ergonomic and anthropometric attributes are important aspects of the facilities and infrastructure that affect the achievement of students in practicum courses. Students working in the studio (laboratory) work for more than 4 hours. It is likely similar in almost all studios such as painting studio, sculpture studio, graphic studio, craft studio (ceramics, batik, wood craft) and visual communication design studio.

The discussion of the ergonomic aspects cannot be separated from the discussion of anthropometric measurement of the size of the wearer's body. Ergonomics studies are related to its user's satisfaction, which can be in the form of comfort or health viewed from the science of anatomy, physiology, psychology, health, and work safety.

The purpose of this study is: To know the dimensions of the furniture product's user's body (dimensions of the student body) and attitude/position sitting, standing position (center of gravity, angular motion) while doing lab work, including the legs, arms, sight and reach.

This research is a descriptive qualitative study, that is used to measure three things: (1) the existence and distribution of a wide range of behaviors or characteristics that occurs naturally, (2) the occurrence of natural

events, and (3) the relationships between the characteristics, behaviors, events, or phenomena of concern and also the magnitude of these relationships (Alwasilah, 2002:151). In regards to the scope and limitations of the study, this study is classified as a macro study that discuss anthropometric and ergonomics aspects. The micro aspects of the research findings are discussed with the purpose of reviewing them in a limited study that supports the above macro aspects. The method used in the discussion is a rapid assessment method that examines a problem which leads to a conclusion acquired by observations and analysis. This study uses the approach of anthropometry and ergonomics theory, because it consists of several areas of study in the areas of ergonomics and anthropometry of students who works in the Arts Education studio/laboratory. With the unit of analysis per region, then information from several areas will be incorporated into the analysis to formulate the conclusions of the study, hence this research is a multiple case study (Yin, Robert K.1987: 56). The subject of this study is factors affecting the comfort of the studio work of students. The factors in question can be viewed from the standpoint of anatomy, physiology, and work safety which is summarized as anthropometric (human beings factors) and ergonomics (safety).

2. Literature Review

The term ergonomics is derived from the Latin word *ergon* meaning work and *nomos* which is the laws of nature. Ergonomics can be defined as the study of human aspects in the working environment that are also viewed in anatomy, physiology, psychology, engineering, management and design. Ergonomics is also related to optimization, efficiency, health, safety, and human comfort in the workplace, home or outside home. In ergonomics, a knowledge regarding the interaction between human, working facilities, and environment to adjust the working atmosphere is required. Ergonomics is also known as the "Human Factors". Ergonomics are also used by various experts and professionals in their fields, such as anatomy, architecture, product design, physics, physiotherapy, psychology, and in the industrial engineering (Nurmianto, Eko; P47). Thus the science of ergonomics is a science of human's quest to improve comfort in the work environment by using the method of approach of analyzing the physical relationship between humans and their facilities. The benefit of applying ergonomics is to study the comfort while working.

The application of ergonomics in general is activity in designing or redesigning. This can include hardwares such as working equipments (tools), work benches, platforms, seats, working tool handles (workholders), control systems, props, passageways, doors, windows, etc. (Kurniawan, Djoeliana, 2003. p : 26). Still in regard to the above issue is the discussion in the design of the working environment, because if the hardware system changes, the work environment might also change.

Ergonomics also play an important role in improving work safety and health factors. To be ergonomic, basic knowledge of the functions and muscular skeletal system is required. Kinesiology (human movement mechanics) and biomechanics (applied mechanics techniques used to analyze human skeletal muscle system) are associated with ergonomics. These sciences will provide the basic knowledge to address the problem of human posture and movement in his workplace and space.

In addition, a vital knowledge in the scientific application of ergonomics is anthropometrics (calibration of the human body). In this case there is fusion and application of anthropometric data and statistics, which is also the main prerequisite.

Ergonomic aspects in a work facility design process are important factors in supporting the improvement of production services, especially in terms of the space and accommodation facilities design. The necessity to include ergonomic factors in public facilities design is due to the fact that the discussion is associated with the role anthropometry of the user's body and the application of the anthropometric data.

