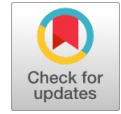


Development of Learning Facilities for ADHD Student Aged 6-9 Years Old at Special School in Indonesia



Bambang Tristiyono, Halimatus Sa'diyah Tualeka

Abstract: Attention-Deficit / Hyperactivity Disorder (ADHD) is a neurobiological disorder in the form of inability to focus attention, easily distracted, impulsive, and hyperactive. Children with ADHD are usually aggressive, unable calm down, are difficult to teach, and have trouble focusing when doing an activity. With this, children with ADHD need treatment, special handling, as well as facilities and infrastructure that are suitable for children with ADHD. One special facility for ADHD that looks significant compared to other normal facilities is a study furniture designed for children with ADHD. The study furniture is important because it often interacts with children with ADHD for a long time. The good consideration of a design is the fulfillment of needs that can adapt to user conditions. To get a solution, interviews with experts were conducted, potential users that is children with ADHD aged 6-9 years, literature studies on ADHD, active seating, fidgeting, ergonomics, color, benchmarking to product existing, and analysis of user needs. The results of this design are furniture sets in the form of tables and chairs that use active seating, calm, adjustable, and safe as the concept to support the learning activities of children with ADHD in special schools. The chair design uses the concept of active seating in the form of whole body fidgeting to support hyperactive and inattention symptoms. This design utilizes digital simulation to digitize the concept and simulate it, reducing trial and error during prototype development. Furniture with adjustable height system for children aged 6-9 years with a simple and safe form for the needs of children with ADHD. This design uses muted brown color to give a clean impression and not cause distraction, combined with a muted blue color to give a calming feel from a psychological standpoint and fulfill user preferences.

Keywords: Active Seating, ADHD, Children, Learning Desk, Digital Simulation

I. INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the neurobiological disorders characterized by an inability to focus attention, easy distractibility, impulsiveness, and hyperactivity. The percentage of children diagnosed with ADHD increases with age. According to a CDC study, hyperactive-diagnosed children have increased by 42% since

2003. Surveys conducted by the Journal of the American Academy of Child and Adolescent Psychiatry in 2014 and 2018 indicate that 2.4% (388,000) of children aged 2 to 5 years, and 9.6% (2.4 million) of children aged 6 to 11 years have diagnosed with ADHD. Research indicates that most children with ADHD will continue to have ADHD as adults, and adults who have learned to manage their symptoms will experience a reduction in hyperactive symptoms over time (Primary Care Companion to the Journal of Clinical Psychiatry, 2009). ADHD can occur due to genetic heritage, neurotransmitter deficits, delayed development of brain systems, and abnormal brain development.

Fidgeting is the act of restlessly moving in a manner that is not socially recognized as important during ongoing events. Fidgeting commonly arises when someone feels uncomfortable, bored, or no longer focused on what is happening. By engaging in fidgeting, an individual becomes more alert. The principle behind using fidgeting to enhance focus is that individuals become restless when bored, unfocused, and lacking stimuli. For children with hyperactive symptoms associated with ADHD they may become restless during class but can sit relatively still when playing video games if actively engaged. This principle suggests that through interest, engagement, and stimuli, hyperactivity can be reduced. Harnessing this restlessness can transform uncontrolled tapping, leg shaking, and so on, potentially leading to increased focus.

Children with ADHD in special education schools have a different learning system than regular schools. The system in place also has therapeutic value and employs specialized supervisors with programs that must be entirely free from distractions. One essential tool for teaching ADHD children is the study desk. With the provision of desks or learning tools tailored to users' needs, it is hoped that the activities of ADHD children and their supervisor during learning can be enhanced. Currently, the study desks in use still do not meet the needs of ADHD children and their supervisor. There are still issues regarding ergonomics, minimal distractions, and comfort. Desk provided by clinics and special education schools do not fit the body sizes of students aged 6-9 years, and the available desks have yet to enhance the independence of ADHD children due to a lack of stimuli.

This design idea is intriguing because it incorporates three phenomena: ADHD, the concept that fidgeting aids learning, and the study desk. This research aims to enhance the optimal learning environment by adjusting to user needs, maximizing the space utilization on the desk, designing a table that can restrain an ADHD child during a tantrum, and creating an ergonomic table.

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With the design idea of a learning tool for children aged 6-9 years with ADHD in a special room along with their instructor, it is hoped to achieve the objective of design.

II. LITERATURE REVIEW

A. ADHD Students

Attention deficit hyperactivity disorder, or ADHD for short is a condition that makes it difficult for a person to sustain or control physical movements. According to MIF. Baihaqi and M. Suqiarman (2006:2), the condition is characterized by children displaying symptoms that lack of concentration, hyperactivity, and impulsiveness [1]. The characteristics of children with ADHD are aggression, high energy, restlessness, difficulty in being taught, and an inability to engage in activities for long periods. The following are some theories about preschool ADHD children:

1. Non-verbal behavior disorders (eye contact, facial expressions, and body posture)
2. Failure to develop peer relationships according to developmental levels.
3. Lack of spontaneity in sharing pleasure, interests, or achievements with others.
4. Qualitative communication disorders (language developmental delays, speech delays)

According to Slameto (2003:86), learning concentration is the act of focusing one thought and attention on a subject, disregarding anything unrelated to the subject matter [2]. By addressing ADHD cases, research shows that students with ADHD can concentrate better if allowed to move around more. One mechanism linking movement and performance is that children with ADHD use movement to regulate their own alertness. An optimal level of stimulation is required for cognitive performance [3].

