A Guideline for Children's Furniture Design to Promote Children's Development

by

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Abstract

This thesis regards children furniture as the object of study and is based on children educational theories to analyze what furniture design elements would have impact on children's development and how children's furniture designers can design furniture to promote children's development.

Children furniture plays an important role in children's development. Childhood is the key period of children's personality forming, perceptual training and cognitive development, and it is the important period of physical growth and children's intelligence development. The parents and the society from all walks of life pay more and more attention to children's growth environment. Children's growth environment has a subtle influence on children's development; children's furniture as necessary elements for children's growth environment also play an important role in children's development.

Firstly, children's furniture is studied to summarize the important elements of children's furniture design. And child development will be studied to conclude the influence factors of children's development. And then, child educational theories and approaches will be studied for their requirements on children's furniture. Secondly, this thesis develops a design guideline for children's furniture design to promote children's development. And a 3D model will be made based on the guideline.

Acknowledgments

Here and now, I would like to extend my sincere thanks to all those who have helped me make this thesis possible and better.

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Table of Contents

List of Figures

List of Tables

Chapter 1 Introduction

1.1 Problem Statement

Children's furniture plays an important role in today's modern world. Not only because children's furniture is a huge market with very high potential that has caught more and more attention from all parties, but also children furniture plays an important role in children's development.

Children's furniture is a huge market with very high potential. Children's furniture is a segment of the overall furniture market based on product use by a specific target audience, those in the age group of 0-18 years. Children's furniture products fall under the broader furniture industry, and account for nearly 8% of the revenue in the industry in the US Market Research Reports (2016). And the global children's furniture market is expected to expand at a considerable pace for the next 10 years. Moreover, emergence of online retailers has also driven the children's furniture market (Kids Furniture Market, 2018). According to a recent report published by Grand View Research, the global kids' furniture market size was valued at USD 29.4 billion in 2018 and is expected to grow at a compound annual growth rate (CAGR) of 4.48% from 2019 to 2025 (Kids Furniture Market, 2020).

Children's furniture has caught more and more attention from all parties. Consumers expect their children's furniture to be of good quality, comfortable, and in compliance with the

safety standards. Designers are designing various children’s furniture to meet children’s different needs. Manufacturers are developing new furniture with the advent of new technology.

Children furniture plays an important role in children’s development. Childhood is the key period of children's personality forming, perceptual training and cognitive development, and it is the important period of physical growth and children's intelligence development. The parents and the society from all walks of life pay more and more attention to children's growth environment. Children's growth environment has a subtle influence on children’s development; children’s furniture as necessary elements for their growth environment also plays an important role in children’s development.

Children furniture is not only an appliance, but also an accompaniment and partner to help children learn, play, and grow. In addition to conforming to the ergonomic data for children and meeting the requirements of function and safety, children’s furniture design should also comply with the goals of child education theories, to help children develop healthily.

This thesis regards children’s furniture as the object of study and is based on child educational theories to analyze what furniture design elements would have impact on children’s development and how children’s furniture designers can design furniture to promote children’s development. The use of children educational theories makes this research distinct from others because it includes some human factors, such as the interactions between furniture and children in order to improve the children growing up, rather than simply focusing on design for functions or styles.

1.2 Need for Study

The role of children's furniture is not only children's appliances but also becoming a children's game and learning partners to help children learn, play and grow.

Firstly, children are in the process of physiological growth, so using incorrect size furniture will affect children's sitting position, sleeping position, and bone growth. What's more, children grow quickly, and their body changes are rapid and profound. It is too expensive and impractical to buy different size furniture for children every year. Therefore, children's furniture should follow the ergonomics principles and grow with children.

Secondly, childhood is the sensitive period of children's psychological and cognitive growth. At this stage, the children's nervous system, consciousness and language develop rapidly, and they have a strong desire to participate in social activities and begin to form their initial personality tendencies. Therefore, children's furniture design not only needs to meet the physiological size of children, but more importantly, needs to enhance children's participation in social activities and understanding as well as increase cooperation and exchanges with others.

Thirdly, children's growth environment has a subtle influence on children's development. Children's furniture as necessary elements for their growth environment also plays an important role in children's development. Children's furniture is an important tool for children to learn and play. Children's furniture, which conforms to children's educational theory, can create a natural cognitive environment for children to improve their sense of development, creativity, and order through the sensory interaction with furniture.

1.3 Objective for Study

This thesis presents an approach for helping designers to design children's furniture that can promote child development. The following are the objectives of this thesis:

- To study the theories of child development.
- To define children's furniture.
- To study and summarize the design elements and design rules in children's furniture design.
- To determine the relationship between furniture and child development.
- To develop a guideline for children's furniture design and design a piece of children's furniture using the guideline.

1.4 Definition of Terms

Children: "A human being below the age of 18 years unless under the law applicable to the child, majority is attained earlier" (the United Nations Convention on the Rights of the Child, 2010).

Child development - As children grow older, they develop in several different ways. Children development includes physical development, cognition development, and social development (Butler, 1978).

Development - The act, process, or result of developing ("Development," n.d.).

Children’s furniture - Mobile and permanent furnishing of residential interiors intended to support children’s life, entertainment, and learning.

1.5 Assumption of Study

The study is based on the following assumptions:

- All the research, approaches, methods, and data I found are correct.
- Furniture will influence children’s development.
- Designers and parents do care about children’s development.
- Children have their own space at home.
- Designers value children’s development, design process and the final design results.
- Designers who using this guideline have a basic understanding and knowledge of furniture design.

1.6 Scope and Limitations

The aim of the guideline is to help designers consider the children’s development while designing children’s furniture. Therefore, this study focuses on the design elements that will influence children’s development. Some other important design elements will not be developed in the guideline, such as manufacturing costs, manufacturing methods, packaging, market trend, culture, etc.

The selection of childhood development is limited. Child development is an essential part of the thesis. Only parts of the children’s abilities which might be influenced or improved by the

furniture design will be discussed in the thesis. The other vital children's abilities which will not be enhanced by the furniture design will not be mentioned in the thesis. Proper furniture design could help children to develop, but it will be not the primary vehicle forchild development.

1.7 Procedures and Methodology

Procedure 1: Study the concepts of children's furniture and the categories of children's furniture.

• Studying online research, dictionaries, articles, and library resources

• Studying the role of furniture in children's development.

Procedure 2: Study the theories of children educational theories.

• Studying online research, dictionaries, articles, and library resources

• Studying STEAM education

Procedure 3: Study the concepts of children's development and summarize.

• Studying online research, dictionaries, articles, and library resources

• Sorting and analyzing research

• Analyzing and concluding the influence factors of children's development.

Procedure 4: Build up the frame of the design flow. And develop the design guideline of designing children's furniture to promote children's development.

Procedure 5: Applying the approach into a product design process.

1.8 Anticipated Outcomes

The primary outcome of this study is providing a new design guideline for designers to design children's furniture that can promote children's development. A product will be developed from the preliminary sketch based on the design guideline.

Chapter 2 Literature Review

2.1 Children's Furniture

2.1.1 Definition of Children's Furniture:

The word "furniture" originated from French "fourniture" and Latin "mobilis" (American Heritage Dictionary Editors, 2019). "Furniture is objects of applied arts intended for mobile and permanent furnishing of residential interiors" (Smardzewski, 2015, p.47). Furniture is intended to support various human activities such as storage, work, eating, sitting, lying down, sleeping and relaxing. Furniture can be scientifically classified by different standards, such as according to the material, furniture can be divided into wooden furniture, metal furniture, plastic furniture, bamboo and rattan furniture etc., and according to the purpose, furniture can be divided into the civil furniture, hotel furniture, office furniture etc. (Jürgen, 2001).

These classifications did not list children's furniture. However, according to the definition of furniture, children's furniture can be understood as mobile and permanent furnishing of residential interiors intended to support various children's activities.

The United Nations Convention on the Rights of the Child (2010) defines child as "a human being below the age of 18 years unless under the law applicable to the child, majority is attained earlier." This is ratified by 192 of 194 member countries. So, children's furniture's specific target audience are those in the age group of 0-18 years.

Childhood is a critical period of children physical and cognitive development, and the best time to develop intelligence and build a positive character for children (Kahn, 2002). And the furniture that accompanies children to grow has crucial effect to the child's healthy growth. Modern children furniture design must be based on children's physiological and psychological characteristics, to adapt to and meet the functional needs of children's life, entertainment, and learning (Brazelton, 2000).

According to the definition of child, children's furniture can be understood as mobile and permanent furnishing of residential interiors intended to support children's life, entertainment, and learning.

2.1.2 Category of Children's Furniture

Children's furniture can be classified by function, age, material, or other elements. Based on function, the children's furniture can be classified into beds, chairs & seating furniture, leaning on furniture, storage furniture, and accessories. In terms of age, children's furniture can be segregated into infants and toddler furniture (about 0-2 years old), early childhood furniture (about 3-6 years old), middle childhood furniture (about 7-12 years old), and teen furniture (about 13-18 years old).

Furthermore, based on material, children's furniture can be split into solid wood furniture, plywood furniture, plastic furniture, bamboo and rattan furniture, paper or cardboard furniture, and others (metal, composites, fiberglass, etc.).

Table 2. 1 Category of Children's Furniture

2.1.2.1 Children's Furniture Category by Function

According to the function, furniture can be divided into beds, chairs & seating furniture, leaning on furniture, storage furniture, accessories etc. (Table 2.2).

Children's Furniture Category by Function	
Category	**Contents**
Beds	Baby bed, single bed, mid-high bed, semi-high bed, bunk bed, high bed, bed parts etc.
Chairs & Seating furniture	Highchairs, armchairs, desk chairs etc.
Leaning on furniture	Desk, table, play table, extension table etc.
Storage furniture	Clothes & shoe organization, hooks & wall organization, dressers and chests, wardrobes, toy storage etc.
Accessories	Coat racks, and growth chart etc.

Table 2. 2 Children's Furniture Category by Function

Beds are the routine furniture that children use when sleeping and resting. Beds occupy an extremely important position in children's daily life. After the children are tired, beds can provide a comfortable sleeping place, to restore body and mind function. Beds include infant bed (also "crib" or "cot"), single bed, mid-high bed, semi-high bed, bunk bed, high bed etc.

Chairs & Seating furniture provides direct support for children's bodies. Seating furniture includes highchairs, armchairs, sofa, armchairs, desk chairs etc.

Leaning on furniture refers to the furniture related to children and objects at the same time. The basic function of leaning on furniture is providing people the ability to lean on or bend over the desk to work. Leaning on furniture is usually designed for safety and creativity. Leaning on furniture is designed specifically for safe use by children so soft wood with curved edges and rounded corners are the usual style and shape. And the leaning of furniture has storage function concurrently. Leaning on furniture includes desk, play table, extension table etc.

Storage furniture is used to store clothing, bedding, book, toy etc. Toys, clothes, books, and eventually school stuff will all need a permanent and tidy place to reside when not in use. Storage boxes, cabinets, drawers, and cupboards can complement the design of children's bedroom. Modern storage furniture is available in virtually every color, shape, and design conceivable. Storage furniture is usually named with use space or type of storage objects, such as big chest, small dresser and small wardrobes.

Accessories are usually small decorations that can improve the design of children's bedroom. Accessories include coat racks, and growth chart etc.

2.1.2.2 Children's Furniture Category by Age

According to children's age, children's furniture can be divided into infants and toddler furniture (about 0-3 years old), early childhood furniture (about 3-6 years old), middle childhood furniture (about 6-12 years old) and teen furniture (about 12-18 years old) (Table 2.3). The children of different age have different demands of furniture.

Children's Furniture Category by Age	
Category	**Contents**
Infants & toddler furniture	Cribs, bassinet, changing table, toddler beds, highchair, kid's wardrobe, toy storage, etc.
Early childhood furniture	Children's bed, junior chair, kid's table and chair, kid's armchair, kid's wardrobe, toy storage, etc.
Middle childhood furniture	Children's bed, kid's nightstand, children's desk and chair, kid's wardrobe, toy storage, etc.
Teen furniture	Teen bed, teen sofa, teen lounge, teen desk and chair, bookcase, dresser, etc.

Table 2. 3 Children's Furniture Category by Age

Infants & toddler furniture includes cribs, bassinet, changing table, toddler beds, highchair, kid's wardrobe, toy storage, etc. In this period children have higher requirement on having a comfortable sleep and activity space (American Academy of Pediatrics, 2012). So, infants and toddler furniture should have a tall and firm security fence, and use green, non-toxic and harmless materials.

Early childhood furniture includes children's bed, junior chair, kid's table and chair, kid's armchair, kid's wardrobe, toy storage, etc. From three to six years old children's body control ability has been further improved, and their ability of walking, running, jumping and other basic movements are more coordinated (Benjamin, 2003). They are full of curiosity about everything. It is through playing that children develop and learn. Early childhood furniture should have cheerful colors and have interesting elements to spark children's imagination and help them discover new things about the world.

Middle childhood furniture includes children's bed, kid's nightstand, children's desk and chair, kid's wardrobe, toy storage, etc. The period from 7 to 12 years old is the formation stage of children's personality. At this age, they have a wide range of hobbies, so they need bigger cabinets to store their toys and models. Also, kids explore their identity and how they fit into the world in this period. Middle childhood furniture helps kids personalize their space and show who they are (Living Space, 2019).

Teen furniture includes teen bed, teen sofa, teen lounge, teen desk and chair, bookcase, dresser, etc. (Living Space, 2019). Good teen furniture should abound with change, easily form a complete set, taking the growth of children into consideration. Teen furniture should avoid choosing heavy color and depressive tones, but should be relaxed, lively, natural, concise.

2.1.2.3 Children's Furniture Category by Material

According to furniture's material, children's furniture can be divided into solid wood furniture, plywood furniture, plastic furniture, bamboo and rattan furniture, paper/cardboard furniture etc. (Table 2.4)

Children's Furniture Category by Material	
Category	**Features**
Solid wood furniture	Ease of maintenance Unique texture Modifiable
Plywood furniture	Good strength and durability Availability of large sizes Economical Easy to curve
MDF furniture	Cost-Effective Furniture Smooth Finish Easy to Install Not Strong and Durable
Plastic furniture	Lightweight Cheaper Strong and unbreakable Durable
Bamboo and rattan furniture	Safe and Sustainable Protect environment Lighter Clean and preserve easily
Paper/ cardboard furniture	Not durable Low-cost Simple to create

Table 2. 4 Children's Furniture Category by Material

Solid wood furniture: The advantages of wooden furniture are undeniable ("Advantages of Wood Furniture", 2010). Solid wood furniture is extremely resilient and requires very little maintenance. Wood's natural grain guarantees that each piece of furniture is unique. Solid wood furniture has natural color and luster, maintains the natural color of wood, and has clear and beautiful texture. It has simple and generous modeling, full and smooth lines,

and warm texture. Solid wood furniture has strong elasticity and air permeability, have good thermal conductivity. The beauty of solid wood furniture is also in that it can be changed over time to give it a second, third or fourth life. By sanding and staining, or painting, a person can refinish wood furniture and give it an entirely new look.

Plywood furniture: Plywood has very good strength and durability. It is resistant to shrinking, warping, twisting and cracking. Plywood by virtue of the crossed lamination can be nailed or screwed near the edges without damage from splitting. Plywood usually is made of different wood species. Plywood has availability of relatively large sizes. It is available in different thicknesses ranges from 6mm to 32mm. It can provide a smooth surface for laminate or veneer to stick on and is easily polished or painted. In addition, it is economical as compared to solid wood. Curved surfaces can easily be made with plywood. While plywood has many advantages, it also is porous and susceptible to water damage if exposed to leaks over time (Mistry, n.d.).

MDF furniture: Firstly**,** since MDF furniture is made with waste wood, it is not only eco-friendly but also more economical in comparison to furniture made from solid wood or plywood. Its boards are popularly used for fabricating lightweight beds, wardrobes, tables, shelves, etc. Secondly, MDF furniture is factory-manufactured and can be finished with materials like laminate, real wood veneer or spray paint. The core material is smooth because of the absence of any knots or splinters, which results in a smooth finish. Since it is a homogeneous material and is easy to work with, it is suitable for creating interesting shapes, incorporating 3D patterns, decorative designs and perforated panels.T hirdly, MDF furniture comes in a ready-to-install form and is usually assembled on site. The best part about it is that it ensures a clean, dust-free and hassle-free installation process.

However, unlike solid wood or plywood furniture, MDF furniture is not very strong and durable but is resistant to termites. It has to be handled with care. In case it gets damaged, it is difficult to repair. Note that the drawers of MDF furniture cannot hold excess weight. MDF furniture has the tendency to soak water, swell and may break or disintegrate under pressure.

Plastic furniture: Plastics vary in ability to withstand heat, scratching, chemicals and sun. Plastics are generally strong but lightweight. This kind of furniture is lightweight and easy to move around and rearrange. Since plastic is usually massively produced and cheaply obtained, furniture made from this material is relatively cheaper compared to furniture made of other materials such as wood, metal, aluminum and many others. Plastic furniture is also much more durable compared to counterparts made of other materials. Plastic furniture is also virtually strong and unbreakable, making it a very durable furniture material. ("Advantages and Disadvantages of Plastic Furniture", 2013).

Bamboo and Rattan furniture: Rattan is strong and durable. Rattan poles should be smooth and consistent in size. High grade rattan is light in color and free of dark blemishes. Bamboo resembles rattan but is hollow, not solid. Joints in bamboo tend to bulge and are dark. Bamboo is less flexible, which limits its bending capability. Bamboo furniture is lighter than wooden furniture. So, it can be easily moved and arranged. Wicker furniture can be made of rattan, reed, willow, bamboo, flexible twigs or branches. Although bamboo and rattan furniture need to be cleaned regularly to avoid dirt and maintain the brightness, it does not need much time and effort to clean and preserve , with only a small broom, soft towel and mild soap necessary to clean it in just a few minutes("The Advantage of Bamboo Furniture", 2016).

Paper/ cardboard furniture: Unless covered with a very protective surface, paper/ cardboard furniture is not as durable to heat, moisture, heavy use, scratches and is not easily

cleaned. It cannot be refinished or repaired easily. It is often used in low-cost furniture. “We can’t think of a better combination than DIY-crafts, cardboard, and kids—and Swiss architect Nicola Enrico Stäubli’s “FoldSchool” furniture does just that” (“Foldschool”, 2014). With a printer, some cardboard, and a pair of scissors, parents and children can make tool, rocker, and chair easily at home.

2.2 Child Development

The early years of a child’s life are very important for his or her development. As children grow older, they develop in several different ways. Child development includes physical development, cognition development, and social development (Butler, 1978). One of the factors that influence child development is the environment. Children’s furniture as necessary elements for their growth environment also play an important role in children’s development. In this part, different ways of child development will be studied to draw conclusions from..

2.2.1 Physical Development

“During the first two decades of life, the human body changes continuously and dramatically. The average individual’s height multiplies more than threefold, and weight increases as much as 15- to 20-fold. The top-heavy, chubby infant, whose head represents a quarter of the body’s total length, gradually becomes the better-proportioned child and eventually the taller, broader, more muscular teenager” (Berk, 2000, p. 176).

Physical development refers to the advancements and refinements of motor skills, or, in other words, children’s abilities to use and control their bodies. Physical development is one of the many domains of infant and toddler development. It relates to the body size development and changes in body proportions.

2.2.1.1 Body Size Development

The most obvious signs of physical growth are changes in overall body size. During infancy, these changes are faster than any other time after birth. Growth slows in early and middle childhood when children add about 2 to 3 inches in height and 5 pounds in weight each year. Then, puberty brings a sharp acceleration, when adolescents gain 10 to 11 inches in height and about 50 to 75 pounds in weight on average (Berk, 2000).

Two types of growth curves are used to track overall changes in body size (Figure 2.15). The first one is a distance curve, which plots the average size of a sample of children at each age, indicating typical yearly progress toward maturity. And the second one shows a second type of growth curve, the velocity curve, which plots the average amount of growth at each yearly interval, revealing the exact timing of growth spurts.

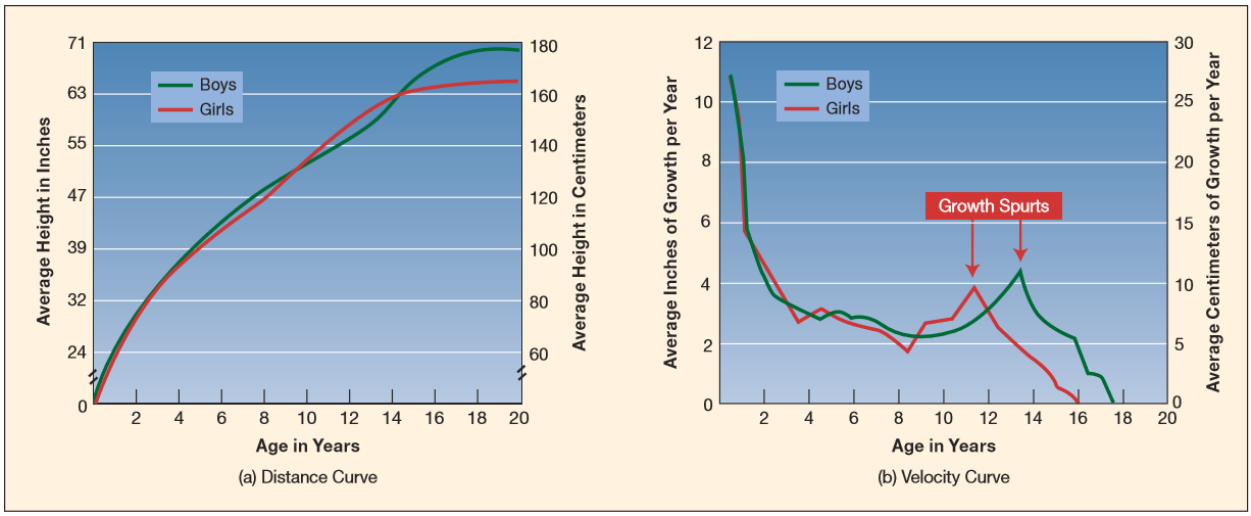


Figure 2. 1 Human Services, 2000) (a) The distance curve plots average size at each age and shows typical yearly progress toward maturity. (b) The velocity curve plots average amount of growth at each yearly interval and reveals the timing of growth spurts. The curves are based on cross- sectional height measurements taken on thousands of U.S. children.

According to the health statistics from Centers for Disease Control and Prevention (CDC,

2000), at the beginning of life, the babies' size change is dramatic and rapid (Figure 2.2 and Figure 2.3). From birth to the end of the first year, babies will increase an average of about 11 inches in length. From the first year to the second year, the rate of growth becomes lower than the first year, but it keeps an average increase about six inches in length. Babies have the most significant growth in the first few months. However, the growth rate dramatically declines from the middle of the first year to the end of the second year. From age two to age three, babies' height increase rate keeps declining, but the weight increase rate remains unchanged.

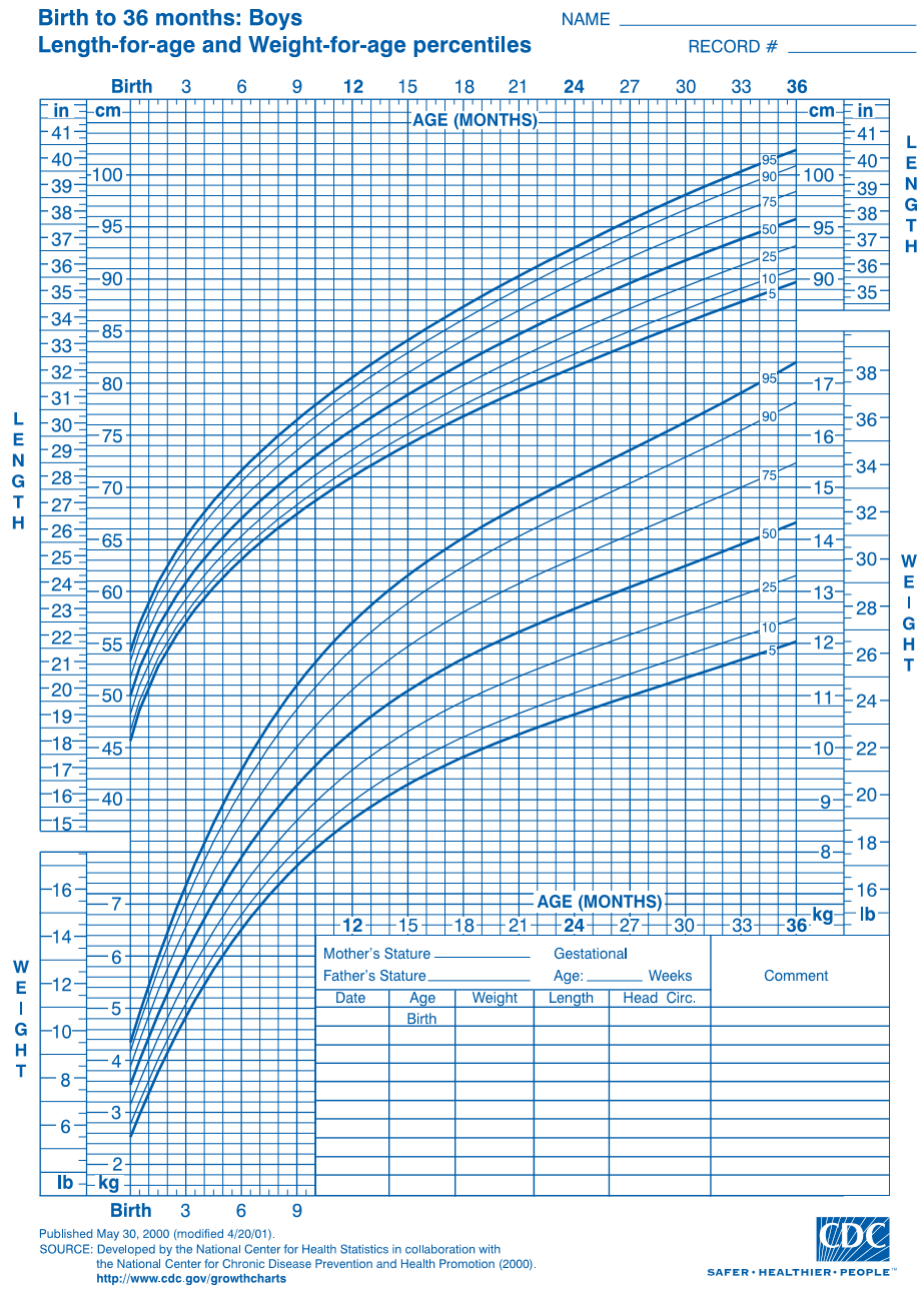


Figure 2. 2 Boys' length-for-age and weight-for age from birth to 36 months (CDC, 2000)

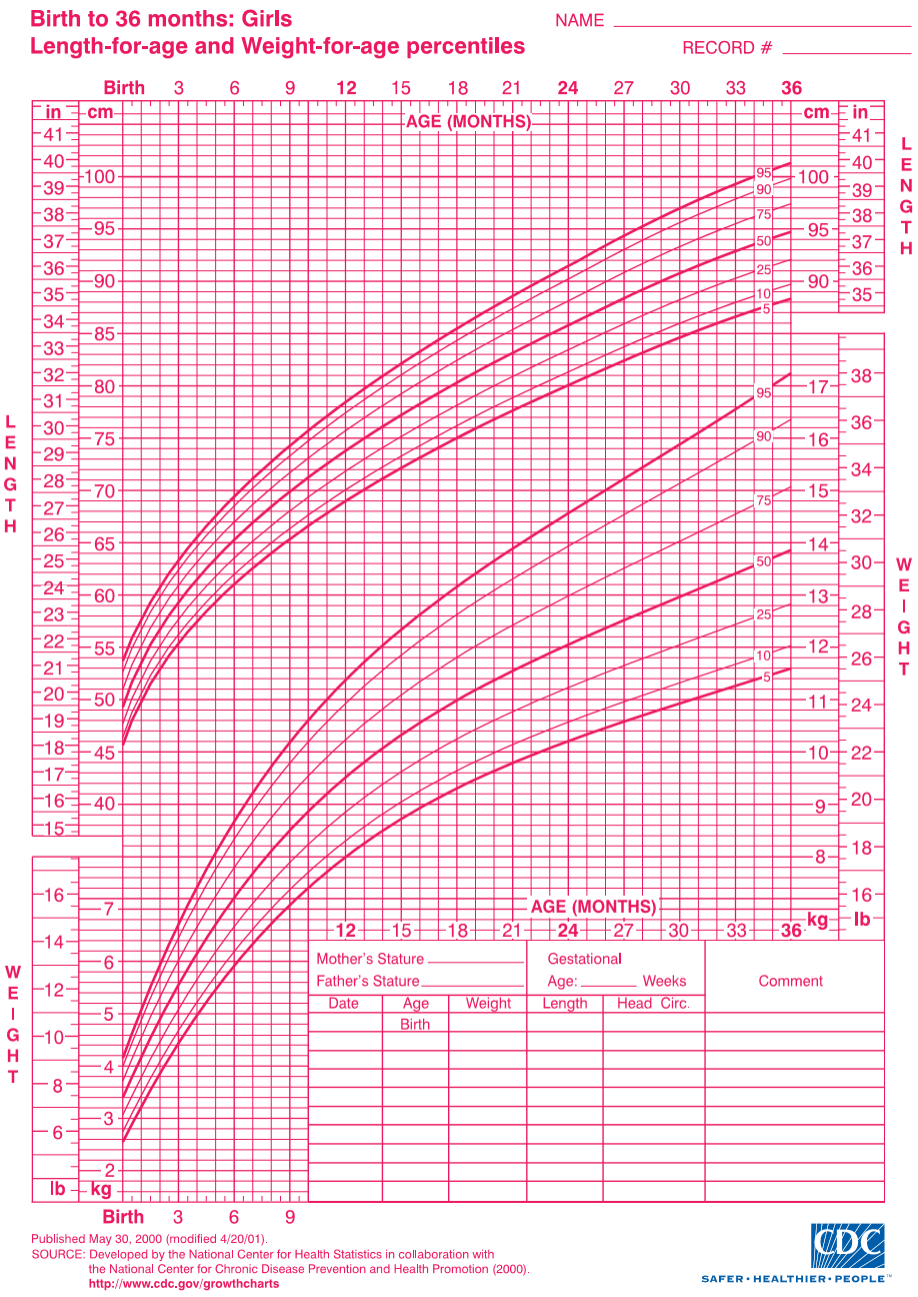


Figure 2. 3 Girls' length-for-age and weight-for-age from birth to 36 months (CDC, 2000)

During early childhood, children grow more slowly than in the infant and toddler period (Figure 2.4 and Figure2.5). The height growth rate remains declining from age six, and at the about age eight, the growth rate is about two inches, which is the lowest point. For girls, the height rate begins to increase from age eight and reach the highest point at around age twelve. For boys, the growth rate will keep slow during early childhood.