To create an accommodation facility that is comfortable and safe for its users, it is necessary to approach it from the study of anatomy, physiology, psychology, health and work safety, and also planning and management. In order to obtain an optimal design of a space and accommodation facilities then one should consider factors such as the length of the dimensions of the human body, both in static and dynamic positions.

Another point to be observed is the weight and center of mass (center of gravity) of a segment/part of the body, body shape, the distance to the circular movement (angular motion) of the hands and feet, etc. According to Stefenson (1998), anthropometric is a collection of numeric data related to the physical characteristics of the human body size, shape, and strength used for the application in handling design issues.

Anthropometric research is usually conducted in association with the military from the civil society. It is reasonable for several reasons. First, it is related to the procurement of military equipment, uniform entity, fighter pilots, etc. Second, related to the conducting government institutions and third, the commission that conducted a study made by the government.

The main disadvantage of anthropometric studies for the military is that it is determined by sex and age of the wearer, whereas it can be done by measuring the dimensions of height and weight. The research report was used as a standard in military clothes production before the World War in the United States , so it cannot be used as a public standard.

In the next development, anthropometric studies was also conducted by civil society, such as which have been conducted by the U.S. Department of Health (by. Dr. Howard W. Stoudt), Education and Welfare by Jean Robert with no less than 7500 samples civilians aged between 18 years to 79 years. Anthropometric research variables also experienced growth except for gender, ethnicity/nation, age group and also clothes (uniform), woman's pregnancy factor, and physical defects of the human body.

A good example of the development of anthropometry in this era is the same facilities provided for people with disabilities and those with the normal physical terms. Ergonomically, each have equal rights in the use of services in the public service facilities, for example a special pathways for wheelchairs, special space in the lavatory, a special line for in and out of offices, campuses, hotels, restaurants, supermarkets, etc.

The size of the human body is taken into consideration in the design of the interior, because of it there is a real impact. The two effects are dimension structural type and the functional dimension type. Structural dimensions refers to static dimensions including measurement of the head , torso , and shoulders in a normal position. While the functional dimension refers to the dynamic dimensions, including the reach at work or physical movement associated with the work. Designing a product using static anthropometric data can be seen using the example in the manufacture of a door, which can use the following formula;

= X + (2,325 SD)

= 1740 + (2.325x70)

= 1903 mm

These results are acquired from the standard (non- ergonomic) calculation, where static anthropometric data should be added. Static anthropometric dimensions are defined as static footwear, hats and dynamic clearance (dynamic slack) because human height will increase when walking or running, known as a dynamic effect. So, the total height of the door that must be made is: Door height = 1903 + height + boots height + hat height + dynamic clearance (1903 +30 +50 +50 = 2033mm. This is the designing of a product that is comfortable.

Designing a product using data dynamic anthropometric data can be seen from an example in making a rack (shelf). In this product the anthropometrical consideration is the maximum reach of the human hand to the front. Therefore the calculation of the design is to measure the shoulder height of the user, which is generally added with dimensions of 7.5 cm to tiptoe. Shoulder height dimension will describe the shelf height that will provide maximum reach.

The dimensions of the human body that are commonly used in the design of a product can be illustrated in Table 2.1: Anthropometric Indonesian society Adults with interpolation and the British Society of Hong Kong. (Page Appendix Table)

It is a big mistake to apply an average anthropometric dimension in the design of a product, because the use of average anthropometric dimensions of a product would not be beneficial to other users, since the anthropometric dimensions between users varies. This is unless the average dimension also includes a standard deviation and percentile.

Guidelines for using the most appropriate average anthropometric dimensions ought to consider the corresponding standard deviation in the design to be performed, the average dimension of the appropriate population, the corresponding percentile values as the basis of design, and appropriate grouping of gender.

In using the data in a static anthropometry chair design work for example, working chair will be used by men and women in the working population, so the main demand would be a simple adjustable chair. What is the range of dimensions of the work chair? For the requirements of most major office chair, the sole of the foot

should be located on the surface of the floor, and the seat height should be adjustable in some way so that there will be no pressure on the lower part of the thigh.

