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

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***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 to calm down, challenging 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 standard facilities is a study furniture designed for children with ADHD. The study furniture is crucial because it often interacts with children with ADHD for a long time. The reasonable consideration of a design is the fulfilment of needs that can adapt to the user's conditions. To obtain a solution, interviews were conducted with experts, including potential users aged 6-9 years with ADHD, as well as literature studies on ADHD, active seating, fidgeting, ergonomics, colour, benchmarking of existing products, and analysis of user needs. The results of this design are furniture sets in the form of tables and chairs that utilise active seating, calm, adjustable, and safe features as a concept to support the learning activities of children with ADHD in special schools. The chair design utilises the concept of active seating in the form of whole-body fidgeting to help symptoms of hyperactivity and inattention. This design utilises digital simulation to digitise the concept and simulate it, thereby reducing trial and error during prototype development. Furniture with an adjustable height system for children aged 6-9 years, with a safe and straightforward form for the needs of children with ADHD. This design utilises a muted brown colour to create a clean impression and avoid distraction, complemented by a muted blue colour to evoke a calming psychological effect and cater to 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 hyperactivy. 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 been 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 inheritance, 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 necessary during ongoing events. Fidgeting commonly occurs when someone feels uncomfortable, bored, or has lost focus on what is happening around them. By engaging in fidgeting, an individual becomes more alert. The principle behind using fidgeting to enhance focus is that individuals become restless when they are bored, unfocused, and lacking stimulation. Children with hyperactive symptoms associated with ADHD 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 from 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 children with ADHD is the study desk. By providing desks or learning tools tailored to users' needs, it is hoped that the activities of children with ADHD and their supervisors 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 regarder ergonomics, minimal distractions, and comfort. Desks 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, maximising space utilisation on the desk, designing a table that can restrain an ADHD child during a

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tantrum, and creating an ergonomic table.

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

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 of 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 attetntion 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 alertness. An optimal level of stimulation is required for cognitive performance [3].

B. Special Schools & Facilities for ADHD Students

Special schools are educational institutions that are an integrated part of the national education system, specifically organized for students who have a level of difficulty in following the learning process due to physical, emotional, social-mental disorders, but have ptential intelligence and special talents [4]. According to Mr. Nasichin, Director of Special Education at the Ministry of National Education, Special education is provided at the primary and secondary education levels. It is part of Indonesia's national education system. 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 regular 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 specialised seating, such as 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. This research found that implementing alternative seating as an intervention for children with ADHD in the classroom can improve their behavioural development, particularly 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 by 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 readily 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 eight students for SMPLB and SMALB classrooms.
d. The minimum ratio of classroom area to the number of students is 3 m^2 per student. For learning groups with fewer than five students, the minimum classroom area is 15 square meters.
e. The minimum width of a classroom is 3 m.
f. The classroom features windows that provide adequate lighting for reading and offer 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 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 acitivity [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 centres 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].

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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-organised classroom layout helps students anticipate and engage in activities, allowing them to adjust their behaviour 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 ensures that the product serves as an ergonomic solution.

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

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

Designing furniture for individuals with ADHD requires a tranquil or calming concept to create an environment that supports concentration, reduces distractions, and enhances a sense of calmness. Neutral and soothing colours can establish a serene atmosphere 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 childre. This aspect is always a concern for parents. There are instances when parents may be slighly negligent, thus necessitating safety features in the furniture to prevent accidents involving children. The concept of safety features in the furniture consists of 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 ergonomis. 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 stting 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 noradgrenergic activity in the brain, and the elevation of these neurotransmitters fucntions 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 place. 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 issues related to ADHD children while learning in special classrooms with instructors, considering factors such as focus and hyperactivity levels based on ADHD characteristics, specialised ADHD chairs, 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 conducted with students with ADHD in special classrooms, where learning activities involve 6-8