At the period of puberty, boys will have a sharp acceleration in the rate of growth again (Figure 2.4and Figure2.5). At around the end of thirteen years old, boys reach a high point of growth rate. After thirteen years old, the growth rate on both girls and boys goes down and ultimately stops at around age eighteen.

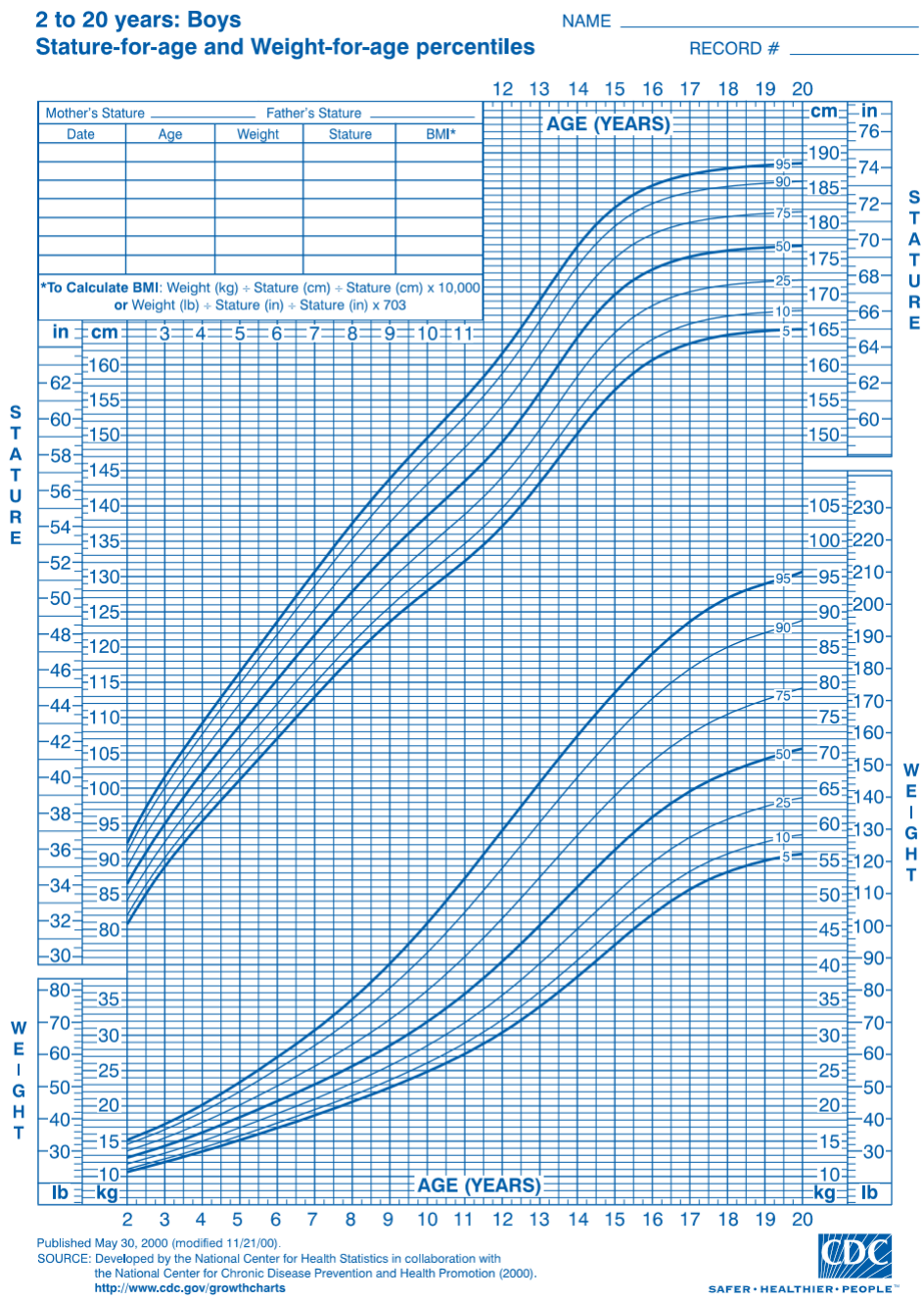


Figure 2. 4 Boys' stature-for-age and weight-for-age from 2 to 20 years (CDC, 2000)

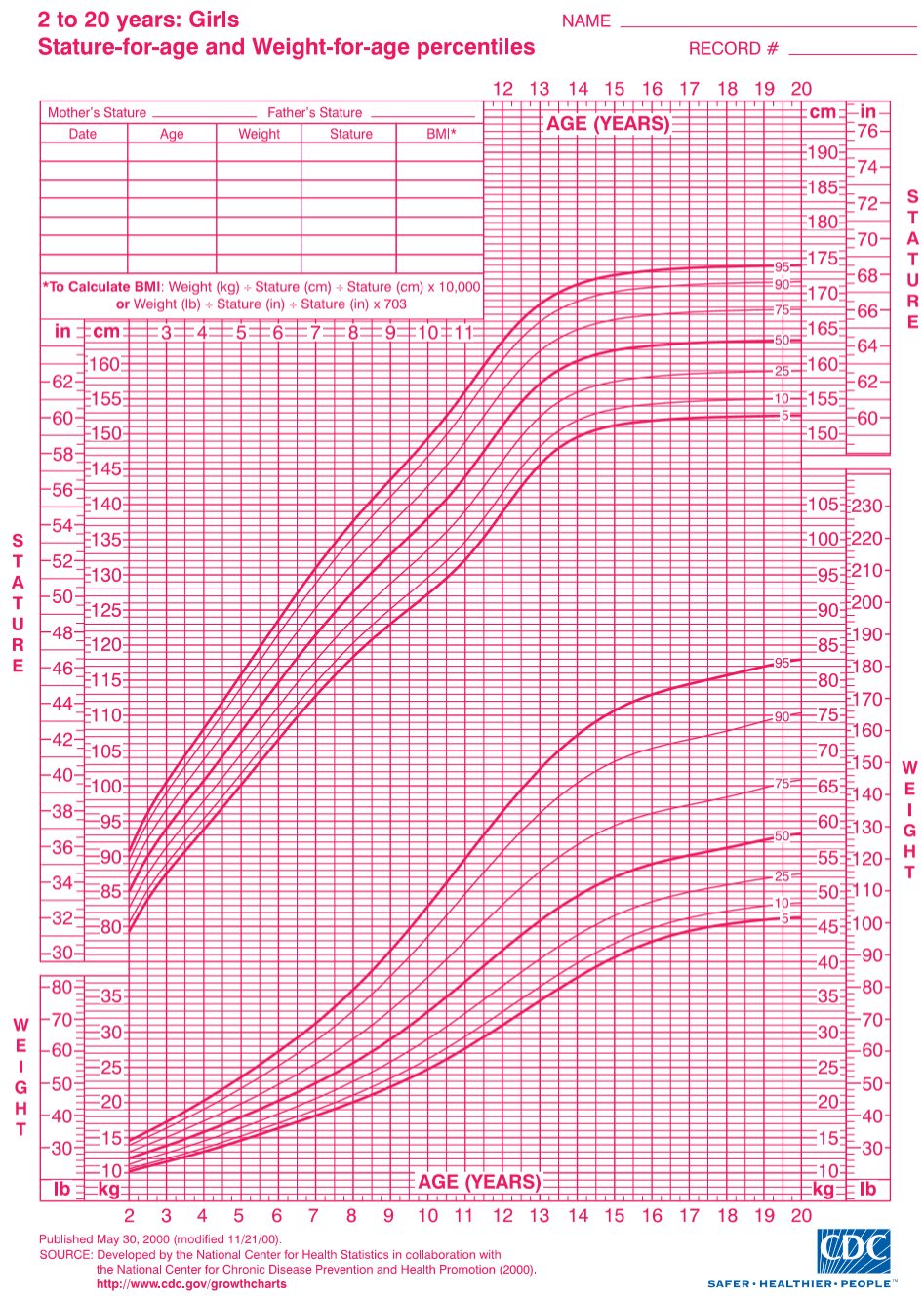


Figure 2. 5 Girls' stature-for-age and weight-for-age from 2 to 20 years (CDC, 2000)

2.2.1.2 Changes in Body Proportions

As the child's overall size increases, parts of the body grow at different rates. In the prenatal period, the head, chest, and trunk grow first, then the arms and legs, and finally the hands and feet. During infancy and childhood, the arms and legs continue to grow somewhat ahead of the hands and feet. During puberty, growth proceeds in the reverse direction. The hands, legs, and feet accelerate first, followed by the torso, which accounts for most of the adolescent height gain (Wheeler, 1991). Figure 2.6 changes in body proportions from the early prenatal period to adulthood illustrates the cephalocaudal trend of physical growth. The head gradually becomes smaller, and the legs longer, in proportion to the rest of the body.

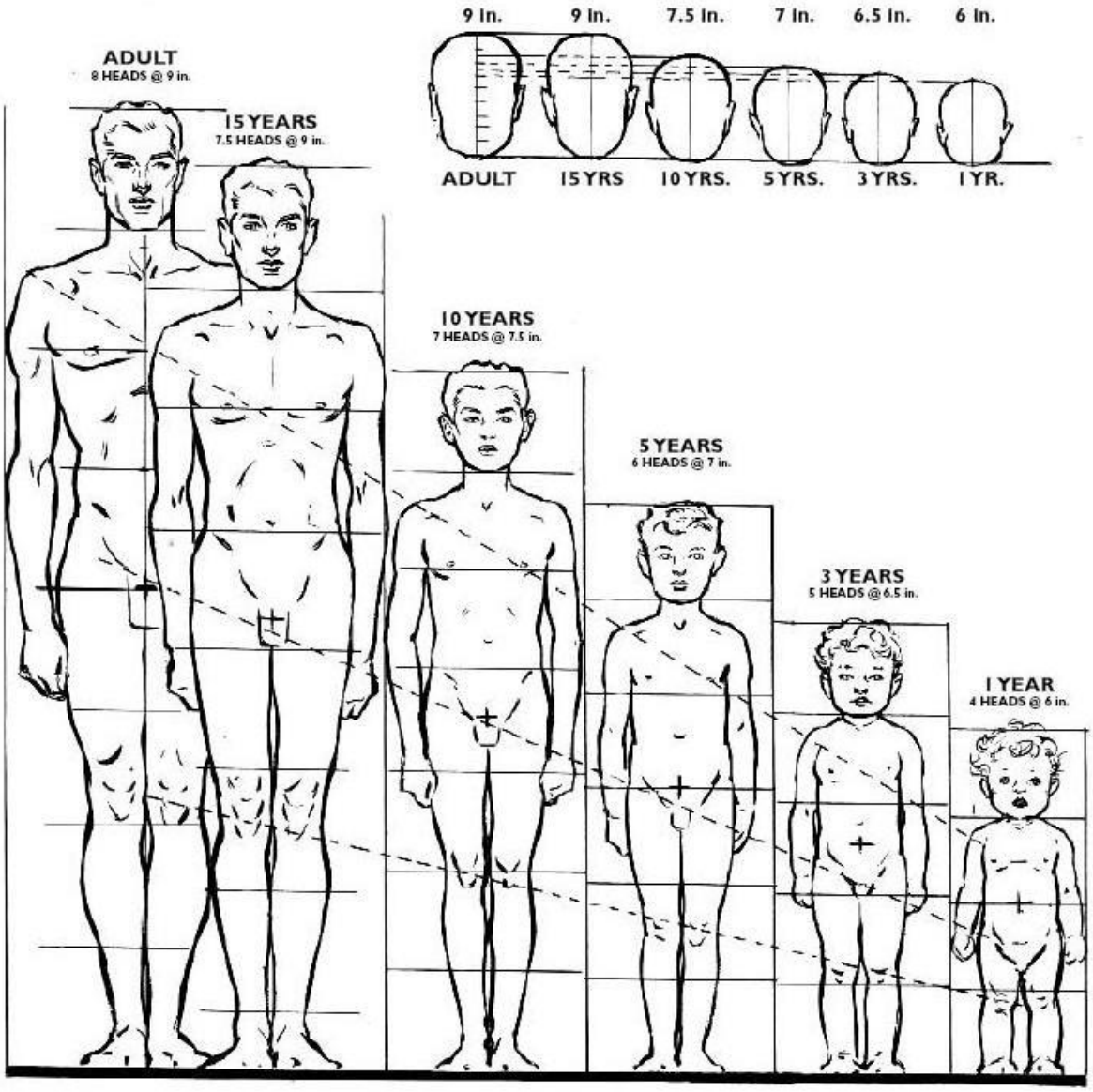


Figure 2. 6 Changes in Body Proportions (Loomis, 2012)

2.2.2 Motor Development

Motor development is a progressive change in motor behavior throughout life, which includes an interaction between the task, the biology of the individual and the influence of the environment (Gallahue & Ozmun, 2006).

In Gallahue and Ozmun's theory (2006), movement skills can be classified as stability, locomotor, and manipulative movement, and the phases of motor development can be classified as reflexive, rudimentary, fundamental, and specialized movement phase (Table 2.5).

	Intended Function of the Movement Task		
Phases of Motor Development	**Stability (Emphasis is on body balance in static and dynamic movement situations)**	**Locomotion (Emphasis is on body transportation from point to point)**	**Manipulation (Emphasis is on imparting force to or receiving force from an object)**
Reflexive Movement Phase: Involuntary subcortically controlled movements in utero and early infancy	• Labyrinthine righting reflex • Neck righting reflex • Body righting reflex	• Crawling reflex • Primary stepping reflex • Swimming reflex	• Palmer grasp reflex • Plantar grasp reflex • Pull-up reflex
Rudimentary Movement Phase: The maturationally influenced movements of infancy	• Control of head and neck • Control of trunk • Unsupported sitting • Standing	• Crawling • Creeping • Upright gait	• Reaching • Grasping • Releasing
Rudimentary Movement Phase: The basic movement skills of childhood	• Balancing on one foot • Walking on a low beam • Axial movements	• Walking • Running • Jumping • Hopping	• Throwing • Catching • Kicking • Striking
Specialized Movement Phase: The complex skills of later childhood and beyond	• Performing a balance beam routine in gymnastics • Defending a goal kick in soccer football	• Running the 100-meter dash or hurdles event in track • Walking on a crowded street	• Performing a goal kick in soccer or football • Striking a pitched ball

Table 2. 5 Gallahue's Two-dimensional Model for Classifying Movement (Gallahue & Ozmun, 2006)

2.2.2.1 Movement Skills

- **Stability Movement Skills**

Stability movement skills form the fundament for all other locomotor and manipulative skills and are referred to as non-locomotor skills. It is a vital element for every child to maintain and acquire balance like static (stationary) balance or dynamic (moving) balance, including reaching, twisting, turning, bending, and stretching (Gallahue & Donnelly, 2007).

- **Locomotor Movement Skills**

Locomotor movement skills "involve projection of the body into external space by altering its location in either a vertical or horizontal plane" (Gallahue, 1976, p. 4). Common locomotor activities in nature are running, jumping, skipping, and galloping.

- **Manipulative Movement Skills**

Manipulative movement skills mean that children are able to physically manipulate an object in their world, such as catching, trapping, and pulling toys. It consists of gross motor skills and fine motor skills, even though there is no clear boundary between both of them.

  - **Gross motor skills**

Gross motor skills are aimed to promote children's large muscle groups and are more broad and positive than fine motor movements. Giving force to objects or receiving force objects is usually referred to as gross motor. For example, children's common gross motor activities include walking, kicking, jumping, climbing stairs, other vigorous activities, and eye-hand coordination such as throwing or catching a ball (Burghardt, 2005).

- **Fine motor skills**

Obviously, fine motor skills involve small muscles groups of limited parts of the body, especially in the hand, such as sewing, writing, and typing (Gallahue & Donnelly, 2007) Violin playing, cutting with scissors, and tying one's shoes are considered to be fine motor skills.

Categories of Fundamental Movement Skills		
Stability Movement Skills	**Locomotor Movement Skills**	**Manipulative Movement Skills**
● Bending ● Stretching ● Twisting ● Turning ● Swinging ● Inverted supports ● Body rolling ● Landing/Stopping ● Dodging ● Balancing	● Walking ● Running ● Jumping ● Hopping ● Skipping ● Galloping ● Sliding ● Leaping ● Climbing	● Throwing ● Catching ● Kicking ● Trapping ● Striking ● Volleying ● Bouncing ● Ball rolling ● Punting

Table 2. 6 Fundamental movement skills details from Gallahue's book Developmental Physical Education for All Children (Gallahue & Donnelly, 2007).

2.2.2.2 Movement Phases

- **Reflexive movement phase(0-4 months)**

The reflexive movement of the fetus and newborn are considered to be the first phase of motor development. Reflexive behaviors are involuntary and subcortically controlled (Gallahue, 1976; Gallahue & Ozmun, 2002).

- **Rudimentary movement phase (0-2 years)**

Rudimentary movements begin developing in the infant from shortly after birth to approximately 2 years of age. They are "maturationally determined and are characterized by a highly predictable sequence of appearance" (Gallahue & Ozmun, 2002, p. 47). The movements involve the stability movements such as gaining control of the head, neck, and trunk along with learning how to sit and stand unaided. They involve the locomotor activities such as creeping, crawling, and walking. They also involve the manipulation experiences such as reaching, grasping and releasing objects.

- **Fundamental movement phase (2-7 years)**

This phase of motor development represents a time in which young children are actively involved in exploring and experimenting with the movement capabilities of their bodies. The involved stability activities can be beam walk and one-foot balance; the involved locomotor activities can be running and jumping; the manipulative activities can be throwing and catching.

- **Specialized movement phase (7-adulthood)**

The specialized movement abilities are an outgrowth of the fundamental movement phase. In this phase, movement abilities are becoming tools which can be applied for the use of daily life, recreation and sports (Gallahue, 1976; Gallahue & Ozmun, 2002). The fundamental movements of hopping and jumping may transform to activities like rope jumping or dancing in the phase of specialized movement. This phase can be divided into three sub-phases. The first stage is called the transitional stage. It's the period when children firstly apply the skills they learned in the fundamental movement phase to the performance of specialized movement in sport and recreational settings. Walking on a rope bridge, jumping rope, and playing soccer are

all examples of common transitional skills. The second stage is called application stage. During this stage, instead of doing all activities as “trials” in the transitional stage, children start to choose their favorite activity based on their increased cognitive sophistication and the broadened experience base as well as the environmental factors. The last stage is lifelong utilization stage. It’s the stage when the individual makes further refinement of the inherited interests from the previous stage and applies them to a lifetime of daily living, recreational, and sports-related activities (Gallahue & Ozmun, 2002).

2.2.3 Perceptual Development

2.2.3.1 Sensory Development

Sensory development includes five senses development: sight, taste, touch, smell and hearing development (Davis, 2019). Sensory development is the gradual process by which an infant’s senses begin to grow. Sensory development begins during gestation. However, an infant’s senses are not entirely developed even after birth. For instance, following birth, an infant’s eyesight is very limited, while sense of touch is well-developed.

Sight:

The visual system begins to develop around the ninth and tenth week of gestation and continues developing until three years after birth. At birth, infants are able to detect motion, can focus on an object about eight inches away, are sensitive to brightness, and have red and green color vision. By the end of the second month, infants are able to track smooth pattern movements and begin to discriminate between colors. During the third month, infants are better able to focus on objects farther away and are beginning to develop depth perception, both of which continue to develop until age two or three.

At around two years, babies' vision will reach to the near-adult level (Courage & Adams, 1990). For the color perception, newborn babies show interest in colorful objects, but they do not develop discrimination of colors until the age of two months. At around four months, the color sensitivity is well established.

Smell:

The odor preference is innate for babies. They will relate different odors to different emotional expressions. Also, they are quite adept at odor discrimination (Berk, 2000).

Hearing:

Children's sense of hearing is well developed at birth; however, there are sounds that a newborn child cannot hear. When children are around 3 months old, they begin to react to sounds by turning their heads to the direction of the sound. Young babies are quickly attentive to high-pitched voices (Aslin, Jusczyk, & Pisoni, 1998). By the time they are 8 months old, children can identify certain voices, and they are able to match voices with faces.

Touch:

The somatosensory system begins to develop during gestation. The nervous system, which is the message carrier to the brain for the senses, begins to develop at the third week of gestation. At the ninth week of gestation the sensory nerves have developed and are touching the skin. "The skin has many different kinds of receptors for receiving sensations of touch, pressure, texture, heat or cold, pain, and movement of the hairs on the skin" (Ayres & Robbins, 2005).

By the twenty-second week of gestation, the fetus is sensitive to touch and temperature. At birth, the sense of touch can be observed through the infant's reflexes when it comes in

contact with different stimuli. One example is the rooting response. This is when an infant will reflexively turn its head in the direction of a touch to its cheek. Touch is the primary way for babies to investigate their world. They will use touch, tongue, and vision to learn different objects (Berk, 2000).

Taste:

Our experiences of tasting are divided into six different types: sweet, sour, bitter, spicy, fresh, and salty. The tongue provides messages of the chemical makeup of the particles that touch it, called the taste (Ayres & Robbins, 2005). An infants' taste buds begin to develop eight weeks after birth. They react to bitter, sour, and sweet tastes. However, when they are around 4 months, they begin to react to salty tastes.

	0-3 mouths	3-6 months	6-9 months	9-12 months
Sight	Limited color, begins to make eye contact	Developing eye rods and cones, tracking objects and people	Eye control, hand-eye coordination, and depth perception improves	Depth perception and distance judgements improve. Easy grabbing of objects
Smell	Fully developed, will turn towards the source of food	Interested in smells of food, stronger reaction to bas odors	Uses sense of smell to help decision whether he/she likes new food	Increase in smell preference and reaction
Hearing	Fully developed, will react to familiar sounds	Sounds become associated with objects sound mimicking begins	Able to identify the direction of sounds & recognize familiar words	Can recognize and react to songs and sounds
Touch	Fully developed, will crave skin-to -skin contact	Able to use both sides of body together, learn push and pull	Recognizes textures and begins grabbing with thumb and forefingers	Crawling and grabbing develops. Baby is now able to grasp hand and held toys
Taste	Attracted to the sweet (but not sugary) flavor of breast milk and formula	Begins to become open to flavors such as salt and shows interest in others' food	Starts to reach for nearby food	Enjoy a greater variety of tase

Table 2. 7 Sensory Development

2.2.3.2 Perceptual Development

When babies come into this world, they observe their surroundings and take in information from the physical world almost all the time. Babies will significantly develop their perception abilities by combining and absorbing this information. There is one point that needs to be noticed: babies do not develop perceptions separately. On the contrast, they will make all the perceptions together. When one ability develops, the other one will be improved. They are in a system, and they are coordinated with each other (Berk, 2000). In the first six months, the development of perceptual ability will be improved most quickly and importantly. The perceptual system will be established at the end of the first year and mature in the second year.

Depth Perception: Depth Perception is "the ability to judge the distance of objects from one another and ourselves." This ability could help prevent children from "bumping into furniture and falling staircases" (Berk, 2000, p. 156). According to the Visual Cliff study, the researchers concluded that the infants already have the depth perception to distinguish depth and avoid falling. Infants will use different methods to help them detect depth. The first method to develop is Kinetic Depth Cues. It appears at around three to four weeks. Babies will take advantage of body movement to learn about depth. With the motor skills development, babies' movement becomes more independent. Thus, their depth of cue sensitivity will be more refined.

The second method is Binocular Depth Cues, which mainly relies on the information received by the two eyes. The third method is Pictorial Depth Cues, which will emerge in the middle of the first year. Examples are receding lines, texture changes and overlapping objects (Berk, 2000). The proper and disciplinary illusion could help infants to judge the space depth.

Pattern Perception: Babies' ability of the visual system improves quickly during the first several months. It becomes mature at the end of the first year. Young babies prefer to look at simple, large and patterned stimuli rather than plain stimuli (Fantz, 1961). They also will respond to the separate parts of a pattern (Bronson, 1991). For older babies around two months, they prefer complex, small and patterned stimuli. They also develop the ability to notice the entire border of a geometric shape (Bronson, 1991). At about four months, babies can even recognize the subjective boundaries that do not exist (Ghim, 1990). By the end of the first year, infants can even "extract meaningful patterns on the basis of very little information" (Berk, 2000, p. 161). At the same time, babies' knowledge about their surroundings is expanding. Also, abundant knowledge is the main factor to improve babies' pattern sensitivity (Bertenthal, 1993).

Object Perception: Researchers observed that infants have the innate capacities to distinguish the objects on the actual size and shape, not only on retinal image size or shape. This ability is called Size Constancy and Shape Constancy (Slater, 1997). Also, Piaget (1985) suggested that young infants cannot perceive the boundary between two different sized, shaped or textured objects, and also, they see the two objects as a single unit.

2.2.4 Cognitive Development

Cognitive development refers to how a person perceives, thinks, and gains understanding of his or her world through the interaction of genetic and learned factors. Among the areas of cognitive development are information processing, intelligence, reasoning, language development, and memory (Cook, 2005).

The most well-known and influential theory of cognitive development is that of French psychologist Jean Piaget (1896–1980). Piaget's theory, first published in 1952, grew out of decades of extensive observation of children, including his own, in their natural environments as opposed to the laboratory experiments of the behaviorists. He envisioned a child's knowledge as composed of schemas, basic units of knowledge used to organize past experiences and serve as a basis for understanding new ones.

Piaget's theory of cognitive development is a comprehensive theory about the nature and development of human intelligence. Piaget identified four stages (Table 2.8) in cognitive development (Piaget, cited in Butler et al, 1978):

(1) Sensorimotor stage (Infancy): The sensorimotor stage is the first of the four stages that Piaget stated in cognitive development. It starts from birth to the acquisition of language. In this period, intelligence is demonstrated through motor activity without the use of symbols.

Knowledge of the world is limited (but developing) because it is based on physical interactions or experiences permanence. Infants acquire the knowledge from the external world by coordinating experiences (such as vision and hearing) with physical interactions with objects (such as grabbing, sucking, and kicking). By the end of this stage, the child will be able to differentiate him or herself with the external object permanently (Butler et al., 1978). Some symbolic (language) abilities are developed.

(2) Pre-operational stage (Toddler and Early Childhood): There are two sub-stages in pre-operational stage: the symbolic function sub-stage (age 2 to 4) and the intuitive thought sub-stage (age 4 to 7). In this period, intelligence is demonstrated using symbols, language use matures, and memory and nation are developed, but thinking is done in a nonlogical, nonreversible manner. Egocentric thinking predominates.

(3) Concrete operational stage (Elementary and early adolescence): The third stage occurs between the ages of 7 and 11. In this stage (characterized by 7 of conservation: number, length, liquid, mass, weight, area, volume), intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects Operational thinking develops (mental actions that are reversible). Egocentric thought diminishes.

(4) Formal operational stage (Adolescence and adulthood): The final stage is from adolescence to adulthood, roughly ages 11 to approximately 15-20. In this stage, intelligence is demonstrated through the log of symbols related to abstract concepts. Early in the period there is a return to egocentric thought. Children are capable of hypothetical and deductive reasoning. They develop the ability to think about abstract concepts.

PIAGET THEORY OF COGNITIVE DEVELOPMENT CHART		
Stages	**Age Range**	**Description**
Sensorimotor	From birth to 2 years	- Identifies object performance, the object still exists when out of sight - Recognition of ability to control object and acts intentionally
Preoperational	2 to 7 years	- Begins to use language - Egocentric thinking difficulty seeing things from other viewpoints - Classified objects by single feature i.e. color
Concrete Operational	7 to 11 years	- Logical thinking - Recognizes conservation of numbers, mass and weight - Classifies objects by several features and can place them in order
Formal Operational	11 years and onward	- Logical thinking about abstract propositions - Concerned with the hypothetical and the future - Create hypotheses and test

Table 2. 8 Piaget Theory of Cognitive Development Chart ("Cognitive Development", n.d.)

2.2.4.1 Cognitive Development Aspects

External stimuli such as books and learning toys are important in developing cognitive abilities. Experts recommend that children be exposed to books at an early age and little amounts of television as this tends to reduce cognitive development. The American Academy of Pediatrics (2016) recommends that children under two years old should not watch any television and that, after this age, television exposure should be limited.

Children who interact frequently with other people tend to become brighter and gain confidence as compared to those who relate with less people. It is important for children to interact with others as this helps them to build their language and speaking skills. They are also likely to be read to, which makes them learn faster.

Play is an essential aspect of cognitive development (Bergen, 2018). Scientists recommend that children be exposed to toys that help build their cognitive abilities such as

abilities to recognize numbers and letters. Playing with other children can also build social confidence which improves cognitive abilities.

According to the theory of cognitive development from Piaget. There are three significant cognitive variables, which is conservation ability, problem solving skills and creativity (Johnson et al., 1987).

Conservation. Conservation shows the ability to understand certain properties of objects. Rubin, Fein and Vandenberg (1983) argued that when children are able to engage in make-believe play, they have already mastered two cognitive conservations, which is decentration and reversibility. Decentration is the realization that they can be themselves and the imagined role at the same time. Reversibility is the ability to switch the roles back to themselves from the make-believe play at any time.

Problem Solving. Bruner (1972) contended that play contributes to children's problem solving ability through increasing their behavioral options. He stated that the meaning of play is more important than the end of play. Because children do not require accomplishing some exact goals when playing, they will make experiments about new or even unusual ways of play. And when they come across some real-life problems, they may use the same approach. So play can promote the problem solving ability by increasing children's behavioral options.

Creativity. Butler, Gotts and Quisenberry (1978) proposed that children use play to express their creativity. Role-playing allows them not only to show their creativity but also display the internal feelings. Building structures and art toys provide children with creative, expressive outlets. Creativity is treated as the strongest link between play and cognition (Johnson et al., 1987). Sutton-Smith (1967) pointed out that during make-believe play, the

symbolic transformations occur and reflect a similar effect on children's mental flexibility and creativity.

2.2.5 Social Development

The same as physical development and cognitive development, social development, children's ability to interact with other children and adults, is a critical piece of the development puzzle. In the social development theory, Leo Vygotsky primarily explains that socialization affects the learning process in an individual (as cited in Chaiklin, 1999). Social development refers to the process by which a child learns to interact with others around them. As they develop and perceive their own individuality within their community, they also gain skills to communicate with other people and process their actions. Social development most often refers to how a child develops friendships and other relationships, as well how a child handles conflict with peers (Isaaca, 1933).

