Design of Hug Machine Portable Seat for Autistic Children in Public Transport Application

I Y Afif¹, M I Maula¹, M B Aliyafi¹, A L Aji¹, T I Winarni², and J Jamari¹

¹Department of Mechanical Engineering, Faculty of Engineering, Diponegoro University, Semarang, Indonesia
²Faculty of Medicine, Diponegoro University, Semarang, Indonesia

Abstract. The prevalence of autism in Indonesia was estimated approximately 2.5 million people. There are at least 500 new cases was diagnosed annually. Self-injurious behaviour is one of the most prevalence in autistic children. Only a few studies had been done in Indonesia regarding autism issue. Therefore, this study aims to design a hug machine portable seat for autistic children, called Autism Hug Machine Portable Seat (AHMPS), which can be used in public transportation (bus and train) to provide safety and for comfortability and can be used for therapeutic aid with deep pressure stimulation. The design was based on the morphological and decision-making matrix to get the best concept. The results of this study were obtained a selected design concept and certain technical specifications for the AHMPS.

Keywords: Autism, design, hug machine, deep pressure

1. Introduction

Autism is a disorder that covers cognitive, emotional, behavioural, social areas, including the inability to interact with people around him [1]. Autistic disorder is a developmental disorder or abnormality in social interaction and communication and is characterized by limited activity and interest. The appearance of this disorder is very dependent on the stage of development and chronological age of the individual. Autistic disorder is considered as early infantile autism, childhood autism, or Kanner’s autism [2].

Autism behaviour is classified into two types, namely: (1) excessive behaviour, and (2) deficit behaviour. Autism behaviour that is included in the type of excessive behaviour is hyperactivity and tantrums in the form of screaming, kicking, biting, clawing, hitting, and sometimes self-abuse. While the deficit behaviour in the form of reduced eye contact, not responding, speaking that is not aimed at communication, echolalia, unable to take care of themselves, lack of fine and gross motor skills, unable to socialize, and others [3].

The number and increase of people with ASD in Indonesia are still inaccurate. The estimated number of autistic children in Indonesia in early 2020 is around 3 million people. The amount is based on estimated data from the Ministry of Women’s Empowerment and Child Protection of the Republic of Indonesia in 2018, wherein that year there were around 2.4 million people with ASD in Indonesia with an increase in new people reaching 500 people per year [4].

Autism therapy methods currently being developed include the deep pressure method. The deep pressure method is the application of certain pressure and in a certain time in-depth on most of the outside of the body evenly. Deep pressure helps overcome the problem of oversensitivity to touch and
can eliminate nervousness as in children with autism and attention deficit hyperactivity disorders (ADHD) [5]. Deep pressure is known to have a good effect on several tests, it is explained that it can produce a calming effect in children with psychiatric disorders. Deep pressure simulations, such as rolling with a mat (gym mat) have been used to calm children with autism and ADHD disorders [6, 7]. King [7] reported that children who have problems sleeping, their sleep will be better if he sleeps in a mummy sleeping bag that can adjust to his body (smugly).

Therapeutic aids for those with autism are still limited. Moreover, therapeutic aids that double as a therapeutic tool as well as a safety device when people with autism are in a vehicle that is running. When an autistic person is in a vehicle, this hug machine will guard against dangerous acts of self-injury behaviour, such as head banging and biting the wrist [8], as well as providing deep pressure stimulation therapy to users at the same time.

The beginning of the creation of a hug machine as the application of deep pressure has been done long ago. Krauss [9], in 1987 introduced Squeeze Box. This machine consists of two air mattresses surrounded by a canvas wrap that is drawn to the pulley. The user is between two mattresses that can be controlled by pressing the rope that tightens the canvas wrap. But because this machine is operated using a rope, the pressure is relatively small.

Grandin [10], first discovered a therapeutic tool to relieve tension (stress relieving devices) or better known as a hug machine. The principle of this tool is to provide a hug simulation or applying pressure to the child's body to produce a deep pressure stimulation that can provide a calming effect. This tool called the Squeeze Machine provides deep pressure to help her learn to tolerate touch and reduce anxiety and anxiety. The squeeze machine works laterally and the pressure is directed towards the lateral aspect of the whole body, by pressing between two walls of wooden boards covered with soft foam material [5]. In 2018, Jih-Sheng Lo [11] introduced a new design hug machine based on Grandin's Squeeze Machine which was modified to become the Sitting Hug Machine. Users can have full control over pressure intensity and time duration with wireless remote controls, which make users feel safer.

