

Ergonomic Considerations in Design of Workstations in Primary Schools

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ABSTRACT

Nowadays, schools have an important role in children's lives because many students spend most of their day and childhood time there. On the other hand, as these school years are the years that children grow very fast and their bodies take shape, the furniture used in the primary schools can have serious effects on their body structures. Classroom furniture has changed during years according to important values such as student's needs and their physical and psychological requirements. The importance of providing ergonomic furniture in the primary schools is widely accepted now. The ergonomic furniture provides students with a better chance to maintain a correct body posture while doing their tasks in the classrooms. The noticeable issue which should be considered in school furniture design particularly the workstations (composed of chairs and desks) is that they should support students' bodies while attending in the classroom and doing all various kinds of tasks, to prevent further disorders such as back pain, pain in the wrists and neck region, and to reduce fatigue.

Moreover, due to variations in body dimensions and proportions in different societies, the furniture designed for the children in one society might not be suitable for the others in another region. Thus, the design and selection of this furniture should be done very carefully and based on proper information. Unfortunately, not much researches are available to designers (as well as authorities) involved in the process of design and selection of this kind of furniture. This shortage of information is even more serious in relation to Turkish children and the suitable school furniture for them. This research concentrates on the importance of using ergonomics furniture for primary school students and the effects of it on the students' learning and well-being.

The purpose of this study is to expose proper ergonomic guidelines which help designers to design and create school furniture which improves students comfort, performance, and behavior.

To achieve the above mentioned aims, all factors related to ergonomic workstations in schools such as posture, body measurements, safety, etc. were explored to create a theoretical base to characterize criteria which then were used to formulate a guideline to be used by the designers in this field. The checklist provides designers in Turkey and Cyprus with the necessary dimensions for design of workstations in this country's primary schools. It also can help designers in other regions to find the proper school furniture dimensions for their target populations as well, based on anthropometric data of each region.

Keywords: primary school, furniture design, ergonomics, anthropometry, physical health, north Cyprus

ÖZ

Günümüzde, okullar çocukların hayatlarında önemli bir rol oynamaktadır, çünkü birçok öğrenci günlerinin çoğunu ve çocukluk zamanlarını burada geçirmektedir. Öte yandan, bu okul yılları çocukların çok hızlı büyüdüğü ve vücutlarının şekillendiği yıllar olduğundan, ilkokullarda kullanılan mobilyaların vücut yapıları üzerinde ciddi etkileri olabilir. Sınıf mobilyaları, öğrencilerin ihtiyaçları ve fiziksel ve psikolojik gereksinimleri gibi önemli değerlere göre yıllardır değişmiştir. İlkokullarda ergonomik mobilya temin etmenin önemi artık yaygın olarak kabul görüyor. Ergonomik mobilyalar öğrencilere sınıflarında görevlerini yaparken doğru vücut duruşunu sürdürmek için daha iyi bir şans sağlar. Okul mobilyası tasarımında özellikle dikkat edilmesi gereken dikkat çeken konu, (sandalye ve masalardan oluşan) iş istasyonlarında, öğrencilerin bedenlerine destek olurken, her türlü görevi yerine getirirken, sırt ağrısı gibi rahatsızlıkların önlenmesi için, öğrencilerin bedenlerini desteklemeleridir.

Ayrıca, farklı toplumdaki beden boyutlarındaki ve oranlarındaki farklılıklar nedeniyle, bir toplumdaki çocuklar için tasarlanan mobilyalar başka bir bölgedeki diğerlerine uygun olmayabilir. Bu nedenle, bu mobilyaların tasarımı ve seçimi çok dikkatli ve doğru bilgiye dayanarak yapılmalıdır. Ne yazık ki, bu tür mobilyaların tasarımı ve seçimi sürecinde yer alan tasarımcılar (ve yetkililer) için pek fazla araştırma bulunmamaktadır. Bu bilgi eksikliği Türk çocuklarına ve onlar için uygun okul mobilyalar açısından daha da ciddi.

Bu arařtırma, ilkokul ğrencileri iin ergonomi mobilyalarının kullanılmasının nemi ve bunun ğrencilerin ğrenmesi ve iyi olma durumu zerindeki etkilerine odaklanmaktadır. Bu alıřmanın amacı, tasarımcıların ğrencilerin konforu, performansı ve davranıřlarını geliřtiren okul mobilyalarını tasarlamalarına ve tasarlamalarına yardımcı olan uygun ergonomik kuralları ortaya koymaktır.

Yukarıda belirtilen amalara ulařmak iin, okulda ergonomik iř istasyonları ile ilgili tm duruř, vcut lleri, gvenlik vb. faktrlerin, daha sonra tasarımcılar tarafından kullanılacak bir kılavuz oluřturmak iin kullanılan kriterleri karakterize etmek iin teorik bir temel oluřturduėu arařtırılmıřtır. Kontrol listesi, Trkiye'deki tasarımcılara bu lkenin ilkokullarındaki iř istasyonu tasarımları iin gerekli boyutları saėlar. Ayrıca, diėer blgelerdeki tasarımcıların, her blgenin antropometrik verilerine dayanarak, hedef poplasyonları iin uygun okul mobilyaları boyutlarını bulmalarına da yardımcı olabilir.

Anahtar Kelimeler: ilkokul, mobilya tasarımı, ergonomi, antropometri, fiziksel saėlık, kuzey kıbrıs

To my dear parents who are always in my mind...

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Chapter 1

INTRODUCTION

After the house, School is the most important place for children. Children spend most of their time in school from childhood to adolescence during the day. So, these places should be appropriate regarding safety and health. Physical conditions have an undeniable effect on human behavior, designing a proper physical environment in schools, can create a pleased and comfortable environment for students, and mutually reinforce the level of education and learning.

In other words, school is a large house where a large number of children and adolescents spend many hours of their precious life. School furniture should be designed in a way which encourages and attract students to use them for a long period of time, learn science and do different school tasks. In general, sufficient and comfortable furniture can increase students' performance.

One of the most important and effective tools to improve the physical quality of the school environment is to use ergonomics science. Ergonomic can be defined as:

“Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance. Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments, and systems to make them compatible with the needs, abilities, and limitations of people. Ergonomics helps harmonize things that interact with people regarding people's needs, abilities, and limitations.”
(URI 1)

Ergonomics science is to study the Relationship between human and objects, and the effect of that on lifestyle, to prevent physical and psychological human problems. This science helps human to improve the daily activities of life by providing the physical and mental health of individuals. Applying the principles of ergonomics in schools, can prevent disorders such as back pain, severe pain in the wrists and neck region, reduce and prevent fatigue. Furniture which is used in modern classrooms should be ergonomic and supportive. It means school furniture should be flexible, adjustable, durable, safe and most important than all it should be suitable for the body dimension of the children.

“Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. (Relevant topics include working postures, materials handling, repetitive movements, work-related musculoskeletal disorders, workplace layout, safety, and health.)” (URI 1),

In the past, the furniture in the classrooms was not ergonomic and flexible to move. Still, in many schools’, this kind of furniture is used. While, the traditional school desks and chairs were made with heavy materials, the new generation of school furniture are made usually from plastic, lightweight metal, and fabric.

Since the year 1890, many changes have been made in the design of school furniture (URL 2). These positive changes have been made to improve the health of students. The old furniture was made of wood or a combination of wood and metal. Most of this furniture was designed for two persons and was not easy to move. The process of these changes has been toward paying more attention to ergonomic requirements and to use the lighter material to facilitate furniture movement by students (appendix 3 demonstrates some examples of school furniture designs made since the end of 19th century and the evolution of this designs in the 20th century). The layout of the old

classes, due to the use of double benches, has often been traditional and rigid if the table and the chair were single, they were too heavy because of the weight of materials which were used in their production. So it was difficult to move them by students. Today's school furniture design considers ergonomics principles. These considerations have a direct effect on the pupil's physical health and provide an ability to change the classroom layout by movable furniture based on each classroom task and to create a collaborative environment. The task of ergonomic science in this field is to provide and make a suitable and standard environment for students at the school. But, many schools still do not have enough knowledge about these issues.

In this context, issues related to the design of supportive furniture for children and teenagers are more important because their body is in the period of growth and evolution. Students' desks and chairs are important products in the school environments in facilitating the learning process.

1.1 Statement of the Problem

School furniture is one of the main considerations in the design of primary school environments as it can seriously affect children's performance and health. While furniture design is still one of the ignored issues in many of educational spaces, the compatibility of furniture designs with educational needs of children has received more attention in interior architecture field more recently. Lack of comfortable and suitable workstations (chairs and desks) in primary schools for children between 6 to 11 years old is of high importance because, during this period, children are growing up fast. So the furniture which they use should support their anatomies. Unfortunately, musculoskeletal symptoms and low back pain are some of the most prevalent health problems experienced by school children across the world (Chung & Wong, 2007;

Currie et al., 2002). Children's behavior (Knight & Noyes, 1999) and performance have also been under the influence of using school furniture (e.g., Cheryan¹, Ziegler, Plaut, & Meltzoff¹, 2014). Therefore, school furniture has several major functions. According to Knight and Noyes (1999), school furniture is first used by students to do school work such as listening to the teacher, writing or drawing for which students may need to take different postures; second, they are used to give students a stable place where they can perform their works; they are also used to facilitate learning by creating a comfortable situation. Also, school furniture design affects the group work and interaction between students during different tasks in the classrooms.

Hence, it is vital to consider the design standards which directly affect the physical and mental health of children. These factors or criteria have been under investigation by researchers. They include, but not limited to factors such as anthropometrics (e.g., Carneiro, Gomes, & Rangel, 2007; Gouvali & Boudolos, 2007; Panagiotopoulou, et.al., 2004) and arrangement of furniture and classroom organization (Barrett, Davies, et.al., 2011; Kaya & Burgess, 2007; Moore, 2008; Rae & Sands, 2013).

However, most of the studies on the ergonomic design of furniture have addressed the design of furniture used in workplaces, have involved population other than school students, have included students in different age groups, or have studied only one or a few influencing factors. Therefore, there is a dire need to explore the factors which affect the design of furniture for school students to assure their physical and mental health. This requires a systematic review of both empirical and theoretical works and researches done in this area of study, and the present study is targeted to do so.

1.2 Objectives of the Research

Given the lack of a systematic review examining all the factors that should be considered while designing workstations for primary schools, this study is set out to identify factors which contribute to developing ergonomic furniture for primary schools by an extensive review of the literature. The existing data indicate a gap in the study of ergonomic furniture for children specifically in primary schools which should be bridged by more in-depth investigation of this issue.

The aim of this study is to investigate the ergonomic considerations in the design of primary school workstations and helping to develop a design guideline to be used by the designer of this furniture as an interior architecture in choosing proper furniture. Different kinds of furniture are used in the classroom. But the focus of this study is just on the student's chair and table. As they have the most direct impact on students' chair and desks.

The case studies have been chosen as sample to examine whether ergonomic rules are considered in these schools? To examine prepared checklist can help the implementation of ergonomic principles in school furniture? And how the prepared checklist can be used to designed to choose ergonomics workstation in school.

However, in the process of this study, no scientific research in this field on children of Turkey and Cyprus was found. In other words, there was no detailed information on the size and body dimension of the Turkish and Cypriot students and the required size of the school furniture in these regions.

1.3 Research Questions

This study intends to find a way to improve ergonomic workstations for students in primary schools. Based on the objectives of this study, this study seeks an answer to the following research questions:

What is the importance of furniture workstation design for primary schools?

What factors should be considered while designing ergonomic furniture in primary school's classroom?

1.4 Methodology

The primary method which is used in this research is a comprehensive literature review to identify the factors involved in making appropriate furniture. Literature review which is defined as “a systematic search of published work to find out what is already known about the intended research topic” (Robinson & Reed, 1998, p. 58) and is helpful for identifying what needs to be considered is suitable for the objectives of the study. This study is intended to be designed in a way that can be used in different regions and particularly for Turkish student's population.

However, the study also takes a step further and provides not only theoretical evidence, but also qualitative evidence by observing and analyzing furniture in some primary schools in Northern Cyprus based on the identified factors to examine the extent to which the furniture is designed based on ergonomic factors, and to determine if they are suitable for students of a particular age group.

1.5 Significance of the Study

The present study is significant because it tries to address an under-investigated topic:

Factors or standards of making ergonomically suitable furniture for primary school children. Identifying these factors hopefully assist interior designers to design furniture which improves students' comfort, performance and behavior.

Awareness about these critical factors and their influence on students also encourages manufacturing companies to stop producing traditional school furniture and try to design and build alternative furniture which not only fulfills physical expectations but is also comfortable and functional.

More importantly, this study indicates how classroom education is affected by furniture and how it can be enhanced by designing appropriate furniture because they have a direct impact on students' attention and engagement. Furniture selection and layout in the contemporary era should be done considering education in the 21st century which emphasize collaboration and problem- solving.

1.6 Limitations of the Study

Although this study has reached its purposes, there were some inescapable limitations.

Because of the time limitation, this investigation conducted just in some Famagusta's primary schools in Northern Cyprus. The target of this research is 6 to 11 years old students. The was schools visited during study time, and there are different activities in the classrooms. If the activities change, the classroom furniture arrangement might change too.

In this age range, students have different physical dimensions, so the use of one size of furniture and not regarding of the ergonomics principles will create various problems for student's health and their educational process. In Famagusta, primary

schools have different age groups. It means that in some schools they have only two or three grades of primary school levels.

Stature and height and other physical characteristics vary according to racial and ethnic characteristics. Therefore, the furniture designed for children in one region may appear non-standard and uncomfortable for students in another region.

Unfortunately, no proper study has been conducted for this age group in Turkey by Turkish or Cypriot researchers. During this study, the only body dimension of Turkish children that could be found in academic resources was related to stature (height), Popliteal height and weight. The other necessary dimensions were drive by the author. S.D. (standard deviation) and mean (average) other dimension is necessary to be able to create a proper guideline for the Turkish student population. There was no information about the students of Cyprus. For this reason, Turkish information was used. Because the population living in Cyprus almost has the same race and equally with Turkey. Also due to lack of time each class has been viewed once. In these observations only the furniture has been examined. Although in some of the classes photos of students postures were taken, there is not enough visual information about different postures of students in the classroom.

The other essential dimensions which are explained further in the related chapter. Of course, more thorough research by a scientist working in the field of anthropometry on this issue can provide designers with more accurate dimensions for mentioned furniture.

Chapter 2

ERGONOMIC CONSIDERATIONS IN DESIGN OF SCHOOL FURNITURE

2.1 The Importance of Ergonomic

Schools are one of the most important types of social and educational environments. Spatial qualities of schools can significantly affect the physical and mental development of children. Since inappropriate furniture will cause health issues, it is necessary to utilize suitable furniture in these spaces to create a healthy environment. Therefore, appropriate design of school furniture is still a research topic. In doing so, ergonomics is a useful scientific tool to help improve appropriate school furniture design. In the following sections physical aspects of furniture design, known as ergonomics and anthropometry, dynamics of sitting and measurements, will be explained specifically for the age group between 6 and 11. During this period, children grow up so fast, so if the furniture which they use cannot support their anatomies, students will face many health problems such as back pain (Chung & Wong, 2007; Currie et al., 2002).

The design is an issue closely bounded with humans regarding physical, psychological, cultural, economic and other aspects of life in addition to aesthetics. It is a tool for improving the quality of everyday life and preventing future physical illnesses. Design for children and teenagers is a delicate issue because they are in the ages of physical growth and psychological development. Hence, the physical environment within

which children spend time should provide safety and comfort in general. Ergonomics science provides appropriate basic information about human's physical attributes to improve the quality of design. Thus, to prevent physical problems in school children and to improve their performance and to provide a healthier environment, it is necessary to use ergonomics in the process of design.

According to the Merriam-Webster dictionary, ergonomics is “An applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely” (URL 3).

More specifically, for any type of space, the type of furniture that is going to be used should be designed ergonomically. Ergonomics as a science has different groups, Educational ergonomics, according to Onawumi, Oyawale, and Dunmade (2016):

“Is concerned with the interdependence of Education performance and design of educational facilities” and deals with “how and why design characteristics of the educational process and system influence variability in performance of participants in the system” (p. 94).

Furniture that is frequently used in educational spaces should include certain qualities and features to help the improvement of students' performance at schools. Oyewole, et al. (2010) mention that comfortable classroom furniture not only minimizes distraction but also improves the learning process since the performance and behavior of children can be simply controlled. Moreover, Zunjic et al. (2013) state that ergonomics increases the quality of education in three ways:

- 1) By maintaining students' health
- 2) By creating a comfortable learning environment
- 3) It adjusts the process of education based on students' abilities

In other words, considering ergonomic rules in the design of school furniture can improve postural comfort and dynamics of sitting by using suitable furniture dimensions based on each age and size.

Ergonomics issues related to the design of school furniture particularly workstation (desks and chairs) such as dynamics of sitting, posture, safety, and comfort will be discussed in the following parts.

2.2 Posture in Classroom

According to the Cambridge Dictionary, Posture is: “The way in which someone usually holds their shoulders, neck, and back, or a particular position in which someone stands, sits, etc.” (URL 4)

Generally, the specific positions in which individuals put their bodies in order to perform statically is called the posture. According to ergonomics, there are desirable or undesirable postures.

Knight & Noyes (2014) mention that, the main functions of furniture in classrooms are to support the students while attending the class and also to support them while listening, writing or drawing. These functions have different requirements regarding the physical position of students' bodies. While writing or drawing, the spinal flex forward in a curved position. Also, most people are unable to sit erect in 90-degree posture for long periods and soon adopt a slumped posture (Bennett, 1928) (Figure1). It causes fatigue and pain in the spine. Also, the head in the downward position causes pressure on the neck (Figure2). Therefore, the chair and the table should be designed to support the spine and neck in various positions. Round shoulders is a general

disturbance of the body's balance, involving lower thoracic spinal posture, head posture, pelvic posture, and arm posture (Bennett, 1928) (Figure2).