Corresponding dimensions are knee high fold (popliteal height). The user population includes women so that the appropriate range is 32.5-49.0 cm. Sole height is also a consideration in women, although there are women who prefer not to wear shoes while working. So we get the range of 325-490 mm dimension. While Dreyfuss (The Measure of a Man) recommends a range of 15-18 inch or 381-457 mm (Figure 2.5: Standard Design Work Chair) on the image attachment page.

3. Discussion

Distribution of Arts Education Curriculum are grouped into four areas (See appendix, Table 1: Distribution of Department of Arts Education Curriculum Year 2012-2013): General Courses (*Mata Kuliah Umum*) with course code of KU 100 to 400 with 12 credits. Meanwhile Field Experience Program Course is coded RK 400 and weighs 4 credits. Basic Education Course (MKDK) is coded KD 300-KD 305 with 12 credits. Subjects theory besides those coded KD are grouped to the practicum courses (core subjects Programs) which is RK 111 - RK162 with credit weights 16 credits, which could also be offered to other courses for majors or other majors Practicum courses coded RK 211 - RK 497 with a weight of 94 of credits. For the Bachelor undergraduate program must complete a minimum of 138 credits. (Data acquired from Arts Education Curriculum Document 2013).

The discussion in this study is related to the study of anthropometric and ergonomics furniture design in lab course category. This is reasonable because the student participants who did standard practice is used to standard dynamic dimensional measurements, where the lab motion (angular motion) is conducted with cyclic movement of the feet, hands, vision, and shoulders. Students who attend theory-based classes, only experience static or silence, and they do not do a lot of movement. Therefore both have a different standard of measurements. Distribution of the curriculum is arranged based on the competency target for undergraduate students, with the learning and assessment systems arranged in Courses Syllabus (*Syllabus Perkuliahan* and *Satuan Acara Perkuliahan* (SAP).

Presented is the result of student ergonomics in Class A and B batch 2012/2013 using the standard dimensions, which is hand and shoulder movement using the term elbow free movement and elbow not free to move. The data in question is as follows:

Ergonomic data are divided into two areas, which is Horizontal and Vertical work area. Horizontal work area is a benchmark to judge the normal movement, which is the movement of the rotating forearm that rests on a horizontal plane. This plane could be a work desk surface with working conditions by sitting (See Table 2: Dimensions of Student Ergonomics Force from 2012 to 2013). Horizontal work area assessment standards are used to analyze the design of an office chair height or seat depth, which is measured by the size of the user's ergonomic measurements. Also, maximum working area can be achieved by measuring student's ergonomics, that is measuring student with arms outstretched to measure the spin axis around the shoulder. This measurement needs to be done to analyze the convenience of work table in the studio based on ergonomic standards, including analyzing the space for students in terms of freedom of movement in doing studio work. Vertical work area is used to design work desk by analyzing student's elbow motion when students are doing lab work in the studio. Is student's elbow free to move while they work? Research data presented in Table 4.2 until Table 4.5 are the data of students' ergonomics that have been classified in group based on sex. Information on the movement of the arm in horizontal dimension (angular motion) will be used to analyze the design of the desk or the horizontal work field and vertical movement of the arm will be used to analyze the work chair and furniture objects vertically.

Things assessed on Anthropometric Data are student's body dimensions factors that are related to the use of furniture in the laboratory/studio, including the long dimension of the body in both static and dynamic positions. The observation also include the weight and center of mass (center of gravity) of a body part, body shape, and the distance to the circular movement (angular motion) of the hands and feet. The dimensions of the student body are grouped into two types: structural and functional dimension. Structural dimension is also called static dimension, which include measurements over the head, torso and limbs. Functional dimension is also known as dynamic dimension, which includes measurements while students are working in a practicum or a movement

that occurs in the context of work. Ten major dimensions are used as a benchmark for measuring anthropometric dimensions, they are: height, sitting height, weight, length of the buttocks to the front of the knees the buttocks to the popliteal part, the range between the elbow to the hip in a sitting position, knee height (front and the back), and thigh height. Furthermore, the student anthropometric dimensions data are presented in the form of Normal Curve and Table 6: Anthropometric data of students (see Appendix).