B. Special Schools & Facilities for ADHD Students

Special School are educational institutions that are integrated part of the national education system that are specifically organized for students who have a level of difficulty in following the learning process due to physical, emotional, social-mental disorders, but have potential intelligence and special talents [4]. According to Mr. Nasichin, Director of Special Education, Ministry of National Education, Special education is provided at the primary and secondary education level and is part of the national education system in Indonesia. There are three types of special school in Indonesia that are Sekolah Dasar Luar Biasa or SDLB (Special Primary School), Sekolah Luar Biasa or SLB (special school consist of kindergarten, primary school, junior secondary school, and senior secondary school under one roof), and integrated school (students with special needs are learning together with the normal students)

The provided learning facilities must effectively support the learning programs and facilitate the development of a learning environment to enhance the users' learning experience, including the provision of specialized seating such as the designated benches. According to previous research, alternative seating has been considered as an option to accommodate children with ADHD. This analysis involved the use of therapy balls, cushions, therapy balls with backrests, and stability balls. From this research, it was

found that implementing alternative seating as an intervention for children with ADHD in the classroom can improve their behavioral development, especially in terms of movement patterns, sitting positions, and the ability to focus. Among the various alternatives examined, the use of therapy balls was found to be the most effective [5] [6]. Standardization of facilities in special schools (SLB) classrooms is in accordance with Education Regulation Number 33 of 2008, as follows: [7]

- a. The function of the classroom space is for theoretical and practical learning activities using simple and easily available tools.
- b. The minimum number of classrooms is equal to the number of learning groups.
- c. The maximum capacity of a classroom is 5 students for SDLB classrooms and 8 students for SMPLB and SMALB classrooms.
- d. The minimum ratio of classroom area to the number of students is 3 m² per student. For learning groups with fewer than 5 students, the minimum classroom area is 15m².
- e. The minimum width of a classroom is 3 m.
- f. The classroom has windows that allow adequate lighting for reading and provide a view outside.
- g. The classroom has adequate doors to ensure that students and teachers can exit the room quickly in case of danger and can be securely locked when not in use.
- h. One of the classroom walls can be a semi-permanent wall so that, at some point, two adjoining classrooms can be combined into one room.

C. Ergonomics

Definition of ergonomic by the international Ergonomic Association in 2000, that ergonomic is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance. According to Panero (2003), ergonomics is the technology of work design based on the sciences of human biology, anatomy, physiology, and psychology [8]. In this study, the ergonomics employed include physical ergonomics and cognitive ergonomics. Physical ergonomic mencakup dari anatomi manusia, anthropometric, physiological, and biomechanical characteristics as they relate to physical activity [9]. Antropometri originates from "Anthro," meaning human, and "metri," which refers to measurement. Anthropometric study involves the measurement of human body dimensions, including bones, muscles, and adipose or fat tissue (survey, 2009) [10]. In this design, the focus is on adapting the dimensions to the body size of children aged 6-9 years.

Furthermore, cognitive ergonomics is employed, which centers on mental processes such as perception, memory, reasoning, and motor response, as they influence interactions between humans and other elements. This aims to enable intuitive, comfortable, and efficient user interactions while minimizing cognitive load and potential stress. These principles are assessed using Don Norman's concepts of visceral, behavioral, and reflective aspects [11].



The placement of study desks also significantly affects student behavior. There is a direct correlation between student behavior and the arrangement of study desks in the classroom. A well-organized classroom layout helps students anticipate and engage in activities, adjusting their behavior in various areas. A well-planned classroom space sets clear boundaries for designing where different types of activities will take place [12]. Considering the age of the subjects of this design, which is 6-9 years old, the design requires dimensions that can be adjusted and accessible for that age group. This is to ensure that the product can serve as an ergonomic solution.

D. The Relevance of the Concept of 'Calm' to ADHD

The selection of color for individuals with ADHD become one of the factors to support learning focus. Trsih Buscemi, a color consultant, employs colors to aid children with cognitive learning challenge and their family in creating interiors that are calm and child friendly. The best colors for children with ADHD are blue, green, and muted brown tones (brown colors with low contrast and saturation levels) [13].

Designing furniture for individuals with ADHD requires a tranquil or calm concept to create an environment that can support concentration, reduce distractions, and enhance a sense of calmness. Neutral and soothing colors can establish a serene environment and minimize visual disturbances [14]. Furthermore, well-designed, and comfortable furniture for children with ADHD, such as specialized chairs like sensory chairs and therapy balls, can enhance comfort and cater to the hyperactive needs of children with ADHD [15].

