Marshall Class Room for Disabilities

Preliminary Proposal Report 2017-2018

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1 BACKGROUND

1.1 Introduction

Children with disabilities are often faced with numerous challenges when they are in a school setting since they are required to perform a variety of tasks which require constant movement. As a result this makes them to get tired quickly since they use a lot of energy during various manipulation exercises when they are using normal chairs and desks [1]. As a result, they end up performing poorly in academics and thus denying them access to higher levels in the society. Sensory processing disorders lead to children having a distorted sense of their environs, which at most times disturbs their exploration and learning of their world. Sensory incorporation is our brain's aptitude to interpret, understand and react to sensory information, and individuals with sensory processing disorder at most times have trouble assimilating and retorting to this information.

Using sensory incorporation products is one main way to assist children with sensory processing disorder perceive and make sense of the world; moreover, these products are perfect for children who do not have sensory processing disorder, and and can aid kids in attaining important growing milestones. One of such sensory incorporation product is a sensory board. The main aim of the project is to design a unique device that will have all possible needs of a disabled child localized in one place so as to minimize the movements. Precisely, we will design a sensory board that will be useful in teaching a disabled child several activities such as pulling, pushing, twisting, switching things on and off and so on. The device will also have an audio input whereby an audio response will be generated for each activity done. For instance, if a child performs a certain task correctly, say pushing a button, the device will generate a sound saying, "well done" and so on. Several versions of a sensory board can be adopted but in order to come up with the best that is effective and meets the purpose, we have to consult with the relevant stake holders including the client and the users so we can bring out the best design. Basically, the sensory boards could be standalone boards, incorporated in the walls or even on the desks.

The team seeks to apply different skills and information in developing the new system. There are various requirements and targets the team seeks to attain, including a better functioning model that is attractive and effective. The design will be comfortable, durable and attractive making the children yearn to learn. In addition, the team will include electrical engineering work in order to make the design function better. When these targets are attained, the team will have met all the client's needs.

1.2 Project Description

So that the project can address its intended purpose in an effective manner the proposed design will ensure that it meets all the clients' standards. For instance, the client, Marshall Elementary Cross-Categorical Program requires a learning device for the classroom that helps one or more children with disabilities during a regular school day. However, the design should meet a variety of customer requirements including a sensory board, containment, comfortable, durable, adjustable and easy to operate. Based on these customer requirements, the team devised engineering requirements so as to provide a design and development details. In order to come up with a design which fits the client's needs the team held numerous meetings to brainstorm and exchange probable ideas. The disabled children in a learning institution like this require a good device so as to enable them perform everyday activities without much struggle or using too much physical energy. Therefore our design will help to address all those issues and hence enable them enjoy learning just like normal children. Additionally, it is worth noting that the design will not only be useful for children with sensory disorders, but also children with physical disabilities such as walking. This is because the device will attract even these kind of children and make them stand on their feet as they operate the sensory board. This way, they will be able to do some physical exercise making their legs to grow stronger.

1.3 Original System

As an engineer one should be able to come up with a unique device that is able to assist disabled students while they are in a variety of settings such as schools, hospitals, sports, homes and even in businesses. In that light engineers have ventured in a variety of fields and come up with designs that will be able to assist the disabled carry out their activities. In the market there are a wide range of assistive devices for the disabled including adaptive switches which make it probable for a children with inadequate motor skills to play with toys and games [1].

1.3.1 Original System Structure

The original system structure entailed a normal board with basic functions. Basically it involved a manual structure that did not require any electrical input. Additionally, the design was portable and kids could go with them from place to place. They were tactile boards which offered a sensory experience to kids to calm or soothe them when at the same time feeling nervous, or could stir them when feeling inactive via the sense of touch. The boards worked because whereas the child is touching the texture, the tactile input could elicit a body response such as awakening or calming.

2 REQUIREMENTS

By the end of the project the team will have ensured that both the customer and the engineering requirements are met. These requirements will be included in the final design system to facilitate effective functioning and also ensure that the customer requirements are met.

2.1 Customer Requirements (CRs)

Customer requirements include the requests which were given by both the client and the users. In this case the client is Marshall Elementary Cross-Categorical Program while the users are the disabled students. These are the right people to give the requirements they want since they interact with the devices on a daily basis and hence they exactly know what will best suit them and the necessary adjustments which need to be done include operations which need to be added [3]. Their views on how they want the original device improved will be translated into customer requirements as shown in the table 1 below.