4. Result

The chair which is used by male and female students certainly has a different range of dimensions among them. In the design of the work chair, footwear (shoes) is also calculated, considering while barefooted during work the feet will hang and create pressure on the lower thigh. Therefore the seat should be easy to adjust (adjustable). What is the dimension of a comfortable work chair according to ergonomic standards? A comfortable chair is as high as the knee (popliteal height) or in accordance with the dimensions of the column 13 of Table 7 men and column 7 in table 13 women, namely high-dimensional folding of the knee. Given that chair users consists of men and women so it must use the appropriate range for both, which is between the range of 30.48 (Table 4.8 column 13) - 41.8 cm (Table 4.7 column 13). Meanwhile, according to the Australian Standard on 'Ergonomics in Factory and Office Work' the recommended range is between 34.0 cm - 48.0 cm. Dreyfuss in the book 'The Measure of a Man' recommended the range of 38.1 cm - 45.7 cm and there is a lumbar support in the sitting position. This recommendation emphasizes the provision of the backrest, which can be adjusted to support the lumbar region or lower region of the spine. This is intended to reduce the tendency toward spinal kyphosis, where the spine bends to the back. Therefore, the selection of the chair size (height, width, and depth of the seat) must be based on user student's anthropometric data.

The height of a work chair is distinguished in two ways:

a. Lower chairs that is used to work together with stool or table (desk and tables)
b. Higher chairs that are used to work together with a bench or machine, or with a workshop table that allows working while standing.

The purpose of low chair design is to let the leg rest directly on the floor and avoid pressure on the bottom side of the thigh. In this case the moment of gravity lies in the prominent bone on the buttocks, while the overall weight of a heavy foot will be supported by the leg. The minimum weight of the foot will be supported by lower thigh, considering compression in the area given below this will cause tingling. Therefore anthropometric data is the main basis in designing high seat/chair that is as high as the knee indentation, in accordance with the recommendation of CG Drury and BG Coury in 'A methodology for chair evaluation, the (Journal of Applied Ergonomics, 1982, Vol. 13 P 135).

High chair is designed to work while standing and working on a high stool. High stool is designed based on the user's elbow height. High chair height can be adjusted to support the upper body so that your elbows are a few centimeters high above the work. Anthropometric data size is the vertical distance from the point of elbow bend to the surface to sit horizontally. To anticipate the occurrence of leg fatigue due to the load at the bottom of the foot, it will be moved to the inside of the groin. So it is necessary to design a foot rest on a bench or on a chair leg which is adjustable. In designing a work chair, it should be based on the type of work, resulting posture, the force required, and integrated visual views with tables or benches that are used to work.

Similarly, the basic design of the garage workbench or table also corresponds to Table 4.7 based on the elbow height on column 8 and column 12 which is the knee height in a sitting position. Based on the results of the study, the male elbow height while sitting is 68.13 cm while the lower range is which is 56.96. Thus table height dimension is in the range between 56.96 - 68.13, in accordance with the user student's ergonomic data with added footwear height between 2.60 cm-4.6 cm. So the comfortable workbench to work ergonomically in students are between 59.56-72.73. The width of a table using student ergonomic data based on anthropometric data in Table 4.7 column 18 (the distance from the elbow to the fingertips) plus 20 columns of data (arm length) is 47.7 +20.3 = 68.7 above range. While the lower range is the data in Table 4.8 in column 18 (the distance from the fingertips to the elbow) plus column 20 (arm length) is 41.7 +15.5 = 62.6 cm. The length of the table can use anthropometric data of students that have been presented in Table 4.7 and Table 4.8. The length dimension of the table that is ergonomically comfortable can be referred to the data in Table 4.7 in column 22, which is the distance of the left fingertips to the right fingertips. How long the dimension of a table that is ergonomically comfortable can be seen in Table 4.7 and Table 4.8 column 22, which is the distance of the left fingertips to the