E. The Relevance of the Concept of 'Safe' to ADHD

The safe aspect should be carefully considered when designing furniture products for children. This aspect is always a concern for parents. There are instances when parents may be slightly negligent, thus necessitating safety features in the furniture to prevent accidents involving children. The concept of safety features in the furniture involves creating products that do not cause harm and considering materials that are safe for children [16]. The concept of safety is closely related to ergonomics, specifically safety ergonomics. This branch of ergonomics comprehends how humans interact with various systems in their environment. In any setting, people encounter a variety of products, tools, systems, and methods that either aid or hinder their individual or group functioning. Depending on their design and capabilities, these tools can either assist or pose obstacles. Safety ergonomics pertains to the workplace, involving how the positioning and situations in a workplace affect the body – from the chairs individuals sit on to how they lift heavy boxes. More specifically, ergonomics safety strives to ensure that the tools and user environment meet user requirements and individual capabilities [17] [18]

F. The Relevance of the Concept of 'Active Seating' to ADHD

Active seating occurs when the seating arrangement enables or encourages users to remain active while seated. This concept is also referred to as dynamic sitting, where flexibility and movement while sitting can be beneficial for the human body and promote ease of work [19]. Active seating follows the principles of movement akin to standing and walking, with core muscles constantly adapting to maintain upright posture. Children with ADHD perform

better on tasks requiring complex attention when they are restless. The increased visible movement in children with ADHD, commonly referred to as hyperactivity, is a way for them to associated with ADHD. It is understood that ADHD is linked to both hyper and hypo brain function. Therefore, engaging in physical movement serves as a means to increase dopamine and/or noradrenergic activity in the brain, and the elevation of these neurotransmitters functions to enhance the focus and alertness of children with ADHD [20].

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G. Digital Simulation

Digital simulation involves the integration of data processing, machine learning, and software analytics to generate a digitally simulated representation, mapped with sensors, of a physical system [21]. Digital simulation is utilized during the process of digitally conceptualizing product ideas. In this design phase, digital simulation is applied to convert 2D shapes into 3D concepts. The author employs the fusion 360 application to create these 3D shapes. Subsequently, a simulation extension proves valuable in assessing performance and manufacturability, constituting a simulation study type that aids in comprehending how 3D design will function under real-world conditions before actual product manufacturing takes places. The purpose of this extension is to enable designers to enhance product functionality and identify critical aspects within the design. [22]

III. METHODOLOGY

Here is the research method employed in the study of designing learning tools for children aged 6-9 years with ADHD in special classrooms under the guidance of instructors.

A. Research Data

The data collection process begins with the identification of research aspects. This is useful for investigating the issues related to ADHD children while learning in special classrooms with instructors, considering factors such as focus and hyperactivity levels based on ADHD characteristics, specialized ADHD chairs, the existing classroom conditions for ADHD children, and safety and comfort considerations for users with ADHD. This data collection involves both primary and secondary data. Primary data comprises research conducted by directly engaging users on matters related to the design. Primary data collection methods include observation, in-depth interviews, and questionnaires. In this stage, the process involves observing users and their surroundings directly in special education schools that accommodate ADHD children. The primary data collection is carried out with ADHD students in special classrooms, where learning activities involve 6-8 students with various special needs.



Table- I: primary data

No	Subject	Time	Data
1	Ms. Ita // school principal of SLB Among Asih	May 2023	In-depth Interview
	<ul style="list-style-type: none"> Identifying the needs and challenges of users while learning Enhancing insight into the learning styles of children with ADHD in Special Schools Expanding insights into the learning patterns of children with ADHD in Special Schools 		
2	Ms. Mira // Teacher from SLB AKW Kumara 1	May 2023	In-depth interview
	<ul style="list-style-type: none"> Identifying the needs and challenges of users while learning Enhancing insight into the learning styles of children with ADHD in Special Schools Expanding insights into the learning patterns of children with ADHD in Special Schools 		
3	Ms. Putri // Teacher SLB AKW Kumara 1	June 2023	In-depth interview & feedback for usability test
	<ul style="list-style-type: none"> Identifying the needs and challenges of users while learning Guiding during usability testing of the product with children with ADHD in Special School. Conducting interviews regarding the usability outcomes. 		
4	Doctor Izza // Child Psychologist	June – July 2023	In-depth interview & discussion
	<ul style="list-style-type: none"> Identifying the needs and challenges of users while they are studying. Enhancing insights into the learning styles of children with ADHD in Indonesia Comparing learning tools based on journals with educational system in Indonesia. 		
5	17 ADHD kids' parents	June – July 2023	Questionnaire
	<ul style="list-style-type: none"> Identifying user segmentation and criteria for selected Special Needs Schools (SLB) Knowledge about the provided concept User preferences regarding the concepts User opinions about the implementation of active seating concept in special ADHD schools 		
6	ADHD Student–ALBA (SLB AKW Kumara 1)	June – July 2023	• Observation – Usability Test
	<ul style="list-style-type: none"> Identifying the needs and challenges of users while learning Enhancing insight of studying activity data during learning sessions To ascertain user preferences Conducting usability tests and comparing the to the use of traditional chairs. To identify the existing school environment for ADHD Children 		
7	ADHD Students –SLB Bakti Asih	July 2022	• Observation
	<ul style="list-style-type: none"> Identifying the needs and challenges of users while learning Enhancing insight of studying activity data during learning sessions To know the learning of children with ADHD in groups To identify the existing school environment for ADHD Children 		

Secondary data collection involves gathering supporting data relevant to the design. This includes a review of ADHD, previous research, ergonomics, materials, colors, and design concepts related to ADHD learning tools. Secondary data for this research is sourced from reputable literature, such as journals, books, and official websites. The journals used in this design research have topics related to ADHD, specialized ADHD chairs, and classroom design for ADHD. The books used are related to ergonomics including cognitive ergonomics, safety ergonomics, and anthropometry. Information from official websites was gathered regarding digital simulation and concept explanation.

B. Exploration and Product Development

Concept formulation is aimed at deriving the design concept for ADHD children's learning tools. It begins with an affinity diagram to determine user needs and draw insights from previous designs or products.