The development of hug machines in Indonesia is still very limited. Raswan [12] introduced the hug machine design based on the Squeeze Machine designed by Grandin [10]. This developed hug machine design is reversed, where the autistic child is in a supine sleeping position with deep pressure from three pairs of pressure arms controlled by a pneumatic system. So that most of the child's body under intense and even pressure. Raswan’s hug machine has not portable neither compact design.

Naufal [13], designed an autism mobile seat to generate a deep pressure sensation by applying pressure to the user's body. This pressure uses an inflating balloon that implanted inside the tool. By using this inflating balloon, the tool can put pressure according to the user's wishes. Then by using a binding arm that can be wrapped around the body from the shoulder to the feet. And using a lock fastener with a push to release model. This seat is designed to be used on transportation but is not portable so it cannot be applied to public transportation.

Suryo [14], subsequently developed the hug machine based on the design from Raswan’s hug machine. The inflating wrap type hug machine is designed to produce deep pressure by inflating the balloon inside the hug machine, with a design pattern of fabric that can cover the shoulders up to the feet will give an even pressure. The application of deep pressure therapy in this autism hug machine is expected to help children to adjust their body when receiving physical contact with their social environment and increase the calmness of an autistic child. This hug machine inflating wrap is like a sleeping bag, so it can not be used in public transportation.

Referring to the rapid growth rate of autistic children in Indonesia, the needs of children with autism for therapeutic treatment to prevent self-injury and there are only a few researches on tools for autistic children, especially hug machines, then, the availability of supporting facilities for autistic children is needed and the development of more practical hug machines is needed. The purpose of this paper is to design aids for autistic children in the form of a portable seat which can be applied to public transportation to provide safety and comfort facility to children with autism.
2. Method
In designing this product, carried out several stages of the design process based on Zeid [15], shown in figure 1.

**Figure 1.** Flowchart of the design process

The design process starts with identifying user needs by setting the problem constraints in the hug machine design process. Limitation of the problem, among others:

- a. The autistic seat can be carried everywhere (portable) and lightweight;
- b. The seat design based on the original dimensions of the bus seat;
- c. The autistic seat reserved for children aged 6-14 years;
- d. In manufacturing, the autistic chair is expected to have competitive prices so that it reaches the lower classes because the price is cheap.

**Table 1.** Mission statement. The identification of user needs is outlined in the mission statement table.

| **Product description** | Hug Machine made of foam which is coated with synthetic leather so that it is light and has a supporting frame. |
|-------------------------|---------------------------------------------------------------------------------------------------|
| **Market segment**      | a. Parents of children with special needs (autistic); b. Schools with special needs; c. Hospital; d. Provider of public transportation services. |
| **Assumptions**         | a. Foam material so it is light; b. Practical use; c. Portable; d. Affordable prices. |
Design definition, specification, and requirements adjust the product design to the market needs. This stage is carried out by survey of needs and technical specifications of the product, ranging from market segmentation, anthropometric data literacy as a hugging dimension reference, morphological survey of public transportation chairs as a reference for the dimensions of the hug machine, and to determining the material and colour of the product. Anthropometric data of the Indonesian children [16] that used as a reference for the dimensions of the hugging were arm height, chest width, and distance between buttocks to knees. The seat morphology that is used as a reference for the design of portable seats is small, medium and large public bus in the city of Semarang. Materials selection will be based on aspects of user comfort, ease of finding, and affordable prices. Base material will be chosen with deformable materials, which can provide user’s comfortable [17]. The colour of the chair is chosen according to the colour selection method for autism therapy [18].

The conceptual design starts with determining the design criteria before designing the design choices using Computer Aided Design (CAD) software. There are two kinds of design criteria, namely the must and want criteria.

![Table 2. Must and want criteria.](image-url)
to sensory stimuli [19]. Beige and brown colours are complementary colour schemes selected because they represent individual therapy spaces that are calming and stimulating [18].

3.2. Design conceptualization

Based on the must and want design criteria and following the technical specifications, four design concepts are proposed with the information explained in the morphological matrix. The design concept options can be seen in figure 2.