Social development can impact many of the other forms of development a child experience. "A child's ability to interact in a healthy way with the people around he can impact everything from learning new words as a toddler, to being able to resist peer pressure as a high school student, to successfully navigating the challenges of adulthood" ("Social Development in Children", 2019). Healthy social development can help the child develop language skills, strengthen learning skills and build self-esteem.

An ability to interact with other children allows for more opportunities to practice and learn speech and language skills. This is a positive cycle, because as communication skills

improve, a child is better able to relate to and react to the people around him ("Social Development in Children", 2019).

In addition to the impact social development can have on general communication skills, many researchers believe that having healthy relationships with peers allows for adjustment to different school settings and challenges. Studies show that making new friends in the classroom was associated with gains in school performance, and early peer rejection forecasted less favorable school perceptions, higher levels of school avoidance, and lower performance levels over the school year (Gary, 1990).

Play has a key role in social development by providing a context in which children can acquire important social skills as well as the ability to understand other people's thoughts. Thus, when social environment influences the play, play also affects children's ability in the social environment. Social skills and perspective taking will be reviewed.

Social Skills. "All social play is rule governed" (Johnson et al.,1987, p. 99); even the simple infant game like peek-a-boo requires the right sequences. Also, the rules for play have a great difference from the games with rules which Piaget suggested in the cognitive development theory. Instead of defining the rules before game, rules for play are set by players during the course of the play. Therefore, children are not only learning and following the rules but also thinking about the nature and meaning of rules.

Garvey (1974) indicated that group play such as socio-dramatic play requires children to be able to construct and vary the theme of play together. In order to accomplish a successful socio-dramatic play together, children need to agree to adopt each one's role and to choose the most appropriate object for identity substitution. The story sequences also need to be decided

cooperatively. All of these actions require children to develop and master the communicating and perspective taking skills (which will be discussed below). Social-dramatic play ability correlates with social skill (Butler et al., 1978).

Perspective Taking. According to the definition from Johnson, Christie and Yawkey(1987), perspective taking is "the ability to see things from other people's point of view" (p. 101). It involves what other people see, think and feel, which can also be said as visual perspective taking, cognitive perspective taking and affective perspective taking.

The reason why perspective taking is hard to develop is because its role is deeply opposed to the egocentric human nature. Humans are born to be egocentric. With the development of the mind and the cultivation of the external environment, step by step, the child will realize the world is not his. He starts to realize his mother is separated from him; he starts to realize the objects exist even though he doesn't see them. And during socio-dramatic play, he has to fit himself into the role with the role's personality, which promotes the ability to think from another person's perspective.

2.2.5.1 Social Development Aspects

Emotional Expression and Understanding

At the very beginning at birth, infants begin to express basic facial emotions like happiness, interest, surprise, and fear. In the middle of the first year, emotional expression is well organized and related to social events. Also, infants could express their internal state in multiple and specific ways (Izard, Fantauzzo, Castle, Haynes, Rayias, & Putnam, 1995). At around one to two years old, infants begin to have self-conscious emotions like shame, embarrassment, guilt, envy, and pride. Based on the development of language, they tend to regulate emotions by

talking about feeling as their language ability expands (Saarni, Mumme, & Campos, 1998). Empathy also appears in this period, which means infants begin to sense others negative emotions and try to relieve them. In sum, at the very beginning of life, infants hold the essential ability of emotional expression and understanding. The early months are the most critical period for children to form the cornerstone of adult personality and temperament.

After age three, the self-evaluation emerges, which means children's self-consciousness will be enhanced in this period (Lewis, Alescess, & Sullivan, 1992). The early preschool years are vital for children to learn strategies about how to control their feelings. The strategies include but are not limited to emotion display and emotion judging. Children who can have better instruction of emotional practice will get along better with peers when they go to school after six years old (Eisenberg, Fabes, Murphy, Karbon, Smith, & Maszk, 1996). Also, children's understanding of other's emotion improves in accuracy and complexity. They could distinguish the causes, consequences and behavioral signs of different emotions (Berk, 2000). With language maturing, empathy becomes more reflective. Children show the ability to assess another's feelings and rely on words to console others. The children who get better development of empathy will be more sociable, assertive, and good at regulating emotion.

When children go to school at seven or eight years old, the negative emotions that threaten their sense of self-worth will appear. Therefore, the strategies of emotional self-regulation will increase rapidly after school entry. Children tend to find their internal standards for right action. Their internal conformity and conscious awareness of rules improve. Also, in this period, children's expression may not reflect their true feelings (Berk, 2000). Furthermore, on the side of self-understanding, children will begin to mention personality traits in both

positive and negative aspects about themselves. They are less likely to describe themselves in all-or-none ways (Berk, 2000, p. 447).

Contrasting to the rapid development on the previous time, adolescent's emotional expression and understanding become mature. They might generate a diverse array of self-regulatory techniques and flexibly adjust them to situational demands (Saarni, 1997). Even though children's emotional expression and gains in empathy mainly develop in early ages, and are influenced by caregivers and family experiences, they still have the opportunity to change the ability of emotional self-regulation.

Self-Understanding

At around three months, researchers observe that the I-self emerges. The I-self is a sense of self as subject, or agent, who is separate from but attends to and acts on objects and other people. For infants, the environment performs a vital role in helping them build an image of self separate from the physical world and the social world (Berk, 2000). At about fifteen months, the me-self emerges. The me-self is a reflective observer who treats the self as an object of knowledge and evaluation. Around age two, self-recognition is well established. The appearance of self-recognition precedes the ability of imitation in play (Asendorpf, Warkentin, & Baudonniere, 1996). Thus, toddlers begin to learn copy behaviors and cooperate with peers to solve simple problems.

Around the age of three-four years old, preschoolers' minds become more differentiated, organized and accurate. They could understand the relationship between beliefs, desires, and actions. Wellman (1990) created the belief-desire theory of mind to explain that both beliefs and desires determine behavior and that closely resembles the everyday psychology of adults. Thus,

it is encouraged for children to do the make-believe play, which triggers awareness that beliefs influence behavior (Astington & Jenkins, 1995). Also, the me-self, which appears at around fifteen months, will expand to a self-concept. As language develops, children in this age period usually mention observable characteristics about themselves and describe themselves in terms of typical emotions and attitudes. Also, their self-esteem is typically high and begins to differentiate at this time.

Furthermore, from the age of six to seven, children's self-esteem becomes hierarchically organized and divided into at least three aspects: academic, physical and social. Contrary to the high self-esteem in early childhood, children's self-esteem declines in this period due to their self-judgment on their abilities, behavior, appearance and other characteristics with other peers (Marsh, Bernes, Cairns, & Tidman, 1984). To shield their self-worth, children will tend to find their achievement goals to raise their self-esteem. In this sensitive period, it is crucial for children to form a mastery-oriented fashion (Attributions that credit success to high ability and failure to insufficient effort). They should be encouraged to pursue a learning goal behavior which will highlight a task that will help for their study. In this study mode, children will persist at challenging tasks (Elliott & Dweck, 1988).

The self-concept becomes an organized system of personality traits. Young adolescents usually describe themselves by using contradictory words. This trait comes from "social pressures to display different selves in different relationships" (Berk, 2000, p. 447). Teenagers are struggling to find "which is the real me". Moreover, teenagers show concern about their social virtues, if they are liked or viewed positively by others (Berk, 2000). In the final development stage, adolescents will "move toward the kind of unity of self that is central to

identity development" (Berk, 2000, p. 447). In the process of forming an identity, adolescents usually have four identity statuses, which are identity achievement, moratorium, identity foreclosure, and identity diffusion before constructing a mature identity (Berk, 2000). At the same time, self-esteem continues to rise.

Moral Understanding and Self-Control

From about one to two years old, toddlers begin to notice and be concerned about some acts which have deviations from standards. Also, they will model a wide variety of prosocial acts to try to adopt social norms. The first glimmerings of self-control as the form of compliance appears in this period (Kaler & Kopp, 1990). Opposition also appears at the same time in order for toddlers themselves to assert autonomy. However, the resistance will gradually turn into negotiating compromises during the preschool years.

As preschoolers, children display the reaction of guilt about their transgressions. Also, their internalization of many prosocial standards and prohibitions has occurred. Furthermore, the ability of self-control improves. Children start to learn some strategies from parents. Also, self-control has been transformed into "a flexible capacity for moral self-regulation," an ability that children could monitor and adjust themselves in a changeable circumstance (Bandura, 1991). Children gradually cultivate a delay of gratification, which means children will wait for more time to engage in the desired object (Berk, 2000). School-aged children continue to form an internalization of societal norms and expand more strategies of self-control.

Gender Typing

By one to three years old, because of the gender-stereotyped games and toys, children gradually develop a high stereotype about boys and girls (O'Brien & Huston, 1985).

By age five, with the developing of "gender-appropriate" play, gender stereotyping of activities, occupations, and behaviors is well established. Children might have the preference to play with same-sex peers in this period (Berk, 2000). Moreover, gender identity emerges at the beginning of the period, and gender-linked self-evaluation develops at the end of the period.

When children go to school, they have a more extensive variety of gender stereotypes which expands to the areas of personality traits and achievement (Signorella, Bigler, & Liben, 1993). Contrary to early childhood, schoolers' beliefs about gender stereotypes become more flexible. Especially for girls, although their "overall orientation still leans toward the feminine side," their identification with "feminine" declines. In the contrast, boys strengthen their identification with the "masculine" role (Berk, 2000).

When children enter adolescence, the gender-role conformity begins to increase, but then it will decline, especially in girls. Also, girls will become less gender-typed than boys (Huston & Alvarez, 1990).

Age	0-2years	2-6 years	6-12 years	12+ years
Emotional Expression	Well-organized Clearly Anxiety in crease Self-regulation improves Self-conscious appears	Emotion regulation improves	Self-conscious relates with inner standard Emotion regulating become internal	Further improve
Emotional Understanding	Understand Caregiver's feeling Detect others emotion Empathy appears	Understanding improves in accuracy and complexity	Understand mixed feelings Understand expression may not reflect true feeling	Further improve
Self-Understanding	Self-re cognitive emerges Self-evaluation appears	Self-esteem is high Achievement-related attributions appear	Self-concept emphasizes personality Self-esteem declines	Self-concept becomes organized Self-esteem rise Identity develop
Moral Understanding	Concern emerge Pro social act begins	Guilt reaction emerges Pro social standards occur	Continue develop	Continue develop
Self-Control	Compliance emerges	Self-control emerges	Self-control strategies expand	Continue develop
Gender Typing	Gender stereotyping occur Link to self-evaluation	Gender stereotyping occur Link to self-evaluation	Gender stereotype expand Masculine identity strengthen	Gender-role conformity rises and then declines

Table 2. 9 Social development(Berk, 2000)

2.3 Children's Development Theories

Children's development theories focus on explaining how children change and grow over the course of childhood. Such theories center on various aspects of development including social, emotional, and cognitive growth.

Some of the major theories of child development are known as grand theories; they attempt to describe every aspect of development, often using a stage approach. Others are known as mini-theories; they instead focus only on a fairly limited aspect of development such as cognitive or social growth.

There are many child development theories that have been proposed by theorists and researchers. More recent theories outline the developmental stages of children and identify the typical ages at which these growth milestones occur.

2.3.1 Psychoanalytic Child Development Theories

The psychoanalytic theories of child development tend to focus on things such as the unconscious and forming the ego. The two primary psychoanalytic theories of development are Sigmund Freud's theory of psychosexual development and Erik Erikson's psychosocial theory of development.

1. Freud's Psychosexual Child Developmental Theory

Sigmund Freud was an Austrian neurologist and the founder of psychoanalysis (Freud, 1955). Freud believed that childhood experiences and unconscious desires influenced behavior. His theory suggested that the energy of the libido was focused on different erogenous zones at

specific stages. Failure to progress through a stage can result in fixation at that point in development, which Freud believed could have an influence on adult behavior (Cherry, 2019).

According to Freud's psychosexual theory, child development occurs in a series of stages focused on different pleasure areas of the body. During each stage, the child encounters conflicts that play a significant role during development. The stages of Freud's child development theory are the oral, anal, phallic, latent, and genital stages (Table 2.10). During the oral stage, for example, a child derives pleasure from activities that involve the mouth such as sucking or chewing.

Age	Stage	Pleasure Area	Characteristics
0-1	Oral	Mouth	Pleasure from eating and vocalizing
1-3	Anal	Anus	Pleasure from retention or repulsion of feces
3-6	Phallic	Genitals	Pleasure from touching genitals, Oedipal (male) and Electra (female) complexes
6-12	Latency	None	Identification with same-sex parent
12-18	Genital	Genitals	Heterosexual attraction

Table 2. 10 Freud's psychosexual stages of development

2. Erikson's Psychosocial Child Development Theory

Erik Erikson was influenced by Freud's work, but his own child development theories focused on the importance of social experiences in shaping a child's psychological growth.

Erikson's eight-stage theory of psychosocial development describes growth and change throughout life, focusing on social interaction and conflicts that arise during different stages of development (Cherry, 2019). At each stage of development, people face a crisis that they must

master. Mastering the crisis leads to the development of a psychological virtue (Table 2.11). For example, as children start out in the trust versus mistrust stage, during this early stage of life, it is important for children to receive consistent care so that they can learn to trust the people in the world around them.

Age	Stage	Virtue	Outcome
0-1	Trust vs Mistrust	Hope	Develop basic trust or lack of self confidence
1-3	Autonomy vs Shame and Doubt	Will	Learn self-care and independence or experience shame and doubt capabilities
3-6	Initiative vs Guilt	Purpose	Become more assertive or guilty
6-12	Industry vs Inferiority	Competence	Accomplishment and competence or failure to master cultural and educational skills
12-18	Identity vs Role Confusion	Fidelity	Accept pubertal changes and develop a sense of identity or experience a feeling of confusion
19-40	Intimacy vs Isolation	Love	Develop close relationships (and marriage) or avoid others and become isolated
40-65	Generativity vs Stagnation	Care	Provide for the next generation or turn inward and lack meaningful accomplishment
65+	Ego Integrity vs Despair	Wisdom	Life review and assessment leads to self-acceptance and wisdom or regret

Table 2. 11 Erik Erikson's Stages of Psychosocial Development

2.3.2 Montessori Education

Montessori education is a 100-year-old method of schooling that was first used with impoverished preschool children in Rome (Lillard, 2006). The program continues to grow in popularity. Estimates indicate that more than 5000 schools in the United States—including 300 public schools and some high schools—use the Montessori program (Lillard, 2006). Montessori education is characterized by multi-age classrooms, a special set of educational materials,

student-chosen work in long time blocks, collaboration, the absence of grades and tests, and individual and small group instruction in both academic and social skills (Montessori, 1964). The effectiveness of some of these elements is supported by research on human learning (Lillard, 2005).

Montessori education began in the early 1900s (Montessori, 1964). The first House of Children (Casa dei Bambini) opened in 1907 and served preschool-aged children in a housing project in Rome. Montessori's method quickly spread to serve different populations of children. In just five years, Montessori classrooms had opened round the world, including an outdoor "classroom" at the University of Virginia (Holsinger, Hebich, and Walters 1978). So impressed was Montessori by the transformation of the children in her schools, that despite having expended enormous efforts to become one of the first women in Italy with a medical degree (Povell, 2010), she abandoned her career as a doctor and professor. She spent the rest of her life—almost fifty years—developing and refining the Montessori system, extending it for children from birth through age twelve. When she died in 1952, she was developing Montessori methods for adolescents (Montessori, 1976).

2.3.2.1 Sensitive Period in Child Development

Montessori Sensitive Period Theory talks about sensitive periods in childhood development from birth to six years old and how the child is guided by inner forces that shape their developmental needs. Ten sensitive periods are listed below:

Movement (0~1 Years Old): Random movements become coordinated and controlled: grasping, touching, turning, balancing, crawling, and walking (Montessori, 2013). Parents usually select toys which can help children develop their gross and fine motor skills. As Figure 2.

5 shows below, there are a lot of infant hand toys that children can bite, shake, grasp and touch. At this sensitive period, children are more likely to play by themselves, and parent participation is only an aid.

Language (0~6 Years Old): Use of words to communicate: a progression from babble to words to phrases to sentences, with a continuously expanding vocabulary and comprehension (Montessori, 2013). Parents like to select toys which can help children develop their language skills; thus, I would extract a lot of design elements from the story book in my guidelines for designers to apply them into parent-child toys later on. At this sensitive period, children need to follow parents' lead in a sense. Thus, designers need to add more parent participation theoretically.

Refinement of the Senses (2~6 Years Old): Fascination with sensorial experiences (taste, sound, touch, weight, smell) resulting with children learning to observe and with making increasingly refined sensorial discriminations (Montessori, 2013). At this period, children consciously and constantly improve their senses. I will extract some design elements for designers to apply mixtures of sight, hearing, smell, taste and touch into parent-child toy design.

Small Objects (1~4 Years Old): A fixation on small objects and tiny details (Montessori, 2013). At this sensitive period, children are more likely to play by themselves, because more parent participation would interrupt children's play and reduce their attention.

Order (2~4 Years Old): Characterized by a desire for consistency and repetition and a passionate love for established routines. Children can become deeply disturbed by disorder. The environment must be carefully ordered with a place for everything and with carefully established ground rules (Montessori, 2013).

Music (2~6 Years Old): Spontaneous interest in and the development of pitch, rhythm, and melody (Montessori, 2013). At this sensitive period, children are more likely to pick up music via playing some musical toys. Thus, I will extract some design elements for designers to apply music into parent-child toy design later on.

Reading (3~5 Years Old): Spontaneous interest in the symbolic representations of the sounds of each letter and in the formation of words (Montessori, 2013). I would also refer to the best-selling storybook and try to make reading fun.

Writing (3~4 Years Old): Fascination with the attempt to reproduce letters and numbers with pencil or pen and paper. Montessori discovered that writing precedes reading (Montessori, 2013). I would also refer to the best-selling storybooks and try to make writing fun.

Spatial Relationships (4~6 Years Old): Forming cognitive impressions about relationships in space, including the layout of familiar places. Children become more able to find their way around their neighborhoods, and they are increasingly able to work complex puzzles (Montessori, 2013).

Mathematics (4~6 Years Old): Formation of the concepts of quantity and operations from the uses of concrete material aids (Montessori, 2013). At this period, children will generate interest if parents guide them a little bit. I would extract some design elements for designers to combine simple mathematics problem with entertainment.

2.3.2.2 Montessori Education Requirement on Furniture Design

Montessori was the first advocate of preparing children orderly, clean, aesthetic environments, using child-size furnishings and using harmonious colors and beautiful materials.

The carefully prepared environment is a key component of Montessori's philosophy She states: “The immense influence that education can exert through children, have the environment for its instrument, for the child absorbs his environment, takes everything from it, and incarnates it in himself (Montessori, 1995, p. 66). And According to Montessori, the child must find the environment motivating, so he or she is interested in pursuing the available activities. The child will then want to "conduct his own experiences" (Montessori, 1995, p. 92).

Montessori stressed that the environment needs to liberate the spirit, promote independence, allow activity, and be beautiful, safe, and orderly. It is necessary that the environment be orderly to prevent children from wasting their energy seeking materials (Standing, 1957). Additionally, Montessori believed that when children play in an orderly environment, this desire for order becomes part of the child.

Child-size environments, according to Montessori, applied to not only furnishings but also the proportions within the entire building (windows that are near the ground, low door handles, shallow steps) (Standing, 1957). Montessori promoted using low, open shelves to display self-correcting materials (e. g, knobbed cylinders to seriate by size are placed in a frame that will only allow the correct-sized cylinder to fit). Montessori also advocated providing real working tools (knives and scissors that cut, shovels and trowels that actually dig holes, quality paints and clay) to children.

Montessori also believed in beauty. According to Montessori, the environment and materials should be clean and have harmonious colors. However, Montessori also stressed that materials should be practical. For example, Montessori replaced several expensive, beautiful marble tables that had been donated to the Montessori center with more practical, simpler, wooden tables that could be easily moved by the children.

The goal of the environment according to Montessori is, “As far as it is possible, to render the growing child independent of the adult. That is, it is a place where he can do things for himself –live his own life–without the immediate help of adults.” In this environment the child becomes “increasingly active, the teacher increasingly passive. It is a place where the child more and more directs his own life: and in doing so, becomes conscious of his own powers. As long as he is in a state of dependency on the adult he cannot grow as he should" (as cited in Standing, 1957, p. 267).

2.3.3 Piaget’s Theories

Professor Jean Piaget (9 August 1896 – 16 September 1980) is most widely known as a child psychologist; nevertheless, he was also a zoologist, a mathematician, and a philosopher and a genetic epistemologist. Piaget's theory of cognitive development and epistemological view are together called "genetic epistemology".

Piaget’s Theories Requirement on Furniture Design

Piaget stresses active physical and mental interactions and being able to transform space. Like Montessori, Piaget believed that children learn through play, with curiosity driving their learning. He stressed that children construct their knowledge through active involvement. Piaget stressed, “Active physical and mental interactions of the child with the environment (physical and social interactions) that permit construction are seen as the most important school-related factor in cognitive development” (as cited in Wadsworth, 1989, p. 165).

Piaget believed that the child needs to be able to transform space. This includes looking at things from a different angle, such as looking down upon a scene on the classroom floor from a loft. Piaget encourages teachers to arrange safe, supportive environments for spontaneous

exploration where learners are free to choose from many alternatives (as cited in Bullard & Hitz, 1997).

As stated by Piaget, “Experience is always necessary for intellectual development… but I fear that we may fall into the illusion that being submitted to an experience (a demonstration) is sufficient for a subject to disengage the structure involved” (as cited in Duckworth, 1964, p. 174). However, more than just experience is required. “The subject must be active, must transform things, and find the structure of his own actions on the objects" (Piaget, 1964, p. 4). In addition to experimentation, the child must be interested in the learning experience (DeVries, 2004). Without interest, the child will not exert the effort to make sense of the experience.

2.3.4 Reggio Emilia Approach

The Reggio Emilia approach to early childhood education was created after World War II in the small Italian city of Reggio Emilia. It focuses on fostering relationships between children, teachers, parents, and community. And, it builds on the idea that each child has the desire to connect with others, engage in learning, and enter into a relationship with his or her environment. The hands-and-minds-on exploration of materials and media is an essential part of the approach.

In the Reggio approach, teachers base the educational environment and activities upon the image of the child. The child is seen as unique, curious, capable, competent, having potential, relationship seeking, an active constructor of knowledge, and a possessor of rights rather than needs (Gestwicki, 2002; Gandini, 2004). This image affects the way that teachers work with children. They view themselves as co-constructors of knowledge, or as partners in children’s learning.

Reggio Emilia Approach Requirement on Furniture Design

The Reggio Emilia environments are referred to as the "third teacher" (the parents and teachers are considered the other two teachers) (Bullard, 2017). In the Reggio Emilia approach, the environment and children's furniture are aesthetic, providing rich sensory experiences and supporting flexibility and creativity.

The same as Montessori, Reggio Emilia also believed in aesthetic, containing beautiful materials and spaces. There is intense attention to detail in every environment feature, with no overlooked corner, wall, ceiling, or floor. The decorations can be highly personalized, reflecting the culture and interests of the inhabitants through photos, materials, artwork, and transcriptions (Gandini, 2004)

Reggio Emilia encourages interaction with materials through the use of provocations (activities, materials, or questions that provoke thought, problem solving, and creativity), many different types of objects (realistic objects, colorful beautiful objects, natural objects, authentic furniture, tools, and uten sils), beautiful displays that highlight materials, and mirrors that are placed to see objects in new ways (Strong-Wilson & Ellis, 2007). Reggio Emilia believed that providing rich sensory experiences can encourage "investigation and discovery using the whole body. And the environment itself (walls, floors, ceilings) is also multisensory, with different sensory media so each individual person's needs can to meet (Ceppi & Zini, 1998, p. 8).

Reggio Emilia also encourages creativity and flexibility through encouraging children and adults to use objects and space in imaginative ways. The environment is not passive; instead, it is like a living being, conditioning and being conditioned by children's and adult's actions (Fraser & Gestwicki, 2002: Gandini, 2012). It "fosters encounters, communication, and

relationships" (Gandini, 2004, p 17) through the design of activities and space. Spaces are available for children to work in small groups, and to work individually if they choose. Common areas such as a central piazza, encourage children, parents, and teachers from different groups to interact. The environment is also rich in documentation of efforts. It is a “living testimony to interactions that happen in the environment” (Strong-Wilson & Ellis, 2007.p. 42).

2.4 Children’s Furniture Design

2.4.1 Ergonomics

Children’s furniture as necessary elements for their environment also plays an important role in children’s physical development. Ergonomics design principles on children’s furniture are the most important factors influencing the children’s physical development.

Ergonomics Definition:

Ergonomics is the study of the interaction between people and machines and the factors that affect the interaction. Its purpose is to improve the performance of systems or products by improving human-machine interaction. This can be done by ‘‘designing-in’’ a better interface, or by ‘‘designing-out’’ factors in the work environment, the task, or in the organization of work that degrade human-machine performance (Bridger, 1995).

Anthropometry:

The word ‘‘anthropometry’’ is derived from the Greek words ‘‘anthropos’’ (man) and ‘‘metron’’ (measure) and means measurement of the human body. Anthropometry can be defined as the conventional art or system of measuring the human body and its parts. The systems of measuring the skull and the skeleton are known separately as craniometry and

osteometry, but these terms are frequently merged with that of anthropometry (Hrdlicka, 1920). Anthropometric data are used in ergonomics to specify the physical dimensions of workspaces, equipment, vehicles, and clothing to ensure that these products physically fit their users.

Application of Ergonomics in Children's Furniture

The design of children's furniture should vary from person to person. The design application to the reality should differ according to ergonomics, the universality and difference of children, and the actual using situation. Children's physical growth is obvious in different ages. The functional dimensions of furniture should be reasonably designed by using ergonomic principles, such as the length, width and height of furniture. Only furniture in line with the physiological characteristics of children and created by designers really concerned about their physical needs, will allow children to feel comfortable when they use it, and be a benefit to their healthy growth.

Following are weight, height, upper arm length and upper leg length measurements for children from birth to 19 years old (Table 2.12-2.15).

Weight

Sex and age[1]	Number of examined persons	Mean	Standard error of the mean	Percentile								
				5th	10th	15th	25th	50th	75th	85th	90th	95th
Male		Pounds										
Birth–2 months	75	11.8	0.22	8.7	9.5	9.7	10.3	11.7	12.9	14.0	14.4	14.8
3–5 months	90	16.1	0.27	12.8	13.2	13.7	14.3	16.0	17.7	18.1	19.1	19.5
6–8 months	103	18.7	0.27	15.2	15.8	16.3	16.9	18.5	20.2	21.1	21.4	22.2
9–11 months	97	21.5	0.36	16.9	17.7	18.3	19.2	21.0	23.3	24.8	25.2	26.0
1 year	240	25.2	0.22	20.4	21.3	22.3	23.0	24.9	26.5	28.7	29.2	30.7
2 years	258	31.3	0.30	25.3	26.2	27.3	28.6	30.8	33.0	35.2	36.6	38.7
3 years	234	35.3	0.34	29.4	30.3	31.2	32.4	34.6	37.3	39.9	40.3	42.2
4 years	230	40.8	0.39	32.1	33.8	34.4	36.1	39.8	43.9	45.6	47.6	52.8
5 years	195	46.6	0.87	37.2	38.6	40.1	41.5	44.4	50.9	53.6	56.0	64.2
6 years	247	52.8	0.85	40.3	42.1	44.3	46.3	50.8	56.8	60.5	63.4	71.7
7 years	231	61.9	1.15	45.0	47.9	48.3	51.3	57.4	66.4	74.4	85.8	93.6
8 years	228	69.4	1.27	47.8	50.7	53.2	57.2	65.5	77.2	83.7	88.3	102.3
9 years	218	74.4	1.52	51.4	55.3	57.1	62.1	70.2	79.9	92.6	101.9	111.1
10 years	207	88.7	2.76	58.6	63.4	67.9	70.8	80.5	100.9	111.4	119.3	138.5
11 years	186	107.0	3.07	68.2	73.4	78.0	83.8	100.9	122.7	140.1	157.4	167.8
12 years	181	111.6	3.17	73.6	79.3	82.2	90.9	105.0	121.1	141.3	154.7	175.9
13 years	175	133.9	3.61	87.8	92.1	96.1	107.1	125.1	149.2	166.0	184.9	207.0
14 years	184	145.2	4.03	96.7	104.7	113.3	118.9	135.4	163.1	185.5	198.1	223.6
15 years	156	157.3	4.20	104.0	113.7	118.1	127.3	144.5	182.1	186.9	207.7	243.2
16 years	178	164.1	2.67	116.0	122.7	126.7	135.1	151.4	185.7	198.9	211.8	243.2
17 years	147	165.5	4.58	115.5	124.9	130.0	136.1	156.8	177.8	201.7	219.6	251.7
18 years	160	179.4	7.09	118.9	127.4	132.3	145.3	168.5	193.6	221.1	237.6	†
19 years	144	174.0	4.95	120.2	122.8	131.3	140.8	162.5	192.5	212.3	249.3	†
Female												
Birth–2 months	72	10.6	0.18	8.2	8.6	8.9	9.5	10.4	11.2	11.9	12.7	†
3–5 months	104	14.9	0.26	11.3	11.9	12.3	13.4	14.7	16.4	17.2	17.4	18.1
6–8 months	91	17.7	0.26	13.6	14.7	14.9	16.1	17.2	18.8	19.5	20.3	†
9–11 months	104	20.4	0.36	15.6	17.0	17.5	18.4	20.1	22.3	23.1	23.3	25.3
1 year	224	24.6	0.30	18.7	20.0	20.9	21.7	24.4	26.9	28.3	29.3	30.6
2 years	293	29.3	0.26	23.6	24.7	25.0	26.3	28.8	31.5	33.1	34.0	36.0
3 years	201	34.5	0.49	28.1	28.8	29.9	31.3	33.4	36.3	38.6	41.2	42.8
4 years	206	40.3	0.62	30.7	31.7	32.8	35.0	39.5	43.6	45.3	47.2	56.0
5 years	179	45.0	0.74	33.7	35.2	36.6	39.5	43.8	48.0	52.6	54.3	61.3
6 years	216	52.4	1.05	38.2	39.2	41.1	44.4	49.0	58.4	64.8	67.8	73.7
7 years	211	58.7	1.38	42.4	43.8	45.6	48.0	53.9	64.9	74.1	80.2	89.7
8 years	197	69.9	1.37	49.7	51.4	52.5	56.0	63.3	78.1	86.1	94.8	102.0
9 years	206	82.7	1.90	54.9	58.6	59.9	64.4	75.5	93.0	106.2	112.9	129.4
10 years	187	90.9	2.80	56.5	61.1	65.3	72.8	85.3	104.2	114.4	126.3	139.0
11 years	230	104.5	2.58	66.2	73.4	76.4	83.4	97.0	119.2	131.1	142.8	167.0
12 years	166	122.9	3.61	76.3	83.6	88.5	95.2	112.2	144.8	159.5	171.3	199.9
13 years	160	122.4	3.25	85.1	90.3	95.7	100.1	113.2	135.2	156.6	170.7	172.3
14 years	169	131.4	3.35	93.7	99.5	104.1	109.9	118.5	145.9	165.1	179.4	187.7
15 years	150	141.7	5.50	96.3	103.8	108.8	115.2	128.1	158.9	181.0	195.4	†
16 years	187	143.3	5.73	100.9	103.5	107.8	112.1	132.3	155.0	184.6	210.1	†
17 years	139	148.5	4.11	103.8	111.2	113.2	118.1	133.8	170.9	189.0	199.6	239.7
18 years	154	148.2	5.72	99.1	105.3	113.1	119.6	137.0	160.2	180.5	201.0	†
19 years	152	150.9	4.77	97.5	101.4	109.6	119.6	137.9	174.1	188.5	220.5	249.9

† Estimate not shown because the standard error could not be computed due to small sample size.
[1]Age at time of examination.