The outcomes of the affinity diagram are formulated and analyzed to generate concepts to be explored in the research. The concepts generated include active seating, safety, calmness, and adjustability. The author creates a concept framework to comprehensively explain the concepts to be discussed, as depicted in

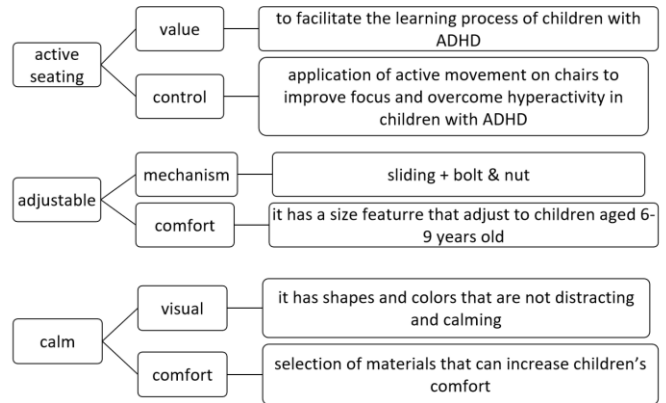


Fig. 1. Concept Framework

Continual study and analysis are performed on the provided concepts, including dimensional studies, anthropometric studies, concept analysis, form studies, material analysis, safety considerations, and usability testing of the product. Selection of study and analysis methods is conducted using metric-based approaches. Form exploration is carried out by creating ideation sketches aligned with the outcomes of concept studies and analyses – active seating, calmness, and adjustability.

This is done after obtaining the design concept based on primary and secondary data requirements. The design concepts result in 90 thumbnail sketches. From these, three design alternatives that best align with the concept requirements are selected and developed using 3D applications for visualization. One of these three alternatives will be chosen for further development into the final design of the learning tool for ADHD children aged 6-9 years. The final design's progress involves digital simulation to evaluate product safety and durability. Following the final design outcome, a prototype is developed before mass production commences.

The prototype for this design utilizes materials closest to the real product. Subsequently, usability testing is performed using the prototype to assess the strengths and weaknesses of the product for further refinement.

IV. RESULTS AND FINDING

A. Field Study Results

The field study was conducted using various methods including observation, depth interviews, and questionnaires.








The results from observation data and questionnaires were summarized into several sub-sections that align with the discussion, including existing classroom studies and needs, affinity diagram, and activity studies depicted through customer journey mapping.

Existing Classroom Study

This study was derived from observations carried out by observing the classroom situations at ADHD schools such as SLB Bakti Asih, SLB Putra Mandiri, and SLB AKW Kumara 1 Surabaya.

Table- II: Observation Data in Existing Classroom

No	Observation data
1	 <p>room</p> <ul style="list-style-type: none"> Variations in the size of the observed SBL rooms are: 2m x 3.9m, 3.3m x 3.3m, Room color: green, Yellow, White
2	 <p>Student furniture</p> <ul style="list-style-type: none"> Table size: W70 x W40 x H75 Seat size: 40 x 39 Material: iron, plywood Bench color: beige, dark wood brown.
3	 <p>Noises</p> <ul style="list-style-type: none"> Several special schools use partitions as a barrier between classes, causing a lot of noise from other classes Floors using ceramics The SLB uses ceramics on the walls
4	 <p>Visual</p> <ul style="list-style-type: none"> Several SLBs put up learning posters such as posters with numbers,

No	Observation data
5	 <p>ADHD Students</p> <ul style="list-style-type: none"> Students with ADHD find it difficult to focus while studying. Students with ADHD are constantly moving their bodies. Students with ADHD get out of their chairs while explaining material. Students with ADHD often disturb their friends

Affinity Diagram

Based on the studies of ADHD students and existing classrooms, the author identified problem points and compiled them into an affinity diagram. From these issues, features and mechanisms necessary for designing the ADHD children's learning tool can be determined.

Table- III: Affinity Diagram

There is no sensory integration to accommodate the symptoms of children with ADHD	The kids are easily distracted by small things	attracted by bright colors	It is difficult for children to focus when the teacher is explaining the material
Need to look at table safety seeing from age ie 6-9 years	Children need to be guided when answering questions from the teacher	It is difficult for children to sit still on a chair	Children are more interested in other things other than studying
Children like to interrupt or can not take turns when	Children need the teacher's attention while doing the task to complete it	Children are easily attracted to new things.	Need safety for children with ADHD seeing the many movements of the child
There are still visual distraction around children's learning areas such as educational posters on the walls		ADHD children don't last long in a seat because of their sensory deprivation	

From the above affinity diagram, the issues were grouped according to the following criteria:

Active Seating

- Implementing the concept of active seating to improve the behavior of ADHD children while seated. This concept has been researched for its effectiveness in enhancing focus and sitting posture of ADHD children in the classroom (Rahman, Zahari, Jasmani, & Kamarudin, 2018) (Wu, Wang, Chen, & Lai, 2012) (Alqhtani, 2015).
- Allowing ADHD children to remain active can enhance their focus. This active movement is known as fidgeting, which comprises three types: hand fidgeting, feet fidgeting, and whole-body fidgeting (Carey A. Heller, 2017).



Safe / Kid Friendly:

- o Safe seating is required for ADHD children due to their hyperactivity characteristics. The safety aspects include both material and design.