Table 1: Customer requirements

Customer Requirements	**Description of customer requirement**
Improve the original system	To improve the original system to have a sitting and a writing area which is comfortable and also have wheels to facilitate movement.
Flexible design	The design should be adjustable to fit people of various sizes and disabilities.
Sensory board	To guide students on various operations.
Containment	Include an entertainment teaching device
Strength of the device	Strong materials should be used to ensure the device lasts longer.
Comfortable design	The sitting area should be soft and the writing board at the user's level.
Durable design	The material used should be durable as the device will be in use most of the time.

Discussion

In the above table, customer requirements have been shown as per the specifications of the client. They will be followed by the team when they will be designing the device. The original system will be improved by ensuring that the board has an electrical component so it can produce lighting and sound. The design will be flexible to suit various sizes of the disabled students. This way, its location on the wall could be adjusted depending on the height of the user. Strong plastic will be used to ensure that the device is strong and durable. It will also have a containment so as to entertain the users while they are operating the device.

2.2 Engineering Requirements (Ers)

From the customer requirements which were got from the specifications of the client so as to improve the original design, they were then translated into various engineering requirements. This is very crucial since it ensures that the requirements are translated into aspects which are specific and measurable for later analysis and interpretation. The engineering requirements are as shown in Table 2 below.

Table 2: Engineering requirements

Engineering Requirements	**Targets**
Flexible design	Adjustable to a length ranging from 5cm to 15cm
Strength of the device	Yield strength of at least 6Mpa.
Soft material	Low pulling force of below 5 Pascal
Containment	It should have an entertainment-teaching feature
Sensory board	Should have instructional lights and a voice prompt

Discussion

The design that our team intends to make should be flexible so that it is able to fit people of various heights. Therefore the device will have an adjustment knob so as to adjust the height accordingly. The device will also be strong such that it will yield strength of 6Mpa. It will also be soft and hence soft material will be used. In this case, the soft material will be the one with a pulling force of less than 5 Pascal. The device will also have a containment so as to keep the disabled student busy and entertained while at the same time teaching them something. They will also have a sensory board to guide the students through various operations.

2.3 Testing Procedures (TPs)

1. Flexible to a length ranging from 5cm to 15cm

The adjustment mainly entails the writing board and the height of the seat. In this case the seat and the writing board were adjusted to the lowest position possible and measurements taken. Then they were adjusted to the highest position possible and measurements taken. This enabled the team to get the range of 5 to 15 cm.

2. Yield strength of at least 6 Mpa:

To test the yield strength of the material, the team subjected it to a force. A clamp and several weights of about 50Mpa were required. Using the clamp the material was first clamped with the clamp and weight was then placed over the material. After the test the material did not give in to the weight.

3. Soft material

The measure for the softness of a material is the force required to break a fiber. In order to measure the breaking force of the fiber, the material was tied on one end to a firm position while the other end was tied to a spring balance. The end of the spring balance was pulled and readings made. Before a reading f 5N was attained the fiber snapped. A soft fabric should not exceed a toughness of 5 Newtown.

4. Containment

A device which was to teach the disabled students on how to count numbers and the months of the year was fixed and tested for its effectiveness.

5. Sensory board

The sensory board was supposed to have instructional lights and voice prompts to guide the disabled student on various operations.

2.4 House of Quality (HoQ)

There will be application of House of Quality so that it assists in analyzing gadgets given various parameters. Its major aim is to investigate the plan that the tea will select to assist them in settling on the most appropriate plan. This will involve integration of the requirements which have been discussed above the requirements include, a device that is flexible, strong, comfortable, light, durable, and simple to operate. [3].The house of quality enabled the team to improve the original design to meet the engineering requirements.