NOTE: Data exclude pregnant females.

SOURCE: NCHS, National Health and Nutrition Examination Survey.

Table 2. 12 Weight in pounds for children and adolescents from birth through age 19 years and number of examined persons, mean, standard error of the mean, and selected percentiles, by sex and age: United States, 2011–2014 (National Center for Health Statistics, 2016)

Height

Sex and age[1]	Number of examined persons	Mean	Standard error of the mean	Percentile								
				5th	10th	15th	25th	50th	75th	85th	90th	95th
Male		Inches										
2 years	220	36.3	0.18	33.5	34.1	34.5	34.9	36.4	37.6	38.0	38.4	†
3 years	225	39.0	0.14	36.0	36.5	37.3	37.6	39.0	40.1	40.9	41.2	42.4
4 years	229	42.0	0.15	39.1	39.7	40.3	40.5	41.9	43.4	43.9	44.2	44.9
5 years	195	44.8	0.21	41.6	42.2	42.7	43.6	44.5	46.3	47.1	47.6	48.0
6 years	246	47.2	0.19	44.1	44.6	45.1	45.6	47.3	48.6	49.5	49.8	50.9
7 years	231	49.8	0.19	45.7	46.7	47.2	48.0	49.9	51.5	52.4	52.7	53.8
8 years	227	51.9	0.24	47.2	48.7	49.2	50.2	51.7	53.4	54.8	55.4	56.1
9 years	218	53.7	0.23	50.0	50.3	51.4	52.1	53.4	55.3	56.4	57.1	†
10 years	207	56.3	0.26	51.4	52.5	53.3	54.3	56.3	58.0	58.7	59.2	60.3
11 years	186	59.2	0.31	54.5	55.1	55.9	56.8	58.7	61.2	63.0	63.9	†
12 years	181	61.4	0.31	56.4	57.4	58.1	59.3	61.2	63.5	64.4	64.9	66.3
13 years	175	64.3	0.32	57.8	59.7	60.4	62.1	64.5	66.4	67.8	68.3	69.1
14 years	184	66.7	0.31	60.5	62.7	63.8	65.1	66.5	68.5	70.2	70.7	†
15 years	156	68.3	0.28	64.2	64.6	65.1	66.3	68.4	69.6	70.8	71.5	73.6
16 years	178	68.5	0.24	64.0	65.4	66.0	66.9	68.7	69.9	70.7	71.8	73.0
17 years	147	68.9	0.40	63.6	64.6	65.3	66.4	68.8	71.0	72.6	73.9	75.0
18 years	160	69.1	0.33	64.1	64.8	65.7	66.9	69.0	71.3	72.2	73.0	73.6
19 years	144	69.4	0.44	64.0	65.4	66.4	67.2	69.3	71.3	72.2	73.0	†
Female												
2 years	264	35.4	0.11	32.9	33.2	33.8	34.3	35.2	36.5	37.3	37.7	38.2
3 years	199	38.6	0.13	35.8	36.5	37.2	37.6	38.5	39.6	40.3	40.7	41.3
4 years	206	41.7	0.16	38.2	39.2	39.5	40.4	41.7	42.9	43.5	44.1	44.5
5 years	178	44.2	0.21	40.6	41.1	41.8	42.5	44.0	45.6	46.8	47.4	48.2
6 years	216	46.7	0.17	43.3	44.1	44.6	45.1	46.7	48.3	49.0	49.4	50.3
7 years	211	49.0	0.18	45.2	46.1	46.7	47.7	48.7	50.4	51.6	52.2	53.0
8 years	197	51.8	0.18	47.7	48.6	49.0	50.0	51.7	53.6	54.6	55.4	56.2
9 years	206	54.2	0.24	50.2	51.2	51.6	52.5	54.1	55.9	56.6	57.3	58.8
10 years	187	56.8	0.30	51.8	53.3	54.0	54.9	56.3	58.7	59.8	61.3	†
11 years	230	59.3	0.25	53.5	55.7	56.3	57.6	59.5	61.1	61.9	63.0	63.8
12 years	166	61.5	0.27	56.5	57.3	58.7	59.6	61.5	63.4	64.6	65.0	65.8
13 years	160	62.4	0.23	58.4	59.5	60.0	61.1	62.4	63.7	64.9	65.5	66.6
14 years	169	63.1	0.21	59.0	59.9	60.3	61.6	63.4	64.6	65.3	66.1	66.3
15 years	150	63.4	0.30	58.7	59.1	60.6	61.6	63.6	65.4	66.0	66.8	67.2
16 years	187	63.9	0.28	60.1	60.8	61.3	61.9	63.7	65.6	66.9	67.7	68.1
17 years	140	64.0	0.20	60.5	60.9	61.5	62.3	64.1	65.1	66.2	67.3	68.0
18 years	154	63.6	0.22	59.6	60.1	61.0	61.7	63.9	65.4	66.0	66.5	67.2
19 years	152	64.2	0.16	60.1	60.5	61.4	62.7	64.4	66.1	66.7	67.0	67.7

† Estimate not shown because the standard error could not be computed due to small sample size.

[1]Age at time of examination.

SOURCE: NCHS, National Health and Nutrition Examination Survey.

Table 2. 13 Height in inches for children and adolescents aged 2-19 years and number of examined persons, mean, standard error of the mean, and selected percentiles, by sex and age: United States, 2011–2014 (National Center for Health Statistics, 2016)

Upper Arm Length

Sex and age[1]	Number of examined persons	Mean	Standard error of the mean	Percentile								
				5th	10th	15th	25th	50th	75th	85th	90th	95th
Male		Centimeters										
2–5 months	93	14.1	0.11	12.1	12.4	12.8	13.2	14.1	14.9	15.3	15.6	16.5
6–8 months	103	14.8	0.12	13.1	13.2	13.3	13.9	14.8	15.5	16.1	16.2	16.4
9–11 months	95	15.4	0.15	13.3	13.8	14.2	14.5	15.3	16.2	16.5	16.7	17.3
1 year	228	15.5	0.08	13.6	14.2	14.4	14.9	15.4	16.1	16.7	16.9	17.3
2 years	227	16.2	0.09	14.5	14.8	15.1	15.4	16.1	16.7	17.1	17.5	18.6
3 years	214	16.6	0.11	14.9	15.2	15.5	15.9	16.4	17.4	17.9	18.1	18.4
4 years	217	17.3	0.10	15.2	15.5	15.8	16.1	16.9	18.1	18.9	19.2	20.8
5 years	184	18.1	0.21	15.4	15.8	16.3	16.8	17.6	18.9	19.7	20.3	22.6
6 years	238	18.8	0.20	15.7	16.5	16.8	17.4	18.3	19.5	20.8	21.2	22.7
7 years	228	20.0	0.21	16.5	16.9	17.1	18.0	19.1	21.0	22.9	24.8	26.4
8 years	223	20.9	0.23	16.9	17.4	17.9	18.4	20.3	22.8	24.2	25.2	26.6
9 years	216	21.4	0.30	17.1	17.7	17.8	18.9	20.6	22.9	24.8	26.2	28.2
10 years	199	22.9	0.45	17.6	18.7	19.1	19.9	21.9	25.4	27.2	28.7	29.9
11 years	182	25.2	0.42	19.2	20.0	20.4	21.7	24.9	27.9	29.6	30.6	32.6
12 years	173	25.4	0.45	20.0	20.7	21.4	22.2	24.7	27.5	29.5	31.4	34.1
13 years	170	27.5	0.42	21.2	22.0	22.8	24.0	26.6	30.4	32.2	34.0	35.1
14 years	177	28.3	0.33	21.8	23.8	24.0	25.2	27.6	29.8	33.2	35.0	37.3
15 years	153	29.7	0.50	22.4	23.8	24.5	26.0	28.7	33.1	35.2	35.7	39.8
16 years	174	30.8	0.33	24.6	25.7	26.0	27.1	30.2	33.8	35.6	36.4	39.3
17 years	144	30.7	0.47	24.3	25.1	26.2	27.5	30.4	32.9	34.6	37.1	38.3
18 years	157	32.8	0.70	26.0	26.5	27.5	28.9	32.0	34.9	37.8	39.5	42.1
19 years	142	32.1	0.53	25.4	25.9	27.2	28.6	31.3	34.7	37.0	39.4	42.9
Female												
2–5 months	113	13.6	0.10	11.5	12.1	12.3	12.9	13.5	14.3	14.7	14.9	15.2
6–8 months	90	14.5	0.13	12.8	13.1	13.2	13.7	14.4	15.0	15.5	15.8	†
9–11 months	104	15.3	0.19	13.2	13.8	13.9	14.4	15.2	16.3	16.7	16.9	†
1 year	215	15.6	0.10	13.5	14.0	14.3	14.7	15.6	16.3	16.7	17.0	17.6
2 years	267	16.2	0.10	14.4	14.6	14.8	15.2	16.1	16.9	17.4	17.7	18.3
3 years	184	16.8	0.15	14.6	15.0	15.3	15.8	16.5	17.4	18.1	18.7	19.4
4 years	196	17.5	0.19	15.0	15.4	15.7	16.2	17.3	18.5	19.0	19.5	21.3
5 years	171	18.1	0.17	15.5	15.9	16.2	16.8	17.7	18.9	19.4	20.8	22.6
6 years	211	19.1	0.26	15.7	16.2	16.7	17.3	18.6	20.2	22.1	23.0	23.6
7 years	204	19.9	0.30	16.0	16.7	17.1	17.7	19.0	21.5	22.6	24.8	26.0
8 years	192	21.3	0.24	17.4	17.9	18.1	18.8	20.5	23.4	24.4	25.0	26.8
9 years	201	23.0	0.31	17.8	18.7	19.3	20.0	22.0	25.0	27.2	28.3	30.2
10 years	182	23.5	0.41	17.5	18.6	19.4	20.6	23.2	25.7	27.7	28.5	29.7
11 years	226	24.6	0.37	18.9	19.4	20.3	21.5	23.7	27.1	28.9	30.6	32.2
12 years	164	26.5	0.50	19.9	21.0	21.6	22.8	25.5	29.5	31.7	33.0	36.5
13 years	157	26.0	0.52	20.4	21.1	21.7	23.1	25.2	28.7	30.5	31.8	34.0
14 years	164	27.3	0.54	21.2	22.0	22.7	24.2	25.7	30.4	32.7	34.0	34.9
15 years	148	28.5	0.70	22.1	23.9	24.3	24.8	27.6	30.4	34.0	35.1	37.9
16 years	180	28.8	0.53	23.0	24.3	24.8	25.4	27.1	31.0	34.4	37.0	39.6
17 years	134	29.4	0.48	22.9	24.1	24.4	25.9	27.8	32.5	34.3	35.8	36.6
18 years	153	29.4	0.80	21.8	24.2	25.2	25.6	28.1	31.2	34.1	36.7	†
19 years	149	30.0	0.63	23.1	24.1	24.8	25.8	28.3	32.6	36.4	38.8	42.6

† Estimate not shown because the standard error could not be computed due to small sample size.

[1] Age at time of examination.

NOTE: Data exclude pregnant females.

SOURCE: NCHS, National Health and Nutrition Examination Survey.

Table 2. 14 Upper arm length in centimeters for children and adolescents aged 2 months through 19 years and number of examined persons, mean, standard error of the mean, and selected percentiles, by sex and age: United States, 2011–2014 (National Center for Health Statistics, 2016)

Upper Leg Length

Sex and age[1]	Number of examined persons	Mean	Standard error of the mean	Percentile								
				5th	10th	15th	25th	50th	75th	85th	90th	95th
Male		Centimeters										
8 years	203	30.7	0.23	27.0	27.8	28.1	28.9	30.6	31.9	32.9	33.5	34.5
9 years	216	31.9	0.18	28.2	28.5	29.1	30.2	32.2	33.2	34.3	34.7	36.1
10 years	198	34.2	0.25	30.2	30.9	31.2	32.4	34.2	35.8	36.4	37.1	38.2
11 years	182	36.2	0.25	32.0	32.5	32.9	34.3	36.0	37.9	38.9	39.7	40.6
12 years	171	37.7	0.29	33.6	34.8	35.2	35.9	37.5	39.5	40.1	40.6	41.2
13 years	168	39.9	0.24	35.6	36.5	37.1	38.1	39.9	41.2	42.4	43.6	44.1
14 years	176	41.2	0.24	37.2	38.2	38.6	39.1	40.8	43.0	44.2	44.5	45.7
15 years	151	42.2	0.22	37.9	38.4	39.0	40.5	42.0	44.2	44.7	45.6	46.0
16 years	173	42.3	0.27	38.6	39.5	39.9	40.7	42.0	43.8	44.9	45.5	46.4
17 years	141	42.7	0.33	38.4	39.6	39.9	40.0	42.8	44.4	45.5	46.4	47.8
18 years	157	42.5	0.34	38.4	38.8	39.4	40.6	42.0	44.4	45.3	46.0	47.9
19 years	140	42.5	0.37	37.6	39.1	39.8	40.3	42.2	44.8	45.9	46.3	†
Female												
8 years	175	30.7	0.18	26.9	27.6	28.3	29.4	30.6	32.2	32.8	33.4	34.4
9 years	201	32.5	0.22	29.1	29.6	30.0	30.7	32.3	34.0	34.9	35.2	36.2
10 years	182	34.5	0.28	30.4	30.8	31.2	32.1	34.5	35.9	37.7	38.0	38.9
11 years	222	36.1	0.19	30.9	32.7	33.5	34.8	36.1	38.0	38.5	39.0	39.7
12 years	164	37.5	0.25	33.3	34.4	34.8	35.7	37.3	38.9	39.7	40.5	42.4
13 years	156	38.3	0.26	33.8	35.6	35.9	36.6	38.2	39.5	40.6	41.2	42.2
14 years	164	38.7	0.25	34.7	35.5	36.4	37.1	38.6	40.1	41.2	41.9	42.9
15 years	147	38.6	0.31	34.3	35.3	35.6	36.5	38.6	40.4	41.2	41.7	42.9
16 years	178	38.7	0.19	34.5	35.3	35.9	37.0	38.8	40.2	41.3	41.5	43.1
17 years	134	39.0	0.27	34.9	35.8	36.8	37.3	38.8	40.5	41.7	41.9	42.4
18 years	152	38.4	0.20	34.7	35.4	35.9	36.4	38.0	39.9	40.6	41.5	43.1
19 years	147	39.0	0.25	34.9	35.2	36.2	36.9	39.2	40.4	41.2	42.1	43.2

† Estimate not shown because the standard error could not be computed due to small sample size.

[1]Age at time of examination.

SOURCE: NCHS, National Health and Nutrition Examination Survey.

Table 2. 15 Upper leg length in centimeters for children and adolescents aged 8–19 years and number of examined persons, mean, standard error of the mean, and selected percentiles, by sex and age: United States, 2011–2014 (National Center for Health Statistics, 2016)

2.4.2 Safety of Children's Furniture

Design Standards

The safety of children's furniture is very important. Children are the most prone population to injury, considering they have not had the knowledge or life experiences necessary to understand why something may harm them. Although children's furniture companies are concerned with the physiological and psychological characteristics of children in the design and development process of children's furniture, they are concerned more about the connotation, continuity and culture of the branding. In this section, the United State laws, regulations and other design standards are discussed to understand the importance of safety in children's furniture and children's furniture design.

2.4.2.1 Laws and Regulations

The United State has listed security issues as an important issue to protect minors. Relevant laws and regulations have been released, such as the American *Consumer Product Safety Act (CPSA)* and *Child Protection and Toy Safety Act of 1969.* There are also other countries have relevant laws and regulations related to these problems, such as the European Union *General Product Safety Directive (2001/95/EC)* and *Decision 2013/121/EU* , Canada *Hazardous Products (Toys) Regulations* (2011), the UK *Consumer Protection Act 1987*, etc.

Consumer Product Safety Act (CPSA):

Consumer Product Safety Act, or CPSA, was enacted in 1972 by the U.S. Congress. The Act established an agency which provides a safety standard to avoid any risks associated with consumer products. The Act also prohibits those products that are substandard. Under the Act, the products are also recalled if they are found to be hazardous in nature.

Consumer Product Safety Act is an umbrella statute for customers. The CPSA provides means and laws necessary to protect children from perilous children's products. The main purposes of the Act are to protect the public against unreasonable risks of injury associated with consumer products, to assist consumers in evaluating the comparative safety of consumer products, to develop uniform safety standards for consumer products and to minimize conflicting state and local regulations, and to promote research and investigation into the causes and prevention of product related deaths, illness and injuries ("CPSA Law and Legal Definition", n.d.).

Child Protection Act of 1966：

Congress realized that the imposition of a warning requirement for product packages had not eliminated most of the product related tragedies and that more stringent regulations were necessary. Accordingly, the Child Protection Act of 1966, or CPA was enacted. The CPA mandated two essential changes (Biggs, 1974). First, coverage was extended to include unpackaged as well as packaged hazardous household substances. Thus, a label had to be displayed either on the package, or directly on the article itself. The second major change authorized the Secretary of Health, Education and Welfare to ban the sale of toys or other children's articles which contained any hazardous substances. Previously, no Act had provided such a banning provision.

For example, federal law requires that full-size baby cribs comply with the full-size crib standard and with additional requirements, including those of the Consumer Product Safety Improvement Act of 2008 (CPSIA).

The standard prohibits traditional drop sides and has stringent requirements for various parts of the crib, such as mattress supports, slats, and hardware. More specifically, the principal requirements for full-size cribs include:

- Dynamic impact testing of the mattress support system - intended to address incidents involving collapse or failure of mattress support systems;
- Impact testing of side rails and slat strength/integrity testing - intended to prevent slats and spindles from breaking and/or detaching during use;
- Mattress support system testing - intended to ensure that the mattress support does not become detached from the frame, potentially resulting in a fall;
- Latching mechanism tests - intended to ensure that latching and locking mechanisms work as intended, preventing unintended folding while in use;
- Crib side configurations - intended, in part, to limit movable (drop) sides; addresses the numerous incidents related to drop-side failures;
- Label requirements - cover numerous hazards, such as falls from the crib, suffocation on soft bedding, and strangulation on strings and cords;
- Openings requirement for mattress support systems - addresses gaps in the mattress support system to reduce the possibility of entrapment;
- Requirements for wood screws and other fasteners - eliminates the use of wood screws that serve as the primary method of attachment on key structural elements; also includes other fastener requirements to address incidents related to loose hardware and poor structural integrity;

- Cyclic testing - addresses incidents involving hardware loosening and poor structural integrity;
- Improper assembly issues - addresses the need to make it impossible to improperly assemble key elements or that those elements have markings that make it obvious when they have been assembled improperly;
- Test requirement for accessories - intended to address any cribs that now, or may in the future, include accessories, such as bassinets or changing tables;
- Component spacing - intended to prevent child entrapment between uniformly and non-uniformly spaced components, such as slats.

2.4.2.2 Administrative Agencies

The United State also set up special administrative agencies, such as the U.S. Consumer Product Safety Commission (CPSC). The products will be examined by specialized agencies. If the product has defective design or manufacturing, which is inconsistent with the regulations and standards and may or have caused safety or environmental problems, the "recall" system will be carried out on the problem product to prevent accidents. And for children's products, there are special associations responsible for regulating the safety of children's products.

Consumer Product Safety Commission (CPSC)

The U.S. Consumer Product Safety Commission was created in 1972 through the Consumer Product Safety Act. The commission protects the public from unreasonable risks of serious injury or death from thousands of types of consumer products under its jurisdiction, including products that pose a fire, electrical, chemical, or mechanical hazard or can injure

children. A series of laws and regulations on safety requirements for children's products was published by CPSC. It regulates that all the manufacturer who produce the products listed in the laws or regulations must be tested as required, confirming that its products comply with the CPSC regulations. Products that are not tested are strictly prohibited and selling such products in the United States is illegal. For example, the *U.S. Toy Safety Standards* requires that toys used by children under 36 months must be tested for small parts to avoid the danger of choking on small parts.

For example, a high chair is a freestanding chair for a child up to 3 years of age that has a seating surface more than 15 inches above the floor and elevates the child normally for the purposes or feeding or eating. The principal performance requirements from the ASTM F404-18 High Chair Standard are:

- testing for high chair tray integrity
- testing for stability of the high chair to ensure that the chair cannot tip over in any direction
- testing for restraint-system strength and integrity
- testing for protruding protective components
- requirements for a passive crotch restraint, to prevent a child from sliding through the front or sides of the seat;
- a leg opening requirement to prevent children from sliding through these openings.

2.4.3 Color

Color and Emotion: The color's significance in the physical environment to psychology is well established. Children will live more comfortably when they are surrounded by soft colors rather than discordant colors. The bright color would bring children a positive manner. Also, it was generally noticed that the cool color would be more soothing and relaxing, and the warm color would be stimulating. Moreover, the color is the essential factor to recognize personality. Everyone will have a preference for color. Also, different colors have their characteristics. Designers need to consider their features when choosing them for decoration (Gilliatt, 1985).

Color	Emotion
Blue	Cool, Soothing
Green	Serene, Friendly
Red	Conspicuous, Gay, Stimulating
Yellow	Sunlight, Reveraling, Demanding
Gold	Affluence
Pink	Delicate, Subtle, Feminine, Soft, Flattering
Violet	Dramatic
Brown	Warm, Comfortable, Earthy
Gray	Formal
Near-Black and Off-White	Cleaner, Livelier

Table 2. 16 Color and Emotion

Color Scheme: All color schemes have two main categories: related and contrasting. Related colors produce harmonious schemes. Also, the contrasting schemes will bring a more exciting environment. There are often three ways to create a proper color scheme: onochromatic (one-color plan), analogous (three-to-six-color plan), and complementary (contrasting-color plan).

A color wheel is an abstract illustrative organization of color hues around a circle, which shows the relationships between primary colors, secondary colors, tertiary colors, etc. ("Basic Color Theory", n.d.).

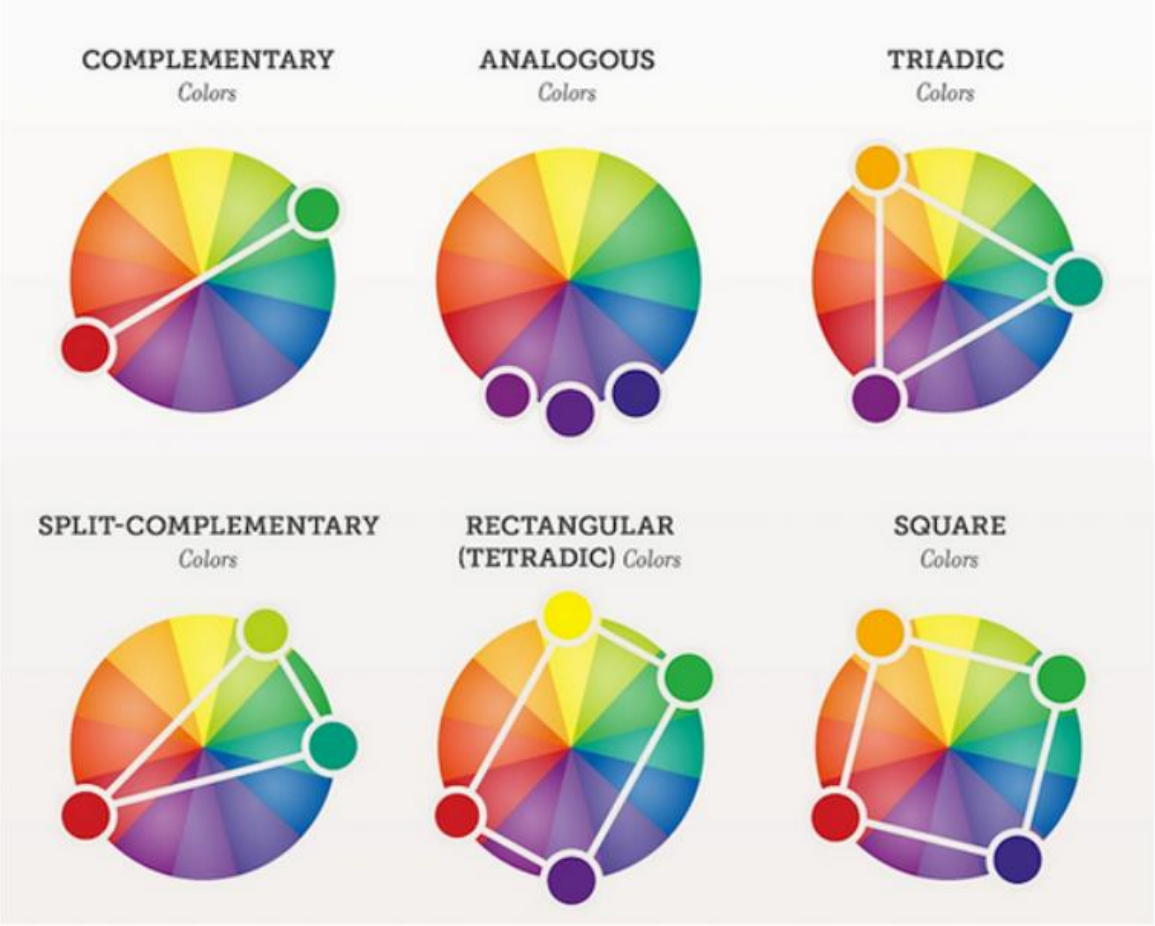


Figure 2. 7 Color wheel (adapted from Pinterest, n.d.)

2.4.4 Materials

Children's Furniture Category by Material	
Category	**Features**
Solid wood furniture	Ease of maintenance Unique texture Modifiable
Plywood furniture	Good strength and durability Availability of large sizes Economical Easy to curve
MDF furniture	Cost-Effective Furniture Smooth Finish Easy to Install Not Strong and Durable
Plastic furniture	Lightweight Cheaper Strong and unbreakable Durable
Bamboo and rattan furniture	Safe and Sustainable Protect environment Lighter Clean and preserve easily
Paper/ cardboard furniture	Not durable Low-cost Simple to create

Table 2. 17 Children's Furniture Materials

2.4.5 Joints

"Joint is a very traditional skill in furniture making which can show a craftsman's skill, sense of beauty and united functional artistry" (Chou, 2007). Because of the importance of the tenon joint, this feature cannot be removed even with mass production, but an adjustment needs to be made. Designers should make certain adjustments according to their own design intent. The joints that are mostly used currently for massive production are listed below (Table 2.18).

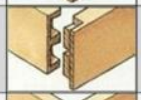
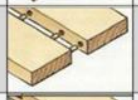
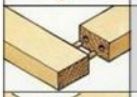
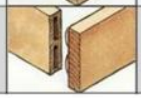
Joint	Application	Joint	Application	Joint	Application	Joint	Application
	Vertical and Horizontal Timber Corner Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface Solid Wood Plywood
	Vertical and Horizontal Timber T Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface Solid Wood Plywood
	Vertical and Horizontal Timber T Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood		Surface and Surface Solid Wood Plywood
	Vertical and Horizontal Timber Corner Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood		Surface and Surface Solid Wood Plywood
	Vertical and Horizontal Timber Corner Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface T Shape Solid Wood Blockboard
	Vertical and Horizontal Timber Corner Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface T Shape Solid Wood Blockboard
	Vertical and Horizontal Timber Corner Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface T Shape Solid Wood Plywood Blockboard
	Vertical and Horizontal Timber Corner Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		
	Vertical and Horizontal Timber Corner Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		

Table 2. 18 Joint by Application form (Albert Jackson, 1995)

Butt Joint

The simplest and most easy joint to learn or create is the butt joint (Udemy, 2020). To create a butt joint, simply place the end of a piece of wood against another piece and fasten either using a metal clip, a nail or a screw. Butt joints may not be the fanciest or nicest looking joints, but they are extremely stable and can hold up heavy loads.

Figure 2. 8 Butt Joint

Mitered Butt Joint

The mitered butt joint is very similar to the standard butt joint, in that it typically joints two boards at their ends, or one board at an end meeting the side of another board. The difference is in how those ends meet. In a standard butt joint, the end or ends are left square, so they meet at a 90-degree angle. In a mitered butt joint, the end or ends are mitered to a 45-degree angle. This allows two boards to turn a corner neatly, or for an angled board to die into a straight board. The mitered boards are fastened together either with nails or screws and are often easier to fasten to one another than a standard butt joint. Because the boards themselves are angled, the nail or

screw can be put in straight, rather than the other way around. This makes for a cleaner looking joint, as well as giving more possibilities in how the two boards can be angled or placed themselves(Udemy, 2020).