right fingertips, and is in the range of 160.4 to 164.7. Therefore workbench dimensions (workshop) that is ergonomically comfortable should be: upper range table length 164.7, width 68.7, and height 72.73. While the bottom range table length 160.4 cm, width 62.6 cm, and height 56.96 cm. The data is the analysis of the dimensions of the table is convenient for Arts Education student practicum according to calculations from the data findings after measuring the male students and female students. The recommendation of Panero, Julius and Zelnik, and Martin in his book 'Human Dimension and Interior Space': the length 152.4 cm - 182.9cm, width 76.2-91.4 cm, height 73.7cm - 76.2cm.

Analysis on the office chair and work table is an example of the analysis that has been done to the overall types of furniture that are present in the laboratory/studio in Arts Education Department. Overall, the analysis of the furniture is the same, by using the percentiles of the largest and small percentile after the Mean (X) and Standard Deviation (SD) of known ergonomics students dimensions.
To ergonomically analyze a good and comfortable Etsel height we can refer to Table 4.2 vertical work area, which is Elbow-Free Move (SBB) and also consider students' anthropometric dimensions Table 4.7 Column 3 which is visual height. Therefore an Etsel that is both ergonomic and anthropometric is to have a height of between 212.98 upper percentile and 186.02 lower percentile. Besides determining Etsel height, 212.98 or 186.02 position can also determine observer's comfortable distance to the works being exhibited. The data of the horizontal working area is therefore used to analyze the horizontal field such as the table width, total room space, total space motion, the seat width, cupboard depth and length, width and length of the corridor, etc. While the vertical working area is the data that will be used to analyze object height such as work table height, chair height, stool height, cabinet height, ceiling height, etc.

Referring to the rules of the science of ergonomics, it has not been implemented fully in the process of designing a piece of furniture that will used by students in practicum courses. The reality is that finished products are brought regardless of the anthropometric dimensions of the user students. Finished products are just aiming for profit as much as possible in making furniture. While the design process and functional characteristics of human users (students) are less considered by the manufacturers, such as capacity of the senses, response time, and the optimal position of the hand and foot muscles to work.

From the table it is known that average value (mean) and standard deviation (SD) is 1.96. While the 95 percentile of the body size and the 5th percentile indicates a small body. To accommodate 95% of the population the 2.5 and 97.5 percentile range limits can be applied.

$$N (X.бX) 95 \%$$

$$2.5 \% 2.5 \%$$

$$-1.96 +1.96 X б б$$

For example, analyzing the depth of the dryer rack (dry shelf) at Graphic Studio students work while standing. In calculating the depth of the shelf, it is better to select 5 percent of the population that can reach all the shelves. The smallest percentile 1 % should not be used to avoid the consequences of high shelf because there is only one tall student.

To analyze the level of comfort of drying rack, anthropometric data in Table 4.7 can be used. According to Table 4.7: Anthropometric Data Male Student Column 7 and Column 12 (using shoulder height dimension in a standing position) with a small percentile 2.5, then the convenient shelf height is 144.13 cm so that all population can reach the shelf depth. If the 95 % percentile is used as a design standard, then 151.97 is obtained for the shelf height. Between 144-152 cm, every student can still reach the depth of the rack. But the shelf cupboard that is available is 170 cm long, 120 cm wide with a depth of 45 cm. From the shelf that is high, not all students can reach the height of the rack. Only 2.5 percentile of students can reach the high shelf. The rest of the students must use the stepping stool or tiptoed to be able to reach the base.

The dimensions of the fancy furniture available in studio of Arts Education mostly use 50^{th} percentile, or average dimensions. As a result, the amount of furniture cannot accommodate all of the users. Furniture is supposed to be used comfortably by all the dimensions of the student body. It would be better if in designing the furniture, the installation can be set or changed (the built -in adjustment), that can be adjusted to the student user. Furniture such as office chair or shelves which can be installed differently is a product that can be applied to the system's built-in adjustment.