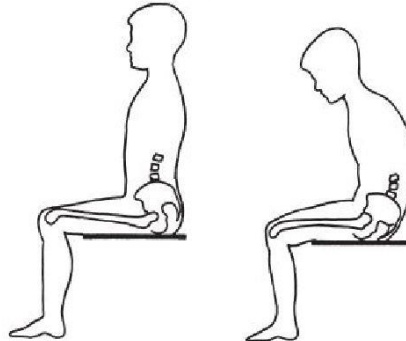


Figure 1. Comparison between 90-degree seating and flex forward spinal seating (Bennett, 1928)

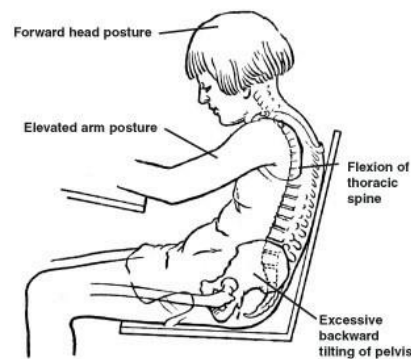


Figure 2. The spinal flex forward in a curved position (Bennett, 1928)

The other function of school furniture is to create a space in which children can stay in comfortably to be supervised and ordered easily in the classroom and also to minimize chances of distraction. Furthermore, school furniture should provide comfortable workstations in order to facilitate learning and decrease the level of stress. For achieving the mentioned qualities, Glover (1994) suggests that school furniture should be designed in a way that allows students to move about their workstations; and as Laville (1985) mentioned, immobilization of students while attending classes can cause localized muscle fatigue and pain.

A Research is done in 2008 by the Furniture Industry Research Association, known as FIRA. The purpose of this research is to increase awareness of the issue of inappropriate school furniture. FIRA has released a report within which it is mentioned that children spend about 15000 hours in the sitting position during the educational years in school mentioning that, around 13% of the children in the age range of 10-16 significantly experience persistent back pain. By the age of 16, this statistic is considered in the criteria of the adult age group. This condition could be the result of various factors including inappropriate seats that don't match with the body proportions of children, and the wrong height of the utilized tables in classrooms (FIRA, 2008 cited in Banfield, 2012).

The diagram related with posture theory, created by Max Banfield (2012) (Figure 3), illustrates: “a man sitting at a desk leaning forward to read”; and he summarizes what occurs to the human body while sitting on unsuitable and non-ergonomic furniture.

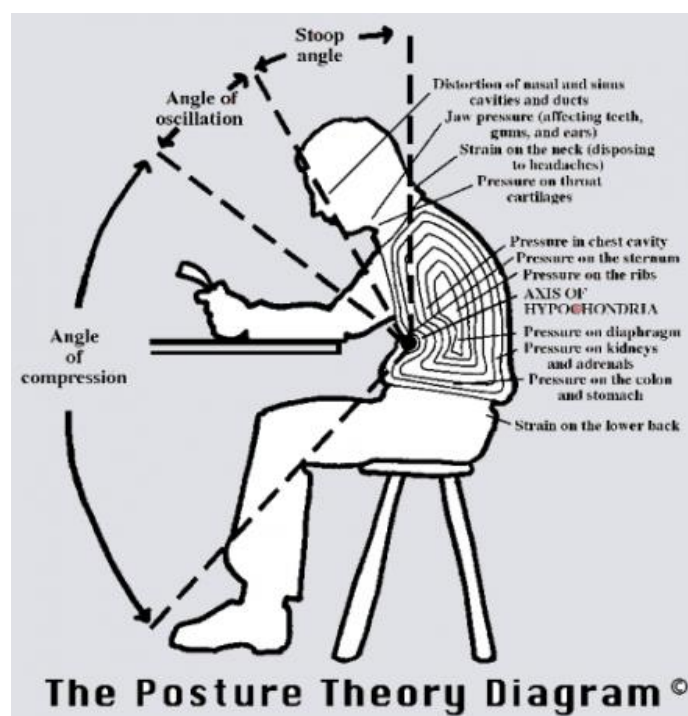


Figure 3. The Posture Theory Diagram (Banfield, 2012)

Poor seating posture is a posture when shoulders and head flex forward of the spine and puts a strain on the joints and muscles. consequences of this posture are neck and back pain and some physical problems for spine (Banfield, 2012).

The straight dash lines on the left show the movement of the body while leaning forward; and the curved line, also on the left, illustrates the external pressure created on the body. There is a large point in the middle which is the point from where the upper body rotates, leaning forward or backward, while slouched at the waist. The lines illustrated inside the body are representing the way in which mechanical pressure puts an effect on the internal organs and structure while the person is leaning forward. The text on the right side of the image indicates different symptoms as the result of such pressure and movements (Banfield, 2012).

Some poor sitting postures affect the body according to the above Posture Theory Diagram as below (Figure 3):

- Straining to the neck (resulting headaches)
- Putting pressure on the chest cavity
- Pressuring the sternum
- Pressuring the ribs
- Pressuring the diaphragm
- Straining the lower back (Banfield, 2012)

In the interest of a healthy and harmonious physical, emotional and mental development, ergo dynamically designed work areas have to meet the following criteria:

- Chair and desk form a unit that can be adjusted to the student's height
- The chair has to fulfill the student's need to move
- The chair has to adapt to various activities (Banfield, 2012)

The next step after recognition of the mentioned issues is to identify important details related to posture.

2.2.1 Types of Sitting in the Classroom

Postural positions while seated come in various types. According to Floyd and Ward (1969), there are three major types of posture frequently observed:

- i. Sitting with lying on the backrest; the times when just one arm rests on the desk or the time when both arms are far from the table
- ii. Sitting with the body inclined forward
- iii. Sitting while leaning forward with both arms on the desk

On the other hand, Domljan et. al. (2010); And Panagiotopoulou, et. al. (2004) mention that, students spend a lot of time in the classrooms in the seating posture. Therefore, their posture can also be affected by the activities that they perform during school hours. Working postures are influenced by task chairs, teachers' behavior, time, age and gender and the postures varied among children.

In the sitting posture, the heavy weight of the body falls on only 26 cm² of the surface, and it causes high pressure on ischial parts of the body (the bone on pelvis), which is not a stable support system. Hence, in order to decrease the pressure on this part of the

body and to have a more stable posture, other body parts such as legs, feet, and hands should be involved. Moreover, the normal anterior curve of the lumbar vertebrae, which is referred to as lumbar lordosis, transfers some of the weight to the posterior thighs. Thus, chairs with rearward sloping backrest are more suitable for sitting (Keegan, cited in Parcell et al., 1999).

Sitting can be considered as a dynamic act. It cannot be considered as static even within the time of fixed activities such as writing. A person moves and changes sitting position while writing. Children, also, should be posited in a correct position in the time of their writing activities in the classroom. The appropriate positioning typically suggests a general 90/90/90-degree position on the hips, knees, and feet. Therefore, for making the posture of the seated child while writing, there are some proper positions suggested as follows:

The factors that are included in proper posture during writing are:

- Fixation at the hips with an upright back
- Sitting straight in a way that the student is posited in a perpendicular line with the desk
- Legs located parallel neutrally positioned
- Feet floating above the floor
- Dominant arm abducted a little at the shoulder while the elbow is bent
- Elbows located even with the surface of the desk
- Wrists slightly stretched supporting the person to hold the pencil functionally
- Non-dominant arm is abducted a little with a bent elbow, which enables steadiness and re-positioning of the paper. (URL 5)

In general, although furniture may invoke a particular sitting position, particular types of sitting by children can also cause discomfort for them. The school furniture was usually hard and one-size-fits-all desks, which are still popular in some schools around the world because their production is easier and cheaper. However, more recent investigations indicate that appropriate sitting postures are fundamental to human health; and right posture prevents excessive stress and load on body organs such as muscles, and bones and musculoskeletal symptoms. (Zunjic et al., 2013) Therefore, there should be an increasing effort to design ergonomic furniture and foster habits of correct sitting among children. In order to do so, investigation on seated posture and its related issues is the first step.

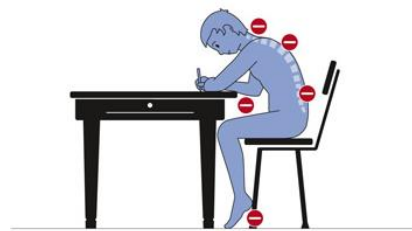


Figure 4. Round shoulders while writing (URL 6)



Figure 5. Seating posture while listening(URL6)

Seating in 90-degree position makes a correct supportive posture (Figure 6), but figure 4 shows round shoulders while writing position by flexing the spinal forward. It causes fatigue and pain in the spine, and pressure on the neck by the downward position of the neck. Also, figure 4 illustrates incorrect posture, because the head is in the forward

position. So there is pressure on the neck. Also, spine flexions in prolonged seating should cause the back pain and fatigue.

According to Breithecker (2007) two steps are necessary to define the correct posture in adjustable furniture:

Chair: Seat height should be adjusting somehow which front edge of the seat is approximately level with the lower part of the kneecap. The angle between the torso and the thigh should be marginally larger than 90° . Both feet should support by the floor with full contact. When student seat in backward position, the front edge of the seat should not press on the lower leg. When student seats in a listening posture, the backrest should support the back below the shoulder blades.

Desk: Sit sideways next to the desk and let the arms hang down. Bend the arms in a 90° angle. The elbows must be near 2 to 3 centimeters lower than the desktops front edge (Breithecker,2007) (Figure 6).



Figure 6. Chair and desk adjustment (Breithecker,2007)

Adjusting chair height and table height based on student stature to have an ergonomic work area prevent physical pains and problems(Breithecker,2007) (Figure 7).



Figure 7. Ergonomic work area (Breithecker,2007)

There is no pressure on the neck and spine. This is the correct posture for seating in the classroom (Breithecker,2007) (Figure 7).

2.2.2 Issues and Factors that Affect Seated Posture in the Classroom

Seated posture in the classrooms is affected by some external factors such as the design of furniture. On the other hand, there are factors related to the children and their behavior that should be taken into consideration too. Murphy, Buckle, and Stubbs (2004) explain that: “School furniture is designed for students to sit and work with a 90° flexion of the hip joint and a preserved lumbar lordosis (p.114)”.

But the children use it differently. Using the Portable Ergonomic Observation method (PEO) developed by Fransson-Hall et al. (1995) they recorded the sitting postures of children in the real-time classroom. Children were found to sit in very different positions in the classroom regardless of their furniture which was either too high or low for them. But, still, there are numerous factor to be considered while designing and selection of school furniture.

According to Mandal (1982), improvement of seated body posture had occurred mostly because of the misunderstood design principles that suggested the following four:

- i. Lack of support for lumber
- ii. seat with backward sloping
- iii. low chair
- iv. low desk

Moreover, chairs with proper height and depth prevent students from flexion of knees, bending forward and feeling unstable. Knees and elbows are two body parts that play a major role in studying posture. According to Parcell et al. (1999), the low height of the chairs causes students' feet to hit chair legs, forcing them to stretch their legs forward. Similarly, the low height of elbow rest enforces excessive pressure on the posterior neck musculature to keep the head steady. Therefore, parameters related to a sitting posture are considered riskier and harmful for the human body than standing posture.

Moreover, prolonged sitting makes children tired, so they try to change their posture to find a better position and feel more comfortable; in fact, "Human body is built to move about, not to remain still. There is not any prolonged position (sitting, standing, lying or other positions) of a body which could be comfortable and painless after a period" (Domljan, Vlaovi, & Grbac, 2010, p.40).

Movement is an essential part of seating. Nowadays most office chairs have designed to allow dynamic sitting while most school chairs have remained rigid. When students cannot move freely, they have to create their postures by, for example, frequent change

of position or leaning the chair back on two legs (British Council for School Environment, 2008).

On the other hand, as Domljan (2010) claims, there are two distinct groups of issues and factors in posturing related to the furniture. There is furniture poorly-designed in some cases, and there is incorrect usage of furniture. These issues and factors can be briefed as listed below: Usage of old furniture that is not designed according to standards:

- a) Intensified growth curve of children in the last fifty years
- b) The traditional approach to purchasing only two sizes (low and high) classroom furniture
- c) Limited budget of schools
- d) Fixed furniture design which promotes static sitting (Domljan et al., 2010)

2.2.3 Postural Comfort in the Classroom

The design of school furniture should aim to enhance children's comfort since it is essential to their effective performance. Generally, sitting posture is more comfortable than standing posture. Thus chairs and other seating furniture are one of the most important tools for children (Onawumi, Oyawale & Dunmade, 2016). Many children have painful experiences in writing, painting, and learning in the classroom which is rooted in uncomfortable seating.

These standards can extensively guarantee the physical safety of the chairs and desks designed for children. However, safety is not the only essential factor to qualify the school furniture for use. On the other hand, comfort is another matter to be considered during the selection of furniture for classrooms.

In general, the purpose of design in the case of school furniture is to improve the conditions of sitting and improve the quality of performance for students in the class. However, the mentioned issues are not the only aims of furniture design for classrooms. There are other issues that are important to be considered in order to achieve a legit level of quality in design as a whole.

Therefore, there should be an increasing effort to design ergonomic furniture and foster habits of correct sitting among children. In order to do so, investigation on seated posture and its related issues is the first step.

2.3 Anthropometry of Primary School's Students

There are certain data needed in order to design furniture for schools. One of the essential sets of data is related to human body dimensions. The science that provides designers with the necessary data on body dimensions is called Anthropometry.

“Anthropometrics are a set of non-invasive, quantitative body measurements used to assess growth, development, and health parameters. Anthropometric measurements, including length or height, weight, and head circumference, help providers determine if a child is growing properly and can indicate when the child's health and well-being are at risk. Additionally, anthropometric measurements assist providers in selecting appropriate treatment options for children and adolescents.” (URL 7)

Information obtained from anthropometric measurements is applicable in different fields, such as sports, health, etc. Given the high prevalence of back problems among school children, researchers have become interested in anthropometric measurements of this age group in order to help them cope with the related health problems, which stem from the furniture they use. This section summarizes the results of studies that have taken anthropometric measurements of 6-11 children who use school furniture.

2.3.1 Importance of Anthropometry in Primary School Furniture Design

In a survey-based study, Mokdad and Al-Ansari (2009) examined the anthropometric parameters of 1174 Bahraini students within the 6-12 age range. They measured the students' six body dimensions including popliteal height, popliteal-buttock length, hip breadth, shoulder height, elbow height, and knee height. It was found that Bahraini students had a different body size compared to those of the other nationalities, and also had a gradual body growth from 6 to 12 years of age. Thus, in order to avoid physical injuries starting at early ages and to design appropriate school furniture, obtaining anthropometric data of this type are crucial and should be considered by the designers.

In a similar study by Castellucci, Arezes and Viviani (2010) with 195 students in the eighth grade, eight dimensions of school furniture and six anthropometric body characteristics were measured. Similar to most other studies, there was a mismatch between body dimensions and furniture characteristics, and also in the results were found by Gouvali and Boudolos (2006), there was a mismatch between student's body dimension and furniture dimension.

Likewise, in a more recent study, Salunke and Kallurkar (2017) found a mismatch between classroom furniture design and the anthropometric parameters of students in three schools in India. The researchers investigated the degree of match between the dimension of school furniture as set by Bureau of Indian Standards and ergonomic design principles in IS 4837:1990, and anthropometric dimensions of the Indian students. The analysis was done using Ergonomic Quality Assessment Index (EQAI), proposed by the researchers. Ten students from every division of each standard (5th-10th) were randomly selected. The dimensions of the school desk were examined in

the frame of the recommended standard values. It is found that some desks at school were in critical risk zone (i.e., risk levels for different body postures).

All these researches demonstrate the importance of using correct anthropometric data in the design of school furniture, and the consequences of using desks and chairs with inappropriate dimensions in the classes. On the other hand, the above researches show that the problem of mismatch between the furniture dimensions and body dimensions of children is a rather worldwide issue.

2.3.2 Essential Anthropometric Data for Designing School Chair and Desk

Designing a school's desk and chair should cover different sizes of students and should be suitable for all of them. From the ergonomic point of view, the proposed sizes for the desk and chairs must be such that students be able to use them in an appropriate and comfortable situation and to be able to do their works with high performance.

Anthropometric measurements are used for various purposes, one of which is pertinent to school furniture. In order to design ergonomically suitable furniture, using suitable anthropometric data (body measurements) and the correct percentiles of certain body parts such as elbow height, knee height, and buttock–popliteal length are essential. Percentile range defines that proportion of a population with a dimension at or less than a given value. For example, 95th percentile means 95 percent of the population has less than this anthropometric data value. 5th percentiles mean 5 percent of the population has less this anthropometric data value. Several studies investigated this issue majorly by examining body dimensions (Figure8) in relation to furniture dimensions (Table1) (Altaboli, et. al .2015; Altaboli, et. al. 2015; Carneiro, Gomes & Rangel, 2017; Chung & Wong, 2007; Gouvali & Boudolos, 2006; Moktari & Al-Ansari, 2009; Oyewole, Haight, & Freivalds, 2010).