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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
	• 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
	• 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
	• Identifying the needs and challenges of users while learning • Guiding during usability testing of the product with children with ADHD in a Special School. • Conducting interviews regarding the usability outcomes.		
4	Doctor Izza // Child Psychologist	June – July 2023	In-depth interview & discussion
	• 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 the educational system in Indonesia.		
5	17 ADHD kids' parents	June – July 2023	Questionnaire
	• Identifying user segmentation and criteria for selected Special Needs Schools (SLB) • Knowledge about the provided concept • User preferences regarding the concepts • User opnions about the implementation of the active seating concept in special ADHD schools		
6	ADHD Student– ALBA (SLB AKW Kumara 1)	June – July 2023	• Observation – Usability Test
	• Identifying the needs and challenges of users while learning • Enhancing insight into studying activity data during learning sessions • To ascertain user preferences • Conducting usability tests and comparing the to the use of traditional chaiirs. • To identify the existing school environment for ADHD Children		
7	ADHD Students – SLB Bakti Asih	July 2022	• Observation
	• Identifying the needs and challenges of users while learning • Enhancing insight into 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, colours, and design concepts related to ADHD learning tools. Secondary data for this research are sourced from reputable literature, including journals, books, and official websites. The journals used in this design research cover topics related to ADHD, specialised ADHD chairs, and classroom design for individuals with ADHD. The books used are related to ergonomics, including cognitive ergonomics, safety ergonomics, and anthropometry. Information was gathered from official websites regarding digital simulation and concept explanations.

B. Exploration and Product Development

Concept formulation aims to develop the design concept for learning tools tailored to children with ADHD. 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 analysed to generate concepts that will be explored in the research. The ideas generated include active seating, safety, calmness, and adjustability. The author creates a concept framework to comprehensively explain the ideas to be discussed, as depicted in

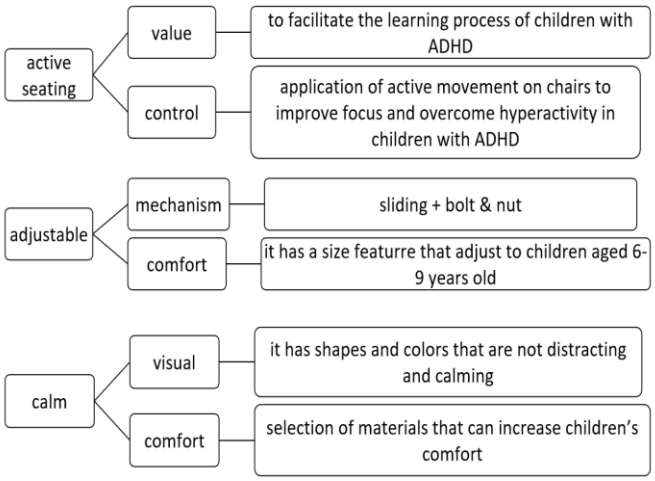

Fig. 1. Concept Framework

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. The 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, focusing on 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 selected for further development into the final design of the learning tool for children with ADHD 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 utilises materials that are as close as possible to the actual product. Subsequently, usability testing is conducted using the prototype to assess the product's strengths and weaknesses, facilitating further refinement.

IV. RESULTS AND FINDINGS

A. Field Study Results

The field study employed various methods, including observation, in-depth interviews, and questionnaires.

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

▪ Existing Classroom Study

This study was based on observations conducted in classroom settings at three schools for students with ADHD, including SLB Bakti Asih, SLB Putra Mandiri, and SLB AKW Kumara 1 Surabaya.

Table II: Observation Data in Existing Classroom

No	Observation data
1	room 
	• Variations in the size of the observed SBL rooms are: 2m x 3.9m, 3.3m x 3.3m, • Room colour: green, Yellow, White
2	 Student furniture
	• Table size: W70 x W40 x H75 • Seat size: 40 x 39 • Material: iron, plywood • Bench colour: beige, dark wood brown.
3	 Noises
	• 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	 Visual
	• Several SLBs put up learning posters such as posters with numbers, animal names, and so on. • The colour of the boards is almost the same as the colour of the walls.
5	 ADHD Students
	• 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 colours	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 in a chair	Children are more interested in 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

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- 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) (Alqahtani, 2015).
- Allowing children with ADHD 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:

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

Calm (minimizing distraction):

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

Adjustable:

- 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:

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

▪ Customer Journey Mapping

Customer journey mapping was obtained from existing product users, specifically those with ADHD who 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	• Sitting on the bench • Will do learning activities in class	• Benchdoesn not match the size of the body • hyperactive	Adjust the size of the user's body.
During	Study 'a (thematic lesson, Eg, math)	• nNeed focus • stress/anxiety • 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)	• do therapy witha therapist/teacher • need to socialize with friends/teachers	• table to adjust to class size limitation • ease of setting up benches • sensory room
After usage	After school	• Pray before finishing orclosinge the class • Get up from the bench	Ease of use and maintencance of the product.

B. Concept Design Analysis

Active Seating

Active seating encourages users to maintain movement while sitting, promoting natural postural changes similar to those experienced 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 sits		The therapy ball is made of rubber and filled with air. When seated, the ball compresses by a few centimetres 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 backwards.
While sitting		Due to its air-filled rubber composition, the therapy ball provides a bouncing effect.
While sitting		Sers sit in a relaxed manner (legs extended) when using the therapy ball.