It is a big mistake if the average anthropometric dimensions of students is used as in the standard design of used furniture (chair or desk), because the use of anthropometric dimensions of the average student does not benefit the other and ince the anthropometric dimensions of the students varies. Guidelines for using the most appropriate in the average Anthropometric dimensions ought to consider standard deviation, the average (mean), gender groups, and has a corresponding percentile values.

Applying static anthropometry in designing a work chair can be taken as an example. Working chair will be used by male and female population; hence the first consideration is that the chair should be adjustable. What is the dimensional range of the chair? The main prerequisite for a working chair is that the sole should be positioned on the floor, and the seat height should be adjustable to prevent pressure on the bottom of the thigh.

The dimension that fits is popliteal height. Female population range is 32.5-49.0 cm. footwear height will be the main support in female, although there are some female that prefer to not wear shoes while working. Therefore the range is 32.5-49.0 cm. Dreyfuss (*The Measure of Man*) recommended the range 15-18 inches or 381-457 mm.

Human body size is taken into consideration in designing furniture, for it may result in two effects, namely structural dimension and functional dimension. Structural dimention refers to static dimension, including measurements of the head, torso, and shoulders in normal position. Functional dimension refers to dynamic dimension, which include reach while working or physical movement that is related to the work.

If anthropometric dimensions are not considered in designing a furniture, it may result in several unwanted effects, such as *algias* or muscle pain due to leaning forward position. Or it may result in vertebral syndrome in students with heavy loads. Osteo articular deviations might also occur, such as scoliosis in students with kyphosis (hunchback). Muscle and tendon pain might also happen, such as achilles damage, extensor tendons in carving artist, or tenosynovitis in sculpture artists.

Incidents such as tenosynovitis or injury of the wrist are categorized epicondylitis, peritendinitis, and carpal tunnel syndrome. These incidents are termed Repetitition Strain Injury (RSI), which was introduced in Australia, referring to all pain syndromes due to work.

5. Conclusion

5.1 Students' Ergonomic and Anthropometric Dimensions

Research data presented in Table 4.2 up to Table 4.5 is the data of students' ergonomic. Information on the movement of the arm in the horizontal and vertical (angular motion) dimension has been used in analyzing the workbench design and student work chair. Student's work chair has a range of dimensions of 30.48 (Table 4.8 column 13) - 41.8 cm (Table 4.7 column 13). Meanwhile, according to the Australian Standard on 'Ergonomics in Factory and Office Work' the range recommended is 34.0 cm - 48.0 cm. Dreyfuss in the book 'The Measure of a Man' recommended range of 38.1 cm - 45.7 cm and there is a lumbar support in the sitting position. This recommendation emphasizes the provision of the backrest that can be adjusted to support the lumbar region or lower region of the spine. It is intended to reduce the tendency toward spinal kyphosis form. The election of the chair size (height, width, and depth of the seat) should be based on anthropometric data of the corresponding user.

Moment of gravity lies in the prominent bone on the buttocks, while the weight of the foot will be supported by leg. The minimum leg weight will be supported by the lower thigh, since compression in the area given below this will cause tingling. Therefore anthropometric data is the main basis in designing the seat height/chair.

In summary, the design of work chair should be based on the type of employment, dimensions of user's ergonomics, the force required, and integrated visual views with tables or benches that is used for work.

Overall, the analysis of the furniture is the same, by using the percentiles of the largest and small percentile after the Mean (X) and Standard Deviation (SD) of known ergonomics students dimensions. In analyzing all furniture, the standard vertical working are, which is the Elbow-Free Move (SBB) column should be considered, as well as the students' anthropometric dimensions in Table 4.7 column 3, which is visual height.

The data of the horizontal working area is therefore used to analyze the horizontal field such as the table width, total room space, total space motion, the seat width, cupboard depth and length, width and length of the

corridor, etc. While the vertical working area is the data that will be used to analyze object height such as work table height, chair height, stool height, cabinet height, ceiling height, etc.