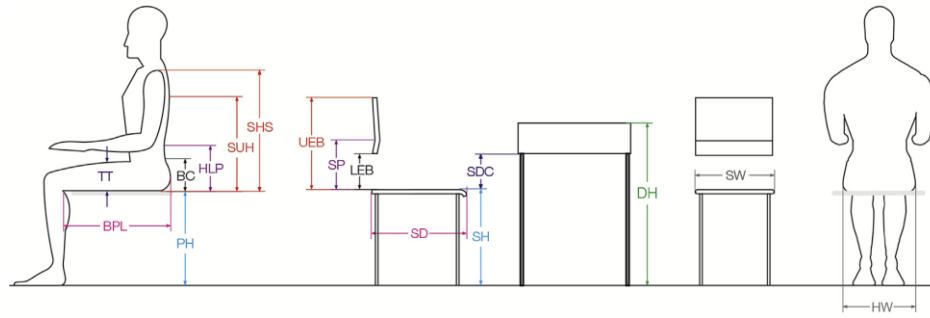


Figure 8. Relevant anthropometric variables for classroom furniture sizing and its correlation with the furniture dimension (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

Table 1. Components of chair dimensions and its description (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

| Dimension | Description |
|-------------------------------|---|
| Seat height | Vertical distance from the highest point on the front of the seat to the floor |
| Seat width | The horizontal distance between the lateral edges of the seat. |
| Seat depth | The vertical distance from the back of the sitting surface of the seat to its front edge. |
| Backrest height | The vertical distance from the sitting surface to the top edge of backrest. |
| The distance between armrests | The vertical distance between two internal edges of the armrests. |
| Desktop-seat height | The vertical distance from the sitting surface to the upper edge of desktop. |

As can be seen in the table above when designing furniture for children or adjusting furniture to the correct fit for individual children the most important measurements are:

Seat height: Popliteal height is the correct seat height. This dimension is taken from the floor to the back of the knee when the student is seated with horizontal thighs and vertical lower leg with feet supported by the floor. (Figure 1). As a principle, using a short chair for tall men is less harmful and more comfortable than using the high chair for short people. Therefore, based on anthropometric dimensions, it is generally recommended that the height of the seat be equal to the female 5th percentile popliteal height of the racket in the target community.

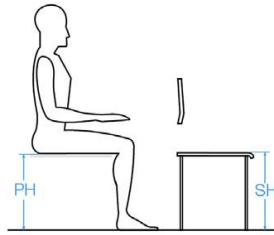


Figure 9. Correlation between popliteal height (PH) with seat height (SH) (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

Seat depth: To define this dimension Buttock-Popliteal Length is used. The recommended dimension is based on the female 5 percentile of the Buttock- popliteal Length(Figure 2) (Carneiro, V.Gomes, Â., & Rangel, B., 2017).

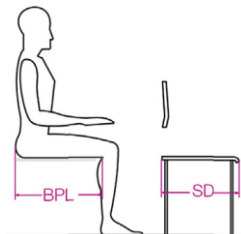


Figure 10. Correlation between the buttock-popliteal length (BPL) with seat depth (SD). E (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

Seat width: To explain seat width dimension, a measure of Hip Width is used. The standard is for single-seated armchairs, and the recommended size is determined by a female 95 percentile of female Hips width (Figure 3). (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

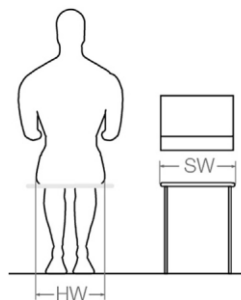


Figure 11. Correlation between the hip width (HW) with seat width (SW). (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

The upper edge of the backrest: It is measured from the lowest point at the seating surface to the highest point located on the back of the seat(Figure 4). To explain this dimension, Shoulder Sitting Height should be considerate on. According to Pheasant (1984), the upper edges of the support should be roughly up to 100 mm below the shoulder height, so that the shoulders are not restrained. (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

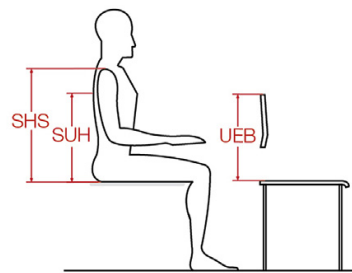


Figure 12. Correlation between subscapular height (SUH) or shoulder height sitting (SHS) with the upper edge of the backrest (UEB) (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

Desk height: Usually, the upper surface of the table is placed horizontally. If sloped, its slope should be between 10 and 15 degrees. Most researchers recommend that the height of work should be commensurate with the height of the elbow in the sitting position or slightly less than that. The basis of the work is that the higher level of work requires lifting the arm and causing fatigue. The height of Lumbar Point (HLP)= Sitting Elbow Height (SEH)

This anthropometric assessment is helpful to design ergonomic classroom furniture which is not only adjustable to the children dimensions but also increases the level of wellbeing and relaxation for students.

A mismatch between furniture and body dimension result in inappropriate sitting postures. Observations of primary school children in Panagiotopoulou et al.'s (2004) study highlighted that to cope with wrong furniture dimensions; students are driven to change their sitting postures. For example, when chairs are too high or low, children sit on the edge of the seats and put their buttocks forward to be able to read and write. In another occasion, when the chair was high for the elbow rest, children were impelled to lift their shoulders and arms up. Or as seen in, if the seat depth (SD) is too much pushback of the knee, it will make the blood circulation in the legs and feet difficult (Figure 5) (Carneiro, V.Gomes, Â., & Rangel, B., 2017).

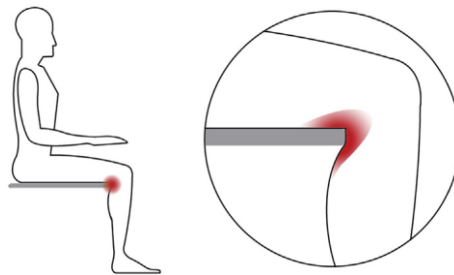


Figure 13. Relation between seat depth (SD) and the buttock-popliteal length (BPL) (Carneiro, V.Gomes, Â., & Rangel, B., 2017)

Regarding all the above discussions about different important parameters of furniture design, there is another important factor to be considered. All the issues mentioned above are related to children with healthy physical conditions. It is worthy to mention that many design factors will change according to physical disabilities of the user. Design of school furniture for disabled children, for sure, includes different considerations and will give a different outcome. Therefore, it can be considered as another type of design for a special group of users.

Solution to solve the problems associated with the unsuitability of school furniture according to students' dimension is to design new furniture according to each region defined standards.

2.3.3 Universal Chair and Desk Sizes for the 6-12 Age Group

BS EN 1729 is a British standard for school's furniture. This standard is to make sure that schools furniture is comfortable and suitable for students. BS EN 1729 purpose is to find a universal size for different age groups and mark color coding, to be used in easily identifying different chair sizes. Adjustable furniture should support two or more size marks based on the standard (Table 2).

Table 2. Classroom furniture sizing based on different age group (BSI,2012)

| COLOUR CODE | ORANGE FEET | VIOLET FEET | YELLOW FEET | RED FEET | GREEN FEET | BLUE FEET |
|------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| SIZE MARK | 1 | 2 | 3 | 4 | 5 | 6 |
| AGE RANGE | 3 - 4 | 4 - 6 | 6 - 8 | 8 - 11 | 11 - 14 | 14 - Adult |
| POPLITEAL HEIGHT RANGE | 250 - 280 | 280 - 315 | 315 - 355 | 355 - 405 | 405 - 435 | 435 - 485 |
| STATURE RANGE | 930 - 1150 | 1080 - 1210 | 1190 - 1420 | 1330 - 1590 | 1460 - 1765 | 1590 - 1880 |
| STANDING TABLE HEIGHT | 590 | 710 | 760 | 900 | 1000 | 1000 |
| TABLE HEIGHT | 460 | 530 | 590 | 640 | 710 | 760 |
| CHAIR HEIGHT | 260 | 310 | 350 | 380 | 430 | 460 |

Table 2 and figure 14 show suitable table heights and seat heights of different size marks. This size marks and color coding are divided into seven parts and colors are based on the age groups. This chart includes three years old to adults. This guide shows the body measurements of each age group and the necessary dimensions of desk and chair. This information is for guidance to design or choose the correct furniture for the classroom (Figure 6).

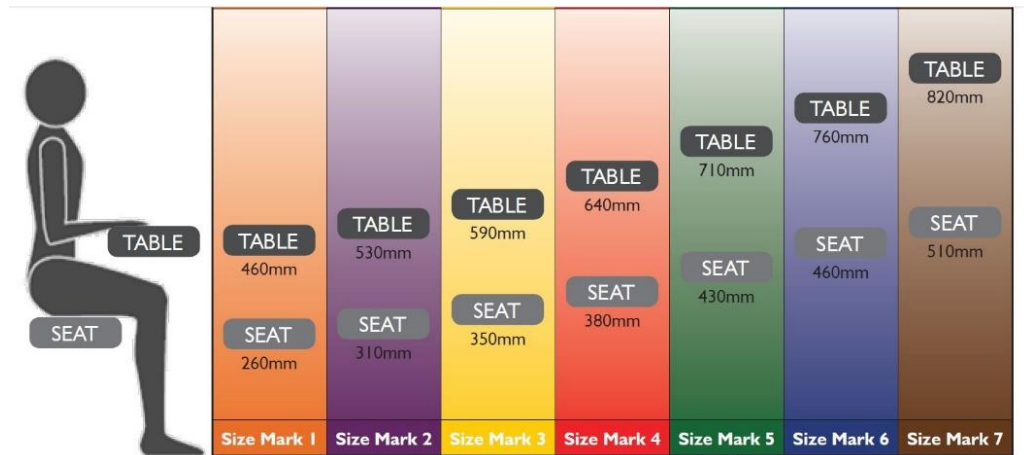


Figure 14. Size marks and color coding, seat heights and table heights suitable for various age groups (BSI, 2012)

The deficiencies that are created by the mismatch of the children body dimensions and furniture sizes has led some researchers to suggest the design of adjustable furniture. In section A.4 of BS EN 1729 in ‘Adjustable desk and chairs Requirements’ part, the criteria about the design of adjustable furniture are listed as below:

- Adjustment controls shall be designed so that;
 - a) All users have easy access;
 - b) Can control the easily without requiring specialized tools or excessive force.
- Adjustable furniture should cover two or more size marks. It should have the potential to recognize the color codes or size marks of the adjusted chair and desk.
- Adjustable desk and chair designed to cover a different variety of size marks should have complied with the dimensional requirements of each size mark which is covered.
- Adjustments could be in fixed steps or persistent.
- When two different workers sharing a double desk may need different height, adjustable desks are more appropriate for one user.

2.3.4 Gender Differences in the Design of Furniture for a Primary School Age Group

Some researchers have pointed to gender differences in the design of furniture for this age group. Jeong and Park (1990) administer an observation with male and female school children. Due to the differences that were found between male and female students regarding their BMI (Body Mass Index) and body dimensions. Accordingly, the researchers indicated that boys generally required higher desks and chairs whereas girls needed chairs with larger depths and breadths.

Similar results were found by Mououdi and Choobineh (1997) who took anthropometric measurements of 17 parts of 1700 randomly selected male and female children between 6-11 to analyze their fitting to the school furniture in various provinces of Iran and observed significant differences between the two genders according to the measured dimensions.

Moreover, in another study, Chung and Wong (2007) studied primary students between 10 and 13 years of age in order to understand the appropriation of school furniture for the children's anthropometry in Hong Kong. The anthropometric measurements indicated that girls had lower BMI and wider hip breadth in both sitting and standing positions. While seat depth was found to be suitable for most of the students, the height of the seat was unsuitable for almost all of them. Therefore, in order to find out proper solutions for these differences, it is necessary to go into the detail of their related dimensions and get suitable results for anthropometric design.

2.3.5 Anthropometrics Data Related to Turkish Primary School Children

There is a lack of data about dimensions of children's body parts in Turkey to be used in the design or choosing ergonomic school furniture. Although there are some studies

about the stature and weight of students in Turkey, it doesn't include the dimensions necessary to design furniture. In one study which done by Neyzi, O., Bundak, R., et. al. (2015) realized in Turkey stature and buttock-popliteal lengths of children in different age ranges and different genders are investigated and the 3rd, 10th, 25th, 75th, 90th and 97th percentile values for each range is defined. But the other necessary dimensions to be used in a chair and table design such as popliteal height, etc. are not given in this study.

On the other hand, in another study done or school age children in Ankara, 19 different body dimensions of boys and girls and their standard deviations and means have been determined. (Table3-4). Based on this research, there are no significant differences in mean body sizes in each age group between girls and boys either. (Hastürk, E. Y., & Usta, İ. , 2014)

Table 3. Mean and standard deviation for boys (Hastürk, E. Y., & Usta, İ., 2014)

| Dimensions | Age | | | | | | | | | | | |
|---------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | |
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| A: Height | 1220 | 71.1 | 1271 | 65.9 | 1317 | 79.9 | 1388 | 77.1 | 1441 | 76.7 | 1480 | 70.1 |
| B: Eye Height | 1116 | 65.1 | 1167 | 60.5 | 1224 | 74.3 | 1284 | 71.2 | 1339 | 71.2 | 1376 | 65.3 |
| C: Shoulder Height | 994 | 58.4 | 1035 | 53.6 | 1087 | 66.1 | 1142 | 63.5 | 1191 | 63.4 | 1238 | 58.9 |
| D: Elbow Height | 727 | 42.4 | 754 | 39.0 | 798 | 48.5 | 840 | 46.6 | 879 | 46.8 | 925 | 43.9 |
| E: Elbow-Hand Extremity | 295 | 17.2 | 307 | 15.9 | 326 | 19.8 | 344 | 19.2 | 357 | 18.9 | 368 | 17.4 |
| F: Forward Arm Reach | 468 | 27.3 | 494 | 25.4 | 517 | 31.4 | 540 | 29.9 | 563 | 30.0 | 587 | 27.9 |
| G: Maximum Vertical Reach | 1458 | 85.0 | 1530 | 79.3 | 1622 | 98.4 | 1694 | 94.1 | 1762 | 93.8 | 1831 | 86.8 |
| H: Thorax Depth | 150 | 8.8 | 153 | 7.9 | 159 | 9.7 | 162 | 9.0 | 168 | 8.9 | 173 | 8.2 |
| J: Side Arm Reach | 530 | 30.9 | 559 | 28.9 | 582 | 35.3 | 612 | 33.9 | 639 | 33.9 | 666 | 31.5 |
| K: Maximum Bideltoidale Breadth | 285 | 16.6 | 290 | 15.1 | 297 | 18.0 | 314 | 17.5 | 324 | 17.3 | 335 | 15.8 |
| L: Elbow to Elbow Breadth | 342 | 19.9 | 355 | 18.4 | 374 | 22.7 | 382 | 21.2 | 409 | 21.8 | 435 | 20.8 |
| N: Hipbreadth | 246 | 14.4 | 259 | 13.5 | 276 | 16.8 | 279 | 15.5 | 298 | 15.9 | 318 | 15.2 |
| P: Buttock to Knee Length | 411 | 23.9 | 433 | 22.5 | 457 | 27.7 | 477 | 26.5 | 501 | 26.7 | 525 | 24.8 |
| R: Buttock to Popliteal length | 339 | 19.8 | 359 | 18.7 | 379 | 23.1 | 397 | 22.0 | 416 | 22.1 | 438 | 20.8 |
| S: Height, Sitting | 650 | 37.9 | 672 | 34.8 | 694 | 42.2 | 722 | 40.1 | 746 | 39.8 | 765 | 36.3 |
| T: Knee Height | 370 | 21.6 | 390 | 20.2 | 412 | 25.0 | 431 | 23.9 | 449 | 23.9 | 469 | 22.2 |
| U: Popliteal Height | 312 | 18.2 | 329 | 16.9 | 346 | 21.1 | 359 | 19.9 | 373 | 19.8 | 390 | 18.5 |
| Y: Acromion Height | 400 | 23.3 | 419 | 21.8 | 437 | 26.6 | 458 | 25.5 | 477 | 25.4 | 485 | 23.1 |
| W: Weight | 25.5 | 1.39 | 30.6 | 1.60 | 32.6 | 1.78 | 35.7 | 2.19 | 42.0 | 2.29 | 46.4 | 2.44 |

Table 4. Mean and standard deviation for girls (Hastürk, E. Y., & Usta, İ., 2014)

| Dimensions | Age | | | | | | | | | | | |
|---------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | |
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| A: Height | 1230 | 71.6 | 1280 | 69.7 | 1332 | 68.6 | 1373 | 83.8 | 1448 | 76.9 | 1479 | 77.0 |
| B: Eye Height | 1122 | 65.0 | 1172 | 67.5 | 1224 | 66.0 | 1264 | 81.6 | 1338 | 75.3 | 1358 | 70.9 |
| C: Shoulder Height | 1002 | 58.5 | 1038 | 56.5 | 1086 | 55.9 | 1085 | 66.3 | 1191 | 64.1 | 1219 | 63.9 |
| D: Elbow Height | 727 | 41.8 | 760 | 41.4 | 795 | 40.9 | 824 | 50.3 | 879 | 46.6 | 905 | 47.1 |
| E: Elbow-Hand Extremity | 295 | 17.2 | 302 | 16.4 | 329 | 16.9 | 324 | 19.8 | 362 | 19.2 | 372 | 19.4 |
| F: Forward Arm Reach | 472 | 27.5 | 496 | 26.9 | 519 | 26.8 | 534 | 32.7 | 564 | 30.0 | 581 | 30.3 |
| G: Maximum Vertical Reach | 1473 | 85.8 | 1559 | 84.8 | 1632 | 83.9 | 1681 | 103 | 1778 | 94.5 | 1824 | 94.9 |
| H: Thorax Depth | 151 | 8.9 | 157 | 8.5 | 162 | 8.4 | 165 | 10.1 | 172 | 9.1 | 174 | 9.2 |
| J: Side Arm Reach | 538 | 31.3 | 564 | 30.7 | 587 | 30.2 | 608 | 37.1 | 645 | 34.2 | 664 | 34.6 |
| K: Maximum Bideltoideal Breadth | 284 | 16.7 | 292 | 15.9 | 299 | 15.3 | 313 | 19.1 | 325 | 17.2 | 331 | 17.3 |
| L: Elbow to Elbow Breadth | 347 | 20.3 | 363 | 19.7 | 379 | 19.6 | 386 | 23.5 | 412 | 21.9 | 428 | 22.3 |
| N: Hipbreadth | 248 | 14.5 | 262 | 14.2 | 269 | 13.8 | 281 | 17.2 | 292 | 15.6 | 298 | 15.6 |
| P: Buttock to Knee Length | 409 | 23.9 | 429 | 23.4 | 451 | 23.3 | 468 | 28.6 | 501 | 26.7 | 517 | 26.9 |
| R: Buttock to Popliteal length | 335 | 19.5 | 352 | 19.2 | 369 | 18.9 | 384 | 23.5 | 409 | 21.8 | 424 | 22.0 |
| S: Height, Sitting | 655 | 38.2 | 677 | 36.9 | 697 | 35.9 | 710 | 43.3 | 731 | 38.9 | 736 | 38.3 |
| T: Knee Height | 370 | 21.6 | 389 | 21.2 | 411 | 21.3 | 427 | 26.1 | 454 | 24.1 | 468 | 24.4 |
| U: Popliteal Height | 312 | 18.1 | 327 | 17.9 | 346 | 17.8 | 358 | 21.8 | 379 | 20.2 | 391 | 20.4 |
| Y: Acromion Height | 403 | 23.5 | 421 | 22.9 | 434 | 22.4 | 447 | 27.3 | 470 | 25.0 | 470 | 24.5 |
| W: Weight | 25.7 | 1.53 | 29.3 | 1.59 | 32.8 | 1.70 | 36.1 | 2.21 | 40.9 | 2.17 | 44.5 | 2.32 |

But in this research also only the mean values (average) and standard deviations (“the degree of variability in the population concerned, i.e. the ‘width’ of the distribution or the extent to which individual values are scattered about or deviate from the mean” (Pheasant, 1984, p.17) are given which are not enough for designing the furniture as in design of chair and desk mostly 5 percentile and 95 percentile values are used. On the other hand, using mean and standard deviation values, it is possible to derive the other percentages.