Calm (minimizing distraction):

- o Material and design selections are crucial to minimize distractions for ADHD children.
- o The right color combinations are necessary for ADHD children, as they can help provide sensory stimulation during learning and contribute to their well-being.
- o Colors can influence emotional stability, focus or attention, cooperative behavior, productivity, and effective communication.
- o The design of the furniture should not draw attention from other children and should not disturb other students when the furniture is being used.
- o The furniture should not produce noise (friction sound between the product and the floor) to avoid disturbing other students.

Adjustable:

- o Considering that children aged 6-9 have different body sizes, an adjustable system for both chairs and desks is needed to ensure user comfort.

Sensory needs:

- o ADHD children require sensory elements to aid their tasks' completion.

▪ Customer Journey Mapping

Customer journey mapping was obtained from the existing product users, specifically when ADHD students use the chairs and facilities at the special education school (SLB). This customer journey mapping is divided into three phases: before, during, and after usage.

Table- IV: Customer Journey Mapping

Time	Action	Needs & pains	opportunity
Before	<ul style="list-style-type: none"> • Sitting on the bench • Will do learning activities in class 	<ul style="list-style-type: none"> • Bench doesn't match the size of the body • hyperactive 	Adjust the size of the user's body
During	Study 'a' (thematic lesson. Eg: math)	<ul style="list-style-type: none"> • need focus • stress/anxious • inattention 	Active chair, peaceful colour, sensory integration
	Study 'b' (art & culture)	Need creativity	Need a classroom area to help increase creativity
	study 'c' (self improvement)	<ul style="list-style-type: none"> • do therapy with therapist/teacher • need to socialize with friend / teacher 	<ul style="list-style-type: none"> • table size adjust to class size limitation • ease of setting up benches • sensory room
After usage	After school	<ul style="list-style-type: none"> • Pray before finishing or close the class • Get up from the bench 	Ease of use and maintenance of the product.


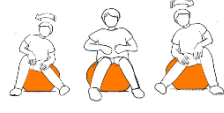
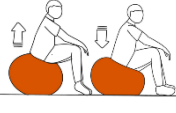

B. Concept Design Analysis

Active Seating

Active seating encourages users to maintain movement while sitting, promoting similar natural postural changes as when standing or walking. There is a neurological pathway that shifts from the body's balance and movement system to the alert system in the human brain. Based on previous

studies, it is known that active seating functions for children with ADHD can help reduce ADHD symptoms, particularly inattentiveness and hyperactivity.

Table- V: Active Seating Study

Activity	Activity overview	explanation
When the user will sit		Therapy ball is made of rubber and filled with air. When seated, the ball will compress a few centimeters to adjust to the user's weight and the amount of air inside the ball.
While sitting		There are several movement variations when using the therapy ball, including tilting sideways, forward, and backward.
While sitting		Due to its air-filled rubber composition, the therapy ball provides a bouncing effect.
While sitting		Users sit in a relaxed manner (legs extended) when using the therapy ball.

From the analysis of active seating movements using the therapy ball/gym ball, it can be observed that the movements that occur when using the therapy ball as a seating tool include tilting the body sideways, moving forward and backward, and bouncing movements. This analysis also reveals that when using the therapy ball, the device will be slightly lower by a few centimeters (according to the amount of air inside the ball). Following the analysis of active seating movements, the author proceeded to explore the conceptual form of active seating along with its mechanisms.



Fig. 2. Form Exploration of Active Seating

Adjustable

Function of the Adjustable feature in this design is to allow the height of the product to be adjusted according to the anthropometric and dimensional needs of children aged 6-9 years. This is aimed at enhancing comfort and safety for users by accommodating the anthropometric data for the specified age range.



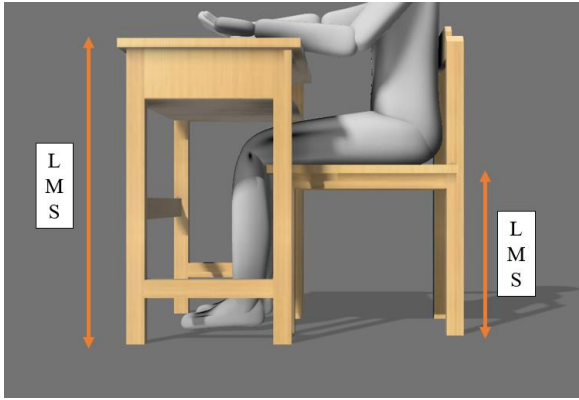


Fig. 3. Size of the Adjustable height

The chair and desk heights are divided into the following sizes:

- a) Sizemark S: Small, Seat Height: 300 mm // desk height: 540 mm
- b) Sizemark M: Medium, Seat Height: 340 mm // desk height: 580 mm
- c) Sizemark L: Large, Seat Height: 380 mm // desk height: 625 mm

Utilizing anthropometric data is crucial in designing the learning tool, specifically chairs and desks for children with ADHD. This enhances compatibility between users and the product.

Calm

concept analysis of calm is conducted to explore the development of the calm concept, which aims to reduce distractions, manage hyperactivity symptoms, and enhance inattention. The development of this concept considers the product's form and the safety of the inclination or movement derived from the active seating concept in the chair.

- Sensory Strategy

In this design, the sensory strategy involves the use of active seating and the application of tactile sensory (tactile) perception, which pertains to material choices and sensory feeling in the product.

- Color

Color selection is tailored to the activities of children with ADHD, especially within a special education setting like the classroom. Activities are divided into three categories.