5.2 Student Movement Dimension While Doing Practicum

The weight and center of mass (center of gravity) of a body part, body shape, the distance to the circular movement (angular motion) of the hands and feet should be taken into account.

The dimensions of the student body are grouped into two types: structural and functional dimension. Structural dimension is also called static dimension, which include measurements over the head, torso and limbs. Functional dimension is also known as dynamic dimension, which includes measurements while students are working in a practicum or a movement that occurs in the context of work. Ten major dimensions are used as a benchmark for measuring anthropometric dimensions, they are: height, sitting height, weight, length of the buttocks to the front of the knees the buttocks to the popliteal part, the range between the elbow to the hip in a sitting position, knee height (front and the back), and thigh height.

From the table it is known that average value (mean) and standard deviation (SD) is 1.96. While the 95 percentile of the body size and the 5th percentile indicates a small body. To accommodate 95% of the population the 2.5 and 97.5 percentile range limits can be applied.

The dimensions of the fancy furniture available in studio of Arts Education mostly use 50^{th} percentile, or average dimensions. As a result, the amount of furniture cannot accommodate all of the users. Furniture is supposed to be used comfortably by all the dimensions of the student body. It would be better if in designing the furniture, the installation can be set or changed (the built -in adjustment), that can be adjusted to the student user. Furniture such as office chair or shelves which can be installed differently is a product that can be applied to the system's built-in adjustment.

Furniture inconvenience due to non-compliance of anthropometic and ergonomics standard has no effect on student achievement. Effect might occur if algias, or muscle pain produced by leaning forward, is present. Effect might also occur if there is vertebral syndrome or osteo articular deviations: scoliosis and kyphosis in students might affect the work that resulted in the minimum quality of the work.

6. Acknowledgements

I would like to thank to:

1. Muhammad Natsir, The Minister of Research and Technology of Higher Education.
2. Furqon, The Rector of Indonesia University of Education Bandung,
3. Zakarias S. Soetedja, Dean of Faculty of Arts Education and Design, Indonesia University of Education, for their contribution to run the research very well.

7. Bibliography

[1] Alwasilah, A.Chaedar, (2002), *Pokoknya Kualitatif*, Jakarta: Pustaka
[2] Nurmianto,Eko. (1996), *Ergonomi Konsep Dasar dan Aplikasinya*, edisi prtama, PT Guna Widya Jakarta
[3] Nurmianto, Eko. (1991). *Aplikasi desain tempt kerja industry*: Tinjauan Ergonomi dalam Industri. Seminar nasionalDesain Produk Industri, FTSP-FTI IYS, Surabaya
[4] Panero, Julius., Zelnik, Martin.(1979). *HumanDimension and Interior Space*, source book of design reference standard, United Stade, Canada
[5] Patton, M.Q., (1984), *Qualitative data Analyzis Source of New Methods*, Beverly Hills, Sage Publication
[6] Pheasant, Stephen. (1991). *Ergonomics, Work and Health,* Macmillan Academic And Professional LTD, London
[7] Pheasant, Sulfiant. (1986).*Body Space: anthropometry, ergonomic and Design*. London: Taylor and Francis
[8] Sanders, M.S and Mc Cormick E.J. (1991). *Human Factors in Enginerering and Design*. 6^{th}. Ed. Toronto; Mc Graw-Hill Inc.
[9] Supriyanto, Untung. (2011). *Faktor-faktor yang mempengaruhi kemampuan menggambar konstruktif mahasiswa* Jurusan Pendidikan Seni Rupa, Tesis Fakultas Pasca Sarjana, UPI
[9] Yin, Robert K., (1987), Case Study Research ; *Design and Mehods*, Newbury Park, Ca : Sage

Journal

[10] Drury, C.G.(1982). *A methodology for chair evaluation*. Applied. Ergonomics, Vol. 13, p.195 http://dx.doi.org/10.1016/0003-6870(82)90006-0