In one study present the formula to calculate the correct dimensions of furniture based on the mean and standard deviation values (Hari Purnomo, Fajriyanto et .al., 2016) (Table5).

To calculate correct furniture measurement these applications of anthropometry in characterizing chair and desk dimensions should be considered.

- Seat height has been designed based on the Popliteal Height. The female 5th percentile of the Popliteal Height has been choosing,

- Seat depth has been determined based on the of Buttock Popliteal length. The female 5th percentile of the Buttock Popliteal length has been considered.
- For seat width Hip Breadth has been considered, the female 95th percentile of the Hip Breadth has been adopted to guarantee that pupils with large hips would be able to sit comfortably.
- The upper edge of the backrest has been designed based on Sitting Shoulder Height with a male 5th percentile of the Sitting Shoulder Height.
- The desk height has determined with Sitting Elbow Height.

Table 5. Seat and desk size conforming to anthropometry (Hari Purnomo, Fajriyanto and Rina Mulyati, 2016)

| Seat and desk sizes | |
|----------------------------|--|
| Dimensions | Measurement |
| Front seat height | Mean of PH – (1.645 × standard deviation (Std. dev))+ 2 cm |
| Seat depth | Mean of BPL – (1.645 × Std. dev) |
| Seat width | Mean of HB + (1.645 × Std. dev) |
| Upper edge of backrest | Mean of SSH – (1.645 × Std. dev) |
| Backrest length | Mean of SB – (1.645 × Std. dev) + 2 cm |
| Front desk height | Mean of SEH + 10 cm + Front seat height |
| Desk width | Mean of SB + (1.645 × Std. dev) + twice the forearm length |
| Desk depth | Mean of ULL – (1.645 × Std. dev) + 5 cm |
| Floor-to-desk clearance | Mean of KH + 1.645 (Std. dev) + 2 cm |

Based on these formulas and the values taken from the study by Hastürk, E. Y., & Usta, İ. (2014) The correct furniture dimensions for each age group in Turkey have been calculated. The related detailed calculations are presented in Appendix 2. The continuation of this chapter defines the correct chair and desk dimensions for Turkish children.

As was mentioned above, in this study Turkish Children's Mean (average) and S.D. (standard deviation) values are taken from tables 4 and 5. The formula which mentioned in table 5, can help to achieve correct dimensions in different regions with different anthropometric data. These data together give information that is needed to calculate proper furniture dimension for primary school's pupils in different age ranges.

Table 6. Seat height

| Seat height: Mean of PH – (1.645 × standard deviation (Std. Dev)) + 2 cm | | | | | | | | | | | |
|--|--------|---------|--------|---------|--------|----------|--------|----------|--------|----------|--------|
| 7 years | | 8 years | | 9 years | | 10 years | | 11 years | | 12 years | |
| Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 302 | 302 | 321 | 317 | 331 | 336 | 346 | 342 | 360 | 365 | 379 | 377 |

Table 6 shows the proper Seat height for school chairs for 7 to 12 years old students. These dimensions were achieved based on *Seat height: Mean of PH (Popliteal Height) – (1.645 × standard deviation (Std. Dev)) + 20mm* formula. 2 cm which is added to the end of the formula is for a student's shoe height. All of the measurements are in millimeter (mm).

Table 7. Seat depth

| Seat depth: Mean of BPL – (1.645 × Std. Dev) | | | | | | | | | |
|--|--------|---------|--------|---------|--------|----------|--------|----------|--------|
| 7 years | | 8 years | | 9 years | | 10 years | | 11 years | |
| Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 306 | 302 | 328 | 320 | 341 | 337 | 360 | 345 | 379 | 373 |

Table 7 shows the Seat depth for 7 to 11 years old Determined based on Buttock-Popliteal Length (BPL).

Table 8. Seat width

| Seat width: Mean of HB + (1.645 × Std. Dev) | | | | | | | | | |
|---|--------|---------|--------|---------|--------|----------|--------|----------|--------|
| 7 years | | 8 years | | 9 years | | 10 years | | 11 years | |
| Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 289 | 291 | 301 | 305 | 323 | 311 | 324 | 330 | 344 | 337 |

Table 8 shows the Seat width standard dimension for 7 to 11 years, old students. Hip Breadth (HB) dimension.

Table 9. Upper edge of the backrest

| The upper edge of backrest: Mean of SSH – (1.645 × Std. Dev) | | | | | | | | | |
|--|--------|---------|--------|---------|--------|----------|--------|----------|--------|
| 7 years | | 8 years | | 9 years | | 10 years | | 11 years | |
| Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 361 | 364 | 383 | 383 | 393 | 397 | 416 | 402 | 435 | 428 |

Table 9 shows the standard dimension of Upper Edge of Backrest, Determined from Sitting Shoulder Height (SSH).

Table 10. Desk height

| Desk height: Mean of SEH + 10 cm + Seat height | | | | | | | | | |
|--|--------|---------|--------|---------|--------|----------|--------|----------|--------|
| 7 years | | 8 years | | 9 years | | 10 years | | 11 years | |
| Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| - | - | - | - | - | - | - | - | - | - |

There is no significance information about Sitting Elbow Height of Turkish population. Table 10 shows the measurement of desk height based on SEH, to which near 10 cm has been added to eliminating pressure while reading and writing. Sitting Elbow Height (SEH)= Height of Lumbar Point (HLP)

To sum up, each table above shows one of the standard chair and desk dimensions for various age groups of students. These values can be used in evaluating the dimensions of desks and chairs in Primary schools in Turkey.

2.4 Other Considerations about School Furniture

Apart from the above-mentioned issues and data, there are other important issues that directly affect the design of school furniture (Figure 7). These issues vary from posture related factors to safety; and also physical qualities that have an impact on the functionality of the school furniture. The other important matter is the consideration of disabled children and the consequences of their conditions. All these issues are also very effective in the design and manufacturing of school furniture.

2.4.1 Safety of Classroom Furniture

Safety is a matter that usually comes to the foreground in most of the design processes as an essential quality. According to Merriam Webster Dictionary, safety is defined as: “the condition of being safe from undergoing or causing hurt, injury, or loss” (URL 8).

Here it is useful to define safety within the framework of design and also regulations related to school furniture. In ergonomic school furniture, four main factors must be considered which mentioned in the below figure 15.



Figure 15. Ergonomic school furniture (URL 9)

There are some general safety requirements or standards set out for ‘Quality Management’ (BS EN 1729-2 2012) that all chairs should adhere to (cited in Griffith, 2013, p. 72):

- a) Rounded edges with at least 2 mm chamfer on the front part of the seat, armrests and all parts which are in contact with the user’s body while sitting on the chair;
- b) All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth.
- c) Adjustment controls should not activate accidentally or unconsciously;
- d) Parts shall not be detachable without the use of an appropriate tool;
- e) Chairs should not overturn. The chairs should be designed with a base that holds the center of gravity in different positions of the user. ("Domestic furniture, Seating, Determination of stability," 2005 Edition, March 1997)
- f) Chairs should not show any structural fracture which is able to affect safety while tested for durability. And also they should be functional after a structural failure.

The human body is a common issue apart from the variety of cultures and races, and so on, thus some rules and principles apply to create safety standards for furniture design. Regarding the principles set by the Department of Defense Education Activity (DoDEA), 21st-century school furniture is healthy and safe if they meet the following conditions:

- To be made of a non-toxic, non-irritant and non-carcinogenic material with no negative influence on indoor air quality or human health
- Can be frequently sanitized and cleaned because they are in constant contact with multiple users
- Can promote movement and physical activity in the classroom or even outdoors; because the movement is useful for posture, focus, alertness, physical health, and individual work habits
- To be designed, considering safety features, particularly adjustable and movable lightweight furniture
- To be posited within layouts that do not block fire and emergency exits

2.4.2 Thermal Comfort in Classrooms Furniture

There is a heat exchange between the body and the environment including the furniture used by people. The material that the chair is made of should be capable of heat exchange helping the body to sustain its normal temperature. Permeability, or ventilation quality of the material, and the thermal conductivity of the material are factors that influence the heat exchange in furniture surfaces (School Furniture Handbook, 1979). Moreover, three body parts that are found to be "most influential group" affecting by thermal comfort are back, chest, and pelvis (Zhang, 2003, cited in Hedge et al., 2005).

On the other hand, as stated in *School Furniture Handbook* (1979, p. 95), there are two elements of comfort associated with body heat stability:

- Avoiding the large areas of the body from contact with the surface without the vents, and increasing the permeability of chair materials to allow more evaporation heat loss using materials with high thermal conductivity when cooling is important

Some researchers have tried to evaluate the thermal comfort of different chair types. McCullough Olesen and Hong (1994) assessed the insulation value of seven chair types. Chairs with solid seats and backs had a value between 0.1 –0.3 clo; and a value of 0.87 for overall clothing insulation was identified.

More recent studies evaluate modern adjustable heated/cooled chairs that allow people to adjust their body temperature using personal comfort systems. These chairs incorporate two fans in the back and seat bottom which provide cooling airflow (Hedge, Saito & Jagdeo, 2005); however, their use in educational contexts is still very limited. These chairs have usually found to be appropriate compared with other types of chairs such as mesh chair and cushion chair (Hedge et al., 2005).

Another aspect of comfort deals with how students feel when their bodies are in contact with school furniture. Usually, couches and soft seats are not designed to be used in the classroom. The fabric used to make this sort of furniture usually: “cannot be disinfected and must be discarded in the event of spills, infestations or the presence of bodily fluids” (URL 10).

Therefore, the choice of fabric is very important when it comes to educational settings. The fabrics used in classrooms should be moisture and stain-resistant.

Many school furniture has traditionally been made of wood and metal or plastic and metal. Wood is “an organic material, a natural composite of cellulose fibers embedded in a matrix of lignin which resists compression” (Arakistain & Barrado, 2012, p. 1). Wood has several advantages that make it a suitable material to be used in manufacturing furniture. As Arakistain and Barrado (2012) argue, wood contributes to the warmth and comfort of the atmosphere, is environment-friendly and so on; and also has a soothing interaction with skin and acts as an insulator. The warmth from one’s hand or skin can be transferred to the wooden surface to make it warm unlike the other materials such as metal, which remains cold and forces the need for the use of the additional heating system in low temperature. These materials are suitable for children’s furniture since “they are strong, long lasting and can be colored to appeal to children” (McGarry, 2013, p. 15).

2.4.3 Disabled Children in Regular Classrooms

The physical disability of the students is not the same, and they do not fit into a common spectrum. Some disabilities do not detrimentally harm people and do not disrupt life. For example, a student with a physical disability has the opportunity to study in regular schools and among other students (Figure 16). Physical conditions for schools and classes should be provided for students with disabilities.



Figure 16. A pupil in wheelchair working at his desk (URL 11)

Those children enter public schools and therefore should attend in usual classroom conditions. In order to face the challenges of education for them, school designers must delve into broader concepts of accessibility to provide them with maximum comfort in an educational environment.

Modular furniture is an important element that can increase the versatility of spaces. Work tables can be multifunctional in order to support various activities to people with wheel chair in the classroom such as individual work, group projects, and class discussions. As well as data outlets must be put within instructional spaces. This type of arrangement provides enough flexibility in applying instructional technology. Versatility, though, will create flexibility in both teaching and learning processes.

There is an issued called universal design, which means, in schools, serving people with temporary or permanent alternations in mobility and perceptual insight. Design requirements for disabled people are almost the same as for others. Within the design and manufacturing/ construction processes, those requirements might be compromised because of economic considerations, aesthetic concerns, and other issues. An average person might adapt to such changes, but disabled people could face problems. Universal design indicates that school furniture should amplify the comfort and

minimize potentials for injuries, eye problems, and distraction by excluding lumps and creating rounded edges.

Students with slight physical disabilities should be kept at regular schools. This way, they become familiar with the school space, which is a sample of the communities' atmosphere; and this prevents future frustration while confronting the society. Disabled people are a part of the society and better not to be separated from the ordinary majority of the society in order to learn how to deal with their lives in communities.

Chapter 3

ARRANGEMENT AND ORGANIZATION OF FURNITURE

In this sections, issues related to the arrangement and organization of furniture including standards of 21st century's school furniture arrangement (LS3P Research, 2012, pp. 1-4), the most recent classroom layouts, the concept of territoriality, and effects on student behavior and performance are explained.

3.1 Standards of 21st Century's School Furniture Arrangement

“Every part of classroom furniture inside the classroom must reflect the pupil's specific requirements who will be in this classroom during the school year” (Eash, 2005, p. 29). In different forms of classroom arrangement, students can experience different degrees of territoriality. The arrangement of the classroom can also contribute to their interaction with different class members and affect their performance in different ways. In a report entitled ‘*Facilities for 21st Century Learning*’ prepared by the Department of Defense Education Activity (2011, cited in LS3P Research, 2012, pp. 1-2), three guiding principles have been established for K-12 facilities.

“The K to 12 Program supports Kindergarten and first 12 years’ education to prepare appropriate time for mastery of concepts and abilities and prepare alumnus for next levels of education, entrepreneurship, employment, and middle-level skills improvement.” (URL 12)

K-12 facilities set out to:

1. Create student-centered settings for the learners, and this could be a paradigm shift to move the focus from teachers. This shift aligns with present behavioral patterns that are influenced by technological advancements
2. Be flexible and adaptable: these types of spaces and furniture can be altered throughout the school day and during a longer period. These spaces are required to accommodate the student-centered arrangement and technological facilities and teaching methods and
3. *Be global community-centered within the school and embracing the local and global community:* Improve capabilities of interacting within a diverse but increasingly connected world, while incorporating local cultures and communities (LS3P Research, 2012, p. 1-2)

Above principles have some implications for the selection and arrangement of classroom furniture as outlined below:

- Furniture that suits learning activities
- Furniture which supports innovative teaching styles and varied learning styles and (Figure 17);
- Furniture which meets the physical requests of pupils to help preserve them healthy, comfortable and engaged in learning;
- Furniture that fosters a sense of community
- Furniture which maximizes utilization of classroom space and meets expectations of sustainability criteria and budget (LS3P Research, 2012, p. 3)



Figure 17. A Levine Academy Classroom with Interchange Diamond Desks Configured in Three Different Ways. Used in conjunction with Cascade Mega-Towers (URL 13)

There are some benefits of using flexible seating layout regarding the physical, emotional and academic progress of students:

- Choice: the learning process will be faster while students have control over their surroundings
- Community: they will learn how to share supplies and to take turns
- Collaboration: students will be able to get into group works easily
- Movement: they can change position by sitting, kneeling, leaning, rolling, etc. and release their excess energy and build core strength simultaneously
- Comfort: the more comfortable students are, the more focused and relaxed they will be
- Sensory Input: students' sense of touch is stimulated by flexible seating positions
- Motivation: students will be motivated to find and keep their favorite places

By achieving such standards and their benefits, it will be more appropriate for the students in the contemporary schools to get healthier and more appropriate education. (URL 12)

3.2 Classroom Layout Types

The degree to which students feel comfortable in the classroom and can easily interact with their peers and with the teacher depends on how furniture is arranged in the classroom (Kaya & Burgess, 2007; Martin, 2002). Therefore, seats and other furniture should be placed in a way so that they promote movement and interaction in the classroom environment. Classrooms generally have four common layouts including horseshow, clusters, chairs in a circle, and traditional, which are described below. Whereas the traditional layout has been dominant across the majority of contexts across the world, more modern learning philosophies and psychological as well as cognitive considerations, gradually paved the way for other forms of classroom layout and furniture arrangements to comply with standards or principles of K-12 facilities (URL 12). The most common classroom arrangements and their corresponding functions are explained below.

3.2.1 The Horseshoe

In the horseshoe or semi-circular layout, the seats in a class have a U-shaped layout, or they are arranged in the form of a horseshoe (Figure 18-19). This classroom layout allows putting a lot of desks in a small space. It also facilitates both student-to-student and teacher-to-student interaction. In other words, not only all class members can interact and work with each other but also the teacher can walk around the class and work with each student. This arrangement is less teacher-centered and usually suitable for class discussions and presentations. However, this arrangement can spread out

children in a way that it would be hard to address all of them and to make them engage in group work since moving the chairs would be difficult (Nayeem, 2015).