From the analysis of active seating movements using the therapy ball or gym ball, it can be observed that the movements that occur when using the therapy ball as a seating tool include

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tilting the body sideways, moving forward and backwards, 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

The 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 designed to enhance comfort and safety for users by accommodating the anthropometric data for the specified age range.

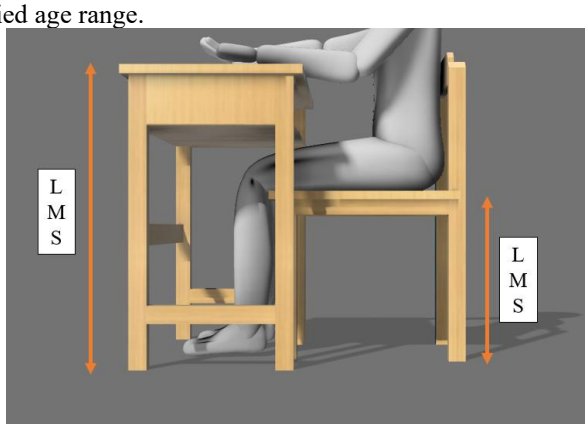

Fig. 3. Size of the Adjustable height

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

Utilising anthropometric data is crucial in designing learning tools, specifically chairs and desks, for children with ADHD. This enhances compatibility between users and the product, allowing for seamless interaction.

Calm

A concept analysis of calm is conducted to explore the development of the calm concept, which aims to reduce distractions, manage hyperactivity symptoms, and improve 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

Colour selection is tailored to the activities of children with ADHD, particularly within a special education setting such as 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 minimises the risk of injury during product use.

• 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 designed to limit the inclination or movement that occurs during the use of active seating.

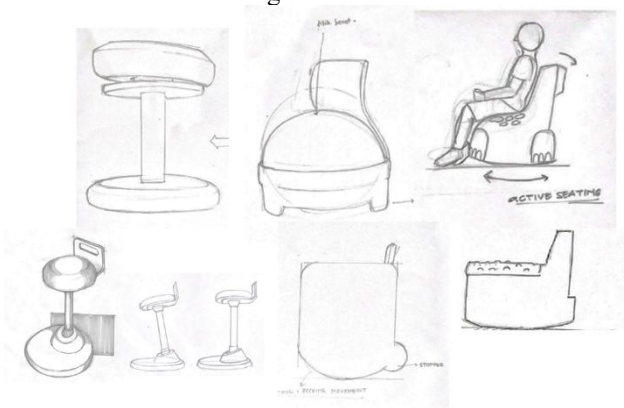

Fig. 4. Form Exploration of Rounded Shape

A. Mechanism 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 its development, aiming to reduce distractions, manage hyperactivity symptoms, and enhance inattention. The development of this concept 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.

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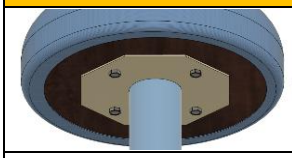
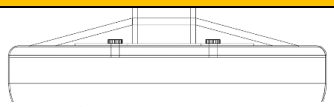
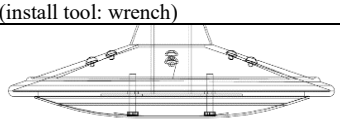
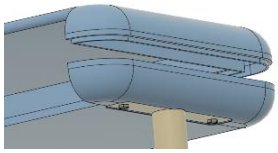
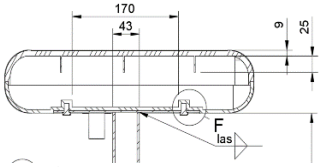
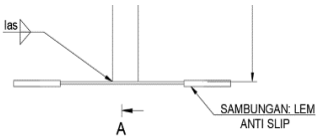
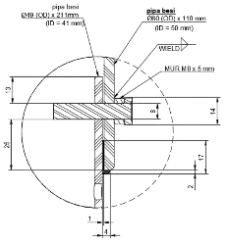
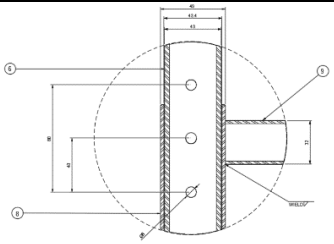
Components that frequently come into direct contact, such as the top table and chair, are made of ABS polymer material, considering both safety and ease of shaping. The active seating surface employs foam and is covered with textured fabric to enhance sensory experiences for children with ADHD.

