Anthropometry in furniture design for early childhood school in West Jakarta

B Setiawan1*, N Abdullah2 and A F Pratama3

1-3 Faculty Member, Interior Design Department, School of Design, Bina Nusantara University, Jakarta, Indonesia 11480

E-mail: bsetiawan@binus.edu

Abstract. In early childhood, schools have a goal to meet the preparation of children's needs in education in terms of academic, social, and emotional. The research studied anthropometry and ergonomics of furniture design in the early childhood education in which furniture become essential supporting facilities. The research focused on furniture located in the Playfield Preschool classroom, within West Jakarta area. The furniture included study tables, study chairs, and storage areas for teaching and learning which were the main facilities in the classroom. In addition to the functional aspects, the design had also be able to provide health, safety, security and comfort for users while using and operating the facilities. The method applied in the research was the goal grid method which was divided into four sections to determine the positive and negative sides of the furniture. By knowing the positive and negative impact, the research can help the user to maximize the function of the furniture and the industry to improve & develop their products.

Keywords: anthropometry, furniture design, early childhood school

1. Introduction

Anthropometry is important data for designers in designing various facilities that will be used by the users. Anthropometric data explains the detailed measurements of each part of the user's body, so that it can help designers when determining the scale and placement of design elements needed in accordance with the activities that will be carried out by the user of the facility. Including in creating a good learning atmosphere. In early childhood education, important things that are emphasized are independence, competence and self-control [1].

The design of early childhood schools plays an important role in influencing the feelings of students who use the facilities. The student’s feeling is influenced by the size and scale of the building, and the size and shape of the interior and all its facilities as well. Anthropometric data about children aged 2-3 years can help designers in achieving these targets. The general application of these data links body measurements with design elements of the product and environment. Some examples are how big or small a toy can be grasped, cracks in the furniture so that the head, hands, and fingers are not pinched or injured [2]. Using anthropometric data in designing equipment, furniture and equipment such as door handles, tables, chairs and others to fit the scale of the child's size and ability to encourage exploration, self-care and independence [3]. Anthropometric data can also help the designers to determine not only the exact scale of specific design elements, but also their specific placement or position. For example: measurement data about the reach of children can be used to determine the height of shelves, cabinets...
or tables. A child will feel more competent and independent if he/she can take books / toys from shelves and tables, or store / tidy things up in drawers or storage cabinets [4].

Early childhood school is a pre-primary level of education aimed at providing guidance aimed at children from birth to 5 years of age aimed at providing educational stimuli to assist physical and spiritual growth and development so that children have readiness to enter further education. Teaching and learning in schools at this stage emphasizes the development of creative power, innovation, and experimentation to spur new ideas that have never existed before.

Furniture is an element of interior filling that is considered to have an important role to support all activities in school spaces for early childhood. The early age stage is the most active and energetic stage so it requires furniture that is appropriate in size, comfortable and safe as well. It also aims to maintain healthy bones and posture of children at an early age because it is still in the growing state and does not have a perfect balance yet [5]. Therefore, the research is conducted to analyze the main facilities (study desks, study chairs and storage cabinets) that have been provided by early childhood schools at Playfield Preschool, West Jakarta. It is hope that the research can be a reference or standard for developing the level of ergonomics for early childhood learning facilities at schools in the future.

2. Methods
The research method applied is a qualitative method by conducting literature studies. The literature review is done by collecting data and images from a study of anthropometry and ergonomics for 2-3 years early childhood furniture and facilities that relevant to materials research. In addition, the writers also used observation method with direct data collection in a school classroom in the early childhood education Preschool Playfield, West Jakarta. These literatures data are used to be a benchmark to analyze the data collected from Playfield.

Goal Grid method are used to clarify the achievements of the furniture facilities in the classroom whether it is in accordance with the anthropometric and ergonomic theory of early childhood 2-3 years. It is expected to be a solution for the early childhood school education sector in its efforts to improve and support the smooth teaching and learning process in schools. Furniture facilities in early childhood schools were analyzed using the goal grid method and using 4 components that explain the advantages and disadvantages, and what needs to be improved and eliminated [6]. This is very useful in supporting learning and teaching activities in schools both in terms of academic, social, and emotional.