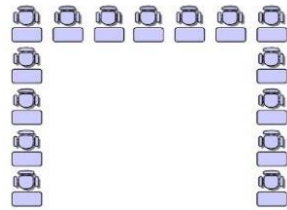


Figure 18. Horseshoe

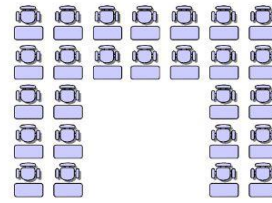


Figure19. Double Horseshoe

3.2.2 Clusters

Clustering the desks to form small groups stimulates student-to-student interaction.(Figure 20-21) Typically, this arrangement is used to give students the opportunity to collaborate, practice communication skills and engage in group works. These small clusters offer safe and relaxed environments to students to share their ideas and experiences. However, some disadvantages are recognized in this form of arrangement. According to Nayeem (2015), this arrangement type can cause the groups to engage in off-task and make a lot of noise and, as a result, it makes classroom management challenges. Also, it would be difficult for the teacher to explain new ideas and thus it disrupts learning.

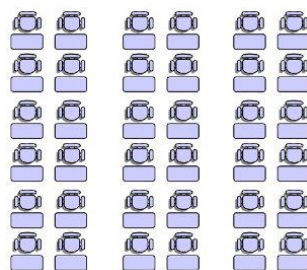


Figure 20. Groups Clusters

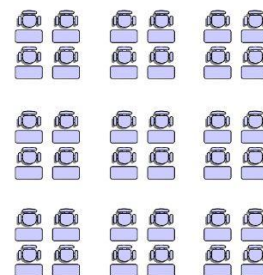


Figure 21. Pairs Clusters

3.2.3 Chairs in a Circle

Circle or half circle arrangement of chairs in the classroom has only one circle row, and anyone in this row is at the front (Figure 22). Circle arrangement can encourage all students to participate in the classroom activities and more importantly encourages social interaction because “The circle has become a universal sign of alliance and simply sitting in this shape(circle) promotes the similar effect” (Pease & Pease, 2006, p. 339). Also, the teacher can have full control over the class as he/she can see all the students, reach them, and communicate with them. This layout is very conducive to group discussions, pedagogical games, introducing new students at the beginning of the class, and high interaction among students. Nevertheless, when there are a large number of desks, this arrangement is not suitable for making a circle locates students so far from each other (Nayeem, 2015).

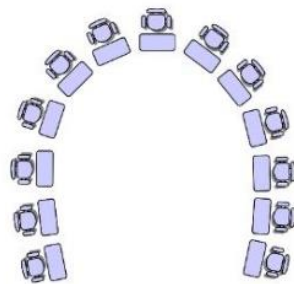


Figure 22. Roundtable

3.2.4 Traditional Layout

The traditional classroom, which is characterized by the rows (or column) configuration has typically been the most typical classroom layout (Figure 23). Although this layout allows accommodating many students in a small space and teacher can maintain eye-contact with all the students (Nayeem, 2015), this arrangement represents teacher-centered teaching where the interaction among students is minimal, and most of the class time is spent mainly by the teacher lecturing

in front of the classroom. Moreover, students are more focused on the individual, rather than a pair or group coursework, and less confident students have a tendency to occupy the back rows, and it makes them even less active and more silent (Nayeem, 2015). Since interaction in these classes is difficult, it contributes to uneven levels of interaction with students sitting in the front row usually concentrate and participate more in class activities than those in the back rows.

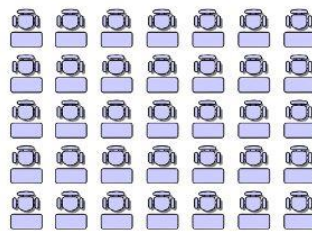


Figure 23. Traditional

3.3 Territoriality in Classroom

Kaya and Burgess (2007) redefine the term ‘territoriality’ originally defined by Altman and Chemers (1980, p856) as: “a behavioral mechanism that individuals utilize to establish and regulate social contact through territorial markers”.

They further explain that physical dimensions such as the arrangement of furniture can affect students’ defensibility and the way they orient themselves in the classroom, their on-task behavior, and social interactions.

Classroom layout has traditionally been divided based on territorial concerns, that is, space structured by individual desk ownership or functional concerns, that is, space organized by a certain activity (Lackney & Jacobs, 2002). As stated earlier, the traditional classroom arrangement suggests a teacher-centered classroom.

In these classrooms, chairs or desks are arranged in rows facing the teacher's desk implying that listening to the lesson and didactic teaching strategies the center of instruction. On the other hand, non-traditional classroom layouts or functional arrangements are student-centered, and seats are arranged in a cluster and U-shaped layout. Such arrangements are usually feasible in small size classes, and they allow students to perform a variety of tasks (Budge, 2000; Kaya & Burgess, 2007; Lackney & Jacobs, 2002; Martin, 2000). However, in all types of layouts, students show territoriality often by putting their personal belongings such as a bag on their chair. Moreover, students tend to occupy seats with higher territoriality, for instance, seats at the head and end of a row (Kaya & Burgess, 2007).

3.4 Effects on Student Behavior and Performance

As indicated in the previous sections, classroom arrangement is highly related to functions expected students to perform in the classroom. Therefore, classrooms should be arranged appropriately to enhance student learning and comfort.

In an early study investigating this topic, Weinstein (1977) administered an experimental study to explore changes in students' behavior after some modifications were made to the physical design, including the arrangement of furniture. The participants of this study, 25 second and third graders, worked in an area called the 'Tile' that contained filing cabinet, two student's desks, teacher table and a 'corner' in which a small table and a student desk were placed.

The students decided themselves where to work on their assignments. After preliminary observation, students' behavior was coded, and problems with the design and the learning environment were identified. The five identified problems were:

- First, students did not locate evenly across the room
- Second, students especially girls tended to avoid science and game areas
- Third, very few behaviors were observed in the given areas
- Fourth, the manipulative materials placed in the room were hardly used by the students
- Fifth, students used the reading area for looking at people, communicating, etc., than for studying purposes

Then, the second phase of the study started, and some changes were made to the classroom in order to solve these problems which included the rearrangement and addition of furniture and some color changes to make the environment more attractive. Comparing the classroom before and after the changes were made showed that the changes were able to modify student behavior desirably.

Three specific behavioral changes were identified:

- First, spatial patterns were changed, and students went to areas that where they previously did not
- Second, they indicated more behavior than before
- Third, they showed some behaviors with higher frequency

The researchers concluded that some of the undesirable behaviors were due to poor designs (e.g., conflict due to locating the block area in a traffic lane), and some reside within the students (e.g., providing study carrels for easily distracted individuals) which can be effectively removed by environmental and design changes.

Marx, Fuhrer, and Hartig (1999) compared two seating arrangements, the traditional row and column versus semi-circular, among the 25 Germany fourth graders over an 8-weeks period. The classroom was equipped with 15 tables and 30 chairs. Children first sat in a semicircular arrangement and after that in a row-and-column format. The researchers' observations and the recorded verbal interactions indicated a difference in children's question and answered behavior, with children asking more questions in the semicircular arrangement where the orientation of students' seats was closer to each other; and this facilitated their interaction. However, when sitting in both T- and triangle-shaped action zones in the row-and-column arrangement, students the rate of questions asked by the students sitting in the central positions was more than both sitting in non-central positions.

Similarly, Guardino and Fullerton (2010) studied whether changing the arrangement of furniture can result in changes in student behavior in an elementary school in the southeastern United States. Before the investigation. A fourth-grade class had several reports of misbehaviors including refusing from writing the assignments and throwing objects. Therefore, in the first phase of the study, the disruptive behaviors and engagements with academics were identified through observation. In the second phase of the study, some modifications including changing the seating arrangement, adding of materials and creating clear pathways were made to the classroom environment. The results of these modifications were quite positive, for example providing chair bags helped students to arrange their supplies and keep their pace of work and thus prevented them from leaving their supplies. Overall, students' academic engagement increased by 45%, and a reduction was observed in the rate of disruptive behaviors.

The results of the reviewed studies generally suggest that school furniture arrangement has the potential to affect a student's behavior in the classroom. Therefore, it is important to arrange the seats according to students' needs to contribute to their academic performance and reduce the frequency of misbehaviors.

Chapter 4

ANALYSIS OF CASE STUDIES IN NORTH CYPRUS, FAMAGUSTA

This thesis investigates the ergonomics issues about school furniture in primary school age ranges of Turkish students in North Cyprus.

The aim of this case study is to implement the designed checklist to evaluate the ergonomic features of furniture in primary schools in Northern Cyprus. It aims to see whether the existing ones fit the target population or for characterizing this subject anthropometric data is essential, but anthropometrics is an extensive topic and needs specialized studies on body measurements by experts. which is beyond the scope of this study. So in this study, existing data has been used. This chapter defines a case study, and it introduces a process of research, tools of data collection, analysis of the data and presents the evaluation tables of the results.

In general, this chapter is set out to evaluate factors which contribute to designing ergonomic furniture for primary schools by observation and test various cases based on existing data.

4.1 The Context of the Case Studies

The research context is the primary schools of Famagusta city, in Northern Cyprus (Figure 24). They have been chosen to collect the data of school furniture that this research needs.

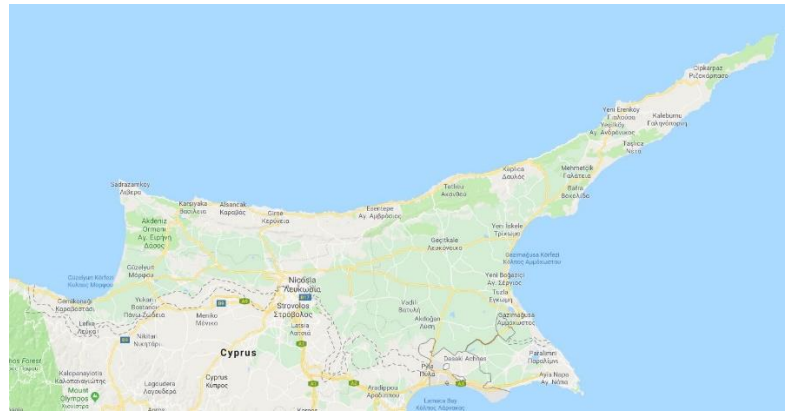


Figure 24. Northern Cyprus map(URL14)

Primary schools in Northern Cyprus generally provide 5 years of education for pupils between 6 to 11 years old (URL 15).

Nine primary schools are existing in Famagusta city. Six of them were selected) (more than 50 % randomly) to study (Table 11). All chosen schools except one are governmental schools. Permission was asked from all school's administrations, but only six schools agreed to cooperate in this research. The table below shows the list of the schools which were observed and some general information about these. In total 10 classrooms in these schools were observed the furniture. Some of the schools the full serve the full range and some have a few classes.

Table 11. Primary schools and number of classes that were selected as case studies

| School name | Number of the classroom which observed | The age range of students |
|--------------------------|--|---------------------------|
| Karakol primary school | 1 | 7-8 |
| Canbulat primary school | 1 | 7-8 |
| Polatpaşa primary school | 3 | 8-11 |
| Gazi primary school | 2 | 9-11 |
| Alasya primary school | 2 | 8-10 |
| Doğu Akdeniz Doğa | 1 | 8-9 |

4.2 Research Methodology of Case Study

This research has a qualitative research method. This thesis aim's is to examines the applications of ergonomic considerations design of workstations in primary schools in North Cyprus. As the first part of the study, literature review to identify ergonomic factors which involved in making appropriate classroom furniture was concluded. According to the literature reviews, In the previous chapters, a checklist containing the required data has been prepared. Based on this checklist, three tables for data analysis were prepared. As a part of the study, several schools were selected in Famagusta. Data were collected through direct measurements and observation. In these observations, it is tried to examine the fit between the furniture and the students. These tables provide enough information to conclude and evaluating data. In the following part, the planned tables are demonstrated.

The first table introduces location and general information about each case (Table 12).

Table 12. General information

| | | |
|--------------------|--|--------------|
| School name | | Description: |
| Location | | |
| Number of students | | |
| Range of ages | | |
| Ownership | | |
| Location | | |
| | | |

The second table is designed to compare the essential measurements of school furniture and measurements of existing school furniture (Table13). Based on international size marks of children, that was mentioned in chapter two, this table had to be prepared in three different age groups. This table identifies the match and mismatch between school furniture and students.

Table 13. Identifying match between school furniture and students

| Dimensions | - years old | | | Furniture figures and photos |
|---------------------------|-----------------------|--------------------|-----------------|------------------------------|
| | Recommended dimension | Observed dimension | Match/mis match | |
| Seat height | | | | |
| Seat width | | | | |
| Seat depth | | | | |
| Seat pan-armrest distance | | | | |
| Backrest height | | | | |
| Desk height | | | | |
| Desk width | | | | |
| Desk length | | | | |

In the third table of these data analyses, the factors related to how school furniture support students body postures while attending in the classroom, and guide them to sit in a correct position to prevent physical problems are illustrated (Table 14). The table also include the issues related to safety, comfort and organization layout.

Table 14. Factors related to students' body postures while attending in the classroom

| | | | |
|--|--|--|--|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | |
| | | The back should be supported in the lumbar area | |
| | | Feet should be well supported(full support for the feet) | |
| | | Head and neck should remain upright when not writing | |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | |
| | | The Desk should be modified to the student's height. | |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | |
| | | The chair should fulfill the need to move of the pupils. | |
| | | The chair should absorb the student's body moisture due to perspiration | |
| | | Work areas should enough for each student. | |
| | | Highly accessible furnishings for all students including those with disabilities. | |
| | | There should be a normal heat exchange between the chairs and students body. | |
| | | The materials that used in chairs should not have high thermal conductivity. | |
| Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | | | |
| All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | | | |
| Chairs should be unattached and movable in the classroom | | | |
| Use of modular tables. | | | |
| The chair should allow for various combinations | | | |
| Ergonomics | Seats are organized as clusters. | | |
| | Seats are organized as semicircular. | | |
| | Seats are organized as traditional. | | |
| | Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | | |
| | Each desk should placed for easy access to material of different tasks | | |
| | Tables should be re-arrangeable, and they are not too large/heavy. | | |

| | | | |
|--|--|--|--|
| | | Chairs should be re-arrangeable, and they are too large/heavy. | |
| | | All students should easily seen by the teacher at all times. | |
| | | Tables for groups of 4-6 to work easily. | |
| | | Desks should arranged in a way that each student can see and participate in classroom tasks. | |

The continuation of this chapter examines the match or mismatch between Turkish student's body dimensions and school furniture dimensions which are used in six different schools in Famagusta city.

4.2.1 Case 1

The first case is Doğu Akdeniz Doğa primary school (Table15). The students of this school are between 6 and 11 years old. This school manager did not give permission to view many classes as well as to take a photo of students. The teachers of this school mentioned that all of the furniture in this school are the same regarding design but there are three different sizes for different age groups. One of the classes at this school was observed. In this class, the students were between 8 and 9 years old.

Table 15. General information of Case study1

| | | |
|-----------------------------|-------------------|--------------|
| School name | Doğu Akdeniz Doğa | Description: |
| Location | Famagusta city | |
| Range of ages | 6 to 11 | |
| Number of observed classes | 1 | |
| Age of classroom number one | 8-9 | |
| Ownership | Private | |

Location

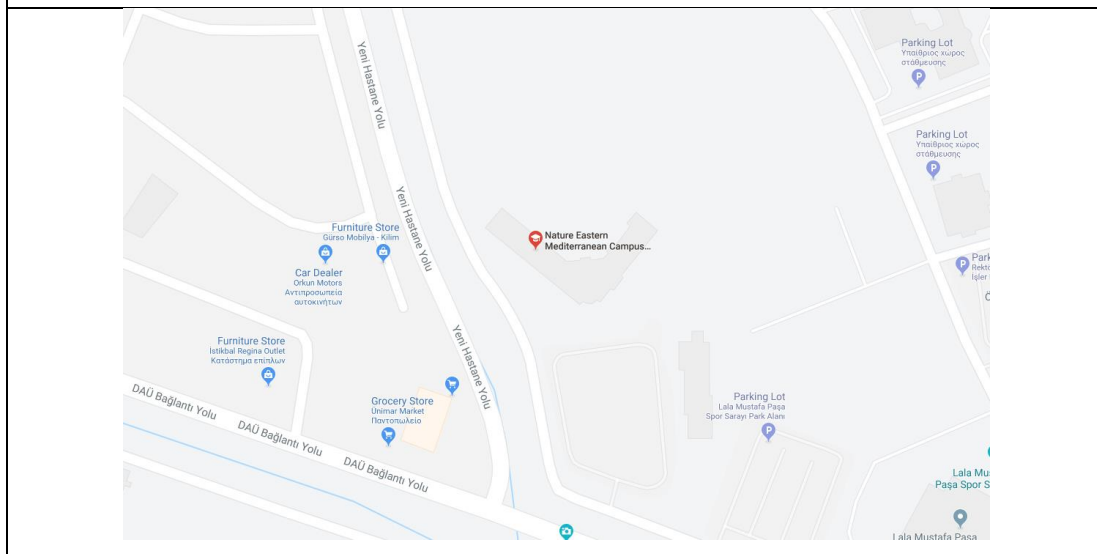


Table 16. Identifying match between school furniture and students




| Emu Doğu primary school | | | | |
|--|---------------------------|---|--------------------|--|
| Dimensions | 8- 9 years' old | | | Furniture figures and photos |
| | Recommende d dimension | Observed dimension | Match/misma tch | |
| Seat height | 32.33.5 | 38 | × |  |
| Seat width | 32 | 39 | × | |
| Seat depth | 32-33.5 | 36 | × | |
| Seat pan-armrest distance | - | - | - | |
| Seat backrest | 36 | 31.5 | × | |
| Desk height | - | 64 | - | |
| Desk width | 40 | 49.5 | ✓ | |
| Desk length | 120 | 128 | ✓ | |
| Floor to desk clearance | 44.5-47 | - | - | |
|  | |  | | |

Table 17. Factors related to students body postures while attending in the classroom.
Case 1

| | | | |
|--|-----------------|--|----------------------------------|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | ✓ |
| | | The back should be supported in the lumbar area | ✓ |
| | | Feet should be well supported(full support for the feet) | × |
| | | Head and neck should remain upright when not writing | ✓ |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × |
| | | The Desk should be modified to the student's height. | ✓ |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ |
| | | The chair should fulfill the need to move of the pupils. | ✓ |
| | | The chair should absorb the student's body moisture due to perspiration | × |
| | | Work areas should enough for each student | ✓ |
| | | Highly accessible furnishings for all students including those with disabilities. | ✓ |
| | | There should be a normal heat exchange between the chairs and students body. | ✓ |
| | | The materials that used in chairs should not have high thermal conductivity. | ✓ |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ |
| | | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ |
| | | Chairs should be unattached and movable in the classroom | ✓ |
| | | Use of modular tables. | ✓ |
| | | The chair should allow for various combinations | ✓ |
| | | Ergonomics Considerations | Seats are organized as clusters. |
| Seats are organized as semicircular. | ✓ | | |
| Seats are organized as traditional. | × | | |
| Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | × | | |
| Each desk should placed for easy access to material of different tasks | × | | |
| Tables should be re-arrangeable, and they are not too large/heavy. | ✓ | | |
| Chairs should be re-arrangeable, and they are too large/heavy. | ✓ | | |
| All students should easily seen by the teacher at all times. | × | | |
| Tables for groups of 4-6 to work easily. | × | | |
| Desks should arranged in a way that each student can see and participate in classroom tasks. | ✓ | | |

4.2.2 Case 2

A second case study is Alasya primary school. The students of this school are between 6 and 11 years old (Table 18).