- Joint

Joint analysis is conducted to understand the process of assembling and integrating various components 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)
	 Connection: 1. top table: stacking + polymer glue 2. top table+upper leg: stacking + bolt (m8x17mm) (Install tool: wrench)
	 **Joint**: weld.  **Joint:** 1. Leg + Leg base: Welding 2. Leg base + non-slip: slide + power glue
	 **Joint**: Slide + bolt (M8 x 25mm) (install tool: wrench)

Joint Dimension	Detail
	 **Joint**: Sliding + bolt (M8 x 25mm) ((install tool: wrench)

B. Digital Simulation (FEA)

The utilisation of learning facility products, such as 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 evaluate the product's behaviour 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).

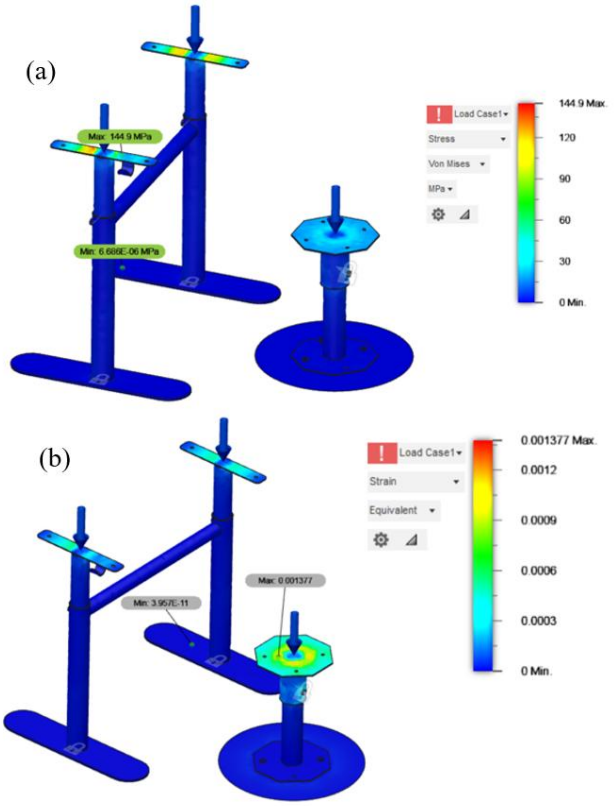


Fig. 5. Stress & Strain Simulation

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 colour, with a maximum displacement of 144.9 MPa. These points represent the locations with the highest pressure within the product.

In the strain simulation (b), the goal is to identify potential areas where bending or material deformation may occur after prolonged use. Points with brighter surfaces suggest a likelihood of bending, with a displacement of approximately 0.001377 mm. This value is minimal, categorising the product frame as safe when subjected to a load of 1,000 N.

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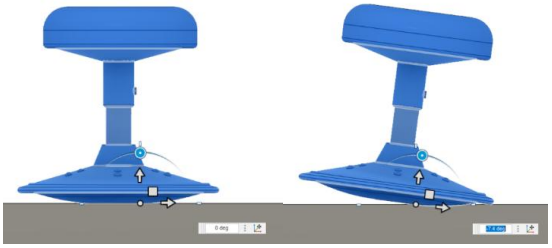
C. Product Safety Analysis

Table VII: Product Safety Analysis

No	Product Safety Analysis
1	 **Rounded Shape** 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 device. To address this, the shape of the blunt side becomes an alternative form.
2	 **Stopper on Active Seat** A rounded base is implemented on the front side of the desk, with a height of 20 mm and a diameter of 328 mm. The rounded base features a flat side measuring 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.
3	 **Maximum weight** The analysis results indicate that the chair can safely accommodate users weighing up to 65 kg. However, it's essential to note that this design is specifically tailored for a 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 at the age of 9 years.

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 incorporates features such as 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, behavioural, and reflective aspects. The visual attributes of the product encompass the concepts of active seating and calmness. The colours displayed on the product include muted pastel blue and muted brown tones. Muted blue is more dominant than muted brown, intended to capture users' attention and align with the psychological significance of blue, symbolising calmness and tranquillity. Blue is also associated with stability, reliability, safety, and productivity. According to Verywell Mind, blue has been shown to slow the 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 colour 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 colour 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 colour psychology, the distinct placement of colours for the upper and lower components of the chair highlights the adjustable concept.