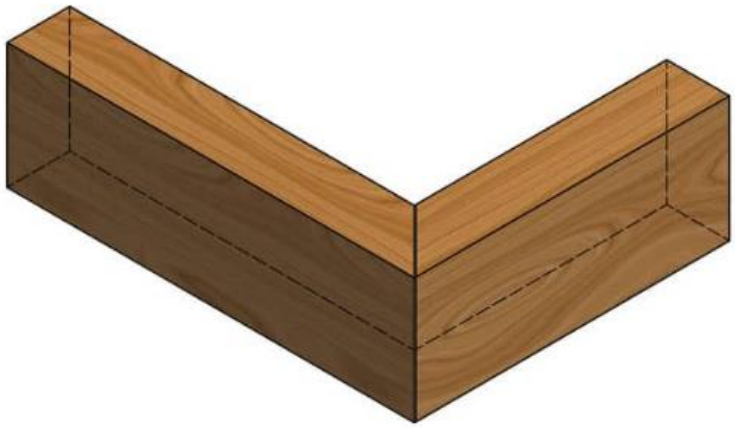


Figure 2. 9 Mitered Butt Joint

Half Lap Joint

The half lap joint is ideal for some types of furniture making where two pieces of wood need to be joined in the middle, rather than on the ends. To create this type of joint, a small portion of the wood is removed in a notch from each of the two boards. The notches then fit together like a puzzle piece to join the boards. Depending on how tightly the notches are cut, one may not need more than a small amount of wood glue to hold them together. Obviously, because some of the wood is being removed from each of the boards, this does result in a slightly weaker join than some other types. However, because they allow joining the boards in the centers, rather than on the ends, this can be an ideal way of creating some types of frames (Udemy, 2020).

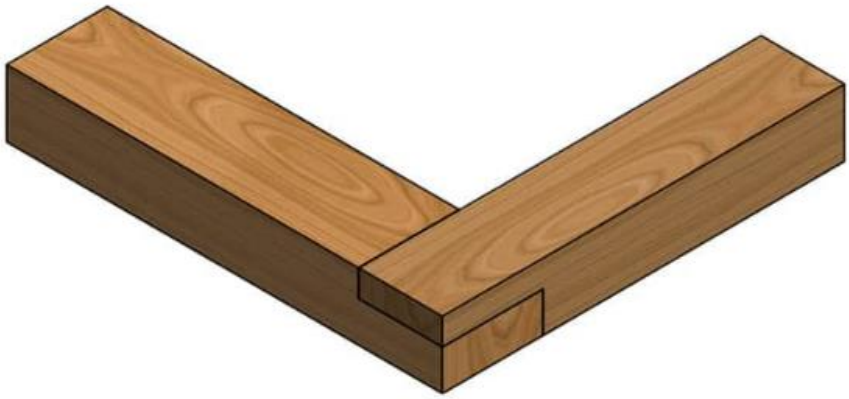


Figure 2. 10 Half Lap Joint

Tongue and Groove Joint

In a tongue and groove joint, the edge of one board is notched out into a groove. The edge of the joining board is extended into a thin tongue that fits the groove. Often both tongue and groove are curved slightly so that the tongue needs to enter the groove at an angle. When the boards are laid side by side, they “lock” together and cannot be separated unless one is lifted up at an angle first (Udemy, 2020).

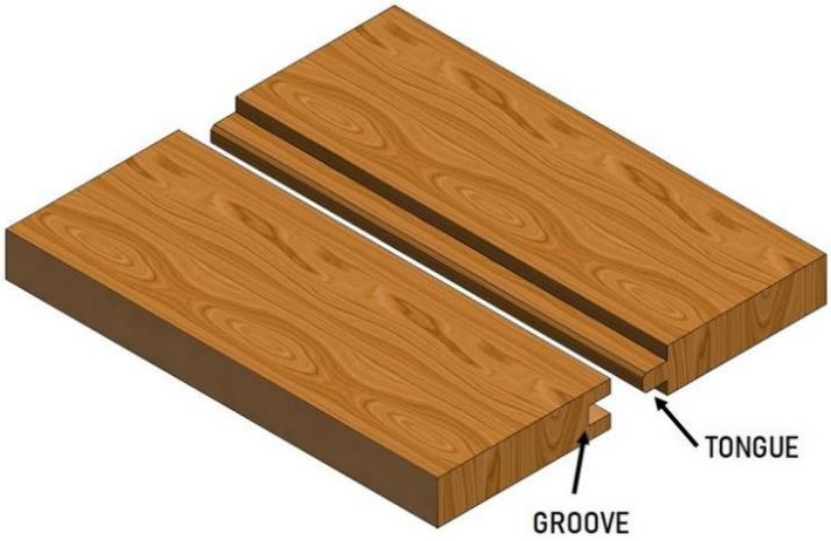


Figure 2. 11 Tongue and Groove Joint

Mortise and Tenon Joint

The mortise and tenon joint is one of the oldest forms of wood joints used. Like the tongue and groove joint, it involves one board being fitted inside of a second board. The mortise is a square hole carved into the side of a board. The tenon is a protruding piece coming off the end of a second board. The tenon fits very tightly inside the mortise, extending through to the other side of the mortised board. This type of join is very useful for creating trestle tables and exposed beams where nails would detract from the beauty of the workmanship (Udemy, 2020).

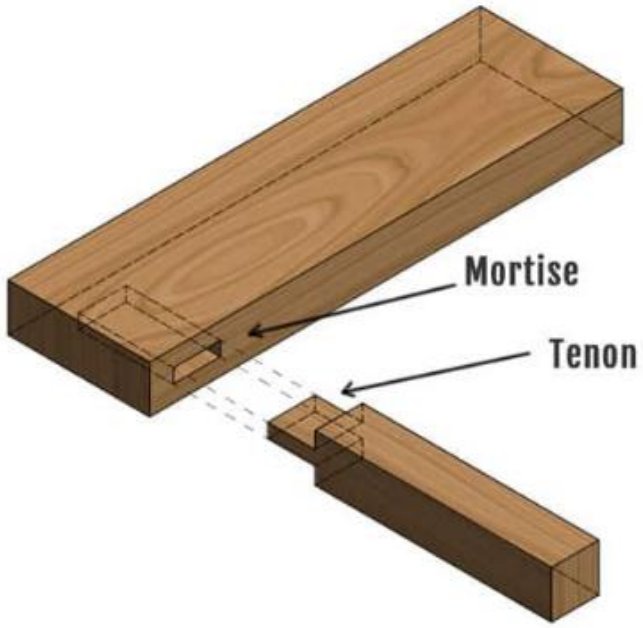


Figure 2. 12 Mortise and Tenon Joint

Dovetail Joint

The dovetail joint is one of the most beautiful and frequently sought-after joints in furniture and cabinet making. This joint is very strong and relies on only the workmanship and a

little glue to hold it in place; no nails or metal fasteners are required. To make a dovetail joint, notches are cut into the ends of two boards. The notches are precisely detailed so that they will fit together very tightly like puzzle pieces. If creating a box or a drawer, the dovetail joint is a beautiful and very strong method of connecting your ends together. Because the notches are so tightly fitted, this type of joint rarely comes loose, so the finished piece can often sustain a lot of very heavy use (Udemy, 2020).

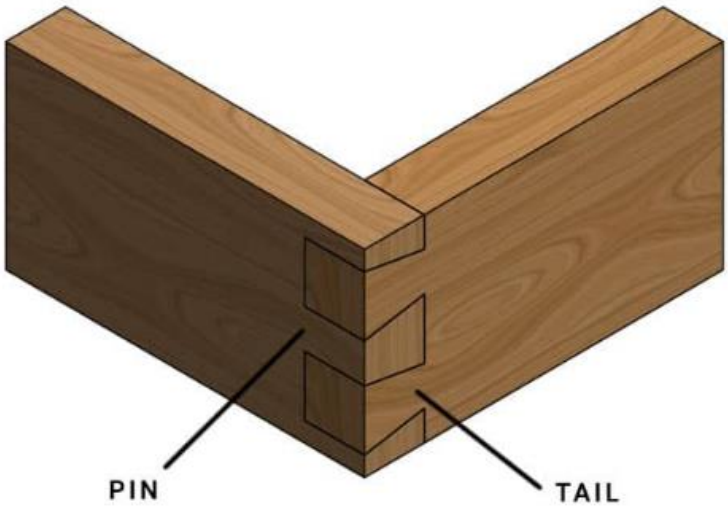


Figure 2. 13 Dovetail Joint

Dado Joint

The dado is a simple joint often used in carpentry. Like the tongue and groove joint, it involves a notch cut into one board where the other board will fit. Unlike the tongue and groove, however, this type of joint joins the edge or end of one board to the center of another. It's often used in joining two pieces of plywood together, or for putting together the backs and sides of cabinets and dressers with the top (Udemy, 2020).

Figure 2. 14 Tongue and Groove Joint

Rabbet Joint

The rabbet joint is a dado cut along the edge of a board, rather than into the center of it. It's also used for joining cabinets or for making boxes where two edges need to fit together tightly (Udemy, 2020).

Figure 2. 15 Rabbet Joint

2.4.6 Adaptable Furniture

According to the research of the furniture company Lifetime (2018), it concluded four features about the children's adaptable furniture. The first feature is adjustability, which helps the furniture to fit children's physical development. The second feature is modularity, which provides furniture the opportunity to be deconstructed and reassembled to form furniture with a new function. The third feature is a combination of repetition. The fourth feature is multifunction. Single furniture mixes different functions to meet different needs in the same period.

For the most part, the goal of adaptable furniture is using limited resources to achieve the combination, variation, and transformation of different functions. However, if the designers fail to grasp the fundamental characteristics of physiological and psychological changes in children development, adaptable furniture might not provide proper functions for children's activity.

2.4.6.1 Adjustability

Adjustable furniture can grow with children. An example of the adjustable furniture is illustrated in the Figure 2.4 below. In May 2013, FLEXA launched FLEXA Baby High Chair that grows with the child and converts from a high chair into a junior chair (Figure 2.4). This chair has received the prestigious Red Dot Design Award.

FLEXA Baby High Chair unites great ergonomics, functionality and contemporary Scandinavian design. And the FLEXA Baby High chair is made of PP plastic and solid beech, suitable for 0-12 years old children. It has 3 seating heights and 7 footrest heights. And it has a safety bar with a safety strap and safety T-belt for the highchair ("Unique Child's High Chair", 2013).

Figure 2. 16 FLEXA Baby High Chair ("Unique Child's High Chair", 2013)

2.4.6.2 Module and Modularity

Definition of Module and Modularity

A module can be defined as a changeable part that provides a considerable amount of functionality compares to the final product (Miller & Elgard, 1998). It is emphasized that the function unit that a module holds is self-contained, which means by switching the installed module, one can easily modify the functionality that the whole product has. So, one module always has a system behind it. The system has standardized interfaces and interactions that allow to make composite products through different combinations.

Modularity is an attribute of a system related to structure and functionality. A modular structure is a structure consisting of self-contained, functional units (modules) with standardized interfaces and interactions in accordance with a system definition. Replacing one module with another creates a new variant of the product (Miller & Elgard, 1998, p. 16)

Modularity types

According to Kamrani and Salhieh (2000), modularity can be applied in three main areas, which is product design, design problem, and production system.

Modular products are products that fulfill various overall functions through the combination of distinct building blocks or modules, in the sense that the overall function performed by the product can be divided into sub-functions that can be implemented by different modules or components (Kamrani & Salhieh, 2000, p. 20).

The application of design problem modularity is breaking a massive problem down into a set of easier-to-solve sub-problems. After the overall problem is divided into functionally independent sub-problems, the interaction or interdependence between sub-problems is minimized and becomes easier to manage.

Modularity in production systems aims at "building production system from standardized modular machines" (Kamrani & Salhieh, 2000, p. 20). Four basic groups of production elements need to be considered in order to achieve production system modularity. These are process machine primitives, motion units, modular fixtures, and configurable control units.

Modular System Development

Kamrani and Salhieh (2000) indicated an approach for developing modular system. They listed three steps, "decomposing a system into its basic functional elements, mapping these elements into basic physical components, then integrating the basic components into a modular system capable of achieving the intended functions" (p. 25). And two challenges, decomposition and integration, were emphasized to be vital in this approach.

Benefits of Modularity

Miller and Elgard (1998) stated that modularity could be seen as a means to balance two opposite forces: standardization and customization. Starting from these two aspects, researchers discovered many benefits that modularity provides (Ulrich & Tung, 1991; Pahl & Beitz, 1996; Huang, 2000; Kamrani & Salhieh, 2000).

- **Economies of scale**: Since the standard modules will usually be manufactured in relatively large quantities, the economies of scale arise.
- **Ease of product maintenance and repair**: Since the product can be decomposed to several independent single modules, just replacing the modules can easily achieve maintenance and repir.
- **Decrease order lead-time:** Modular products always consisted of standardized and customized components. Once the modular system is formed, standard components are inventoried, and then customization can be focused on differentiating components. This will support the company's fast response and lead to reduction in order lead-time.
- **Reduce product-developing time**: Since the interfaces and modules have been standardized, their interfaces enable design tasks and production tasks to be decoupled. This decoupling will eventually result in the reduction of the product-developing time.
- **Increase feasibility of product/component change and upgradability**: Since each module interface is strictly defined, it is obvious that each module is independent, which means changing components and upgrading is relatively much simpler.

- **Increase feasibility to meet customer needs**: The module system is made with a combination of several standardized and customized components. Manufacturers can always develop customized modules to meet individual needs.

An example is IKEA STUVA Storage System. IKEA STUVA Storage System is a collection of bed, drawer dresser, wardrobe, table, etc. STUVA Storage System gives a lot of settled options. It also allows parents and children to create their own combination.

Figure 2. 17 IKEA STUVA Storage System ("IKEA STUVA Storage System", n.d.)

2.4.6.3 Combination of Repetition

Here is an example of combination of repetition. The Hexagon - the basic building block of Float - supports endless combinations and layouts. The Float Collection includes a dividing screen, stool and table element, which have been designed to work together, seamlessly. The generous, comfortable arm-pad of the Float chair can be specified in a contrasting finish to its seat.

Figure 2. 18The Hexagon (“GreyFox”, n.d)

2.4.6.4 Multifunction

Multifunctional furniture goes by several names: multipurposed furniture, space saving furniture and transformable furniture. The basic idea of multifunctional furniture is that they, as the name suggests, perform more than one function. There are a lot of different versions at the market. An example of the furniture is illustrated in the Figure 2.18 below. This furniture, named Sunflower Chair, designed by He Mu and Zhang Qian, performs the function as a bookshelf, as storage as well as a chair (Noe, 2012).

Figure 2. 19 Example of Multifunctional Furniture

Transformable furniture is very special under the category of multifunctional furniture. It is now very popular among furniture industry.

A very famous and old design is Murphy Bed (Rockler.com, n.d.), which is the bed that could be folded back when people is not using it. Murphy Bed has been popular for decades. Here is another example of a transformable book shelf into a table (homeli.co, n.d.).

Figure 2. 20 Murphy Bed

Figure 2. 21 Example of Transformable Furniture

Chapter 3 Design Guideline

3.1 Overview

This guideline is aiming to help designers to design children's furniture that can improve children's development. The guideline can be divided into five steps: background research, identify design goal, concept generation, evaluation, and final design delivery. The main design procedures of the design guideline are shown in Figure 3.1.

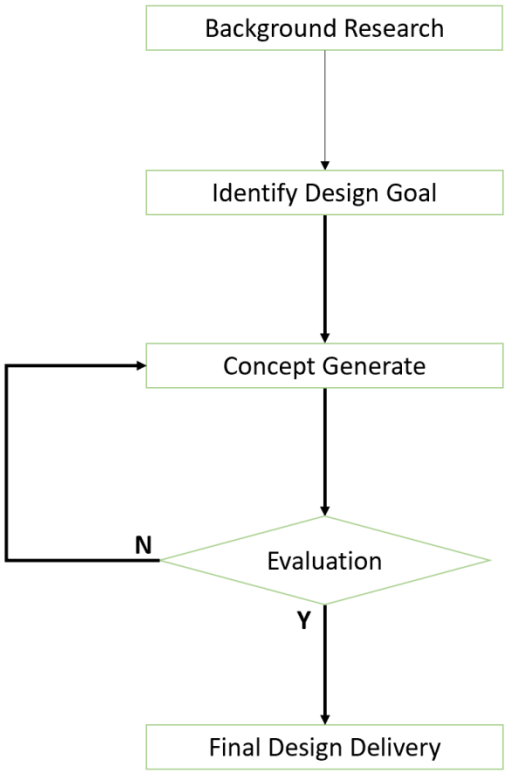


Figure 3. 1 Design procedure for children's furniture that can improve children's development

3.2 Background Research

The first step is to do background research. According to the product function theory, there are three aspects in the function of furniture. They are human function, technical function, and production function. The human function of a product refers to the relationships between target users and user's mind, behavior, body and society, while the technical and production functions of product are related to the direct and indirect technical function, production cost, and product materials factors. In order to satisfy these three aspects of function, several influencing factors associated with a product need to be addressed before design work begins, as listed below:

- Target user information.
- User needs.
- Product usage environment.
- Product usage scenarios or experiences.
- Production technology limitation and cost scope.

3.3 Identify Design Goal

After the background research, designers need to fill the three tables below to identify age range selection, skills selection and furniture type selection.

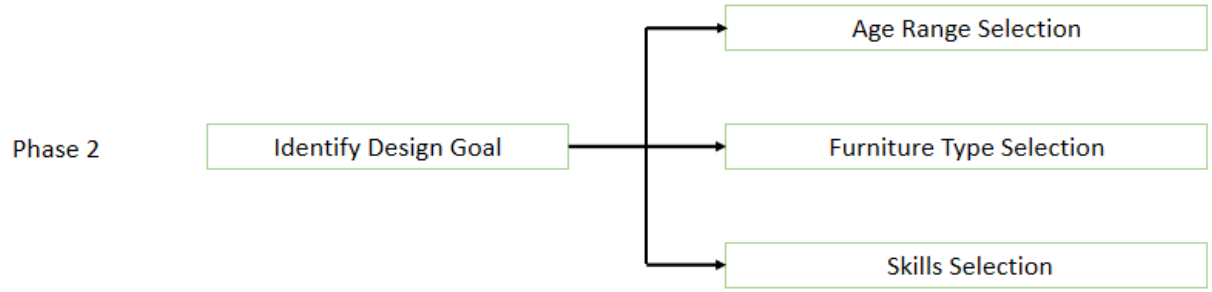


Figure 3. 2 Identify Design Goal Procedure

3.3.1 Age Range Selection

After gathering the basic information, designers should identify what is the target audience age range and complete Table 3.1. Designers can choose only one blank space on the form or a series of blank space on the form. For example, when designers want to design school desks and school chairs for grade one students, they can only fill the 6-7 years blank. And when designers want to design a bookcase that children can use through their middle childhood and teenage years, designers can fill the blanks from 6-7 years to 17-18 years.

Age Selection		
Phase	**Age Range**	**Selection**
Infants & toddler	0-1 years	
	1-2 years	
	2-3 years	
Early childhood	3-4 years	
	4-5 years	
	5-6 years	
Middle childhood	6-7 years	
	7-8 years	
	8-9 years	
	9-10 years	
	10-11 years	
	11-12 years	
Teen	12-13 years	
	13-14 years	
	14-15 years	
	15-16 years	
	16-17 years	
	17-18 years	

Table 3. 1 Identify age range table

3.3.2 Furniture Type Selection

According to the background research, designers should fill the Table 3.2 to determine what type of furniture you want to design. For example, designers may want to make a bookcase that is for small spaces or a chair with added storage. The more specific designers are with your list, the better result of the end product.

Furniture Type Selection					
Function		**Using Place**		**Other Requirements**	**Furniture Type**
Relax		Outdoor			
Seating		Indoor			
Leaning on		Public			
Storage		Home			
Study		Other			
Other					

Table 3. 2 Identify furniture type table

3.3.3 Skills Development Status Table

At this phase, the children's skills selection makes an easier and effective method for designers to see deficit of furniture and generate new concepts.

With the help of earlier research on children development theories, abilities in different periods will be studied. The ability study will focus on each ability's development status, which includes undeveloped, developing, rapid developing and developed. Different colors were applied to these four statuses for the table demonstration (see Figure 3.2). Values are also applied to each status for future evaluation: undeveloped got 0, developing got 0.5, rapid developing got 1, and developed got 0.5.

Color				
Developing Status	Undeveloped	Developing	Rapidly Developing	Developed
Value	0	0.5	1	0.5

Table 3. 3 Demonstration of Color and Value for Ability Table

3.3.3.1 Physical Development

Physical development relates to the body size development and changes in body proportions (Table3.4).

Age	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
Body Size(Boys)									
Body Size(Girls)									
Body Proportions									

Age	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18
Body Size(Boys)									
Body Size(Girls)									
Body Proportions									

Table 3. 4 Physical Development Status

3.3.3.2 Skills in Motor Development

According to Gallahue's (1976) theory of motor development, stability ability, locomotor ability and manipulative ability represent the children's motor development status. The movement development stages are reflexive stage, rudimentary stage, fundamental stage, and specialized stage. Because the specialized movement abilities are an outgrowth of the fundamental movement abilities that become tools applied for the use of daily life, from the standpoint of development, all the abilities are well-developed. So the ability development in fundamental movement stage will be emphasized. Gallahue and Ozmun (2002) used some selected abilities to represent the stability, locomotor and manipulative ability. Stability ability contains dynamic balance (the ability that maintaining one's equilibrium as the center of gravity shifts) and static balance (the ability that maintaining one's equilibrium while the center of gravity remains stationary). The locomotor ability includes walking and running, jumping and hopping, and galloping and skipping. The manipulative ability holds grasping, throwing and catching, striking and kicking (Table 3.5 and Table 3.6).

Age			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-18
Motor	Stability	Static Balance									
		Dynamic Balance									
	Locomotor	Walking & Running									
		Jumping & Hopping									
		Galloping & Skipping									
	Manipulation	Grasping									
		Throwing & Catching									
		Striking									
		Kicking									

Table 3. 5 Motor Development Status

3.3.3.3 Skills in Perceptual Development

According to Gallahue and Ozmun (2002), although children's sight is mature at 2 years old, their visual skills are still incomplete (Gallahue & Donnelly, 2007). Besides, his research defines the visual perception by three aspects, visual acuity (the ability to distinguish details), figure-ground perception (the ability to separate one object from its surrounding visually), and

visual-motor coordination (the ability to integrate using of eye and hands). During the age from two to six years old, children's visual perception – eye hand coordination is the skill to control hand movement guided by vision (see Table 3.7).

Age	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
Sight									
Visual Acuity									
Figure-Ground Perception									
Visual-Motor Coordination									

Age	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18
Sight									
Visual Acuity									
Figure-Ground Perception									
Visual-Motor Coordination									

Table 3. 6 Developing Status in Sight

Age		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
Sensory	**Smell**									
	Hearing									
	Touch									
	Taste									

Table 3. 7 Sensory Developing Status

Age		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
Perceptual	**Depth**									
	Pattern									
	Object									

Table 3. 8 Perceptual Developing Status

3.3.3.4 Skills in Cognitive Development

- **Conservation**

According to Piaget (1965), conservation refers the logical thinking ability that allows a person to determine that a certain quantity will remain the same despite adjustment of the container, shape, or apparent size. He pointed out that children start to develop this ability during the concrete operational stage from ages 7 to 11. Voyat (1982) presented 150 studies that he and

Piaget did to research children's cognitive abilities. Conservation was tested from the aspects of length, shape, volume, number, weight, quantity, etc. From the average statistics, children at the age of 4 to 8 display absence of conservation; for children at the age of 6 to 10, conservation is a possibility; children at the age of 7 to 11 are capable of conservation. Rubin, Fei and Vandenberg (1983) argued that children are developing the conservation ability at a much earlier age when comparing with Piaget's opinions. Though Piaget justified that children are not able to utilize conservation skills for achieving tasks, the conservation ability starts to emerge from the age of 3, at which age symbolic play dominates the play type.

Age	**0-3**	**3-7**	**7-11**	**11+**
Conservation				

Table 3. 9 Developing Status in Conservation

- **Problem-solving**

Convergent & Divergent: Convergent and divergent problem-solving abilities are essential for children development with different purpose. "Convergent problems require children to organize pieces of disparate information to arrive at one correct answer" (White, 2012, p. 12). Divergent problems require children to consider a range of possible solutions rather than one single right answer (White, 2012). Play contributes to children's problem-solving ability through increasing their behavioral options (Bruner, 1972). So when children come across some real-life problems, they may use the same method.

Age	0-2	2-7	7-11	11-18
Convergent				

Table 3. 10 Developing Status in Convergent

Age	0-2	2-3	3-6	6-7	7-18
Divergent					

Table 3. 11 Developing Status in Divergent

Logic & Reasoning: It is easy to notice that Piaget directly indicated the children's logic and reasoning development by naming the third and fourth cognitive development stages, the concrete operational stage (7 to 11) and formal operational stage (11 to adulthood). During the concrete operational stage, concrete events and objects will be applied for solving problems, in which case children are using inductive logic, "going from a specific experience to a general principle" (Cherry, 2018, para. 2). During the formal operational stage, children are capable of understanding the world by using deductive reasoning, "using a general principle to determine the outcome of a specific event" (Cherry, 2018, para. 3). Dumontheil (2014) stated that children during pre-operational stage develop relational reasoning. "Children under 5 years can solve 0- and 1- relational problems, but fail to solve 2-relational problems" (Dumontheil, 2014, p. 6). She also indicated that the focus of relational reasoning will shift from object similarity to relational similarity, which will promote the inductive reasoning that dominate the concrete operational stage. So, children's logic and reasoning ability is developing from the simple relational logic and reasoning during the pre-operational stage (2 to 7) to inductive logic and reasoning during

the concrete operational stage (7 to 11), then to deductive logic and reasoning in formal operational stage (11 to adulthood). The fast-developing period for logic is the from the starting time of inductive logic to the end of deductive logic, 7 to adulthood.

Age	0-2	2-7	7-18
Logic & Reasoning			

Table 3. 12 Developing Status in Logic & Reasoning

- **Creativity**

Interests are motivation for children's creative play. Children at different ages have different preferences. From 2 to 4, children show more interests in the familiar schemes, such as mom and dad role-play, kitchen pretend play, etc. (Piaget, 1962). From 4 to 6, children would love to step into more roles and play them out in order to better understand these roles. The roles may include doctor, policeman, teacher, and etc. The advanced symbolic play, social-dramatic play, is preferred in this age group. From 6 to 9, children are deeply attracted by sports, games and licensed characters such as superhero and friends themed toys. And from 9 to 12, children's role interest shifts towards to real-life characters such as singer and movie stars while sports and games still occupy most of their entertainment time (Phillips, 2018). Children's interest is changing all the time from 2 years old but there is no sign of intensity changing.

Age	0-1	2-18
Creativity		

Table 3. 13 Developing Status in Creativity

- **Summary**

Age		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
Conservation										
Problem Solving	Convergent									
	Divergent									
	Logic & Reasoning									
Creativity										

Age		9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18
Conservation										
Problem Solving	Convergent									
	Divergent									
	Logic & Reasoning									
Creativity										

Table 3. 14 Cognitive Development Status

3.3.3.5 Skills in Social Development

Age	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
Emotional Expression									
Emotional Understanding									
Self-Understanding									
Moral Understanding									
Self-Control									
Gender Typing									

Age	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18
Emotional Expression									
Emotional Understanding									
Self-Understanding									
Moral Understanding									
Self-Control									
Gender Typing									

Table 3. 15 Social Developing Status

3.3.3.6 Other Skills

According to different children's development theories, there are some other skills not mentioned above.

- **Language**

Vygotsky (1964) claimed that language plays two critical roles in cognitive development, "It is the main means by which adults transmit information to children, " and "Language itself becomes a very powerful tool of intellectual adaptation". In this stage, children could absorb information, knowledge or language around them (Heo, Han, Koch, & Aydin, 2011). Catts and Kamhi (1999) defined five features of language skill, including phonology (speech sounds of language), semantics (meanings of words and phrases), morphology (meaningful parts of words and word tenses), syntax (rules for combining and ordering words in phrases), and pragmatics (appropriate use of language in context). Between the ages of two and four, children's language rapidly grows (see Table 3.16), particularly in understanding the meanings of words, interrelationships, and grammatical forms (Scarborough, Neuman, & Dickinson, 2009).

Age	**0-2**	**2-4**	**4-6**	**6-18**
Language				

Table 3. 16 Developing Status in Language

- **Mathematical**

Mathematics knowledge in preschool predicts mathematics achievement even into high school (Geary et al., 2008). Logica & Reasoning is the most important ability in mathematics,

and refers to thinking through problems and applying strategies for solving them, and is an essential phase in child development (see Table 3.17). Albeit young children learn informal knowledge of mathematics at preschool or kindergarten, their logical and reasoning thinking are stimulated in play activities to solve the simple arithmetic problems through play activities such as counting objects, comparing magnitudes, exploring patterns, shapes (Council, 2015).

Age	**0-2**	**2-4**	**4-6**	**6-18**
Mathematical				

Table 3. 17 Developing Status in Mathematical

- **Musical**

Schoen (1940) lists the important components of musicality as being primary factors, including auditory sensitivity and musical feeling and understanding. In the Montessori approach to education, children are able to learn rhythm, pitch, and melody, instrumental, listening, musical memory abilities in their sensitive period (Montessori, 1959).

Age	**0-2**	**2-6**	**6-18**
Musical			

Table 3. 18 Developing Status in Musical

Age	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-18
Language									
Mathematical									
Musical									

Table 3. 19 Developing Status in Other Skills

3.3.3.7 Summary of Skills Table

Age			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
Physical	Body Size(Boys)										
	Body Size(Girls)										
	Body Proportions										
Motor	Stability	Static Balance									
		Dynamic Balance									
	Locomotor	Walking & Running									
		Jumping & Hopping									
		Galloping & Skipping									
	Manipulation	Grasping									
		Throwing & Catching									
		Striking									
		Kicking									
Perceptual	Sensory	Sight									
		Smell									
		Hearing									
		Touch									
		Taste									
	Perceptual	Visual Acuity									
		Figure-Ground Perception									
		Visual-Motor Coordination									
		Depth									
		Pattern									
		Object									
Cognitive	Conservation										
	Problem Solving	Convergent									
		Divergent									
		Logic & Reasoning									
	Creativity										
Social	Emotional Expression										
	Emotional Understanding										
	Self-Understanding										
	Moral Understanding										
	Self-Control										
	Gender Typing										
Others	Language										
	Mathematical										
	Musical										

Table 3. 20 Skills in the Child Development(a)

Age			9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18
Physical	Body Size(Boys)										
	Body Size(Girls)										
	Body Proportions										
Motor	Stability	Static Balance									
		Dynamic Balance									
	Locomotor	Walking & Running									
		Jumping & Hopping									
		Galloping & Skipping									
	Manipulation	Grasping									
		Throwing & Catching									
		Striking									
		Kicking									
Perceptual	Sensory	Sight									
		Smell									
		Hearing									
		Touch									
		Taste									
	Perceptual	Visual Acuity									
		Figure-Ground Perception									
		Visual-Motor Coordination									
		Depth									
		Pattern									
		Object									
Cognitive	Conservation										
	Problem Solving	Convergent									
		Divergent									
		Logic & Reasoning									
	Creativity										
Social	Emotional Expression										
	Emotional Understanding										
	Self-Understanding										
	Moral Understanding										
	Self-Control										
	Gender Typing										
Others	Language										
	Mathematical										
	Musical										

Table 3. 21 Skills in the Child Development(b)

3.3.4 Skills Selection

In this step, designers need to choose which skills they prefer to apply into concepts generation phases. This table is the tool to help with designers to mark which skills are selected.