Safety

The concept analysis of safety is conducted to explore the development of the safety concept. This development considers the product's form and the maximum inclination or movement derived from the active seating concept in the chair. This concept is applied to the design of tables and chairs, tailored to the needs of children with ADHD aged 6-9 years.

- Rounded Shape

The rounded shape concept in styling is intended to avoid sharp edges in the design of learning tools used by children with ADHD, considering hyperactivity symptoms. This concept minimizes the risk of injuries during product usage.

- Anti-slip

The anti-slip concept in the learning tool aims to prevent desks and chairs from being slippery when used, considering the hyperactivity symptoms of children with ADHD who have difficulty remaining still. Anti-slip features are applied to the legs of desks and chairs in direct contact with the floor.

- Stopper on Active Seating

The concept of a stopper on active seating is intended to limit the inclination or movement during the usage of active seating.

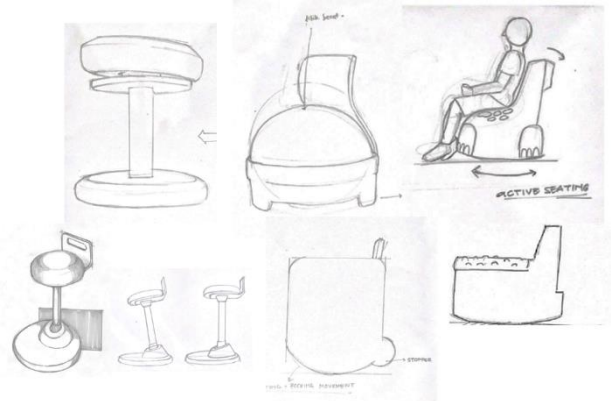


Fig. 4. Form Exploration of Rounded Shape

A. Mechanisme Analysis

This mechanism analysis covers aspects of product materials & joint analysis. This is conducted to assess the safety and strength of material usage.

- Product Materials

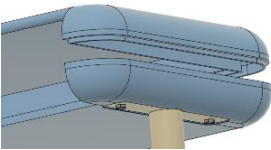
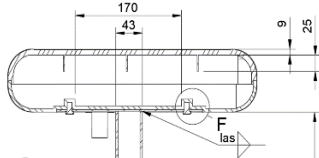

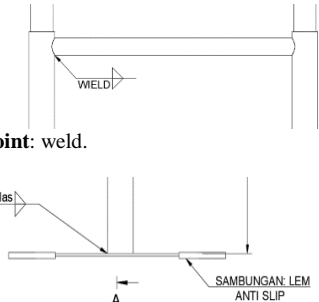

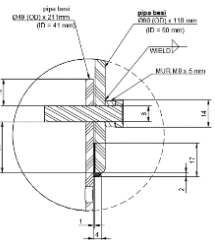

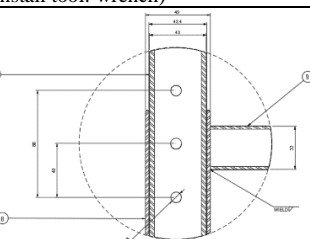
The analysis of the "calm" concept is conducted to explore the development of the calm concept, aiming to reduce distractions, manage hyperactivity symptoms, and enhance inattention. This concept's development considers the product's form and the safety of inclination or movement derived from the active seating concept in the chair. For this product, a combination of steel and wood is utilized as the framework material. Components that frequently come into direct contact, such as the top table and chair, use ABS polymer material considering safety and ease of shaping. The active seating surface employs foam and is covered with textured fabric to enhance sensory experiences for children with ADHD.

- Joint

Joint analysis is conducted to understand the process of arranging and uniting various component parts into a single product. The products analyzed in this design are chairs and desks.

Table- VI: Joint dimension and detail

Joint Dimension	Detail
	 Connection: nut (install tool: wrench)
	 Connection: nut (M8x5mm) + bolt (M8x39mm) (install tool: wrench)

Joint Dimension	Detail
	 <p>connection: 1. top table: stacking + polymer glue 2. top table+upper leg: stacking + bolt (m8x17mm) (Install tool: wrench)</p>
	 <p>joint: weld. 1. Leg + Leg base: Welding 2. Leg base + non-slip: slide + power glue</p>
	 <p>joint: Slide + bolt (M8 x 25mm) (install tool: wrench)</p>
	 <p>joint: Sliding + bolt (M8 x 25mm) ((install tool: wrench)</p>

B. Digital Simulation (FEA)

The utilization of the learning facility products, namely active seating chairs and desks, involves the possibility of bearing substantial loads. Therefore, a product stability test is conducted through digital simulation using the Fusion360 application. The following test aims to assess the product's behavior when in use. In the digital simulation test, the author applies a load of 1000N on the chair and 500N on each leg of the desk (with a total of 1000N).