Table 18. General information of Case 2






| | | |
|---|-----------------------|--|
| School name | Alasya primary school | Description: Two classrooms which observed in this school, have been evaluated in the same table. |
| Location | Famagusta city | |
| Range of ages | 6 to 11 | |
| Number of observed classes | 2 | |
| Age of classroom number one | 8-9 | |
| Age of classroom number two | 9-10 | |
| Ownership | Governmental | |
| Location | | |
|  | | |

Table 19. Identifying match between school furniture and students. Case 2

| Dimensions | 8- 9 years old | | | Furniture figures and photos |
|---|-----------------------|--------------------|----------------|--|
| | Recommended dimension | Observed dimension | Match/mismatch | |
| Seat height | 32 | 43 | × |  |
| Seat width | 32 | 36 | × | |
| Seat depth | 32-33.5 | 36 | × | |
| Seat pan-armrest distance | - | - | - | |
| Seat backrest | 36 | 34 | × | |
| Desk height | - | 72 | - | |
| Desk width | 40 | 44 | ✓ | |
| Desk length | 120 | 128 | ✓ | |
| Floor to desk clearance | 44.5-47 | - | - | |
|  | | | | |
|  | | | |  |

Classroom Number 1 and 2-Alasya Primary School


Table 20. Factors related to students body postures while attending in the classroom.
Case 2

| | | | | |
|--|---|--|-----------------------------------|--|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | ✓ | |
| | | The back should be supported by the lumbar area | ✓ | |
| | | Feet should be well supported(full support for the feet) | × | |
| | | Upright head and neck should remain when not writing | ✓ | |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × | |
| | | The Desk should be modified to the student's height. | × | |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ | |
| | | The chair should fulfill the need to move of the pupils. | ✓ | |
| | | The chair should absorb the student's body moisture due to perspiration | × | |
| | | Work areas should enough for each student. | ✓ | |
| | | Highly accessible furnishings for all students including those with disabilities. | ✓ | |
| | | There should be a normal heat exchange between the chairs and students body. | ✓ | |
| | | The materials that used in chairs should not have high thermal conductivity. | ✓ | |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ | |
| | | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ | |
| | | Ergonomics Considerations | Organization and classroom layout | Chairs should be unattached and movable in the classroom |
| | Use of modular tables. | | | ✓ |
| | The chair should allow for various combinations | | | ✓ |
| Seats are organized as clusters. | × | | | |
| Seats are organized as semicircular. | ✓ | | | |
| Seats are organized as traditional. | × | | | |
| Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | × | | | |
| Each desk should placed for easy access to material of different tasks. | × | | | |
| Tables should be re-arrangeable, and they are not too large/heavy. | ✓ | | | |
| Chairs should be re-arrangeable, and they are too large/heavy. | ✓ | | | |
| All students should easily seen by the teacher at all times. | × | | | |
| Tables for groups of 4-6 to work easily. | × | | | |
| Desks should arranged in a way that each student can see and participate in classroom tasks. | ✓ | | | |

4.2.3 Case 3

The third school is Gazi primary school. This school is located in Famagusta city (Table 21). The students of this school are between 9 and 11 years old. This school has two types of furniture in different classrooms. In some classes, old furniture which made if wood and metal are used. This furniture is not suitable for students. Because of the old furniture, In the design of this furniture, the principles of ergonomics are not met. And also the weight of the furniture for heavy students. Newer furniture is used in other classrooms. This furniture is made of metal and plastic. The principles of ergonomics are partly respected in this furniture. The following of this part have been investigated on furniture size and dimension, classroom layout and their impact on students. The manager and staff of this school kindly and friendly corporates to carry out this research.

Table 21. General information of Case 3

| | | |
|--|---------------------|---|
| School name | Gazi primary school | Description: This school has two kinds of furniture. – Old furniture – New furniture |
| Location | Famagusta city | |
| Range of ages | 9 to 11 | |
| Number of observed classes | 2 | |
| Age of classroom number one | 9-10 | |
| Age of classroom number two | 10-11 | |
| Ownership | Governmental | |
| Location | | |
|  | | |

Classroom Number 1-Gazi Primary School

Table 22. Identifying match between school furniture and students. Case 3. Classroom 1








| Gazi primary school | | | | |
|---|-----------------------|--------------------|----------------|--|
| Dimensions | 9-10 years old | | | Furniture figures and photos |
| | Recommended dimension | Observed dimension | Match/mismatch | |
| Seat height | 33.5 | 40 | × |  |
| Seat width | 33 | 36.5 | × | |
| Seat depth | 33.5-34.5 | 36.5 | × | |
| Seat pan-armrest distance | - | - | - | |
| Seat backrest | 40 | 37 | × | |
| Desk height | - | 69 | - | |
| Desk width | 40 | 44 | ✓ | |
| Desk length | 120 | 108.5 | × | |
| Floor to desk clearance | 47-49 | - | - | |
|  | | | | |

Table 23. Factors related to students body postures while attending in the classroom.
Case 3. Classroom 1

| | | | | |
|--|---------------------------|--|--|---|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | ✓ | |
| | | The back should be supported in the lumbar area | ✓ | |
| | | Feet should be well supported(full support for the feet) | × | |
| | | Head and neck should remain upright when not writing | ✓ | |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × | |
| | | The Desk should be modified to the student's height. | ✓ | |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ | |
| | | The chair should fulfill the need to move of the pupils. | × | |
| | | The chair should absorb the student's body moisture due to perspiration | × | |
| | | Work areas should enough for each student. | ✓ | |
| | | Highly accessible furnishings for all students including those with disabilities. | × | |
| | | There should be a normal heat exchange between the chairs and students body. | ✓ | |
| | | The materials that used in chairs should not have high thermal conductivity. | ✓ | |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ | |
| | | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ | |
| | Ergonomics Considerations | Organization and classroom layout | Chairs should be unattached and movable in the classroom | ✓ |
| | | | Use of modular tables. | ✓ |
| | | | The chair should allow for various combinations | ✓ |
| | | | Seats are organized as clusters. | × |
| Seats are organized as semicircular. | | | ✓ | |
| Seats are organized as traditional. | | | × | |
| Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | | | ✓ | |
| Tables should be re-arrangeable, and they are not too large/heavy. | | | ✓ | |
| Chairs should be re-arrangeable, and they are not too large/heavy. | | | ✓ | |
| All students should easily seen by the teacher at all times. | | | ✓ | |
| Tables for groups of 4-6 to work easily. | | | × | |
| Desks should arranged in a way that each student can see and participate in classroom tasks. | | | ✓ | |

Classroom Number 2-Gazi Primary School

Table 24. Identifying match between school furniture and students. Case 3. Classroom 2

| Gazi primary school | | | | |
|---|---------------------------|--|--------------------|---|
| Dimensions | 10.-11 years old | | | Furniture figures and photos |
| | Recommende d dimension | Observed dimension | Match/misma tch | |
| Seat height | 34 | 42 | ✓ |  |
| Seat width | 34.5 | 34 | ✓ | |
| Seat depth | 34.5-37 | 35 | × | |
| Seat pan-armrest distance | - | - | - | |
| Backrest height | 40-43 | 32 | × | |
| Desk height | - | 89.5 | - | |
| Desk width | 40 | 45 | × | |
| Desk length | 120 | 105 | × | |
| Floor to desk clearance | 49-51 | - | - | |
|  | |  | | |
|  | |  | | |

The furniture used in this classroom is in the old form of furniture. This furniture is not usable in term of ergonomics principles. The backrest of the chairs do not support 3 natural curves in the spine. The height of the chair is not standard for 10-11 years old students. The only advantage of this furniture is that it has footrest in both chairs and desks. There is no slop on chairs seat to support different classroom positions such as listening posture. Due to the materials that are used in this furniture which are heavy metal and wood, is not easy to move it by students.

Table 25. Factors related to students body postures while attending in the classroom. Case 3. Classroom 2


| | | | |
|--------------------------------------|---|--|---|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | × |
| | | The back should be supported by the lumbar area | ✓ |
| | | Feet should be well supported(full support for the feet) | ✓ |
| | | Head and neck should remain upright when not writing | × |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × |
| | | The Desk should be modified to the student's height. | × |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | × |
| | | The chair should fulfill the need to move of the pupils. | × |
| | | The chair should absorb the student's body moisture due to perspiration | × |
| | | Work areas should enough for each student. | × |
| | | Highly accessible furnishings for all students including those with disabilities. | × |
| | | There should be a normal heat exchange between the chairs and students body. | × |
| | | The materials that used in chairs should not have high thermal conductivity. | × |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ |
| | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ | |
| | Organization and | Chairs should be unattached and movable in the classroom | ✓ |
| | | Use of modular tables. | × |
| | | The chair should allow for various combinations | × |
| Seats are organized as clusters. | | × | |
| Seats are organized as semicircular. | | × | |

| | | |
|--|--|---|
| | Seats are organized as traditional. | ✓ |
| | Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | × |
| | Each desk should be placed for easy access to material of different tasks. | × |
| | Tables should be re-arrangeable, and they are not too large/heavy. | × |
| | Chairs should be re-arrangeable, and they are not too large/heavy. | × |
| | All students are easily seen by the teacher at all times. | × |
| | Tables for groups of 4-6 to work easily. | × |
| | Desks should be arranged in a way that each student can see and participate in classroom tasks. | × |

4.2.4 Case 4

The fourth school is Polatpaşa primary school. This school is located in the old city of Famagusta (Table 26). The students of this school are between 6 and 12 years old. Three classes with different age groups were observed in this school. The furniture used in this school is available in different sizes based on different age groups. This furniture is made of metal and plastic. The principles of ergonomics are partly respected in this furniture.

Table 26. General information of Case 4

| | | |
|--|--------------------------|--------------|
| School name | Polatpaşa primary school | Description: |
| Location | Famagusta city | |
| Range of ages | 6 to 12 | |
| Number of observed classes | 3 | |
| Age of classroom number one | 8-9 | |
| Age of classroom number two | 9-10 | |
| Age of classroom number three | 10-11 | |
| Ownership | Governmental | |
| Location | | |
|  | | |

Classroom Number 1- Polatpaşa Primary School

Table 27. Identifying match between school furniture and students. Case 4. Classroom 1



| Polatpaşa Primary School | | | | |
|---------------------------|---|--------------------|----------------|--|
| Dimensions | 8-9 years' old | | | Furniture figures and photos |
| | Recommended dimension | Observed dimension | Match/mismatch | |
| Seat height | 32 | 33 | ✓ |  |
| Seat width | 32 | 40 | × | |
| Seat depth | 32-33.5 | 30 | × | |
| Seat pan-armrest distance | - | - | - | |
| Seat backrest | 36 | 32 | × | |
| Desk height | - | 58 | - | |
| Desk width | 40 | 44 | ✓ | |
| Desk length | 120 | 108 | × | |
| Floor to desk clearance | 44.5-47 | - | - | |
| |  | | | |

Table 28. Factors related to students body postures while attending in the classroom.
Case 4. Classroom 1

| | | | | |
|--|---------------------------|--|--|---|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | ✓ | |
| | | The back should be supported in the lumbar area | ✓ | |
| | | Feet should be well supported(full support for the feet) | × | |
| | | Head and neck should remain upright when not writing | ✓ | |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × | |
| | | The Desk should be modified to the student's height. | × | |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ | |
| | | The chair should fulfill the need to move of the pupils. | ✓ | |
| | | The chair should absorb the student's body moisture due to perspiration | × | |
| | | Work areas should enough for each student. | ✓ | |
| | | Highly accessible furnishings for all students including those with disabilities. | ✓ | |
| | | There should be a normal heat exchange between the chairs and students body. | ✓ | |
| | | The materials that used in chairs should not have high thermal conductivity. | ✓ | |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ | |
| | | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ | |
| | Ergonomics Considerations | Organization and classroom layout | Chairs should be unattached and movable in the classroom | ✓ |
| | | | Use of modular tables. | ✓ |
| | | | The chair should allow for various combinations | ✓ |
| | | | Seats are organized as clusters. | × |
| Seats are organized as semicircular. | | | ✓ | |
| Seats are organized as traditional. | | | × | |
| Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | | | × | |
| Each desk should placed for easy access to material of different tasks. | | | × | |
| Tables should be re-arrangeable, and they are not too large/heavy. | | | ✓ | |
| Chairs should be re-arrangeable, and they are not too large/heavy. | | | ✓ | |
| All students should easily seen by the teacher at all times. | | | × | |
| Tables for groups of 4-6 to work easily. | | | × | |
| Desks should arranged in a way that each student can see and participate in classroom tasks. | | | ✓ | |

Classroom Number 2- Polatpaşa Primary School

Table 29. Identifying match between school furniture and students. Case 4. Classroom 2

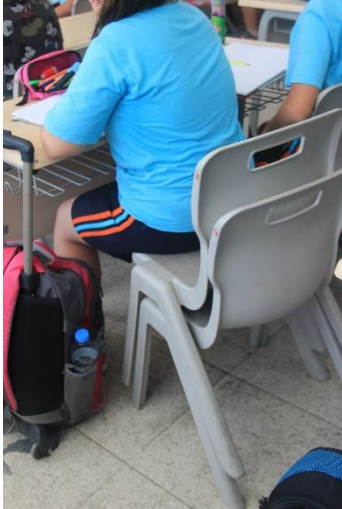


| Polatpaşa Primary School | | | | |
|---|-----------------------|--|----------------|--|
| Dimensions | 9-10 years' old | | | Furniture figures and photos |
| | Recommended dimension | Observed dimension | Match/mismatch | |
| Seat height | 33.5 | 37 | × |  |
| Seat width | 33 | 41 | × | |
| Seat depth | 33.5-34.5 | 31.5 | × | |
| Seat pan-armrest distance | - | - | - | |
| Seat backrest | 40 | 34 | × | |
| Desk height | - | 63 | - | |
| Desk width | 40 | 44.5 | ✓ | |
| Desk length | 120 | 109 | × | |
| Floor to desk clearance | 47-49 | - | - | |
|  | |  | | |

Table 30. Factors related to students body postures while attending in the classroom.
Case 4. Classroom 2

| | | | |
|---|-----------------------------------|--|---|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | ✓ |
| | | The back should be supported in the lumbar area | ✓ |
| | | Feet should be well supported(full support for the feet) | × |
| | | Head and neck should remain upright when not writing | ✓ |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × |
| | | The Desk should be modified to the student's height. | ✓ |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ |
| | | The chair should fulfill the need to move of the pupils. | ✓ |
| | | The chair should absorb the student's body moisture due to perspiration | × |
| | | Work areas should enough for each student. | ✓ |
| | | Highly accessible furnishings for all students including those with disabilities. | ✓ |
| | | There should be a normal heat exchange between the chairs and students body. | ✓ |
| | | The materials that used in chairs do not have high thermal conductivity. | ✓ |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ |
| | | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ |
| | Organization and classroom layout | Chairs should be unattached and movable in the classroom | ✓ |
| | | Use of modular tables. | ✓ |
| | | The chair should allow for various combinations | ✓ |
| | | Seats are organized as clusters. | × |
| Seats are organized as semicircular. | | ✓ | |
| Seats are organized as traditional. | | × | |
| Seating plans have been designed so that all students can easily see presentations during whole group instruction and displays. | | × | |
| Each desk should placed for easy access to material of different tasks. | | × | |
| Tables should be re-arrangeable, and they are too large/heavy. | | ✓ | |
| Chairs should be re-arrangeable, and they are too large/heavy. | | ✓ | |
| All students should easily seen by the teacher at all times. | | × | |
| Tables for groups of 4-6 to work easily. | | × | |
| Desks should arranged in a way that each student can see and participate in classroom tasks. | ✓ | | |

Classroom Number 3- Polatpaşa Primary School

Table 31. Identifying match between school furniture and students. Case 4. Classroom 3