Skills Selection			
Physical	Body Size(Boys)		
	Body Size(Girls)		
	Body Proportions		
Motor	Stability	Static Balance	
		Dynamic Balance	
	Locomotor	Walking & Running	
		Jumping & Hopping	
		Galloping & Skipping	
	Manipulation	Grasping	
		Throwing & Catching	
		Striking	
		Kicking	
Perceptual	Sensory	Sight	
		Smell	
		Hearing	
		Touch	
		Taste	
	Perceptual	Visual Acuity	
		Figure-Ground Perception	
		Visual-Motor Coordination	
		Depth	
		Pattern	
		Object	
Cognitive	Conservation		
	Problem Solving	Convergent	
		Divergent	
		Logic & Reasoning	
	Creativity		
Social	Emotional Expression		
	Emotional Understanding		
	Self-Understanding		
	Moral Understanding		
	Self-Control		
	Gender Typing		
Others	Language		
	Mathematical		
	Musical		

Table 3. 22 Skills Selection

3.4 Concept Generation

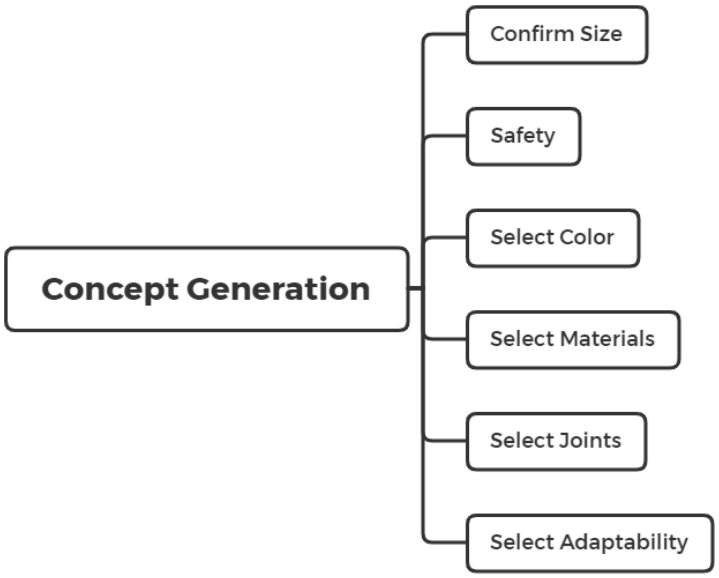


Figure 3. 3 Concept Generation Procedure

3.4.1 Confirm Size

If children have furniture shaped to support their bodies' best posture, they can stay focused on the work, or play in front of them. Determine the best chair height by seating a child with knees at 90° and feet flat on the floor. As it is shown in the Figure4.1, the distance from the floor to the seating surface is the chair height wanted (Hedge, n.d.). The general rule for tables is the space between the seat of the chair and the underside of the table should be 7-8 inches. That's just the right amount of space for children to be able to fit their legs under the table, and it also ensures that the table is low enough for children to comfortably rest their elbows (KAPLAN, n.d.).

Figure 3. 4 To determine correct chair and table height (Hedge, n.d.)

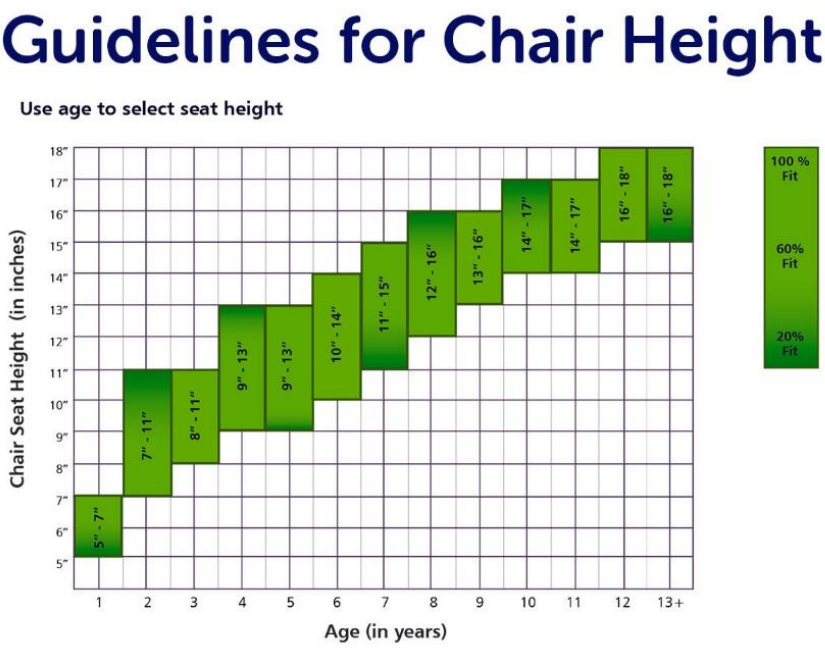


Figure 3. 5 Guidelines for Chair Height (Children's Chair, n.d)

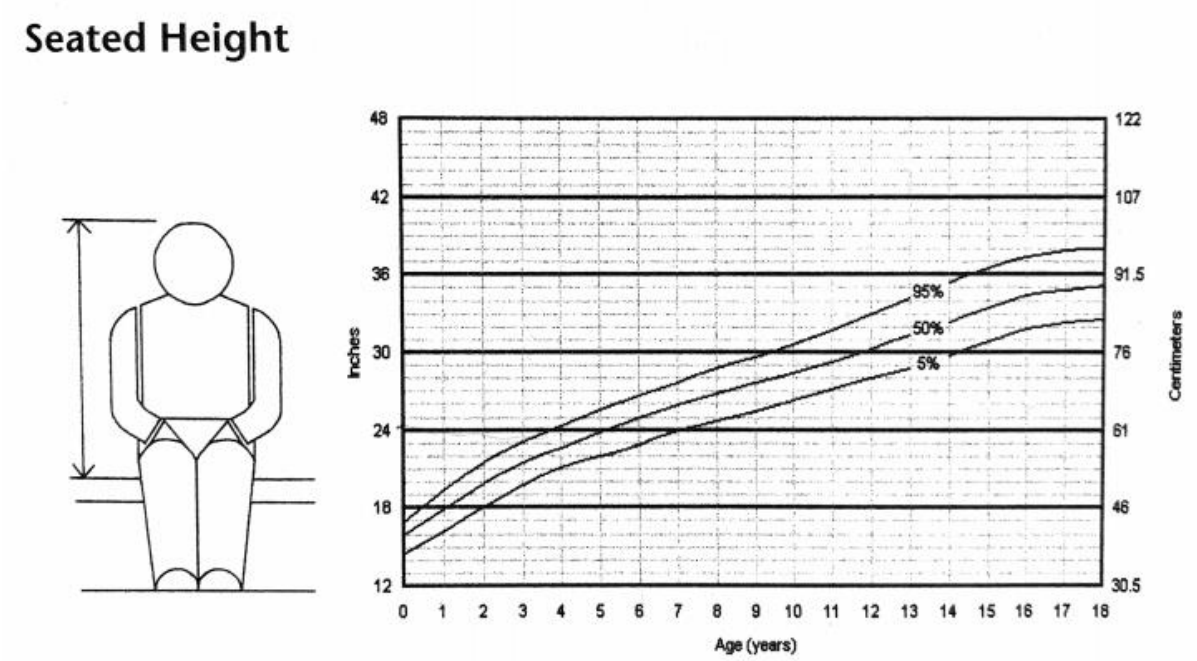


Figure 3. 6 Measurement about Seated Height (Ruth, 1999, p. 11)

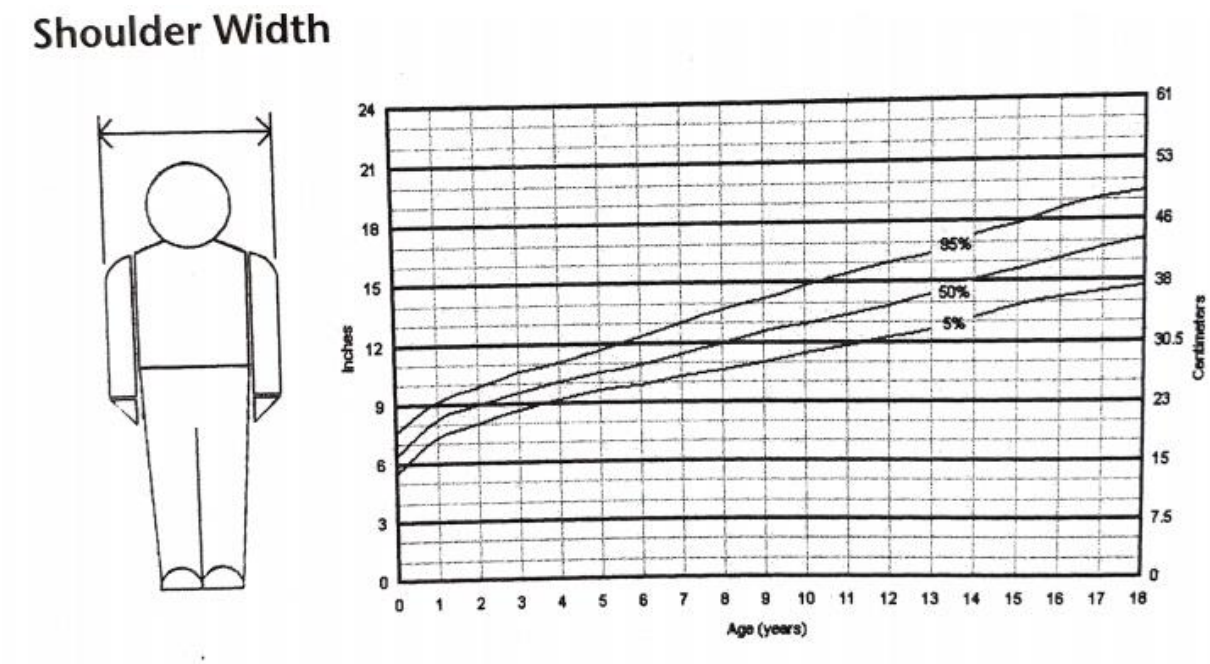


Figure 3. 7 Measurement about Shoulder Width (Ruth, 1999, p. 8)

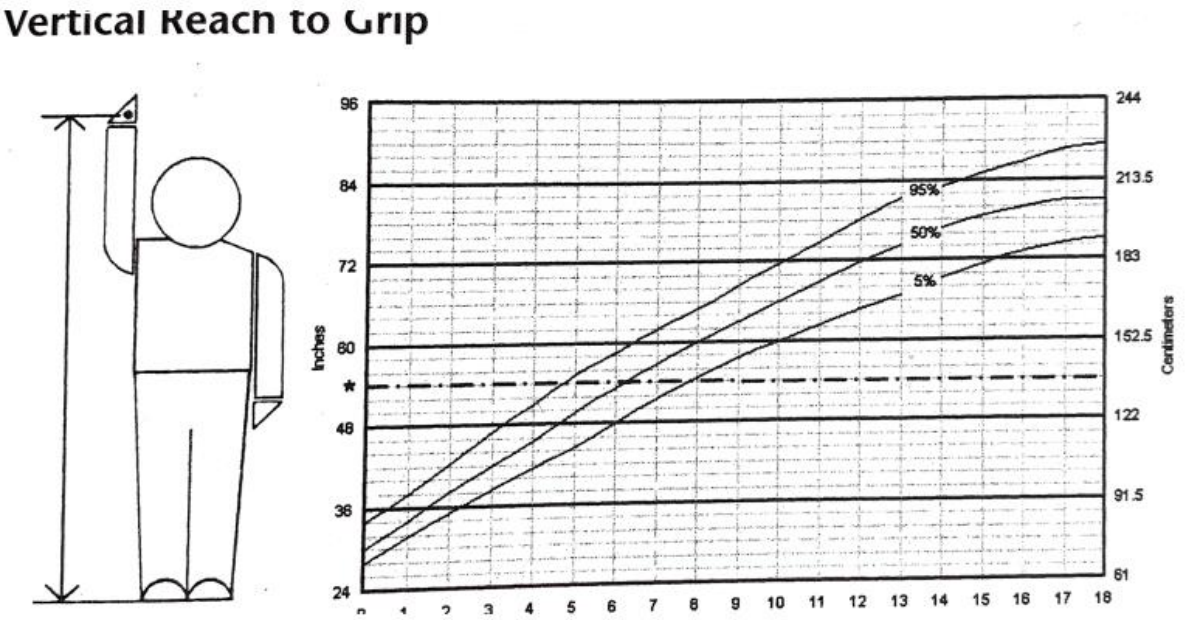


Figure 3. 8 Measurement about Vertical Reach to Grip (Ruth, 1999, p. 9)

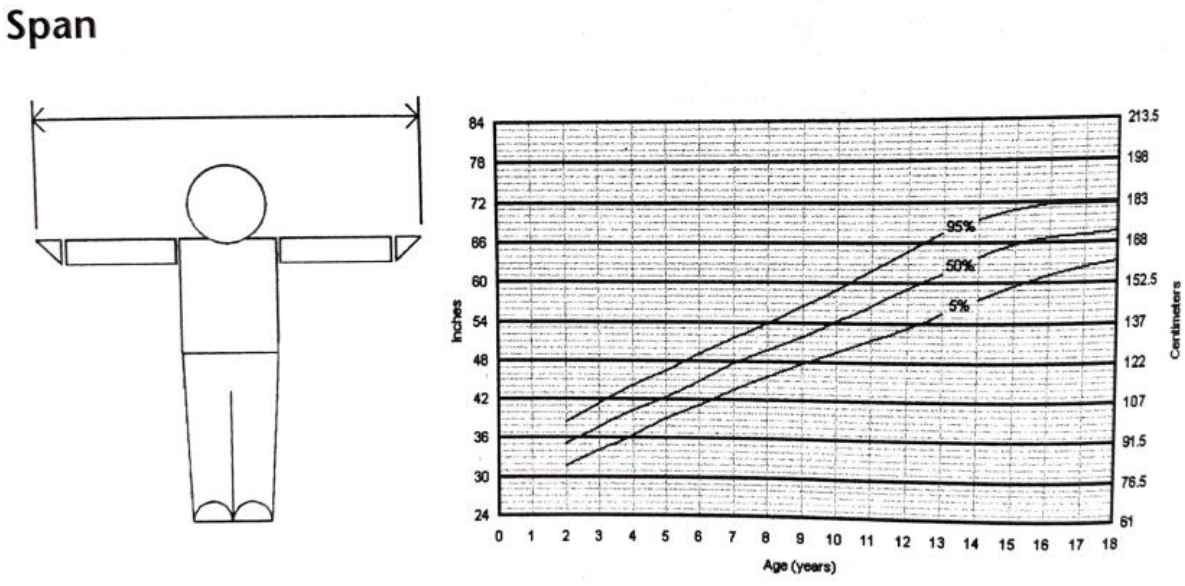


Figure 3. 9 Measurement about Span (Ruth, 1999, p. 10)

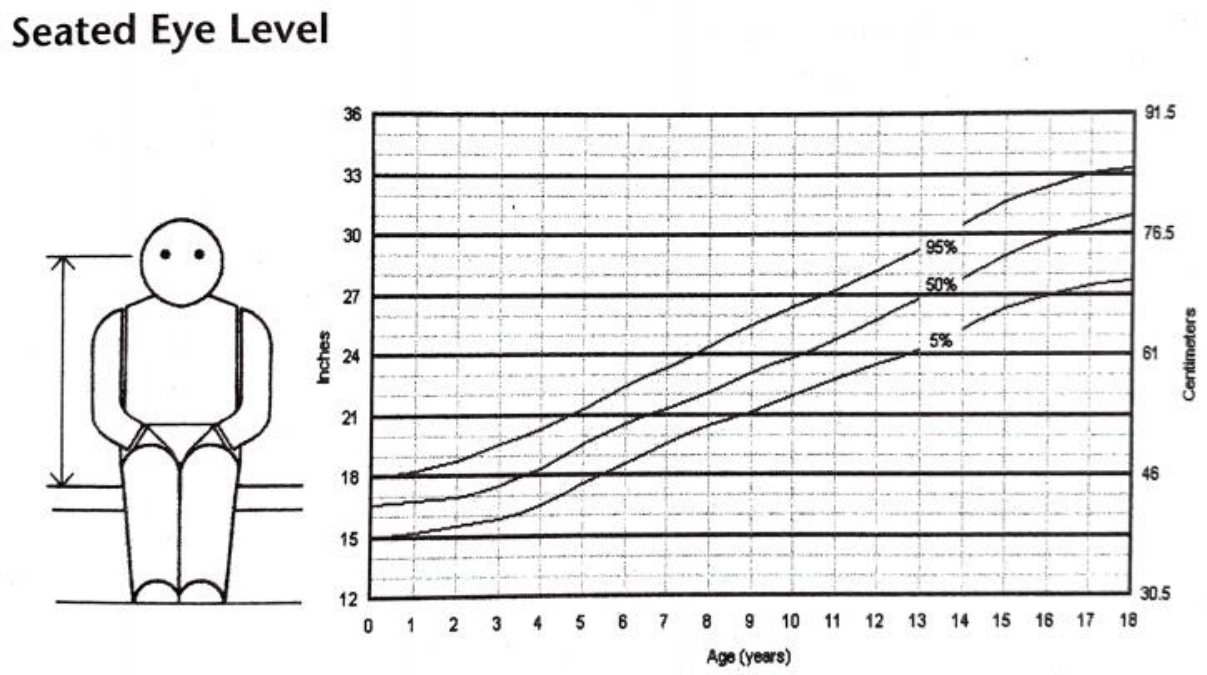


Figure 3. 10 Measurement about Seated Eye Level (Ruth, 1999, p. 11)

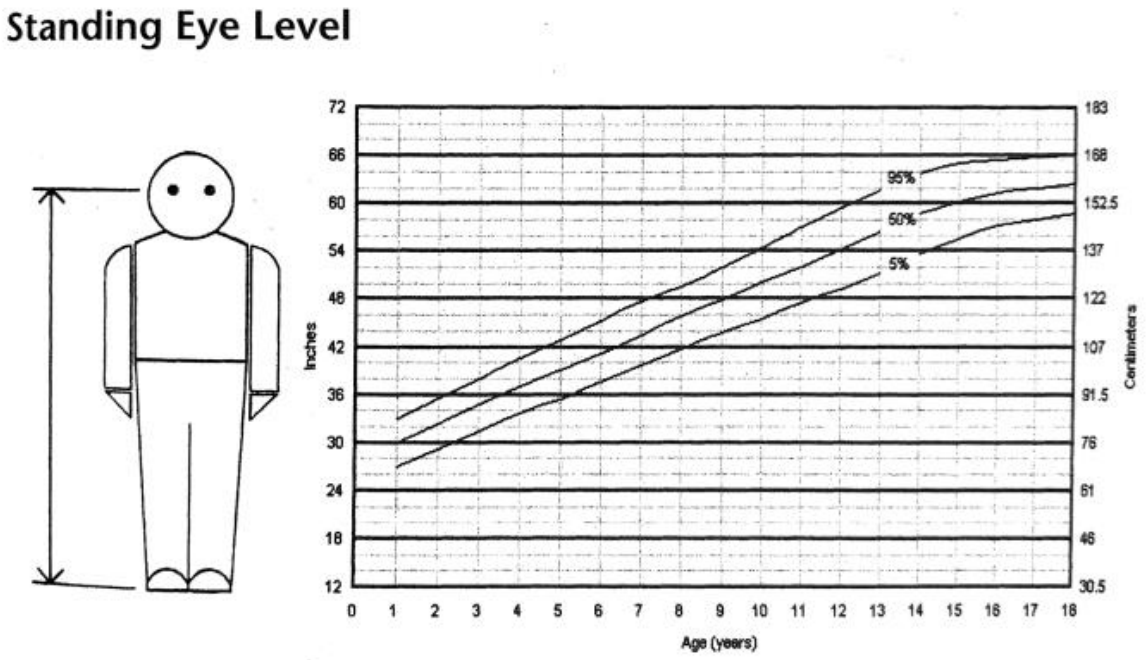


Figure 3. 11 Measurement about Standing Eye Level (Ruth, 1999, p. 7)

Confirming size is aiming to design children's furniture which can improve children's physical development. According to Chapter Two, ergonomics design principles on children's furniture are the most important factors influence the children's physical development. And in order to improve children's physical development, ergonomics principles must be included. So the right size of children's furniture should be strictly complied with during the design progress.

Base on the determined furniture type and age range, designers should first gather information about the needed size for different ages. For example, when designing a children's armchair for age three to six, designers need to gather several sets of ergonomics data including seat height, seat depth, seat width, backrest height, backrest width, armrest height, armrest length and distance between armrests for at least three years old children and six years old children. Or designers can gather more information at different ages. Moreover, designers can gather more information for boys and girls at different ages.

After gathering all the needed data, designers should determine the size and to fill the Confirm Size for Different Stages Table (Table 3.23).

Confirm Size		
	Range	**Notes**
Size 1		
Size 2		
…		

Table 3. 23 Confirm Size

3.4.2 Safety

- **To prevent a tip-over tragedy:**

By far the greatest danger from furniture inside a home is from furniture tip-overs. Anywhere from 22,700 to 31,400 people are injured by falling furniture each year according to the Consumer Product Safety Commission, and most of them are children.

① Use Sturdy Furniture

Televisions should only be placed on furniture designed to hold a television, such as television stands or media centers.

② Secure Your TV

Televisions that are not wall mounted should still be anchored to the wall.

Figure 3. 12 Secure Your TV

③ Mount Flat-Screen TVs

Mount flat-screen TVs to the wall or to furniture to prevent them from toppling over.

④ Follow Instructions

Follow the manufacturer's instructions to secure TVs and furniture properly.

⑤ **Secure Top-Heavy Furniture**

Existing furniture can be anchored with inexpensive anti-tip brackets. New furniture, such as dressers, are sold with anti-tip devices. Install them right away.

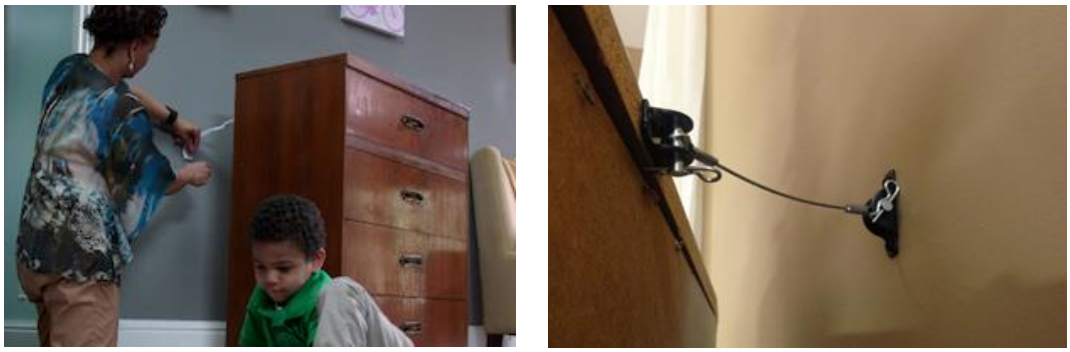


Figure 3. 13 Secure Top-Heavy Furniture

⑥ **Remove Tempting Objects**

Remove items that might tempt kids to climb, such as toys and remote controls, from the top of the TV and furniture.

- **Bunk Bed Safety**

As a rule, bunk beds should never be used for children under six years of age. Even when a child is older than six, make sure to follow these guidelines for greater safety:

① The top bunk should have guardrails on each side, with openings of no more than 15 inches at each end.

② The rails should extend at least 5 inches above the top surface of the mattress, and be sturdy.

③ Use a proper size mattress, and a sturdy ladder to climb to the top bunk.

④ Don't allow horseplay on bunk beds, and don't attach any items to any part of the bunk bed, including hooks, belts and jump ropes.

- **Dressers and Chests**

Look for pieces that meet the voluntary ASTM tip-over standard. People should buy dressers and chests with automatic drawer stops, and drawers that open and close smoothly . Tugging at drawers could cause tip-overs. Never open more than one drawer at a time, and children should be taught not to sit or stand in open drawers.

- **Bookcase Safety**

While entertainment center tip-overs are more common in younger children, falling bookcases have caused injuries in older children and teens. It helps to be careful to not overload bookcase shelves.

It also helps to secure the top portion of a bookcase to the wall to prevent it from tipping over. When shelving is attached to a desk or cabinet, pay attention to the manufacturer's guidelines for securing the two pieces together. Attach the top piece to the wall as an additional safety measure.

- **Blanket Chests, Toy Chests, and Other Storage**

Another potential injury hazard comes from lids on toy chests and blanket chests.

Make sure lids on storage pieces come with safety latches that prevent the top from falling freely or slamming shut. Lids should not be able to lock automatically. For older chests

that do not have safety latches, either contact the manufacturer for a replacement latch or remove the lid altogether to avoid accidents.

- **Baby Cribs**

A baby's crib should be a safe and secure place. To keep it that way, people should make sure to have a newer crib, as most older ones were drop-side cribs that have been recalled. Avoid decorative scrolls, knobs, and finials, and check from time to time to make sure that all parts are functioning smoothly and nothing is coming apart.

3.4.3 Consider Color

Adding color stimuli can improve children's development. In *The Encyclopedia of Memory and Memory Disorders* (Turkington, C., & Harris, J., 2001), the authors state that intensely visualizing colors can help in development of visual memory. *The Secret Language of Color* (Eckstut J., & Eckstut A., 2013) states that certain colors like Lemon and Mauve can improve memory and ability to concentrate.

Frank H. Mahnke (1996) has given out some tips for choosing colors based on the age of kids especially for academic environments in his book *Color, Environment and Human Response* (Table 3.24).

Places	**Tips**
Pre-school and elementary school	Warm and bright color
Upper grade and secondary	Cool colors
Libraries	Cool green or pale/light green

Table 3. 24 Tips on kid’s color selection (Frank, 1996)

By following these steps, designers can choose right colors for children's furniture and fill Table 3.27.

- **Identify Age and Gender Level**

Children furniture color design must take children's sight development into consideration. The age when infants begin showing a preference for color is at about 12 weeks old.

Age	**Preference**	
	B	**G**
0-1 years old	Aqua Blue, Flax Gray, Vanilla Yellow	Sunlit Coral, Blush Pink, Candy Orange
2-10 years old	Arctic Blue, Lime Green, Amber Yellow	Cupid Pink, Lavender Grey, Tiffany Blue
11-18 years old	Charcoal Black, Denim Blue, Splashed White	Jade Black, Crimson Red, Tangerine Orange

Table 3. 25 Age and Gender Based Color Preferences

- **Achieve learning and behavior goals.**

Brighter colors can create energy and excitement in young learners, while more "mature" colors prepare high schoolers for higher-ed environments. Neutral colors can also create a blank canvas for busy walls.

Color	Emotion
Blue	Cool, Soothing
Green	Serene, Friendly
Red	Conspicuous, Gay, Stimulating
Yellow	Sunlight, Reveraling, Demanding
Gold	Affluence
Pink	Delicate, Subtle, Feminine, Soft, Flattering
Violet	Dramatic
Brown	Warm, Comfortable, Earthy
Gray	Formal
Near-Black and Off-White	Cleaner, Livelier

Table 3. 26 Color and Emotion

Select Colors		
	Furniture Parts	**Notes**
Color 1		
Color 2		
Color 3		
…		

Table 3. 27 Select Colors

3.4.4 Consider Materials

Different materials have different features. Material utilization is a way to put concept into practice. Thus, analyzing the features of materials is important. Texture is the visual or tactile surface characteristics and appearance of something (Merriam-Webster, n.d.).

The next step of design development is choosing materials. The features of different materials are listed in Table 3. 28. Designers can choose different materials by filling Table 3.29.

Children's Furniture Category by Material	
Category	**Features**
Solid wood furniture	Ease of maintenance Unique texture Modifiable
Plywood furniture	Good strength and durability Availability of large sizes Economical Easy to curve
MDF furniture	Cost-Effective Furniture Smooth Finish Easy to Install Not Strong and Durable
Plastic furniture	Lightweight Cheaper Strong and unbreakable Durable
Bamboo and rattan furniture	Safe and Sustainable Protect environment Lighter Clean and preserve easily
Paper/ cardboard furniture	Not durable Low-cost Simple to create

Table 3. 28 Different Material

Select Materials		
	Furniture Parts	**Notes**
Material 1		
Material 2		
…		

Table 3. 29 Select Materials

3.4.5 Consider Joints

Designers should choose certain joins according to their design concepts. The joints that are mostly used currently for massive production are listed below. Designers can use them as a reference (Table 3.30). And designers can choose different materials by filling Table 3.31.

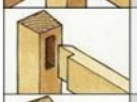
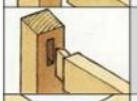
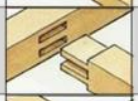
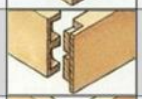
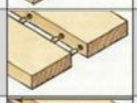
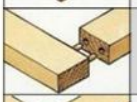
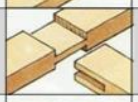
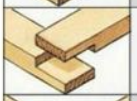
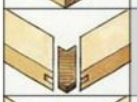
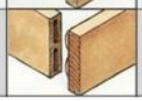
Joint	Application	Joint	Application	Joint	Application	Joint	Application
	Vertical and Horizontal Timber Corner Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface Solid Wood Plywood
	Vertical and Horizontal Timber T Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface Solid Wood Plywood
	Vertical and Horizontal Timber T Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood		Surface and Surface Solid Wood Plywood
	Vertical and Horizontal Timber Corner Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood		Surface and Surface Solid Wood Plywood
	Vertical and Horizontal Timber Corner Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface T Shape Solid Wood Blockboard
	Vertical and Horizontal Timber Corner Shape Solid wood		Vertical and Horizontal Timber or Surface T Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface T Shape Solid Wood Blockboard
	Vertical and Horizontal Timber Corner Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface T Shape Solid Wood Plywood Blockboard
	Vertical and Horizontal Timber Corner Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		
	Vertical and Horizontal Timber Corner Shape Solid wood		Surface and Surface Corner Shape Solid Wood Plywood		Surface and Surface Corner Shape Solid Wood Plywood Blockboard		

Table 3. 30 Joint by Application form (Albert Jackson, 1995)

Select Joints		
	Furniture Parts	**Notes**
Joints 1		
Joints 2		
…		

Table 3. 31 Select Joints

3.4.6 Consider Adaptability

The goal of adaptable furniture is using limited resources to achieve the combination, variation, and transformation of different functions. Designers should use different adaptable furniture based on the fundamental characteristics of physical and cognitive and social changes in children's development. Designers can choose different adaptabilities by filling Table 3.32.