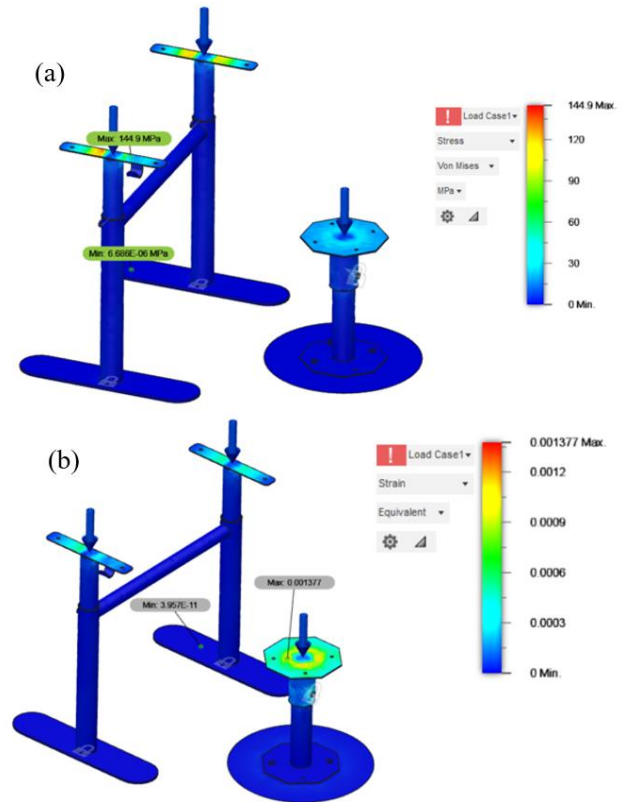



Fig. 5. Stress & Strain Simulation

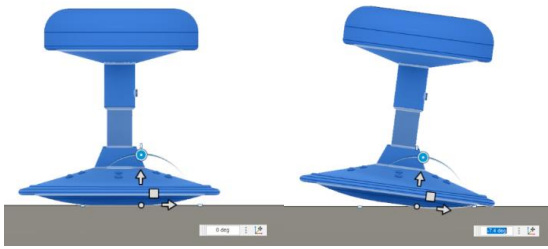

In the stress simulation experiment (a) on the product frame, it is observed that the stress level is concentrated at the midpoint, indicated by the red color, with a maximum displacement of 144.9 MPa. It is evident that these points represent the locations with the highest pressure within the product.

In the strain simulation (b), the aim is to identify potential areas where bending or material deformation might occur after prolonged usage. Points with brighter surfaces suggest a likelihood of bending, with a displacement of approximately 0.001377 mm. This value is extremely small, categorizing the product frame as safe when subjected to a load of 1000N.

C. Product Safety Analysis

Table- VII: Product Safety Analysis

No	Product Safety Analysis
1	 <p style="text-align: center;">Rounded Shape</p>

No	Product Safety Analysis
	<p>During product usage, the points of the user's body that often come into contact with the product are the chest to abdomen area, specifically on the front side of the desk. To address this, the shape of the blunt side becomes an alternative form</p>
2	<div data-bbox="193 304 743 551" style="text-align: center;">  <p>Stopper on Active Seat</p> </div> <p>a rounded base is implemented on the front side of the desk with a height of 20 mm and a base width of 328 mm in diameter. The rounded base features a flat side measu ring 83 mm in diameter, allowing the active seating chair to stand upright when not in use. Additionally, there is a stopper on the leg's base with a diameter of 390 mm and a flat side. The estimated maximum inclination of the rounded base is 7.4 degrees, representing the maximum angle of chair tilting.</p>
3	<div data-bbox="193 801 727 1111" style="text-align: center;">  <p>Maximum weight</p> </div> <p>The analysis results indicate that the chair can safely accommodate users weighing up to 65 kg. However, it's important to note that this design is tailored for a specific user group, namely children aged 6 to 9 years, with an average weight range of 20-29 kg and a 95th percentile weight of 45 kg for the age of 9 years.</p>

D. Final Design

Based on the results of the data and analysis, a product design for learning tools for children aged 6-9 years with ADHD, placed in a special room with instructors, was developed. The design includes features of active seating, calmness, safety, and adjustability. Below are the 3D design outcomes of the predefined concepts.

Based on the cognitive ergonomics employed in this design, which includes the visceral, behavioral, and reflective aspects. The visual attributes of the product encompass the concepts of active seating and calmness. The colors displayed on the product include muted pastel blue and muted brown. Muted blue is more dominant than muted brown, intended to capture users' attention and align with the psychological significance of blue, symbolizing calmness and tranquility. Blue is also associated with stability, reliability, safety, and productivity. As reported by Verywell Mind, blue has been known to slow heart rate, reduce respiratory rates, and promote calmness and focus. This is expected to have an impact on the hyperactivity and inattention commonly seen in children with ADHD. The blue color is complemented by muted brown, which dominates the top surface of the table. Muted brown represents warm earthy tones, known to reduce anxiety in users [14]. Based on color psychology, brown is

associated with earthy elements and exudes a sense of strength and dependability. This addresses the needs of children with ADHD by helping alleviate anxiety during intense concentration tasks that often trigger their inattention and hyperactivity. Apart from color psychology, the distinct placement of colors for the upper and lower components of the chair emphasizes the adjustable concept.



Fig. 6. Final Design

From a behavioral perspective, the product focuses on its functional aspects. The provided functions of the product are active seating and adjustable height. Active seating is achieved through the utilization of a rounded bottom, aimed at accommodating the hyperactivity of children with ADHD. This movement also serves to enhance the focus of children with ADHD. The adjustable height function is designed to cater to users aged 6 to 9 years, contributing to both comfort and safety during the product's usage. Transitioning to the reflective stage, it involves examining the emotional connection fostered by the product and its users.