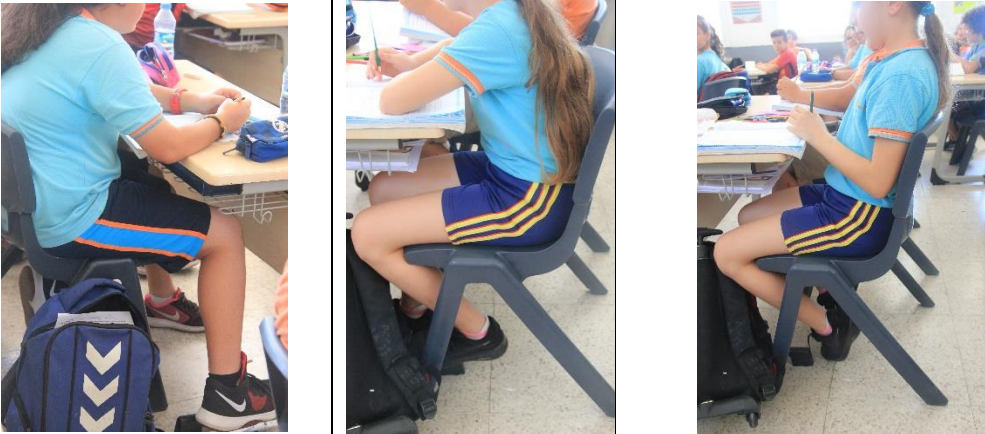
| Polatpaşa Primary School | | | | |
|--|-----------------------|--------------------|------------------------------|--|
| Dimensions | 10-11 years' old | | Furniture figures and photos | |
| | Recommended dimension | Observed dimension | Match/mismatch | |
| Seat height | 34 | 44 | × |  |
| Seat width | 34.5 | 43 | × | |
| Seat depth | 34.5-37 | 38 | × | |
| Seat pan-armrest distance | - | - | - | |
| Seat backrest | 40-43 | 36 | × | |
| Desk height | - | 71 | - | |
| Desk width | 40 | 44.5 | ✓ | |
| Desk length | 120 | 109 | × | |
| Floor to desk clearance | 49-51.5 | - | - | |
|  | | | | |



Table 32. Factors related to students body postures while attending in the classroom.
Case 4. Classroom 3

| | | | |
|---------------------------|---|--|---|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | ✓ |
| | | The back should be supported by the lumbar area | ✓ |
| | | Feet should be well supported(full support for the feet) | ✗ |
| | | Head and neck should remain upright when not writing | ✓ |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | ✗ |
| | | The Desk should be modified to the student's height. | ✗ |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ |
| | | The chair should fulfill the need to move of the pupils. | ✓ |
| | | The chair should absorb the student's body moisture due to perspiration | ✗ |
| | | Work areas should enough for each student. | ✓ |
| | | Highly accessible furnishings for all students including those with disabilities. | ✓ |
| | | There should be a normal heat exchange between the chairs and students body. | ✓ |
| | | The materials that used in chairs should not have high thermal conductivity. | ✓ |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ |
| | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ | |
| | Organization | Chairs should be unattached and movable in the classroom | ✓ |
| | | Use of modular tables. | ✓ |
| | | The chair should allow for various combinations | ✗ |

| | | |
|---------------------------|--|---|
| Ergonomics Considerations | Seats are organized as clusters. | × |
| | Seats are organized as semicircular. | ✓ |
| | Seats are organized as traditional. | × |
| | Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | × |
| | Each desk should be placed for easy access to material of different tasks. | × |
| | Tables should be re-arrangeable, and they are too large/heavy. | ✓ |
| | Chairs should be re-arrangeable, and they are too large/heavy. | ✓ |
| | All students should easily be seen by the teacher at all times. | × |
| | Tables for groups of 4-6 to work easily. | × |
| | Desks should be arranged in a way that each student can see and participate in classroom tasks. | ✓ |

4.2.5 Case 5

The fifth school is Canbulat primary school. This school is located in Famagusta city (Table 33). The students of this school are between 5 and 11 years old. Three classes with different age groups were observed in this school. The furniture used in this school is available in different sizes based on different age groups. This furniture is made of metal and plastic. The principles of ergonomics are partly respected in this furniture.

Table 33. General information of Case 5

| | | |
|-----------------------------|-------------------------|--------------|
| School name | Canbulat primary school | Description: |
| Location | Famagusta city | |
| Range of ages | 5 to 11 | |
| Number of observed classes | 1 | |
| Age of classroom number one | 7-8 | |
| Ownership | Governmental | |

Location

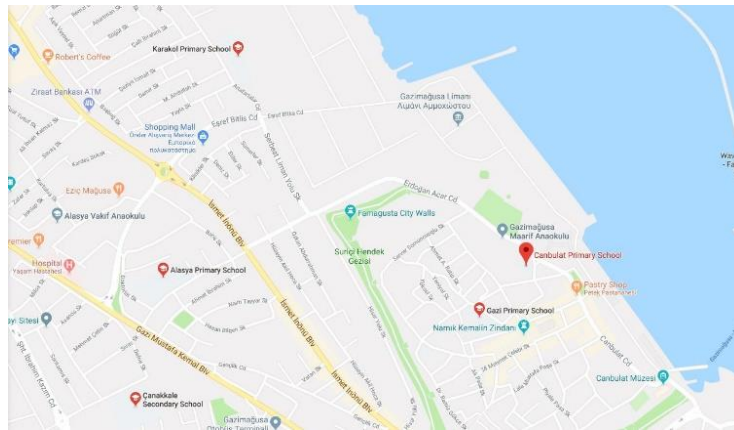


Table 34. Identifying match between school furniture and students. Case 5

| Canbulat Primary School | | | | |
|--|-----------------------|--------------------|----------------|---|
| Dimensions | 7-8 years' old | | | Furniture figures and photos |
| | Recommended dimension | Observed dimension | Match/mismatch | |
| Seat height | 30 | 36.5 | × |  |
| Seat width | 30 | 41 | × | |
| Seat depth | 30 | 30 | ✓ | |
| Seat pan-armrest distance | - | - | - | |
| Seat backrest | 36 | 29 | × | |
| Desk height | - | 60 | - | |
| Desk width | 40 | 44 | ✓ | |
| Desk length | 120 | 108 | × | |
| Floor to desk clearance | 42.5-44 | - | - | |
|  | | | | |
|  | | | | |

Table 35. Factors related to students body postures while attending in the classroom.
Case 5

| | | | | |
|--|---------------------------|--|--|---|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | ✓ | |
| | | The back should be supported in the lumbar area | ✓ | |
| | | Feet should be well supported(full support for the feet) | × | |
| | | Head and neck should remain upright when not writing | ✓ | |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × | |
| | | The Desk should be modified to the student's height. | × | |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ | |
| | | The chair should fulfill the need to move of the pupils. | ✓ | |
| | | The chair should absorb the student's body moisture due to perspiration | × | |
| | | Work areas should enough for each student. | ✓ | |
| | | Highly accessible furnishings for all students including those with disabilities. | ✓ | |
| | | There should be a normal heat exchange between the chairs and students body. | ✓ | |
| | | The materials that used in chairs should not have high thermal conductivity. | ✓ | |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ | |
| | | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ | |
| | Ergonomics Considerations | Organization and classroom layout | Chairs should be unattached and movable in the classroom | ✓ |
| | | | Use of modular tables. | ✓ |
| | | | The chair should allow for various combinations | ✓ |
| | | | Seats are organized as clusters. | × |
| Seats are organized as semicircular. | | | ✓ | |
| Seats are organized as traditional. | | | × | |
| Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | | | × | |
| Each desk should placed for easy access to material of different tasks. | | | × | |
| Tables should be re-arrangeable, and they are not too large/heavy. | | | ✓ | |
| Chairs should be re-arrangeable, and they are not too large/heavy. | | | ✓ | |
| All students should easily seen by the teacher at all times. | | | × | |
| Tables for groups of 4-6 to work easily. | | | × | |
| Desks should arranged in a way that each student can see and participate in classroom tasks. | ✓ | | | |

4.2.6 Case 6

The sixth school is Karakol primary school (Table 36). The students of this school are between 6 to 11 years old. Three classes with different age groups were observed in this school. The furniture used in this school is available in different sizes based on different age groups. This furniture is made of metal and plastic. The principles of ergonomics are partly respected in this furniture.

Table 36. General information of Case 6

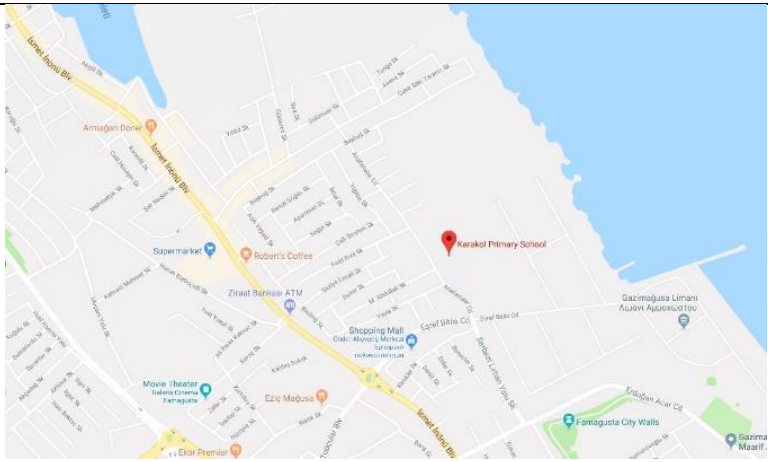
| | | |
|--|------------------------|--------------|
| School name | Karakol primary school | Description: |
| Location | Famagusta city | |
| Range of ages | 6-11 | |
| Number of observed classes | 1 | |
| Age of classroom number one | 7-8 | |
| Ownership | Governmental | |
| Location | | |
|  | | |

Table 37. Identifying match between school furniture and students. Case 6

| Karakol Primary School | | | | |
|--|-----------------------|--------------------|----------------|---|
| Dimensions | 7-8 years' old | | | Furniture figures and photos |
| | Recommended dimension | Observed dimension | Match/mismatch | |
| Seat height | 30 | 37 | × |  |
| Seat width | 30 | 35-33 | ✓ | |
| Seat depth | 30-32 | 31 | ✓ | |
| Seat pan-armrest distance | - | - | - | |
| Seat backrest | 36 | 29 | × | |
| Desk height | - | 58 | - | |
| Desk width | 40 | 44.5 | ✓ | |
| Desk length | 120 | 108 | × | |
| Floor to desk clearance | 42.5-44 | - | - | |
|    | | | | |
|  | | | | |

Table 38. Factors related to students body postures while attending in the classroom.
Case 6

| | | | |
|--|-----------------------------------|--|---|
| Ergonomics Considerations | Postural issues | Chairs back must maintain all 3 natural curves in the spine | ✓ |
| | | The back should be supported by the lumbar area | ✓ |
| | | Feet should be well supported(either by the floor or a footrest) | × |
| | | Head and neck should remain upright when not writing | ✓ |
| | | The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × |
| | | The Desk should be modified to the student's height. | × |
| | Comfort | The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ |
| | | The chair should fulfill the need to move of the pupils. | ✓ |
| | | The chair should absorb the student's body moisture due to perspiration | × |
| | | Work areas should enough for each student. | ✓ |
| | | Highly accessible furnishings for all students including those with disabilities. | ✓ |
| | | There should be a normal heat exchange between the chairs and students body. | ✓ |
| | | The materials that used in chairs should not have high thermal conductivity. | ✓ |
| | | Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ |
| | | All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ |
| | Organization and classroom layout | Chairs should be unattached and movable in the classroom | ✓ |
| | | Use of modular tables. | ✓ |
| | | The chair should allow for various combinations | ✓ |
| | | Seats are organized as clusters. | × |
| | | Seats are organized as semicircular. | ✓ |
| | | Seats are organized as traditional. | × |
| | | Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | × |
| | | Each desk should placed for easy access to material of different tasks. | × |
| | | Tables should be re-arrangeable, and they are not too large/heavy. | ✓ |
| | | Chairs should be re-arrangeable, and they are not too large/heavy. | ✓ |
| | | All students should easily seen by the teacher at all times. | × |
| | | Tables for groups of 4-6 to work easily. | × |
| Desks should arranged in a way that each student can see and participate in classroom tasks. | ✓ | | |

4.3 Data Evaluation of Cases

Table 39 summarizes the information related to suitability of the dimensions of chairs and desks used in the studied primary schools with the ergonomic standards.

Table 39. Match between students' body measurements and classroom furniture dimension of all the cases

| Dimensions | Class 1 | Class 2-3 | Class 4 | Class 5 | Class 6 | Class 7 | Class 8 | Class 9 | Class 10 |
|-----------------|---------|-----------|---------|---------|---------|---------|---------|---------|----------|
| Seat height | × | × | × | ✓ | ✓ | × | × | × | × |
| Seat width | × | × | × | ✓ | × | × | × | × | × |
| Seat depth | × | × | × | × | × | × | × | ✓ | ✓ |
| Backrest height | × | × | × | × | × | × | × | × | × |
| Desk height | - | - | - | - | - | - | - | - | - |
| Desk width | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| Desk length | ✓ | ✓ | × | × | × | × | × | × | × |

As can be seen in the above table in relation to seat height, only 2 out of 10 used chairs had suitable seat heights and seat depth for the target student group. Also only 1 out of 10 used chairs had proper seat width for target age group. All of the backrest have mismatch with students' body dimensions. In all the cases, desk width is appropriate except one class. And in 2 out of 10 classrooms desk length dimensions is suitable. Unfortunately, necessary information about the height of the desks was not found.

The result of this study shows that there was a lack of correlation between the furniture's dimensions which were used in studied primary schools, and the student's body measurements.

In all schools, each desk is designed for two students. Just in Doğa primary school, adjustable desks were found. In the remaining school's desks with different heights

are used for different ages, but the sizes which are selected for students in this schools are not appropriate.

Although same schools have tried to comply with the principles of ergonomics, in some classes, there is a mismatch between student's sizes and furniture sizes that are chosen. Except for one class in Gazi primary school, in the other classrooms, newer furniture has been used. In these new chairs, support for all three natural curves in the spine are maintained. If used at an appropriate size, when students are not in writing position, head and neck remain upright.

Table 40 summarizes the information related to students' body postures while attending in all the studied classrooms.

Table 40. Information related to students' body postures of all the cases

| Classroom | Class 1 | Class 2-3 | Class 4 | Class 5 | Class 6 | Class 7 | Class 8 | Class 9 | Class 10 |
|--|---------|-----------|---------|---------|---------|---------|---------|---------|----------|
| Factors related to students body postures | | | | | | | | | |
| Chairs back must maintain all 3 natural curves in the spine | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| The back should be supported in the lumbar area | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Feet should be well supported(full support for the feet) | × | × | × | ✓ | × | × | × | × | × |
| Head and neck should remain upright when not writing | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| The chair must be adjustable to the student's height. - Seat height should be adjusting somehow which front edge of the seat is approximately level with lower part of the kneecap. | × | × | × | × | × | × | × | × | × |
| The Desk should be modified to the student's height. | ✓ | ✓ | ✓ | × | × | ✓ | × | × | × |
| The front edge of the seat should bent downward so that it does not push the back of the legs. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |

| | | | | | | | | | |
|--|---|---|---|---|---|---|---|---|---|
| The chair should fulfill the need to move of the pupils. | ✓ | ✓ | × | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| The chair should absorb the student's body moisture due to perspiration | × | × | × | × | × | × | × | × | × |
| Work areas should enough for each student. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| Highly accessible furnishings for all students including those with disabilities. | ✓ | ✓ | × | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| There should be a normal heat exchange between the chairs and students body. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| The materials that used in chairs should not have high thermal conductivity. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rounded edges should have at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair; | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| Chairs should be unattached and movable in the classroom | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Use of modular tables. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| The chair should allow for various combinations | ✓ | ✓ | ✓ | × | ✓ | ✓ | | ✓ | ✓ |
| Seats are organized as clusters. | × | × | × | × | × | × | × | × | × |
| Seats are organized as semicircular. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| Seats are organized as traditional. | × | × | × | ✓ | × | × | × | × | × |
| Seating plans should have been designed so that all students can easily see presentations during whole group instruction and displays. | × | × | ✓ | × | × | × | × | × | × |
| Each desk should placed for easy access to material of different tasks | × | × | ✓ | × | × | × | × | × | × |
| Tables should be re-arrangeable, and they are not too large/heavy. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| Chairs should be re-arrangeable, and they are too large/heavy. | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| All students should easily seen by the teacher at all times. | × | × | ✓ | × | × | × | × | × | × |

| | | | | | | | | | |
|--|---|---|---|---|---|---|---|---|---|
| Tables for groups of 4-6 to work easily. | × | × | ✓ | × | × | × | × | × | × |
| Desks should arranged in a way that each student can see and participate in classroom tasks. | ✓ | ✓ | × | × | ✓ | ✓ | ✓ | ✓ | ✓ |

As seen in the table, in the chairs which are used, except in one classroom, the chair's back supports all 3 natural curves in the spine of students and also head and neck remain upright when not writing. The back is supported in the lumbar area of student's body in all of the cases. Because of the inappropriate seat height and lack of foot rest in 9 classes out of 10, feet are not well supported.

Based on information in above table, there is no adjustable chair to adjust with student height. In one case, the desks of classroom were adjustable, in 3 of classrooms there are different desk heights due to the student's body measurements.

The chairs fulfill the need to move of the pupils in 8 of classrooms based on the chairs' designs. The materials that are used in chairs are not have high thermal conductivity in 9 classes. The chairs don't absorb the student's body moisture due to perspiration in none of the classes.

For individual works, work areas are enough and suitable for each student in 9 of classes to do their tasks in the classrooms.

In terms of safety, in 9 classrooms out of 10, the front edge of the seats is bent downward, except in one class so that it does not push the back of the legs. In all of the cases, rounded edges of furniture are with at least 2 mm chamfer on the front of

the seat, armrests and the parts which are in contact with user's body while sitting on the chair; except in the class which the traditional furniture was used.

In all of the classrooms chairs are unattached and movable in the classroom. But in one class in Gazi primary school, the chairs do not allow for various combinations. And also the furniture layout of this classroom is traditional. In the remaining classes which were observed, there are semicircular furniture layout. Except in one class, seating plans have not designed so that all students can easily see presentations during whole group instruction and displays. Because in these classrooms, number of students is too much and semicircular furniture layout is not appropriate for large and numerous classrooms. So All students cannot be easily seen by the teacher at all times. Therefore, tables cannot arrange for groups of 4-6 to work easily students cannot see and participate in classroom tasks.