This research discusses the anthropometry and ergonomics of furniture design in the education system of early childhood 2-3 years, male and female, in the Playfield Preschool school classroom, West Jakarta. The furniture includes study tables, study chairs, and storage areas for teaching and learning which is the main facility in the classroom.
The study desk in Figure 1 is in the Playfield Preschool classroom, Jakarta. The desk has dimensions of 120 cm (length), 60 cm (width), and 52 cm (height).

Figure 1. Desks in Playfield Preschool Classrooms, Jakarta
(Source: Setiawan, 2020)

The study chair in Figure 2 is in the Playfield Preschool classroom, Jakarta. The chair has dimensions of 30 cm (length), 30 cm (width), and 30 cm (height).

Figure 2. Chair in the Playfield Preschool Classroom, Jakarta
(Source: Setiawan, 2020)
The storage area is in the Playfield Preschool classroom, Jakarta (Figure 3). The storage has dimensions 120 cm (length), 40 cm (width), and 100 cm (height) per module.

Figure 4 shows a classroom layout with study desk & chair, writing board, storages for equipment in class activities, and student bag & drinking bottles.

3. Result and discussion

3.1. Anthropometry

Anthropometry is a study of measurements of the body dimensions of humans from bones, muscles and adipose or fat tissue. Anthropometry is a study that deals with measurements of human body dimensions. The field of anthropometry covers various sizes of the human body such as body weight, position when
standing, when stretching out arms, body circumference, leg length, and so on [7]. There are two ways of measuring in humans, namely:

- **Static Anthropometry**
  The dimensions measured in static anthropometry are taken linearly or straight and carried out on the surface of the body. There are several factors that influence human body dimensions, such as Age, Gender, Ethnic & Ethnic Groups, and Body Position or Posture.

- **Dynamic Anthropometry**
  Dynamic anthropometric measurements relate to the measurement of the state and physical characteristics of humans in a moving state or in conditions that might occur if someone is working on activities, as shown in Table 1.

### Table 1. Anthropometric data of children aged 2-5 years
(Society of Automotive Engineers, Inc.)

|   | 2.0-3.5 y.o. | 3.5-4.5 y.o. | 4.5-5.5 y.o. |
|---|-------------|-------------|-------------|
| 1 | Weight      | 31.0        | 35.6        | 40.3        |
| 2 | Stature     | 37.4        | 40.6        | 43.3        |
| 3 | Vertical Grip Reach | 42.9      | 46.6        | 50.4        |
| 4 | Frontal Grip Reach | 15.9      | 17.2        | 18.2        |
| 5 | Lateral Grip Reach | 21.2      | 22.5        | 23.9        |
| 6 | Step Height | 13.3        | 15.8        | 17.2        |
| 7 | Supine Stature | 38.9      | 40.9        | 45.0        |
| 8 | Standing Center of Gravity | 22.4      | 23.8        | 25.8        |
| 9 | Erect Sitting Height | 21.8      | 23.0        | 24.2        |
| 10 | Eye Height (seated) | 17.5      | 18.7        | 19.9        |
| 11 | Maximum Hip Breadth (seated) | 7.6       | 8.0         | 8.3         |
| 12 | Maximum Thigh Breadth (seated) | 7.7       | 8.0         | 8.4         |
| 13 | Thigh Clearance | 3.2       | 3.4         | 3.6         |
| 14 | Buttock-Knee Length | 11.4      | 12.6        | 13.6        |
| 15 | Knee Height | 10.8        | 12.0        | 12.9        |
| 16 | Supine Sitting Height | 23.2      | 23.9        | 25.3        |
| 17 | Seated Center of Gravity (above seat) | 8.0      | 8.2         | 8.2         |
| 18 | Seated Center of Gravity (from back) | 5.2       | 5.4         | 5.9         |
| 19 | Head circumference | 19.8      | 20.1        | 20.3        |
| 20 | Head Breadth | 5.4         | 5.5         | 5.5         |
| 21 | Head Length | 7.0         | 7.2         | 7.2         |
| 22 | Neck Circumstance | 9.5       | 9.7         | 10.0        |
| 23 | Lateral Neck Breadth | 2.8       | 3.0         | 3.1         |
| 24 | Shoulder Breadth | 9.8        | 10.3        | 10.7        |
| 25 | Shoulder-Elbow Length | 7.4       | 8.1         | 8.8         |
| 26 | Acromion-Radiate Length | 6.7       | 7.2         | 7.7         |
| 27 | Upper Arm Circumstance | 6.3       | 6.5         | 6.7         |
| 28 | Elbow-Hand Length | 9.8       | 10.7        | 11.4        |
| 29 | Radiate - Styliion Length | 5.4       | 5.8         | 6.3         |
| 30 | Forearm Circumstance | 6.3       | 6.4         | 6.6         |
| 31 | Wrist Circumstance | 4.5       | 4.6         | 4.7         |
| 32 | Hand Length | 4.2         | 4.8         | 4.8         |
| 33 | Hand Breadth | 2.0        | 2.2         | 2.2         |
| 34 | Minimum Hand Clearance | 17.4      | 18.3        | 19.1        |
| 35 | Maximum Fist Circumstance | 6.5       | 6.8         | 7.1         |
| 36 | Maximum Fist Breadth | 2.3       | 2.4         | 2.5         |
The anthropometric data for children aged 2-5 years old based from Society of Automotive Engineers is presented in Figure 5-8. It shows the basic average of children body measurements, reach, and certain kind of normal activity positions. These figures are important for the school activities, such as sitting, lay down, and other movement.