Drawing from studies, particularly cases involving children with ADHD, the impact of this product is the introduction of active sitting as a concept into the learning activities of children with ADHD. The dimensions of the table and chair are aptly suited for children aged 6 to 9 years. The table's height can be adjusted to 540 – 580 – 620 mm, while the chair's height can be set to 300 – 340 – 380 mm. The application of anti-slip features to the chair enhances safety and diminishes noise generated by the chair when used by children with ADHD. The incorporation of additional features, such as a bag hook for hanging bags and drawers in the table, serves to enhance the tidiness of the classroom environment.

E. Prototype and Usability Test



Fig. 7. Prototype

The prototype was constructed at a 1:1 scale, employing authentic materials for all components, except for the polymer-based ones. For the top table of the desk, a material approximation was achieved by combining plywood with PVC material. The components were then carefully routed, followed by the application of a surfacer coat and, finally, the color and wood sticker finishing to replace High-Pressure Laminate (HPL). As for the polymer material in the chair, 3D printing methodology was employed. The components resulting from 3D printing were initially assembled using adhesive, then meticulously routed and coated with a surfacer layer before undergoing color finishing. In terms of prototype finishing, pylox was utilized as a substitute for the conventional powder coating.

Table- VIII: Usability Test

Activity	Documentation
<p>Student sits on the chair : When instructed to sit on a new chair, the child with ADHD immediately sat on the chair without being asked again.</p>	

Activity	Documentation
<p>Before doing task : The ADHD child begins to move the chair like swinging from right to left and also spinning.</p>	
<p>When given task: The child is silent and does the task while moving the chair and sitting in a variety of ways.</p>	
<p>After finishing the task: ADHD children complete tasks faster than other children</p>	
<p>After finishing the task: The child is asked to remain seated in the chair: the child remains in the chair and does not move from the chair while waiting for the other friends to finish their drawing. The child remains seated in the chair while moving around using active seating.</p>	
<p>Additional free time : The tutor gives the child paper to draw on so the child doesn't get bored on the bench.</p>	

From the utilization of the initial prototype of the chair above, several observations can be made. Hyperactivity tendencies of ADHD users appeared to decrease, such as the reduced frequency of sudden movements off the chair and running around the classroom. Additionally, children with ADHD seemed to be able to remain seated for longer periods. It was also noted that children with ADHD adopted varying sitting positions multiple times. This indicates that the use of the active seating chair provides diverse sitting alternatives to accommodate the user's preferences. However, as for the aspect of inattention, it is not definitively clear whether the product can significantly enhance attention within a specific measure.



V. RECOMMENDATION

Based on the conducted research data, the researcher provides several recommendations for this design and establishes them as product planning for a learning tool for children with ADHD to enhance their productivity in school.

- a) The learning tool's design should prioritize comfort and safety during usage, considering the user's hyperactive nature (difficulty in remaining still).
- b) Developing active seating in the product can accommodate the hyperactivity of children with ADHD in place. This feature helps reduce the child's movements such as standing up from the seat and running around the classroom.
- c) Using foam in the child's chair provides comfort and sensory input, thereby aiding in maintaining the child's calmness.
- d) Incorporating a solid steel frame enhances the product's strength, considering it is a frequently used chair.
- e) Incorporating adjustable features enhances the child's comfort during product usage by accommodating different body sizes.
- f) Rounded edges on the product enhance safety and reduce the risk of injury, given that children frequently interact directly with the product during learning activities.
- g) Implementing advanced technology can be utilized to gauge the effectiveness of the product in addressing inattention symptoms in children with ADHD.
- h) Utilizing digital simulation technology can serve as a valuable alternative in the design process, as it can depict the product in its actual size and simulate its usage over time.
- i) Further development of the facility design could involve integrating advanced technologies.

VI. CONCLUSION

The conclusion of the learning tool design for ADHD students is to facilitate a specialized learning environment for students with ADHD. This consideration is based on the distinctive characteristics of ADHD children, focusing on hyperactivity and inattention aspects, as well as considering ergonomic and anthropometric data of the users, and the activity needs of ADHD children in special schools in Indonesia. This research was prompted by the lack of specialized chairs for ADHD children in Indonesia, given the increasing prevalence of ADHD among children. Additionally, there is a lack of knowledge regarding suitable chairs for ADHD children in Indonesia.

In designing the learning tool for ADHD children, specific requirements must be met after conducting studies and analyses during the design phase. The design must embody the concepts of active seating, adjustability, safety, and calmness. The concept of active seating is drawn from prior research indicating improved productivity in ADHD children when using an active seat. The concept of adjustability stems from the children's body size, 6-9 years old, as this age range often encounters problems with existing products. The use of an adjustable concept with a simple mechanism can enhance user comfort and improve productivity during learning. The calm concept derives from the need for a non-disruptive learning environment for ADHD students, considering visual and auditory disturbances. Moreover, the utilization of color

combinations, known in psychology, can help address some ADHD symptoms. The safety concept directly relates to ergonomic safety concerns due to the specialized design that can be moved in various directions. To address this, the product is designed with stoppers and anti-slip features to prevent excessive movement and noise. By aligning these concepts, the aim is to enhance the productivity of ADHD students during their studies in special schools.

The utilization of digital simulation technology is a viable alternative in the design process. This technology facilitates the accurate transformation of 2D drawings into 3D forms at the actual size. This aids in research and minimizes trial and error. Through simulation, the strength of the design under specific weights and over time can be assessed, enabling the determination of product safety and durability. Therefore, employing digital simulation technology is highly beneficial in ADHD learning tool research.

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