![Figure 2](image_url)

**Figure 2.** Design concept options.

In figure 2, shown four design concepts start from figure 2a as concept 1, figure 2b as concept 2, figure 2c as concept 3, and the last is figure 2d as concept 4. All design concepts have morphological differences, which can be seen in table 3.

| Criteria                  | Variation of concepts          |
|---------------------------|--------------------------------|
| Basic material            | A1 Soft foam                   |
|                           | A2 General foam                |
| Thickness                 | B1 50 mm foam thickness        |
|                           | B2 30 mm foam thickness        |
| Bus seat fastener         | C1 Three Ropes                 |
|                           | C2 Two Ropes                   |
| Model of the hugging      | D1 Straight                    |
|                           | D2 Cross over                  |
|                           | D3 Sliding                     |
| Hook on the hugging       | E1 Velcro                      |
|                           | E2 Buckle                      |
|                           | E3 Carabiner                   |
| The hugging of the legs   | F1 There is the hugging        |
There is no hugging 

Bend of the neck of the chair

- G1 There is a bend
- G2 There is no bend

Upholstery

- H1 Parachute
- H2 Semi leather
- H3 Cotton cloth

Flexibility

- I1 There is a framework
- I2 There is no framework

The four design concepts in figure 2 are then made morphological variations based on table 3. The explanation is as follows:

- Concept 1 = A2 + B2 + C1 + D1 + E2 + F2 + G2 + H1 + I2
- Concept 2 = A1 + B1 + C2 + D1 + E1 + F2 + G1 + H2 + I1
- Concept 3 = A1 + B1 + C2 + D2 + E2 + F2 + G2 + H3 + I2
- Concept 4 = A1 + B1 + C2 + D3 + E1 + F2 + G1 + H2 + I1

3.3. Design evaluation

The four design concepts are then evaluated using a decision matrix or the Pugh method [20], to choose the most appropriate design. The decision matrix for choosing the most appropriate design is explained in table 4.

| Assessment criteria       | Wt | Concept (K) |
|---------------------------|----|-------------|
|                           |    | K1 | K2 | K3 | K4 |
| Strong                    | 10 |  9 | 10 | 10 | 10 |
| Practical                 | 10 |  9 |  9 |  8 |  9 |
| Light                     |  9 |  8 |  8 |  7 |  8 |
| Neatness                  |  8 |  7 |  8 |  7 |  8 |
| Affordable prices         |  9 |  7 |  9 |  8 |  9 |
| Not many components       |  9 |  6 |  8 |  7 |  8 |
| Ease of making            |  8 |  7 |  8 |  7 |  8 |
| Easy installation         |  9 |  6 |  8 |  7 |  9 |
| Durable age               |  9 |  7 |  9 |  8 |  9 |
| Easy to care for          | 10 |  7 |  9 |  8 |  9 |
| **Total**                 | **73** | **86** | **77** | **87** |

Based on the decision matrix of table 4 above, the total point of each concept design are 73 for K1, 86 for K2, 77 for K3, and 87 for K4. Then, the chosen concept design is concept 4 (figure 2d) with the biggest total point. This Autism Hug Machine Portable Seat (AHMPS) concept 4 is very concise and easy to carry everywhere, so this machine is very easy to use on public transportation. The design of this concept can be folded between backrest and sitting part so that it makes AHMPS portable. AHMPS functions as a safety and comfort provider seat for autistic children when they travel using public transportation, as can be seen through the hugging feature and the selected materials. AHMPS has horizontal and vertical belts behind it, to tie AHMPS to the vehicle seat. The belts can be
adjusted so that the AHMPS is firmly attached and does not shake, to ensure this seat stays in its position and it makes sure the safety of using this hug machine.

The design of the AHMPS is very comfortable to wear because it uses a soft foam as a base. Active contact with soft foam can increase the deep pressure effect and then increase the calming sensation and comfortable. Soft foam as a base is coated with a semi-leather fabric so that it can give the impression of a human hug and it has a cheaper price when compared with leather fabric. The AHMPS concept has a neck bend that functions as a pillow so that it can add a comfortable feel to the user. Autism Hug Machine Portable Seat (AHMPS) manufacturing materials are easily found in the market and the design is easy to produce.

AHMPS can be used as a therapeutic tool for autism using the principle of deep pressure stimulation that comes from the two huggings with inflating wraps model located in chest and thigh, which also provides security and comfort from them. The inflating wraps are created from a balloon that implanted in a hugging part. These inflating wraps filled by air through the compressor to produce deep pressure stimulation. This mechanism allows the user or therapist to determine the desired or appropriate pressure. One of the inflating wraps that located in the chest can be adjusted up and down so that the inflating wrap position can be adjusted to the user’s chest.