Select Adaptability			
	Select	**Furniture Parts**	**Notes**
Adjustability			
Module and Modularity			
Combination of Repetition			
Multifunction			

Table 3. 32 Select Adaptability

3.5 Evaluation

The evaluation tool is a measure for the examination of different design concepts. This step evaluates the concepts into scores by filling the ability grading chart and calculating the scores for each stage. The evaluation gives designer a more rational way to judge different concepts.

3.5.1 Grading Development Status

First of all, designers should grade different development status value, undeveloped got 0, developing got 0.5, rapid developing got 1, and developed got 0.5 as well.

Color				
Developing Status	Undeveloped	Developing	Rapidly Developing	Developed
Value	0	0.5	1	0.5

Table 3. 33 Grading Development Status Table

Age			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
Physical	Body Size(Boys)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5
	Body Size(Girls)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5
	Body Proportions		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Motor	Stability	Static Balance	1	0.5	0.5	0.5	1	1	0.5	0.5	0.5
		Dynamic Balance	0	0	0	0.5	1	0.5	0.5	0.5	0.5
	Locomotor	Walking & Running	1	0.5	1	1	1	0.5	0.5	0.5	0.5
		Jumping & Hopping	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Galloping & Skipping	0	0	0	0.5	0.5	1	1	0.5	0.5
	Manipulation	Grasping	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Throwing & Catching	0	0	0.5	1	1	0.5	0.5	0.5	0.5
		Striking	0	0	0.5	1	1	1	0.5	0.5	0.5
		Kicking	0	0.5	0.5	1	1	1	0.5	0.5	0.5
Perceptual	Sensory	Sight	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5
		Smell	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Hearing	1		0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Touch	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Taste	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Perceptual	Visual Acuity	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5
		Figure-Ground Perception	0	0	0	0.5	1	1	1	0.5	0.5
		Visual-Motor Coordination	0	0	0.5	1	1	1	1	0.5	0.5
		Depth	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Pattern	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Object	1	1	1	1	0.5	0.5	0.5	0.5	0.5
Cognitive	Conservation		0	0	0	0.5	0.5	0.5	0.5	1	1
	Problem Solving	Convergent	0	0	0.5	0.5	0.5	0.5	0.5	1	1
		Divergent	0	0	0.5	1	1	1	0.5	0.5	0.5
		Logic & Reasoning	0	0	0.5	0.5	0.5	0.5	0.5	1	1
	Creativity		0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Social	Emotional Expression		0.5	0.5	0.5	0.5	0.5	0.5	1	1	1
	Emotional Understanding		0	0.5	1	1	0.5	0.5	0.5	0.5	0.5
	Self-Understanding		0.5	0.5	0.5	1	1	1	1	0.5	0.5
	Moral Understanding		0	0.5	1	1	1	1	0.5	0.5	0.5
	Self-Control		0	0.5	0.5	0.5	1	1	1	1	1
	Gender Typing		0.5	0.5	0.5	1	1	0.5	0.5	0.5	0.5
Others	Language		0.5	0.5	1	1	0.5	0.5	0.5	0.5	0.5
	Mathe matical		0	0	0.5	0.5	1	1	0.5	0.5	0.5
	Musical		0.5	0.5	1	1	1	1	0.5	0.5	0.5

Table 3. 34 Skills in the Child Development(a)

Age			9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18
Physical	Body Size(Boys)		0.5	0.5	0.5	1	1	1	0.5	0.5	0.5
	Body Size(Girls)		1	1	1	1	0.5	0.5	0.5	0.5	0.5
	Body Proportions		0.5	1	1	1	1	1	0.5	0.5	0.5
Motor	Stability	Static Balance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Dynamic Balance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Locomotor	Walking & Running	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Jumping & Hopping	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Galloping & Skipping	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Manipulation	Grasping	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Throwing & Catching	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Striking	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Kicking	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Perceptual	Sensory	Sight	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Smell	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Hearing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Touch	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Taste	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Perceptual	Visual Acuity	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Figure-Ground Perception	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Visual-Motor Coordination	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Depth	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Pattern	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Object	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cognitive	Conservation		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Problem Solving	Convergent	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Divergent	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Logic & Reasoning	1	1	1	1	1	1	1	1	1
	Creativity		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Social	Emotional Expression		0.5	0.5	0.5	1	1	1	1	0.5	0.5
	Emotional Understanding		0.5	0.5	0.5	1	1	1	1	0.5	0.5
	Self-Understanding		0.5	0.5	0.5	1	1	1	1	1	1
	Moral Understanding		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Self-Control		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5
	Gender Typing		0.5	0.5	1	1	1	1	0.5	0.5	0.5
Others	Language		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Mathematical		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Musical		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table 3. 35 Skills in the Child Development(b)

3.5.2 Grading Age Range Weight

According to the Age Range Table, we can see there are 18 small periods of development time. And designers can grade each period of time. For example, when designers design an adjustable chair, 12-15 years old get 2 and 16-18 years old get 1, because children between 12-15 grow fast and grow slowly after 16 years old.

Grading Age Range Weight			
Phase	**Age Range**	**Selection**	**Weight**
Infants & toddler	0-1 years		**A1**
	1-2 years		**A2**
	2-3 years		**A3**
Early childhood	3-4 years		**A4**
	4-5 years		**A5**
	5-6 years		**A6**
Middle childhood	6-7 years		**A7**
	7-8 years		**A8**
	8-9 years		**A9**
	9-10 years		**A10**
	10-11 years		**A11**
	11-12 years		**A12**
Teen	12-13 years		**A13**
	13-14 years		**A14**
	14-15 years		**A15**
	15-16 years		**A16**
	16-17 years		**A17**
	17-18 years		**A18**

Table 3. 36 Age Range Table

3.5.3 Grading Selected Skills Weight

In this step, designers should grade different selected skills. The grade point is between 0 to 100% based on each skills importance.

Skills Selection			Select	Skills Weight
Physical	Body Size(Boys)			S1
	Body Size(Girls)			S2
	Body Proportions			S3
Motor	Stability	Static Balance		S4
		Dynamic Balance		S5
	Locomotor	Walking & Running		S6
		Jumping & Hopping		S7
		Galloping & Skipping		S8
	Manipulation	Grasping		S9
		Throwing & Catching		S10
		Striking		S11
		Kicking		S12
Perceptual	Sensory	Sight		S13
		Smell		S14
		Hearing		S15
		Touch		S16
		Taste		S17
	Perceptual	Visual Acuity		S18
		Figure-Ground Perception		S19
		Visual-Motor Coordination		S20
		Depth		S21
		Pattern		S22
		Object		S23
Cognitive	Conservation			S23
	Problem Solving	Convergent		S25
		Divergent		S26
		Logic & Reasoning		S27
	Creativity			S28
Social	Emotional Expression			S29
	Emotional Understanding			S30
	Self-Understanding			S31
	Moral Understanding			S32
	Self-Control			S33
	Gender Typing			S34
Others	Language			S35
	Mathematical			S36
	Musical			S37

Table 3. 37 Grading Selected Skills

3.5.4 Grading Selected Skills

In this step, designers should grade the concept. The assigned grade point is between 0 to 100 based on each skills' performance.

Skills Selection			Select	Skills Weight	Assigned Grade
Physical	Body Size(Boys)			S1	T1
	Body Size(Girls)			S2	T2
	Body Proportions			S3	T3
Motor	Stability	Static Balance		S4	T4
		Dynamic Balance		S5	T5
	Locomotor	Walking & Running		S6	T6
		Jumping & Hopping		S7	T7
		Galloping & Skipping		S8	T8
	Manipulation	Grasping		S9	T9
		Throwing & Catching		S10	T10
		Striking		S11	T11
		Kicking		S12	T12
Perceptual	Sensory	Sight		S13	T13
		Smell		S14	T14
		Hearing		S15	S15
		Touch		S16	T16
		Taste		S17	T17
	Perceptual	Visual Acuity		S18	T18
		Figure-Ground Perception		S19	T19
		Visual-Motor Coordination		S20	T20
		Depth		S21	T21
		Pattern		S22	T22
		Object		S23	T23
Cognitive	Conservation			S23	T23
	Problem Solving	Convergent		S25	T25
		Divergent		S26	S26
		Logic & Reasoning		S27	T27
	Creativity			S28	T28
Social	Emotional Expression			S29	T29
	Emotional Understanding			S30	T30
	Self-Understanding			S31	T31
	Moral Understanding			S32	T32
	Self-Control			S33	T33
	Gender Typing			S34	T34
Others	Language			S35	T35
	Mathematical			S36	T36
	Musical			S37	T37

Table 3. 38 Grading Selected Skills

3.5.5 Calculating Grading

Age			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Select	Skills Weight	Assigned Grade	Calculated Score
Age Range Weight			A1	A2	A3	A4	A5	A6	A7	A8	A9				
Physical	Body Size(Boys)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5		S1	T1	D1
	Body Size(Girls)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5		S2	T2	D2
	Body Proportions		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S3	T3	D3
Motor	Stability	Static Balance	1	0.5	0.5	0.5	1	1	0.5	0.5	0.5		S4	T4	D4
		Dynamic Balance	0	0	0	0.5	1	0.5	0.5	0.5	0.5		S5	T5	D5
	Locomotor	Walking & Running	1	0.5	1	1	1	0.5	0.5	0.5	0.5		S6	T6	D6
		Jumping & Hopping	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S7	T7	D7
		Galloping & Skipping	0	0	0	0.5	0.5	1	1	0.5	0.5		S8	T8	D8
	Manipulation	Grasping	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S9	T9	D9
		Throwing & Catching	0	0	0.5	1	1	0.5	0.5	0.5	0.5		S10	T10	D10
		Striking	0	0	0.5	1	1	1	0.5	0.5	0.5		S11	T11	D11
		Kicking	0	0.5	0.5	1	1	1	0.5	0.5	0.5		S12	T12	D12
Perceptual	Sensory	Sight	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5		S13	T13	D13
		Smell	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S14	T14	D14
		Hearing	1		0.5	0.5	0.5	0.5	0.5	0.5	0.5		S15	S15	D15
		Touch	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S16	T16	D16
		Taste	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S17	T17	D17
	Perceptual	Visual Acuity	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5		S18	T18	D18
		Figure-Ground Perception	0	0	0	0.5	1	1	1	0.5	0.5		S19	T19	D19
		Visual-Motor Coordination	0	0	0.5	1	1	1	1	0.5	0.5		S20	T20	D20
		Depth	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S21	T21	D21
		Pattern	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S22	T22	D22
		Object	1	1	1	1	0.5	0.5	0.5	0.5	0.5		S23	T23	D23
Cognitive	Conservation		0	0	0	0.5	0.5	0.5	0.5	1	1		S23	T23	D24
	Problem Solving	Convergent	0	0	0.5	0.5	0.5	0.5	0.5	1	1		S25	T25	D25
		Divergent	0	0	0.5	1	1	1	0.5	0.5	0.5		S26	S26	D26
		Logic & Reasoning	0	0	0.5	0.5	0.5	0.5	0.5	1	1		S27	T27	D27
	Creativity		0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S28	T28	D28
Social	Emotional Expression		0.5	0.5	0.5	0.5	0.5	0.5	1	1	1		S29	T29	D29
	Emotional Understanding		0	0.5	1	1	0.5	0.5	0.5	0.5	0.5		S30	T30	D30
	Self-Understanding		0.5	0.5	0.5	1	1	1	1	0.5	0.5		S31	T31	D31
	Moral Understanding		0	0.5	1	1	1	1	0.5	0.5	0.5		S32	T32	D32
	Self-Control		0	0.5	0.5	0.5	1	1	1	1	1		S33	T33	D33
	Gender Typing		0.5	0.5	0.5	1	1	0.5	0.5	0.5	0.5		S34	T34	D34
Others	Language		0.5	0.5	1	1	0.5	0.5	0.5	0.5	0.5		S35	T35	D35
	Mathe matical		0	0	0.5	0.5	1	1	0.5	0.5	0.5		S36	T36	D36
	Musical		0.5	0.5	1	1	1	1	0.5	0.5	0.5		S37	T37	D37

Table 3. 39 Skills in the Child Development(a)

Age			9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	Select	Skills Weight	Assigned Grade	Calculated Score
Age Range Weight			A10	A11	A12	A13	A14	A15	A16	A17	A18				
Physical	Body Size(Boys)		0.5	0.5	0.5	1	1	1	0.5	0.5	0.5		S1	T1	D1
	Body Size(Girls)		1	1	1	1	0.5	0.5	0.5	0.5	0.5		S2	T2	D2
	Body Proportions		0.5	1	1	1	1	1	0.5	0.5	0.5		S3	T3	D3
Motor	Stability	Static Balance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S4	T4	D4
		Dynamic Balance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S5	T5	D5
	Locomotor	Walking & Running	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S6	T6	D6
		Jumping & Hopping	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S7	T7	D7
		Galloping & Skipping	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S8	T8	D8
	Manipulation	Grasping	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S9	T9	D9
		Throwing & Catching	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S10	T10	D10
		Striking	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S11	T11	D11
		Kicking	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S12	T12	D12
Perceptual	Sensory	Sight	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S13	T13	D13
		Smell	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S14	T14	D14
		Hearing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S15	S15	D15
		Touch	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S16	T16	D16
		Taste	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S17	T17	D17
	Perceptual	Visual Acuity	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S18	T18	D18
		Figure-Ground Perception	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S19	T19	D19
		Visual-Motor Coordination	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S20	T20	D20
		Depth	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S21	T21	D21
		Pattern	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S22	T22	D22
		Object	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S23	T23	D23
Cognitive	Conservation		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S23	T23	D24
	Problem Solving	Convergent	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S25	T25	D25
		Divergent	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S26	S26	D26
		Logic & Reasoning	1	1	1	1	1	1	1	1	1		S27	T27	D27
	Creativity		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S28	T28	D28
Social	Emotional Expression		0.5	0.5	0.5	1	1	1	1	0.5	0.5		S29	T29	D29
	Emotional Understanding		0.5	0.5	0.5	1	1	1	1	0.5	0.5		S30	T30	D30
	Self-Understanding		0.5	0.5	0.5	1	1	1	1	1	1		S31	T31	D31
	Moral Understanding		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S32	T32	D32
	Self-Control		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5		S33	T33	D33
	Gender Typing		0.5	0.5	1	1	1	1	0.5	0.5	0.5		S34	T34	D34
Others	Language		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S35	T35	D35
	Mathematical		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S36	T36	D36
	Musical		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		S37	T37	D37

Table 3. 40 Skills in the Child Development(b)

In this Chart, A1, A2, A3...A18 means the weight of different age ranges.

S1, S2, S3...S37 means the weight of different skills.

T1, T2, T3...T37 means the score.

L means the development status.

When calculating one of the skills in the concept, the final score will be D.

D1=(A1*L+A2*L+A3*L+...+A28*L)*S1*T1

D2=(A1*L+A2*L+A3*L+...+A28*L)*S2*T2

D3=(A1*L+A2*L+A3*L+...+A28*L)*S3*T3

When calculating the whole concept, the final score will be C.

C=(D1+D2+D3+...D37)/N

N means the number of selected skills.

3.6 Final Design Delivery

At the end of this process, designers should have the complete design for children's furniture which can improve children's development. The final design includes furniture form, color, material and other details.

Chapter 4 Design Application

4.1 Overview

This chapter will demonstrate the guidelines and design flow chart that have been developed in previous chapters.

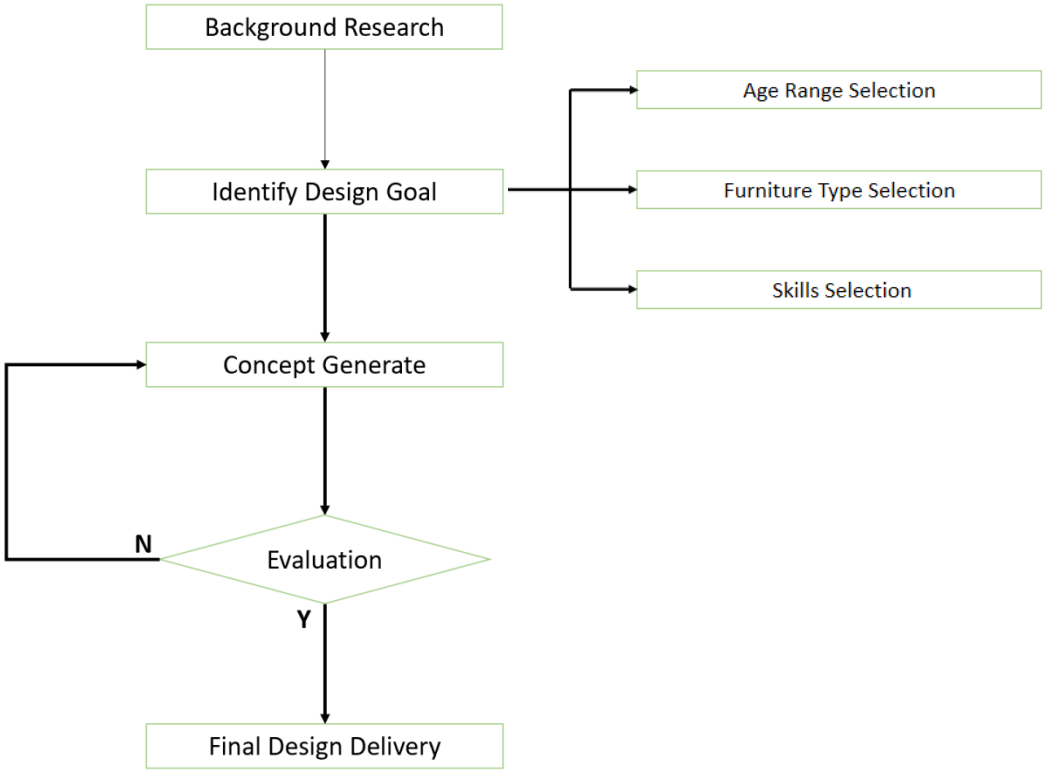


Figure 4. 1 Design procedure for children's furniture that can improve children's development

4.2 Background Research

In this part, I am going to design a chair for child to sit at and play, draw, and do crafts. The child can carry them from room to room.

4.3 Identify Design Goal

4.3.1 Age Range Selection

Age Selection		
Phase	**Age**	**Range**
Infants & toddler	0-1 years	
	1-2 years	
	2-3 years	√
Early childhood	3-4 years	√
	4-5 years	√
	5-6 years	√
Middle childhood	6-7 years	
	7-8 years	
	8-9 years	
	9-10 years	
	10-11 years	
	11-12 years	
Teen	12-13 years	
	13-14 years	
	14-15 years	
	15-16 years	
	16-17 years	
	17-18 years	

Table 4. 1 Identify Age Range Selection Table

4.3.2 Furniture Type Selection

Furniture Type Selection					
Function		**Using Place**		**Other Requirements**	**Furniture Type**
Relax		Outdoor		Young child can move it around	Child Chair
Seating	√	Indoor	√		
Leaning on		Public			
Storage		Home	√		
Study		Other			
Other					

Table 4. 2Identify Furniture Type Selection Table

4.3.3 Skills Selection

Skills Selection			
Physical	Body Size(Boys)		
	Body Size(Girls)		
	Body Proportions		
Motor	Stability	Static Balance	
		Dynamic Balance	√
	Locomotor	Walking & Running	√
		Jumping & Hopping	
		Galloping & Skipping	
	Manipulation	Grasping	√
		Throwing & Catching	
		Striking	
		Kicking	
Perceptual	Sensory	Sight	√
		Smell	
		Hearing	
		Touch	√
		Taste	
	Perceptual	Visual Acuity	√
		Figure-Ground Perception	√
		Visual-Motor Coordination	√
		Depth	√
		Pattern	
		Object	
Cognitive	Conservation		√
	Problem Solving	Convergent	
		Divergent	
		Logic & Reasoning	
	Creativity		√
Social	Emotional Expression		√
	Emotional Understanding		√
	Self-Understanding		
	Moral Understanding		
	Self-Control		√
	Gender Typing		
Others	Language		
	Mathematical		
	Musical		

Table 4. 3 Identify Skills Selection Table

4.4 Concept Generation

4.4.1 Confirm Size

For children between 2 and 6 years old, the seat range is between 7-14 inches. And 10 inches chair height will fit most situations.

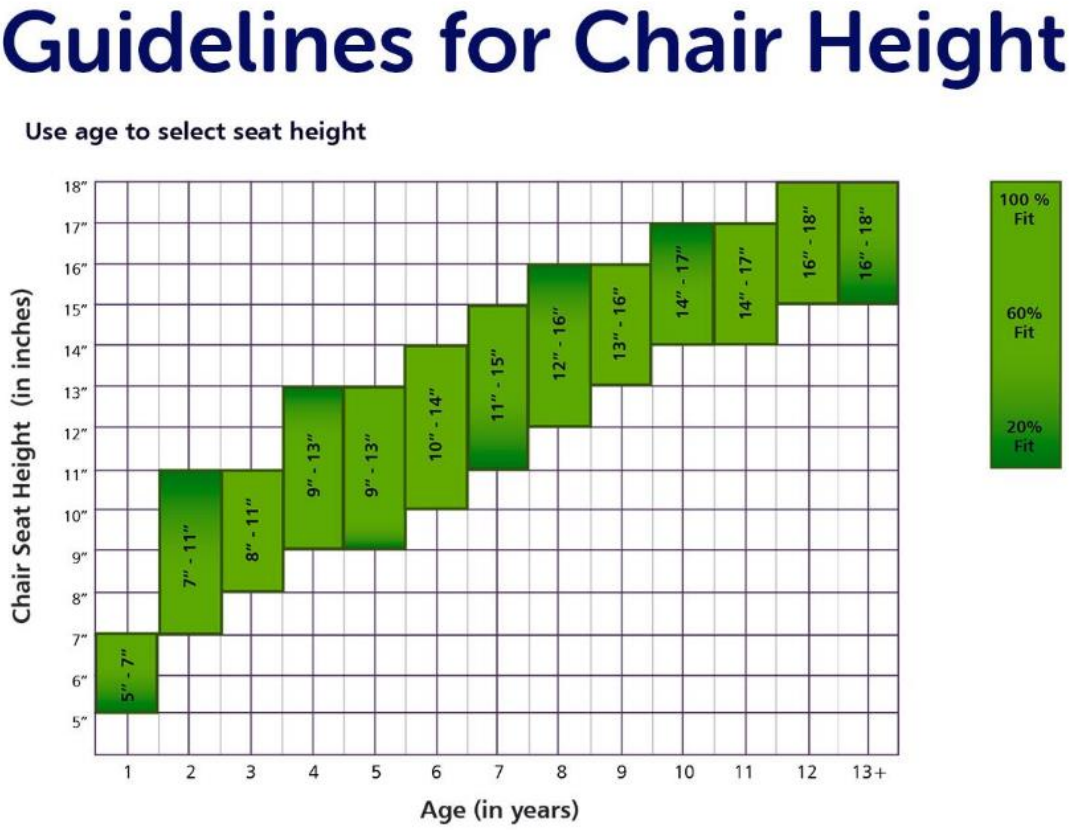


Figure 4. 2 Guidelines for Chair Height (Children's Chair, n.d)

Confirm Size		
	Range	**Notes**
Seat Height	7-14 in	

Table 4. 4 Confirm Size

4.4.2 Safety

In December 2015, the U.S. Consumer Product Safety Commission (CPSC) issued a consumer product safety standard for Children's Chairs and Stools. The standard incorporated by referencing the applicable ASTM voluntary standard. On April 1, 2020, the CPSC published a direct final rule revising the CPSC's mandatory standard for Children's Chairs and Stools to incorporate to ASTM F2613-19 with an effective date on July 6, 2020.

ASTM F2613-19, Standard Consumer Safety Specification for Children's Chairs and Stools, applies to chairs and stools intended to be used by a single child who can get in and get out of the product unassisted. The chair or stool would have a seat height of 15 in. or less, and would be with or without a rocking base. The standard was codified in the Commission's regulations at 16 CFR part 1232. This rule incorporates ASTM F2613-19 as the mandatory standard.

4.4.3 Concepts

Concept 1

This multifunctional children's toy stool is designed base on children's toy train. The main material of the stool is wood and cotton, aiming to increase the affinity and safety with children. The color of the stool is soft wood and light gray. The top of the stool can be opened from one side, and there is a large storage space inside. The setting of handle can guide children to develop fine movements, and the pull or push process when children play can effectively exercise the development of gross movement and strength.

Figure 4. 3 Concept 1

Concept 2

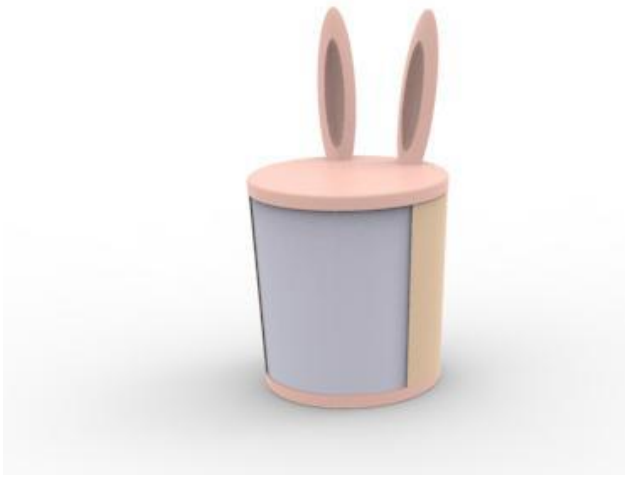
This colourful pencils' children's stool is designed for children to sit and play. The material of the stool is wood. Children can carry them from one place to another. On the top of the stool, there are several holes that can fit different colorful pencils. And the process of grasping and putting pencils can exercise the development of fine movements.

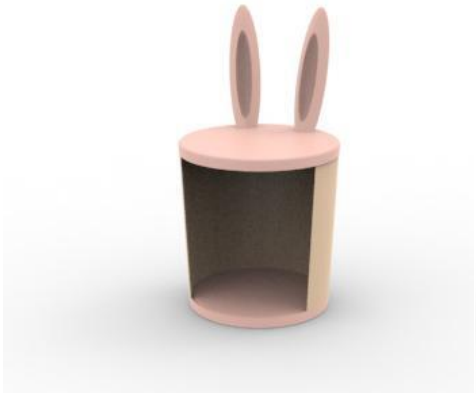

1

Figure 4. 4 Concept 2

Concept 3

This rabbit ear storage chair uses rabbit ear elements as a switch handle, it increases the fun of the furniture and attracts children's curiosity. The rabbit ear is used as the back of the chair at the same time. There is storage space under the chair surface, and the rabbit ear is the handle of the mobile storage door. The main material of the whole furniture is plastic. The rabbit ears are designed to be large, which is convenient for children to grasp and move. The process of using hand grasping and rotation can promote the development of children's gross and fine movements.





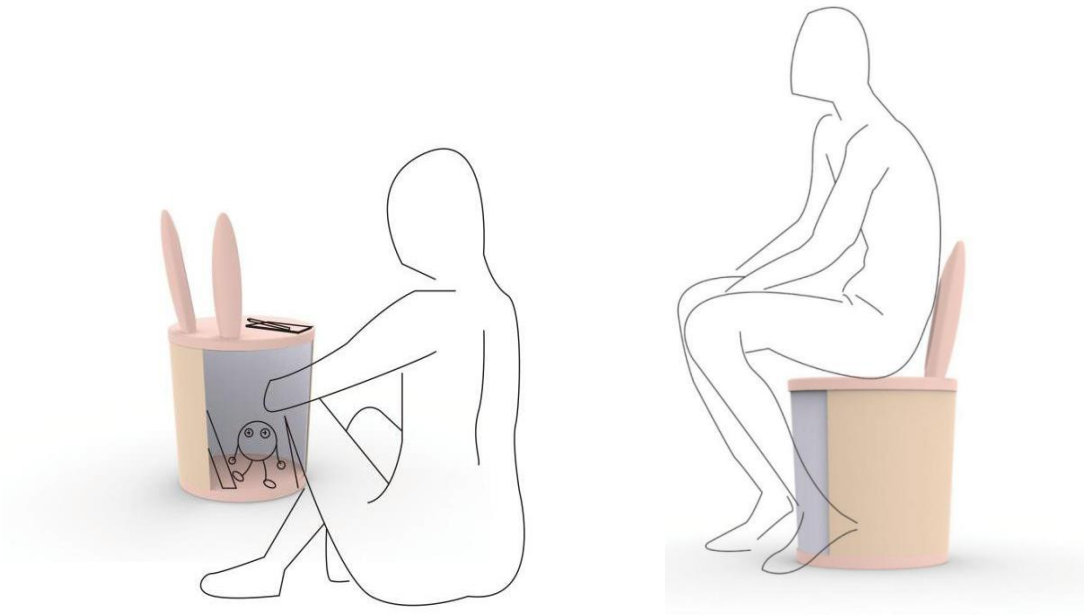
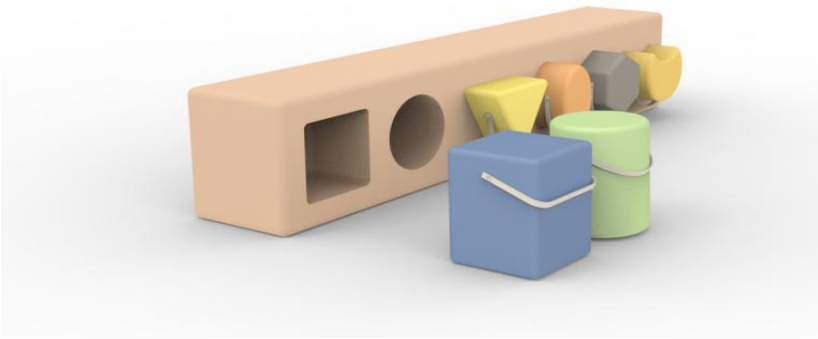


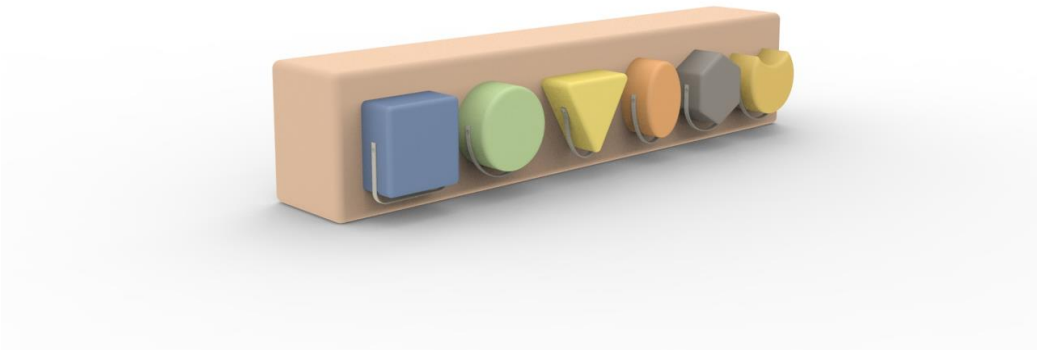
Figure 4. 5 Concept 3

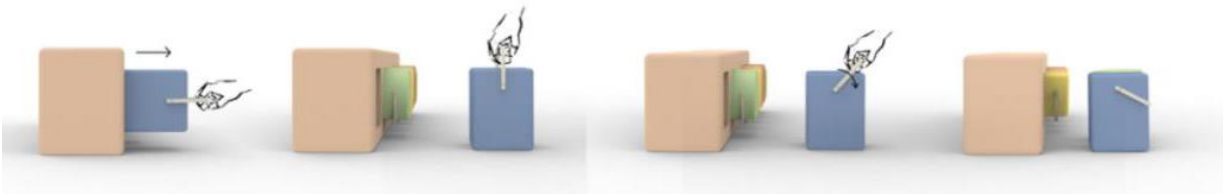
Concept 4

This multishape chair uses various shapes as the main body of the chair, and with a pull ring, it can be lifted. The main body of the chair is made of plastic and cotton cloth. Plastic material is light and convenient for children to lift. A layer of soft cotton cloth is wrapped on the outside to prevent children from damaging the skin when touching. The color of the chair is colorful and bright, which is easier to attract children's attention.