|   | Maximum Fist Depth | 1.8 | 1.9 | 2.1 |
|---|---------------------|-----|-----|-----|
| 38 | Suprasternal Height | 29.0| 31.4| 33.7|
| 39 | Chest Height at Axial | 26.1| 28.8| 31.3|
| 40 | Chest Circumstance | 20.3| 21.1| 22.0|
| 41 | Chest Breadth at Axial | 6.4 | 6.7 | 6.9 |
| 42 | Waist Height | 19.7| 22.2| 24.2|
| 43 | Waist Breadth | 6.4 | 6.8 | 7.1 |
| 44 | Natural Waist Circumstance | 18.8| 19.4| 20.4|
| 45 | Hip Height at Buttocks | 16.2| 18.5| 20.2|
| 46 | Hip Circumstance | 20.7| 21.4| 22.4|
| 47 | Bispinous Breadth | 5.8 | 6.0 | 6.3 |
| 48 | Gluteal Furrow Height | 15.0| 16.7| 18.4|
| 49 | Upper Thigh Circumference | 11.8| 12.4| 13.0|
| 50 | Tibiale Height | 8.9 | 9.6 | 10.6|
| 51 | Calf Circumference Height | 6.7 | 7.4 | 8.1 |
| 52 | Calf Circumference | 8.2 | 8.5 | 8.8 |
| 53 | Ankle Circumference | 5.9 | 6.0 | 6.2 |
| 54 | Foot Length | 5.9 | 6.4 | 6.8 |
| 55 | Foot Breadth | 2.4 | 2.6 | 2.7 |

**Figure 5.** Anthropometric data of children aged 2-5 years  
(Society of Automotive Engineers, Inc.)

**Figure 6.** Anthropometric data of children aged 2-5 years  
(Society of Automotive Engineers, Inc.)
Figures 5-7 show that anthropometry are very important and will be the main indicator to determine every details in designing various facilities that will be used by the users. After the anthropometry data are matched, then it can be proceeded to the ergonomics study.

3.2. Ergonomic
Ergonomics can be interpreted as a science that concerns about safety, human comfort at work, at home, at school, and any place that requires humans to interact with the surrounding environment with the primary goal for humans to adjust to the surrounding environment [8]. The purpose and objective of the ergonomics discipline is to obtain a complete knowledge of the problems of human interaction with technology and its products, so that an optimal human-engineering system or technology is produced [9].

The main points regarding the discipline of Ergonomics are as follows:
- The focus of ergonomics;
- Ergonomics as a discipline concerned;
- The main aims and objectives of the Ergonomics discipline approach are directed at efforts to improve human work performance such as increasing work speed, accuracy, work safety, and to reduce fatigue.
- The special approach to ergonomic discipline of ergonomics has a significant role in determining the success of a work system.