4. Conclusion
The AHMPS uses soft foam and semi-leather material, and the two horizontal inflating wraps located in the chest and thigh provide safety as well as deep pressure stimulation for the user. This study was showed that concept design 4 was the best for AHMPS for three reasons i.e., attractive, concise, and portable design for public transport application. AHMPS has a trial function which are safety and comfort, and deep pressure-based method.

5. Acknowledgment
This study was granted by Diponegoro University in scheme of International Research Publication NO. 329-83/UN7.P4.3/PP/2019.

6. References
[1] Desiningrum D R 2016 Psikologi Anak Berkebutuhan Khusus Edisi Pertama (Psychology of Children with Special Needs 1st Edition) (Yogyakarta: Psikosain).
[2] American Psychiatric Association 2000 Diagnostic and Statistical Manual of Mental Disorders Fourth Edition Text Revision (Washington, DC: American Psychiatric Association).
[3] Sunu, Christopher 2012 Panduan Memecahkan Masalah Autisme (Unlocking Autism) Cetakan Pertama (Guide to Troubleshooting Autism (Unlocking Autism) 1st Edition) (Yogyakarta: Lintangterbit).
[4] Badan Litbangkes 2018 Basic Health Research National Report (Jakarta: INDONESIA, M. O. H. R).
[5] Grandin T & Scariano M 1986 Emergence Labeled Autistic Warner Books (Novato, CA: Arena Press) p 91.
[6] Ayres A J 1972 Sensory Integration and Learning Disorders (California: Western Psychological Services).
[7] King L J 1989 Facilitating Neurodevelopment Proc. of the Autism Society of America p 117–120.
[8] Soke G N, Rosenberg S A, Hamman R F, Fingerlin T, Robinson C, Carpenter L, Giarelli E, Lee L C, Wiggins L D, Durkin M S and DiGuiseppi C 2016 Brief report: Prevalence of self-injurious behaviors among children with autism spectrum disorder—a population-based study J. Autism Dev. Disord. 46 (11) p 3607–3614.
[9] Krauss K E 1987 The effects of deep pressure touch on anxiety Am. J. Occup. Ther. 41 (6) p 366–373.
[10] Grandin T 1992 Calming effects of deep touch pressure in patients with autistic disorder, college students, and animals J. Child Adol. Psychop 2 (1) 63–72.

[11] Lo J S and Huang S C 2018 Creative Design Of Sitting Hug Machine In The Treatment Of Students With Autism MATEC Web of Conferences 213 (01009)

[12] Raswan A, Suryo S H, Jamari J and Haryanto I 2013 Perancangan mesin remas (squeeze machine) untuk terapi autisme (The design of a squeeze machine for autism therapy) ROTASI 15 (3) p 1–7.

[13] Naufal G K, Raswan A, Suryo S H, Jamari J, and Haryanto I 2013 Perancangan kursi autisme untuk mobil sebagai alat bantu terapi autisme (The design of autism chairs for cars as a tool for autism therapy) ROTASI 15 (3) p 19–24.

[14] Suryo S H, Raswan A, Jamari J, and Haryanto I 2013 Perancangan hug machine inflating wrap untuk alat terapi autisme (Design of a hug machine with inflating wrap for autism therapy devices) ROTASI 15 (3) p 25–29.

[15] Zeid I 2004 Mastering Cad/Cam (New York: McGraw-Hill Higher Education).

[16] Widyantı A, Mahachandra M, Soetisna H R and Sutalaksana I Z 2017 Anthropometry of Indonesian Sundanese children and the development of clothing size system for Indonesian Sundanese children aged 6–10 year Int. J. Ind. Ergon. 61 p 37–46.

[17] Li Y, Tsugama T, Kamijo M and Yoshida H 2014 Study on Cardiovascular and Respiratory Responses Relevant to Tactile Softness Evaluation: Based on ECG and PPG Analysis Int. J. Affect. Eng. 13 (4) p 269-277.

[18] Indina G, Handajani R P and Laksmiwiwati T 2014 Penerapan warna dan cahaya pada interior ruang terapi dasar dengan pendekatan visual anak autis (The application of color and light to the interior of basic therapy room with visual approach to children with autism) Jurnal Mahasiswa Jurusan Arsitektur Universitas Brawijaya 2 (2).

[19] Mostafa M 2008 An architecture for autism: Concepts of design intervention for the autistic user Archnet-IJAR 2 (1) p 189–211.

[20] Pugh S and Clausing D 1996 Creating innovative products using total design: the living legacy of Stuart Pugh (Boston: Addison-Wesley Longman Publishing).