Fig. 6. Final Design

From a behavioural perspective, the product emphasises its functional aspects. The product's

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provided functions include active seating and adjustable height. Active seating is achieved through the use of a rounded bottom, designed to accommodate 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, providing both comfort and safety during the product's use. Transitioning to the reflective stage involves examining the emotional connection that has been fostered between 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 the 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 colour and wood sticker finishing to replace High-Pressure Laminate (HPL). Regarding the polymer material used in the chair, a 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 colour finishing. In terms of prototype finishing, Pylox was utilised as a substitute for conventional powder coating.

Table VIII: Usability Test

Activity	Documentation
The student sits in the chair : When instructed to sit on a new chair, the child with ADHD immediately sat on the chair without being asked again.	
Before doing the task : The ADHD child begins to move the chair, swinging it from right to left and spinning.	
When given a task: The child remains silent and completes the task while moving the chair and sitting in various positions.	
After finishing the task: ADHD children complete tasks faster than other children	
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 it while waiting for the other friends to finish their drawings. The child remains seated in the chair while moving around using active seating.	
Additional free time : The tutor gives the child paper to draw on so the child doesn't get bored on the bench.	

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 appeared to be able to

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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 research data, the researcher provides several recommendations for this design and establishes them as a product plan 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. 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 helping to maintain 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 used to gauge the effectiveness of the product in addressing symptoms of inattention 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 students with ADHD is to facilitate a specialised learning environment tailored to their needs. This consideration is based on the distinctive characteristics of children with ADHD, focusing on aspects of hyperactivity and inattention, as well as considering ergonomic and anthropometric data of the users, and the activity needs of children with ADHD 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 with ADHD in Indonesia.

In designing a learning tool for children with ADHD, 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 idea of active seating is grounded in prior research indicating that children with ADHD experience improved productivity when using an active seating arrangement. 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 stems from the need for a non-disruptive learning environment for students with ADHD, considering their visual and auditory sensitivities. 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 specialised design, which 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 goal is to enhance the productivity of students with ADHD 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 minimises the need for trial and error. Through simulation, the design's strength 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 research on ADHD learning tools.

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Authors Contributions	All authors have equal contributions to this.

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AUTHORS PROFILE

Bambang Tristiyono is a prominent academic and researcher in the field of Product Design, assuming the role of a Senior Lecturer within the Product Design Department at the Sepuluh Nopember Institute of Technology (ITS) in Surabaya, Indonesia. With extensive experience, he has dedicated himself to education and advancement across various facets of design. He teaches a diverse array of subjects, encompassing Furniture Design, Product Design Studio, Design Research, Design Management, and Final Projects. His profound expertise and experience enable him to provide students with comprehensive insights into diverse design aspects, ranging from creative concepts to the holistic management of the design process. As a senior researcher at the Management Design Strategy Laboratory, he maintains a strong focus on research about Industrial Product Development, Furniture Products, Sustainable Material Exploration, and Integrated Digital Design. His contributions to this research have had a profound influence on the evolution of industry and design practices in Indonesia. Through his research endeavours, he has promoted the adoption of sustainable materials and processes in product development, leveraging integrated digital technologies to achieve optimal design outcomes. He attained a Bachelor's degree (S1) in Product Design from the Sepuluh Nopember Institute of Technology (ITS), subsequently pursuing a Master's Degree (S2) in Management Science from Airlangga University, Indonesia. Currently, he holds the esteemed position of Head of the Product Design Department at ITS, underscoring his pivotal role in curriculum development, research, and the department's overall trajectory of growth and development.

Halimatus Sa'diyah Tualeka is an individual who possesses a remarkable talent in the field of design, having obtained a Bachelor's Degree in Product Design from the Product Design Department at the Sepuluh Nopember Institute of Technology (ITS) in Surabaya, Indonesia. Throughout his educational journey, she has cultivated a profound understanding of product design, placing a particular emphasis on Furniture Products, Sustainable Material Exploration, and Integrated Digital Design. The education and training she has undergone have equipped her with a robust understanding of design concepts, product development, and the application of digital technology within the creative process. Her specialised focus on Furniture Products and Sustainable Material Exploration underscores her dedication to the application of environmentally conscious and pioneering materials in product manufacturing. The integration of digital technology into her design approach also underscores her preparedness to confront the challenges associated with design advancements in the contemporary era. Beyond his academic pursuits, she actively participates in various student creativity programs and engages in Product Design competitions. His enthusiastic involvement in these activities demonstrates his ardour for applying the knowledge he has acquired in practical scenarios and competing with the finest design works. As a youthful researcher affiliated with the Management Design Strategy Laboratory, she is positioned to delve into research aligned with her area of focus. This encompasses Industrial Product Development, Sustainable Materials Exploration, and the application of integrated design technologies.