Ergonomics is grouped into four areas of inquiry [10]:
- Inquiry into displays;
- Investigation of the capabilities of human physical strength (biomechanics);
- Investigation of the size of the workplace (Anthropometry);
• Investigation of the work environment with regard to the fields of inquiry, a number of disciplines in ergonomics are involved, such as:
  - Anatomy and physiology, structure and function in humans;
  - Anthropometry, body measurements;
  - Physiology of psychology, conditions and brain systems;
  - Experimental psychology, human behaviour.

Ergonomic Furniture for children which includes [11]:
• The height of the child's chair leg is the same as the child's foot length from the sole of the foot to the knee, so that the sole of the foot is flat with the floor and the bottom of the thigh does not compress the seat.
• Enough distance between the bottom of the table with the thighs of children;
• The elbow position is about the same height as the table top;
• The backrest is just below the shoulder blade;
• Enough distance between the back and the seat;
• Easy to manufacture and can be mass produced;
• Easy maintenance and easy to clean;
• Has a simple basic pattern, easy to combine or stand alone;
• Easy and concise to store and organize;
• Flexible so that the mobility of furniture is high.

Based on these ergonomics data and anthropometrics data, furniture design can certainly be more perfect and in accordance with the design goals. The next step is to find a method to process the collected data. One of the major products of any strategic planning process is a set of strategic goals and objectives. In this regard, the Goal Grid is a useful and flexible strategic planning tool.

3.3. Analysis with Goal Grid Method
As the structure of the Goals Grid suggest, there are four basic categories: Achieve, Preserve, Avoid and Eliminate. This structure can be used as a framework for generating goals and objectives. Also to classify, clarify and analyse an existing set of goals and objectives as part of the strategic planning process.

3.4. Achieve
• Table
  - Length and Width are suitable for Activities within 1 up to 4 people, either for side by side or opposite position.
  - Children from 2 to 3 years old with height (min) 90 cm – (max) 110 cm may do proper standing activities.
• Chair
  - The depth and width of seat are large enough for children aged 2-3 years.
  - For children with 110 cm height, they can sit comfortably on this chair.
• Storage
  - Each model length is long enough (120 cm), divided into several segments so that it can store the goods efficiently.
  - Children from 2 to 3 years can put their own goods at the bottom of the cabinet.

3.5. Avoid
• Storage shape that sharp angle may be dangerous to its user.
3.6. Preserve
- Table, chair and storage are made ergonomically so that it can be adjusted with child’s posture growth.
- Table and chair and storage are the main outdoor facilities, so it need to accommodate the safety and security such as eliminate sharp angle in its shape.
- Table, chair and storage are made in modular shape, so that it can be adjusted with learning activities (efficient and effective).
- Need additional rubber/stopper in each table’s foot, so it won’t move easily.

3.7. Eliminate
- Table
  - Children from 2 to 3 years old with height (min) 90 cm – (max) 110 cm may feel uncomfortable, especially in his/her elbows due to table height.
- Chair
  - For children less than 110 cm, they might face difficulties while seating. Their foots will be a bit hanging (bot tread the ground completely), thus, they might feel uncomfortable.
- Storage
  - To put item above the storage, they might face difficulties while trying to see or reach the item.

4. Conclusion
Anthropometry and ergonomics have important roles in early childhood schools that aim to fulfill children's preparation in education in terms of academic, social and emotional aspects. Furthermore, in education, it is undeniable that facilities are one of the main determining factors for the teaching and learning process in schools so that optimization, efficiency, health, safety, and comfort can be achieved as well for its users.

The research facilities focused on furniture located at the Playfield Preschool school classroom, West Jakarta. The furniture includes study tables, study chairs and storage areas for teaching and learning; which is the main facility in the classroom. The furniture are then analyzed using the Goal Grid method which consists of 4 parts (achieve, avoid, preserve and eliminate). From the analysis, it can be seen that the learning desk, learning chair, and storage area are already made with ergonomic measurements that can be adjusted with the child's growth and development in the future. As the main facility for children to carry out their activities in the classroom, these furniture have considered its functional and aesthetic factors, while also have paid attention to its safety, health, safety and comfort factors for users. In addition, the modular form is in accordance with the teaching and learning activities so that it can run efficiently and effectively.

With a good example, hopefully this research can be a reference or standard for parents and schools to really notice the importance of children's learning facilities at school and the industry to improve & develop the level of ergonomics towards early childhood learning facilities in schools in the future.

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