Through the concrete shape, it can promote the development of children's cognition. And at the same time, pull and place process can exercise the development of children's fine movement ability. Using the portability of furniture, it can promote the communication between children, promote their social development.







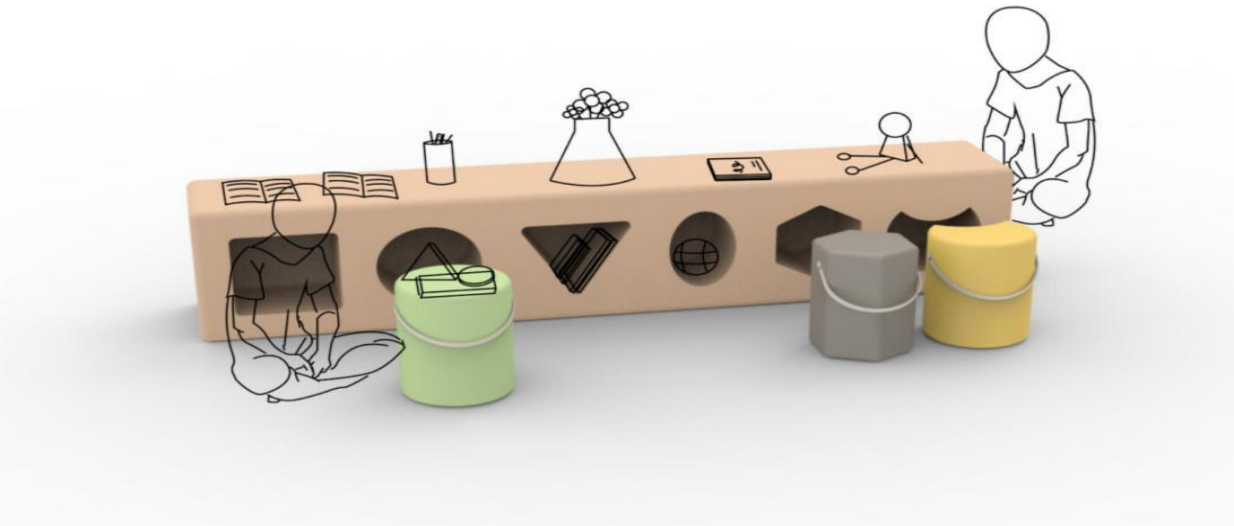


Figure 4. 6 Concept 4

4.5 Evaluation

4.5.1 Grading Development Status

Color				
Developing Status	Undeveloped	Developing	Rapidly Developing	Developed
Value	0	0.5	1	0.5

Table 4. 5 Grading Development Status Table

4.5.2 Grading Age Range Weight

According to Montessori Sensitive Period Theory, 1~4 Years is the Sensitive Period to hold Small Objects. At this sensitive period, children are more likely to play by themselves, because more parent participation would interrupt children's play and reduce their attention.

Grading Age Range Weight			
Phase	**Age Range**	**Selection**	**Weight**
Infants & toddler	0-1 years		
	1-2 years		
	2-3 years	√	**1**
Early childhood	3-4 years	√	**1**
	4-5 years	√	**0.5**
	5-6 years	√	**0.5**
Middle childhood	6-7 years		
	7-8 years		
	8-9 years		
	9-10 years		
	10-11 years		
	11-12 years		
Teen	12-13 years		
	13-14 years		
	14-15 years		
	15-16 years		
	16-17 years		
	17-18 years		

Table 4. 6 Grading Age Range Weight

4.5.3 Grading Selected Skills Weight

Skills Selection			Select	Skills Weight
Physical	Body Size(Boys)			
	Body Size(Girls)			
	Body Proportions			
Motor	Stability	Static Balance		
		Dynamic Balance	√	80%
	Locomotor	Walking & Running	√	80%
		Jumping & Hopping		
		Galloping & Skipping		
	Manipulation	Grasping	√	80%
		Throwing & Catching		
		Striking		
		Kicking		
Perceptual	Sensory	Sight	√	60%
		Smell		
		Hearing		
		Touch	√	90%
		Taste		
	Perceptual	Visual Acuity	√	80%
		Figure-Ground Perception	√	100%
		Visual-Motor Coordination	√	90%
		Depth	√	100%
		Pattern		
		Object		
Cognitive	Conservation		√	60%
	Problem Solving	Convergent		
		Divergent		
		Logic & Reasoning		
	Creativity		√	70%
Social	Emotional Expression		√	70%
	Emotional Understanding		√	70%
	Self-Understanding			
	Moral Understanding			
	Self-Control		√	80%
	Gender Typing			
Others	Language			
	Mathematical			
	Musical			

Table 4. 7 Grading Selected Skills Weight

4.5.4 Grading Selected Skills

Skills Selection			Select	Skills Weight	Assigned Grade			
					Concept 1	Concept2	Concept3	Concept4
Physical	Body Size(Boys)							
	Body Size(Girls)							
	Body Proportions							
Motor	Stability	Static Balance						
		Dynamic Balance	√	80%	95	70	70	85
	Locomotor	Walking & Running	√	80%	90	70	70	90
		Jumping & Hopping						
		Galloping & Skipping						
	Manipulation	Grasping	√	80%	85	85	70	90
		Throwing & Catching						
		Striking						
		Kicking						
Perceptual	Sensory	Sight	√	60%	75	75	75	80
		Smell						
		Hearing						
		Touch	√	90%	80	85	70	80
		Taste						
	Perceptual	Visual Acuity	√	80%	80	85	75	85
		Figure-Ground Perception	√	100%	85	85	80	90
		Visual-Motor Coordination	√	90%	90	85	75	90
		Depth	√	100%	80	80	80	95
		Pattern						
		Object						
Cognitive	Conservation		√	60%	70	70	70	80
	Problem Solving	Convergent						
		Divergent						
		Logic & Reasoning						
	Creativity		√	70%	80	70	70	80
Social	Emotional Expression		√	70%	80	70	70	85
	Emotional Understanding		√	70%	80	70	75	85
	Self-Understanding							
	Moral Understanding							
	Self-Control		√	80%	85	80	70	85
	Gender Typing							
Others	Language							
	Mathematical							
	Musical							

Table 4. 8 Grading Selected Skills

4.5.5 Calculating Grading

Age			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Concept 1 			
Age Range Weight					1	1	0.5	0.5				Select	Skills Weight	Assigned Grade	Calculated Score
Physical	Body Size(Boys)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5				
	Body Size(Girls)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5				
	Body Proportions		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
Motor	Stability	Static Balance	1	0.5	0.5	0.5	1	1	0.5	0.5	0.5				
		Dynamic Balance	0	0	0	0.5	1	0.5	0.5	0.5	0.5	√	80%	95	95
	Locomotor	Walking & Running	1	0.5	1	1	1	0.5	0.5	0.5	0.5	√	80%	90	198
		Jumping & Hopping	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Galloping & Skipping	0	0	0	0.5	0.5	1	1	0.5	0.5				
	Manipulation	Grasping	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	80%	85	102
		Throwing & Catching	0	0	0.5	1	1	0.5	0.5	0.5	0.5				
		Striking	0	0	0.5	1	1	1	0.5	0.5	0.5				
		Kicking	0	0.5	0.5	1	1	1	0.5	0.5	0.5				
Perceptual	Sensory	Sight	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	√	60%	75	90
		Smell	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Hearing	1		0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Touch	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	90%	80	108
		Taste	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
	Perceptual	Visual Acuity	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5	√	80%	80	112
		Figure-Ground Perception	0	0	0	0.5	1	1	1	0.5	0.5	√	100%	85	127.5
		Visual-Motor Coordination	0	0	0.5	1	1	1	1	0.5	0.5	√	90%	90	202.5
		Depth	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	100%	80	120
		Pattern	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Object	1	1	1	1	0.5	0.5	0.5	0.5	0.5				
Cognitive	Conservation		0	0	0	0.5	0.5	0.5	0.5	1	1	√	60%	70	42
	Problem Solving	Convergent	0	0	0.5	0.5	0.5	0.5	0.5	1	1				
		Divergent	0	0	0.5	1	1	1	0.5	0.5	0.5				
		Logic & Reasoning	0	0	0.5	0.5	0.5	0.5	0.5	1	1				
	Creativity		0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	70%	80	84
Social	Emotional Expression		0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	√	70%	80	84
	Emotional Understanding		0	0.5	1	1	0.5	0.5	0.5	0.5	0.5	√	70%	80	140
	Self-Understanding		0.5	0.5	0.5	1	1	1	1	0.5	0.5				
	Moral Understanding		0	0.5	1	1	1	1	0.5	0.5	0.5				
	Self-Control		0	0.5	0.5	0.5	1	1	1	1	1	√	80%	85	136
	Gender Typing		0.5	0.5	0.5	1	1	0.5	0.5	0.5	0.5				
Others	Language		0.5	0.5	1	1	0.5	0.5	0.5	0.5	0.5				
	Mathe matical		0	0	0.5	0.5	1	1	0.5	0.5	0.5				
	Musical		0.5	0.5	1	1	1	1	0.5	0.5	0.5				
Final Score															117.21

Table 4. 9 Calculate concept 1

Age			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Concept 2 			
Age Range Weight					1	1	0.5	0.5				Select	Skills Weight	Assigned Grade	Calculated Score
Physical	Body Size(Boys)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5				
	Body Size(Girls)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5				
	Body Proportions		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
Motor	Stability	Static Balance	1	0.5	0.5	0.5	1	1	0.5	0.5	0.5				
		Dynamic Balance	0	0	0	0.5	1	0.5	0.5	0.5	0.5	√	80%	70	70
	Locomotor	Walking & Running	1	0.5	1	1	1	0.5	0.5	0.5	0.5	√	80%	70	154
		Jumping & Hopping	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Galloping & Skipping	0	0	0	0.5	0.5	1	1	0.5	0.5				
	Manipulation	Grasping	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	80%	85	102
		Throwing & Catching	0	0	0.5	1	1	0.5	0.5	0.5	0.5				
		Striking	0	0	0.5	1	1	1	0.5	0.5	0.5				
		Kicking	0	0.5	0.5	1	1	1	0.5	0.5	0.5				
Perceptual	Sensory	Sight	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	√	60%	75	90
		Smell	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Hearing	1		0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Touch	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	90%	85	114.75
		Taste	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
	Perceptual	Visual Acuity	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5	√	80%	85	119
		Figure-Ground Perception	0	0	0	0.5	1	1	1	0.5	0.5	√	100%	85	127.5
		Visual-Motor Coordination	0	0	0.5	1	1	1	1	0.5	0.5	√	90%	85	191.25
		Depth	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	100%	80	120
		Pattern	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Object	1	1	1	1	0.5	0.5	0.5	0.5	0.5				
Cognitive	Conservation		0	0	0	0.5	0.5	0.5	0.5	1	1	√	60%	70	42
	Problem Solving	Convergent	0	0	0.5	0.5	0.5	0.5	0.5	1	1				
		Divergent	0	0	0.5	1	1	1	0.5	0.5	0.5				
		Logic & Reasoning	0	0	0.5	0.5	0.5	0.5	0.5	1	1				
	Creativity		0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	70%	70	73.5
Social	Emotional Expression		0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	√	70%	70	73.5
	Emotional Understanding		0	0.5	1	1	0.5	0.5	0.5	0.5	0.5	√	70%	70	122.5
	Self-Understanding		0.5	0.5	0.5	1	1	1	1	0.5	0.5				
	Moral Understanding		0	0.5	1	1	1	1	0.5	0.5	0.5				
	Self-Control		0	0.5	0.5	0.5	1	1	1	1	1	√	80%	80	128
	Gender Typing		0.5	0.5	0.5	1	1	0.5	0.5	0.5	0.5				
Others	Language		0.5	0.5	1	1	0.5	0.5	0.5	0.5	0.5				
	Mathe matical		0	0	0.5	0.5	1	1	0.5	0.5	0.5				
	Musical		0.5	0.5	1	1	1	1	0.5	0.5	0.5				
Final Score															109.14

Table 4. 10 Calculate concept 2

Age			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Concept 3 			
Age Range Weight					1	1	0.5	0.5				Select	Skills Weight	Assigned Grade	Calculated Score
Physical	Body Size(Boys)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5				
	Body Size(Girls)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5				
	Body Proportions		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
Motor	Stability	Static Balance	1	0.5	0.5	0.5	1	1	0.5	0.5	0.5				
		Dynamic Balance	0	0	0	0.5	1	0.5	0.5	0.5	0.5	√	80%	70	70
	Locomotor	Walking & Running	1	0.5	1	1	1	0.5	0.5	0.5	0.5	√	80%	70	154
		Jumping & Hopping	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Galloping & Skipping	0	0	0	0.5	0.5	1	1	0.5	0.5				
	Manipulation	Grasping	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	80%	70	84
		Throwing & Catching	0	0	0.5	1	1	0.5	0.5	0.5	0.5				
		Striking	0	0	0.5	1	1	1	0.5	0.5	0.5				
		Kicking	0	0.5	0.5	1	1	1	0.5	0.5	0.5				
Perceptual	Sensory	Sight	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	√	60%	75	90
		Smell	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Hearing	1		0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Touch	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	90%	70	94.5
		Taste	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
	Perceptual	Visual Acuity	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5	√	80%	75	105
		Figure-Ground Perception	0	0	0	0.5	1	1	1	0.5	0.5	√	100%	80	120
		Visual-Motor Coordination	0	0	0.5	1	1	1	1	0.5	0.5	√	90%	75	168.75
		Depth	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	100%	80	120
		Pattern	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Object	1	1	1	1	0.5	0.5	0.5	0.5	0.5				
Cognitive	Conservation		0	0	0	0.5	0.5	0.5	0.5	1	1	√	60%	70	42
	Problem Solving	Convergent	0	0	0.5	0.5	0.5	0.5	0.5	1	1				
		Divergent	0	0	0.5	1	1	1	0.5	0.5	0.5				
		Logic & Reasoning	0	0	0.5	0.5	0.5	0.5	0.5	1	1				
	Creativity		0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	70%	70	73.5
Social	Emotional Expression		0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	√	70%	70	73.5
	Emotional Understanding		0	0.5	1	1	0.5	0.5	0.5	0.5	0.5	√	70%	75	131.25
	Self-Understanding		0.5	0.5	0.5	1	1	1	1	0.5	0.5				
	Moral Understanding		0	0.5	1	1	1	1	0.5	0.5	0.5				
	Self-Control		0	0.5	0.5	0.5	1	1	1	1	1	√	80%	70	112
	Gender Typing		0.5	0.5	0.5	1	1	0.5	0.5	0.5	0.5				
Others	Language		0.5	0.5	1	1	0.5	0.5	0.5	0.5	0.5				
	Mathe matical		0	0	0.5	0.5	1	1	0.5	0.5	0.5				
	Musical		0.5	0.5	1	1	1	1	0.5	0.5	0.5				
Final Score															102.75

Table 4. 11 Calculate concept 3

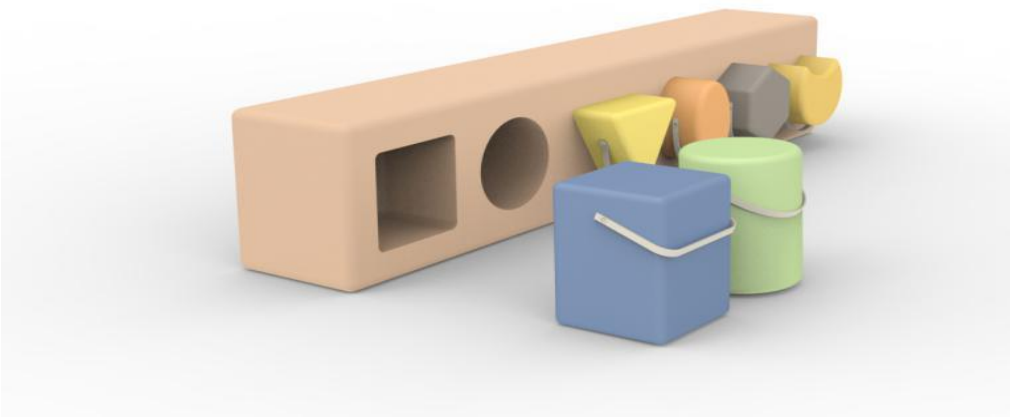
Age			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Concept 4 			
Age Range Weight					1	1	0.5	0.5				Select	Skills Weight	Assigned Grade	Calculated Score
Physical	Body Size(Boys)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5				
	Body Size(Girls)		1	1	1	0.5	0.5	0.5	0.5	0.5	0.5				
	Body Proportions		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
Motor	Stability	Static Balance	1	0.5	0.5	0.5	1	1	0.5	0.5	0.5				
		Dynamic Balance	0	0	0	0.5	1	0.5	0.5	0.5	0.5	√	80%	85	85
	Locomotor	Walking & Running	1	0.5	1	1	1	0.5	0.5	0.5	0.5	√	80%	90	198
		Jumping & Hopping	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Galloping & Skipping	0	0	0	0.5	0.5	1	1	0.5	0.5				
	Manipulation	Grasping	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	80%	90	108
		Throwing & Catching	0	0	0.5	1	1	0.5	0.5	0.5	0.5				
		Striking	0	0	0.5	1	1	1	0.5	0.5	0.5				
		Kicking	0	0.5	0.5	1	1	1	0.5	0.5	0.5				
Perceptual	Sensory	Sight	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	√	60%	80	96
		Smell	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Hearing	1		0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Touch	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	90%	80	108
		Taste	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
	Perceptual	Visual Acuity	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5	√	80%	85	119
		Figure-Ground Perception	0	0	0	0.5	1	1	1	0.5	0.5	√	100%	90	135
		Visual-Motor Coordination	0	0	0.5	1	1	1	1	0.5	0.5	√	90%	90	202.5
		Depth	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	100%	95	142.5
		Pattern	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
		Object	1	1	1	1	0.5	0.5	0.5	0.5	0.5				
Cognitive	Conservation		0	0	0	0.5	0.5	0.5	0.5	1	1	√	60%	80	48
	Problem Solving	Convergent	0	0	0.5	0.5	0.5	0.5	0.5	1	1				
		Divergent	0	0	0.5	1	1	1	0.5	0.5	0.5				
		Logic & Reasoning	0	0	0.5	0.5	0.5	0.5	0.5	1	1				
	Creativity		0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	√	70%	80	84
Social	Emotional Expression		0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	√	70%	85	89.25
	Emotional Understanding		0	0.5	1	1	0.5	0.5	0.5	0.5	0.5	√	70%	85	148.75
	Self-Understanding		0.5	0.5	0.5	1	1	1	1	0.5	0.5				
	Moral Understanding		0	0.5	1	1	1	1	0.5	0.5	0.5				
	Self-Control		0	0.5	0.5	0.5	1	1	1	1	1	√	80%	85	136
	Gender Typing		0.5	0.5	0.5	1	1	0.5	0.5	0.5	0.5				
Others	Language		0.5	0.5	1	1	0.5	0.5	0.5	0.5	0.5				
	Mathe matical		0	0	0.5	0.5	1	1	0.5	0.5	0.5				
	Musical		0.5	0.5	1	1	1	1	0.5	0.5	0.5				
Final Score															121.4

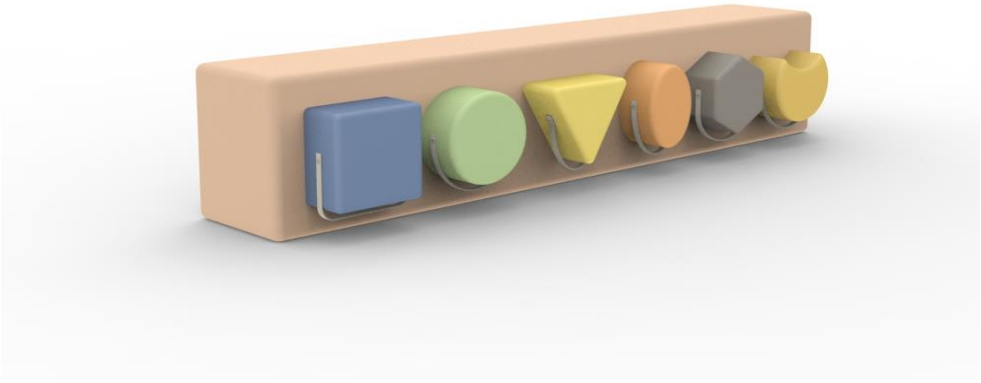
Table 4. 12 Calculate concept 4

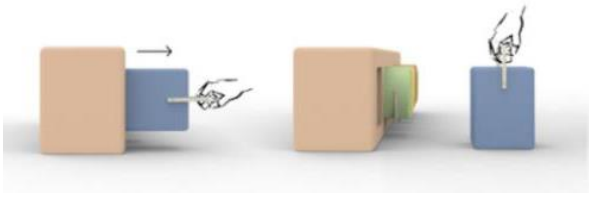
4.6 Final Design Delivery

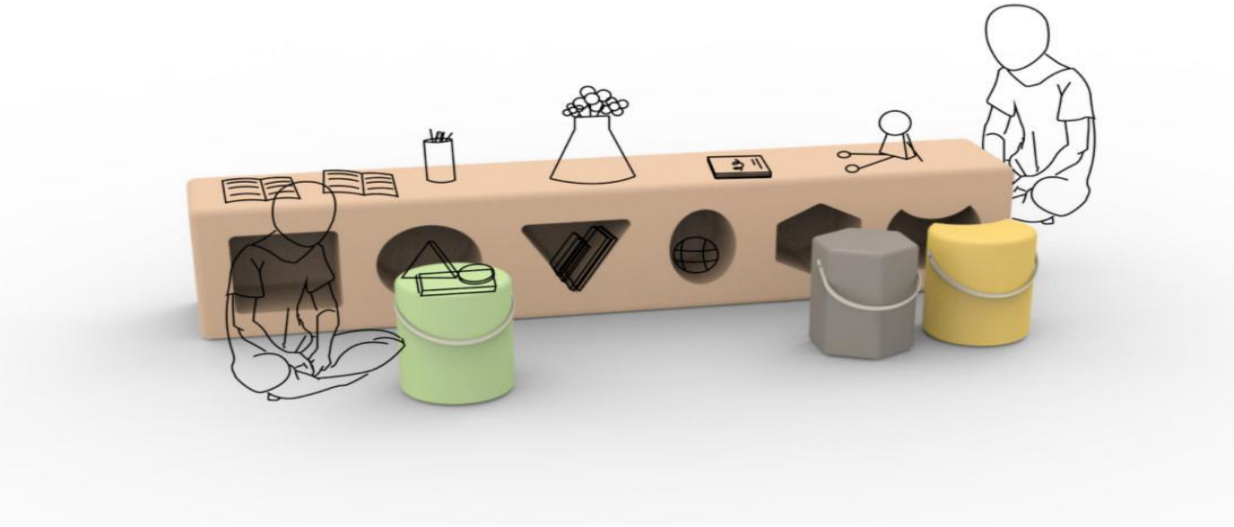
This multishape chair uses various shapes as the main body of the chair, and with a pull ring, it can be lifted. The main body of the chair is made of plastic and cotton cloth. Plastic material is light and convenient for children to lift. A layer of soft cotton cloth is wrapped on the outside to prevent children from damaging the skin when touching. The color of the chair is colorful and bright, which is easier to attract children's attention.

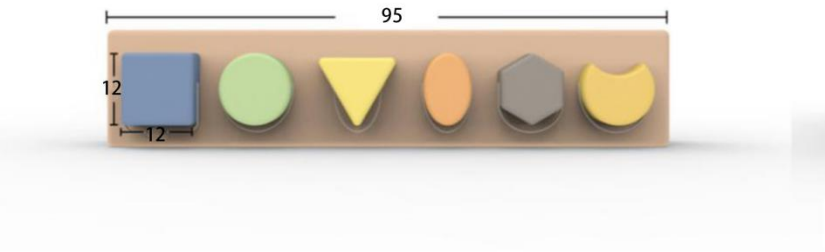
Through the concrete shape, it can promote the development of children's cognition. And at the same time, pull and place process can exercise the development of children's fine movement ability. Using the portability of furniture, it can promote the communication between children, promote their social development.

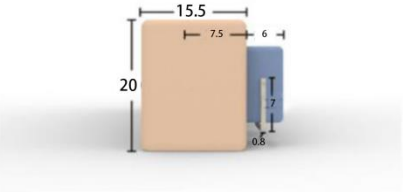









95
12
12


15.5
7.5
6
20
7
0.8

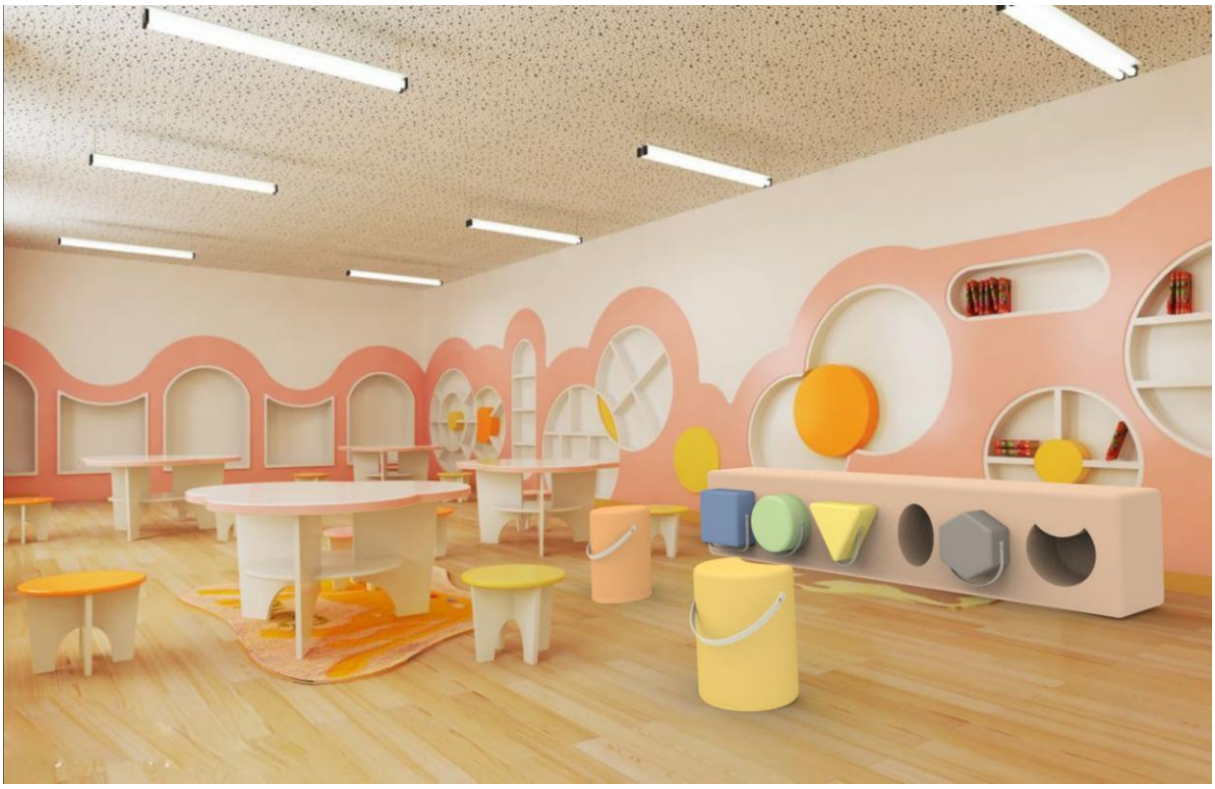


Figure 4. 7 Final Design

Chapter 5 Conclusion

The purpose of this thesis was to develop a guideline for designers to design children's furniture that can promote children's development. Chapter One discusses the current problem behind this thesis. Chapter Two discusses theories of these areas and seeks to support the guideline later. Chapter Three develops the guideline, and Chapter Four follows the guideline to show an example project to prove this approach.

However, this guideline only provides one simple solution. How to promote children's development can be more complicated. Only main factors are mentioned in the guideline. Parents' participation and other factors have not been taken into consideration. There are still more possibilities here.

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