Some students have to put two chairs over each other to have a suitable vision of the class board and teacher. On the other hand, if seat height is higher than the recommended standard, it may cause pain in back of the knee. It means that seat height should be adjusting in a way that front edge of the seat is approximately level with the lower part of the kneecap. Unfortunately, in none of the schools, adjustable chair is used.

Also, the front edge of the seat should be bent downward so that it does not push the back of the legs. Rounded edges should be at least 2 mm chamfer on the front of the seat where it is in contact with the user's body while sitting on the chair; In the new furniture, all the edges or corners which the user may have contact with are chamfered and smooth. Also, these chairs fulfill the need to move of the pupils.

In the case of materials, the chairs which are used in these schools don't absorb the student's body moisture due to perspiration. There is no heat exchange between the chairs and students body and the materials that are used in chairs do not have high thermal conductivity.

The workstations which are used in all observed schools are unattached and movable chairs are used in the classroom. This furniture is not too heavy, so they are transferable to students to changes the classroom layout in different tasks. This is a useful and positive point in choosing the classroom furniture. Because this furniture allows for various combinations in the classrooms. It means that seating plans can have been designed in a way that all students can easily see presentations during whole group instruction and displays and all students are easily seen by the teacher at all times.

In general, modular furniture allows desk to be arranged in a way that each student can see and participate in classroom tasks and increase the level of collaboration and interaction between students in the classrooms.

As mentioned above, this study was conducted in five publics and one private school in Famagusta. It became clear that in this private school more attention is paid to classroom furniture which is most probably because of available budget. But in general, according to school administrators, there is no expert to decide about choices of classrooms furniture.

Chapter 5

CONCLUSION

School is the most important place for children after the house. Children spend most of their time in school from childhood to adolescence, during the day. So, these places should be appropriate regarding safety and health. Physical conditions have an undeniable effect on human behavior, designing a proper physical environment in schools, can create a pleased and comfortable environment for students, and mutually reinforce the level of education and learning. The physical conditions of the class include the dimensions and design of the furniture and also the organization layout of the furniture in the classroom.

Desks and chairs are important factors which can effect on the health of students. The design of the chairs and school desk should be based on children's anthropometry and they should be flexible and adjustable while providing correct ergonomics. This furniture should support the student body in different body postures while attending in the classroom as well. Sitting properly is considered as one of the important factors in the prevention of musculoskeletal disorders. Because at primary school ages children grow fast and also have different body dimensions. One of the most important factors to consider is the seat height of the chair. Feet should be well-supported by floor or footrest and this happens when the seat height has a correlation with student's body measurements. In addition, proper seat height and seat depth prevent students from flexion of knees, bending forward and feeling unstable.

Also, the physical dimensions of children vary from region to region. This design must be based on each country and region anthropometric data. So it's not possible to use the same school furniture for all of the students in different parts of the world. As mentioned, the use of furniture that does not fit the size of the student body, can cause a lot of pain and physical problems in the long term. It can also be a problem for students to learn and participate in the classrooms. Furniture that allow students to sit comfortably for a long period of time also increase concentration and learning. Flexible and adjustable furniture, in long-term, have less negative impacts on students, and provide more comfort.

In other words, the anthropometric assessment is helpful to design ergonomic classroom furniture which not only is adjustable for the children but also increases the level of wellbeing and relaxation for students. As mentioned in the previous chapters, children in each country have different body dimensions and proportions.

Moreover, the chairs should be made of materials which have a heat exchange for helping the body to sustain in normal temperature. The factors such as permeability, or ventilation quality of the material, and the thermal conductivity influence the heat exchange in furniture surfaces.

Ergonomic furniture has been tried to be used in the schools which were observed. But unfortunately, there was not enough knowledge about ergonomics principles to choose the suitable furniture. A fact that this study faced was that there was no expert in designing or choosing school furniture at the Ministry of Education or at schools in Northern Cyprus. For this reason, according to the study, in most schools there is an inconsistency between the student's furniture and body dimensions.

The checklist and the dimensions that have been presented in this study can be a qualified guideline for the ergonomic design of the workstations based on student's anthropometric data.

Another part of this study has been considered about school furniture layout. Different layouts are defined for the classroom. These layouts should be selected based on the size of the classroom, the number of students and based on course type. So the classroom furniture should allow change in the layout and they should be lightweight and removable. Also, the movable furniture, can facilitate the classroom environment for attendance of the students who have a physical disability. Modular furniture is appropriate choice which can increase the adaptability of classroom spaces. Multifunctional desks can help in order to support various activities to especially students using a wheelchair in the classroom environment.

The layout of the traditional classes, due to the use of double benches, has often been traditional and furniture was too heavy for moving by students. But, today's school furniture design, consider the ergonomics principles and making a collaborative classroom environment. These considerations provide the possibility of change in the classroom layout by movable furniture based on each classroom task. Cluster layout is one the best choices to make collaboration, interaction between students, practice communication skills and engage in group works. Horseshoe layout (U shape) permits putting a lot of desks in a small classroom. It also facilitates both student-to-student and teacher-to-student interaction.

Circle arrangement can encourage all of the students to participate in the classroom activities and more importantly encourages social interaction. Also, the teacher can

have full control over the class and see all the students, reach them, and communicate with them. This layout is very helpful for group discussions, pedagogical games, and high interaction among students.

Majority of the classes which have been studied in this research have a traditional layout, but the furniture designs allow easy change of the classroom layout. Still in this classes, furniture can be improved and replaced with newer modular furniture.

As a result, more extensive studies can be suggested for developing design considerations. They should be carried out on this subject and based on the available anthropometric dimensions' database, efforts should be made to design the desk and chair for the various levels of the elementary schools, especially in North Cyprus.

For future studies, it is suggested that studies be carried out on accurate anthropometric information from the Turkish and Cypriot children's populations. In the process of doing this study, this research faced a lack of sufficient and accurate information resources about body measurements of Turkish children.

Another possibility for further research is to investigate the proper furniture designs for the classrooms based on a long-term observation of various postures they maintain during different tasks in the classrooms and educational interior spaces. It is hoped that this study will have a positive impact on the advancement of educational environments for next generations.

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APPENDICES

Appendix A: Checklist for Designing and Selecting Ergonomic Tables and Chairs Ergonomics Chair

- Adjust the height so that the seat's front edge is roughly level with the lower part of the kneecap.
- The angle between thigh and torso is slightly larger than 90° (the hip joint is above the knee joint).
- Both feet have full contact with the floor.
- When seated all the way back, the front edge must not press on the lower leg.
- In a listening posture, the seat back should support the back below the shoulder blades.
- The seat of the chair is designed so that the student can easily change the position and situation.
- The length of the chair's seat is sufficient enough to support the thighs, but not to a degree which causes pressure on the back of the knee of students.
- The front edge of the seat is bent downward so that it does not push the back of the legs.
- The slope of the seat (to the rear) must be calculated comfortably and suitable.
- The height of the seat must be comfortable for sitting; when sitting foot should be on the ground.
- The upper surface of the seat must have heat and cold insulation.
- The backrest should Protect the student's upper and lower parts correctly and appropriately.
- Backrest must be flexible enough to change the back angle.
- The back of the seat should be so large that it does not penetrate the back.

- The back angle should be comfortably suited to the seat. (The angle between seat and backrest: 95 -100 degree) (Dianat, I., Karimi, M. A., et. al., 2013)
- To prevent pressure from the backrest, backrest should have a good softness.
- The back surface of the seat must have heat and cold insulation.

Desk

- Sit sideways next to the table and let the arms hang down. Bend the arms in a 90° angle.
- The elbows should be 2 to 3 centimeters below the tabletop/the table's front edge.
- The low height of the desks causes students' feet to hit chair legs, forcing them to stretch their legs forward.
- The low height of elbow rest enforces excessive pressure on the posterior neck musculature to keep the head steady. (Parcell et al. (1999)

To decrease the pressure on the body and to have a more stable posture:

- Other body parts such as legs, feet, and hands should be involved.
- Chairs with rearward sloping backrest are more suitable for sitting (Keegan, 1953 cited in parcell et al., 1999).
- The appropriate positioning typically suggests a general 90/90/90-degree position on the hips, knees, and feet. Leaning forward slightly, the student will be more comfortable.
- For maintaining a comfortable position, thigh should slope to approximately 20 degrees.

- There should be enough space to move the legs between the lower surface of the table and the upper thigh.
- The height of the table should be appropriate; that is, the height of the elbows should be considered in the sitting position.
- In the leg and knee area, there should be enough space for students to move.
- The height of the table should be sufficient in the leg and knee area of the student.
- The minimum length of the desk's surface should be 700 mm for a person and 1,300 mm for two people.
- The surface of the table should be insulated with heat and cold.

General safety requirements or standards (BS EN 1729-2 2012)

- Rounded edges with at least 2 mm chamfer on the front of the seat, armrests and which are in contact with user's body while sitting on the chair;
- All the edges or corners which the user may have contact with them when using furniture must be chamfered and smooth.
- Can be frequently sanitized and cleaned because they are in constant contact with multiple users;
- Can promote movement and physical activity in the classroom or even outdoors; because the movement is useful for posture, focus, alertness, physical health, and individual work habits.
- To be designed, considering safety features, particularly adjustable and movable lightweight furniture;

Thermal Comfort

- It should make by the materials and fabrics which has heat exchange between the body and the environment including the furniture used by people.
- Avoiding the large areas of the body from contact with soft materials, and increasing the permeability of chair materials to allow more evaporation heat loss;
- using materials with high thermal conductivity when cooling is important.

Table 41. Seat and Desk dimensions' equations

| Seat and desk sizes | |
|----------------------------|--|
| Dimensions | Measurement |
| Front seat height | Mean of PH – (1.645 × standard deviation (Std. dev))+ 2 cm |
| Seat depth | Mean of BPL – (1.645 × Std. dev) |
| Seat width | Mean of HB + (1.645 × Std. dev) |
| Upper edge of backrest | Mean of SSH – (1.645 × Std. dev) |
| Backrest length | Mean of SB – (1.645 × Std. dev) + 2 cm |
| Front desk height | Mean of SEH + 10 cm + Front seat height |
| Desk width | Mean of SB + (1.645 × Std. dev) + twice the forearm length |
| Desk depth | Mean of ULL – (1.645 × Std. dev) + 5 cm |
| Floor-to-desk clearance | Mean of KH + 1.645 (Std. dev) + 2 cm |

Calculation of suitable dimension for any population. (Table 41)

Application of anthropometry in characterizing chair and desk dimensions

- Seat height has been designed based on the PH. The 5th percentile of the PH has been choosing (based on female’s dimension).
- Seat depth has been determined based on the of BPL. The 5th percentile of the BPL has been considered (based on female’s dimension).
- For seat width HB has been considered, the 95th percentile of the HB has been adopted to guarantee that pupils with large hips would be able to sit comfortably (based on female’s dimension).
- The upper edge of the backrest has been designed based on SSH with a 5th percentile of the SSH.
- The desk height has determined with SEH.

Table 42. Recommended dimensions for primary school furniture(cm)

| Furniture measurement | 7-8 years | 8-9 years | 9-10 years | 10-11 years |
|-------------------------|-----------|-----------|------------|-------------|
| Seat height | 30-32 | 32-33.5 | 33.5-35 | 34-36.5 |
| Seat depth | 30-32 | 32-33.5 | 33.5-34.5 | 34.5-37 |
| Seat width | 30.5 | 32 | 33 | 34.5 |
| Upper edge of backrest | 36.1-38.3 | 38.3-39.7 | 39.3-40 | 40-43.5 |
| Floor to desk clearance | 42.5-44.5 | 44.5-47.5 | 47.5-49 | 49-51 |

Appendix B: The Equation for a Correct Dimension Based on Turkish Children Anthropometric Data

*All of the measurement are in millimeters (mm)

Seat height: Mean of PH – (1.645 × standard deviation) + 20 mm

7 years old: Female: $312 - (1.645 \times 18.1) + 20 \text{ mm} = 302.23$

Male: $312 - (1.645 \times 18.2) + 20 \text{ mm} = 302.07$

8 years old: Female: $327 - (1.645 \times 17.9) + 20 \text{ mm} = 317.56$

Male: $329 - (1.645 \times 16.9) + 20 \text{ mm} = 321.2$

9 years old: Female: $346 - (1.645 \times 17.8) + 20 \text{ mm} = 336.72$

Male: $346 - (1.645 \times 21.1) + 20 \text{ mm} = 331.3$

10 years old: Female: $358 - (1.645 \times 21.8) + 20 \text{ mm} = 342.14$

Male: $359 - (1.645 \times 19.9) + 20 \text{ mm} = 346.27$

11 years old: Female: $379 - (1.645 \times 20.2) + 20 \text{ mm} = 365.78$

Male: $373 - (1.645 \times 19.8) + 20 \text{ mm} = 360.43$

12 years old: Female: $391 - (1.645 \times 20.4) + 20 \text{ mm} = 377.45$

Male: $390 - (1.645 \times 18.5) + 20 \text{ mm} = 379.57$

Seat depth: Mean of BPL – (1.645 × Std. dev.)

7 years old: Female: $335 - (1.645 \times 19.5) = 302.93$

Male: $339 - (1.645 \times 19.8) = 306.43$

8 years old: Female: $352 - (1.645 \times 19.2) = 320.42$

Male: $359 - (1.645 \times 18.7) = 328.24$

9 years old: Female: $369 - (1.645 \times 18.9) = 337.91$

Male: $379 - (1.645 \times 23.1) = 341.01$

10 years old: Female: $384 - (1.645 \times 23.5) = 345.35$

Male: $397 - (1.645 \times 22.0) = 360.81$

11 years old: Female: $409 - (1.645 \times 21.8) = 373.14$

Male: $416 - (1.645 \times 22.1) = 379.65$

Seat width: Mean of HB + (1.645 × Std. dev.) + 20 mm

7 years old: Female: $248 + (1.645 \times 14.5) + 20 \text{ mm} = 291.8$

Male: $246 + (1.645 \times 14.4) + 20 \text{ mm} = 289.6$

8 years old: Female: $262 + (1.645 \times 14.2) + 20 \text{ mm} = 305.3$

Male: $259 + (1.645 \times 13.5) + 20 \text{ mm} = 301.2$

9 years old: Female: $269 + (1.645 \times 13.8) + 20 \text{ mm} = 311.7$

Male: $276 + (1.645 \times 16.8) + 20 \text{ mm} = 323.6$

10 years old: Female: $281 + (1.645 \times 17.2) + 20 \text{ mm} = 329.2$

Male: $279 + (1.645 \times 15.5) + 20 \text{ mm} = 324.4$

11 years old: Female: $292 + (1.645 \times 15.6) + 20 \text{ mm} = 337.6$

Male: $298 + (1.645 \times 15.9) + 20 \text{ mm} = 344.1$

The upper edge of backrest: Mean of SSH – (1.645 × Std. dev.)

7 years old: Female: $403 - (1.645 \times 23.5) = 36.4$

Male: $400 - (1.645 \times 23.3) = 36.1$

8 years old: Female: $421 - (1.645 \times 22.9) = 38.3$

Male: $419 - (1.645 \times 21.8) = 38.3$

9 years old: Female: $434 - (1.645 \times 22.4) = 39.7$

Male: $437 - (1.645 \times 26.6) = 39.3$

10 years old: Female: $447 - (1.645 \times 27.3) = 40.2$

Male: $458 - (1.645 \times 25.5) = 41.6$

11 years old: Female: $470 - (1.645 \times 25) = 42.8$

Male: $477 - (1.645 \times 25.4) = 43.5$

Floor to desk clearance: Mean of KH + 1.645(Std. dev.) +20 mm

7 years old: Female: $370 + 1.645(21.6) + 20 \text{ mm} = 425.53$

Male: $370 + 1.645(21.6) + 20 \text{ mm} = 425.53$

8 years old: Female: $389 + 1.645(21.2) + 20 \text{ mm} = 443.87$

Male: $390 + 1.645(20.2) + 20 \text{ mm} = 443.229$

9 years old: Female: $411 + 1.645(21.3) + 20 \text{ mm} = 466.03$

Male: $412 + 1.645(25.0) + 20 \text{ mm} = 473.12$

10 years old: Female: $427 + 1.645(26.1) + 20 \text{ mm} = 489.93$








Male: $431 + 1.645(23.9) + 20 \text{ mm} = 490.31$






11 years old: Female: $454 + 1.645(24.1) + 20 \text{ mm} = 513.64$

Male: $449 + 1.645(23.9) + 20 \text{ mm} = 508.31$

Appendix C: The School Museum Historic School Furniture

Table 43. School Chair and Desk Trend

| Name / designer | Design | Year |
|---|--|-----------|
| Two-seater American school bench |  | 1890 |
| German school benches -Rettig bench by P. Johannes Müller |  | 1895 |
| A school bench by Jean Prouvé |  | 1935-1950 |
| Crow Island School chair and desk |  | 1939-1940 |
| By James Leonard |  | 1947/1948 |
| By Alvar Aalto's school furniture |  | 1950s |
| Skid chair with skid table by Karl Nothhelfer |  | 1950s |
| Movable skid chair instead of fixed school bench by Karl Nothhelfer |  | 1950s |

| | | |
|---|--|--------------------|
| <p>Chair by Karl Nothhelfer, VS patent</p> |  | <p>From 1950</p> |
| <p>Single-seat pupil workplace by American company, Heywood & Wakefield</p> |  | <p>Around 1958</p> |
| <p>School chairs from American company, Brunswick</p> |  | <p>Around 1958</p> |
| <p>Double workplace for pupils</p> |  | <p>Around 1970</p> |
| <p>Ergonomic, mobile, flexible furniture. VS pantomove height adjustable swivel chair with dynamic seat and Ergo-III height adjustable pupil's table with inclinable table top.</p> |  | <p>2004-2005</p> |