Table 3: House of quality

Customer Requirement	**Weight**	**Engineering Requirement**	Yield strength of at least 6Mpa	Adjustable to a length ranging 5cm to 15cm	Use soft fabric	Containment	Sensory board
Should be flexible	4			5	4	5	6
Should be strong and durable	5		4				
Comfortable design	4				5		
Containment	5		4			8	9
Sensory board	4		4			8	9
Absolute Technical Importance (ATI)			10	10	8		
The Relative Technical Importance (RTI)			9	9	7		
Target(s), with Tolerance(s)			6Mpa ± 1 Mpa	5cm ± 2cm	30 pas ± 5 pas		
The Testing Procedure (TP#)			1	2	3	6	6

3 EXISTING DESIGNS

A variety of devices have been designed so as to assist the disabled in carrying out various day to day operations. In this regard, the team has made an extensive research so as to check and compare the various devices which are available to help the disabled. The major focus was on a device that will assist the disabled by meeting their proposed customer requirements. In order to understand the various aspects required to improve the design's performance the team embarked on looking into a variety of already existing designs.

3.1 Design Research

A variety of designs have been created to help the disabled. However, the designs are normally improved as time passes so as to suit the needs of the users. The team analyzed a variety of existing designs in the market so as to come up with an appropriate design.

3.2 System Level

The assistive devices for the disabled such as wheel chairs have evolved over the years so as to suit the needs of the user. The changes are attributed to the technological advancements which have occurred over the years. In this project the proposal is a device which resembles a wheel chair but with a variety of improvements to make it appropriate. The team will learn from the pros and cons of the already existing designs so as to make their design a success.

3.2.1 Existing Design #1: Walgreens Ultra Weight transport chair

Walgreens ultra weight transport chair is a strong chair which can support up to 300lbs, it has removable foot rests, a seat belt and wheel locks for extra safety. Also, it has angled armrests to enhance access to counters tables, and desks. In addition it has washable stain-resistant nylon fabric that is inherently and brakes lock for safety [4].

Figure 1:Walgreens Ultra Weight transport chair

3.2.2 Existing Design #2: Viscco wheel chair

Viscco wheel chair comprises of a removable eating and writing board. Also it has a strong metal frame which is able to withstand tough conditions. It has special sealed bearings used for smooth movement hence adding to the comfort of the user. In addition it has a seat made of double bonded Vinyl Fabric with upholstery for comfort and durability [4].

Figure 2:Viscco wheel chair

3.2.3 Existing Design #3: Wheel chair with a lap hugger

The lap hugger is very crucial since it enhances the security of the user by preventing him from falling forward. It is also crucial for appropriate support to the upper body. In addition, it makes the wheel chair stronger since it is made up of durable foam padding covered with vinyl.

Figure 3:Wheel chair with a lap hugger

3.2.4 Exisitng Design #4 Wodden sensory board

This Sensory can teach kids the basic things in life such as, counting, adding, substracting, zipping, stapling, etc. This is very important since it makes them independent and can do most of the stuff themselves. In addition to that, the size of this kit is very small so that the kid can spend some time figuring out some materials alone. Studies show that some kids need to spend some time alone when studing to avoid any distractions [2].

3.2.5 Existing Design #5 A stand sensory board

The only difference between this design and the previous one is that this design has wooden legs. This design is significant because it enables instrucotrs to teach a group of students at the same time. It exactly works like a regualr board. The instructor, then, can show each student how to use the materials and it can make them practice infornt of all the others. When practicing in classroom settings, the student can barely forget what they learned [2]. This is because they saw their friends practicing the materials upon they started playing with the board.

3.3 Functional Decomposition

In this project, the major aim is to design device which can be used by the disabled students while they are taking their studies in class. Our functional decomposition will be a device which is strong durable, light in weight and easy to operate.

3.3.1 Black Box Model

After a analyzing the original design, the team realized that there were problems with the general operations due to limited functionality. In this regard, the team made a decision of including a black box so as to improve on its performance. The black box will be used to store data. It will also help in coordinating other functions such as movement with minimal efforts. The major setback of the black box is that it is expensive and needs regular maintenance.

3.3.2 Functional Model/Work-Process Diagram/Hierarchical Task Analysis

In order to ensure that the team does not deviate from the objectives of the project, they will make use of a functional model which will act as a guide. The model will have the engineering and customer requirements which will be fulfilled.

3.4 Subsystem Level

After carrying out a thorough research it is evident that when devices are designed in a better way they are able to meet customer requirements. This is accomplished by using proper gadgets [6].

3.4.1 Subsystem 1: Containment

Having a variety of containment such as numbers, texture board and pillows which enabled the users to learn new things and also feel entertained and comfortable.

3.4.1.1 Existing Design #1: Numbers containment

The numbers improve the learner's knowledge by making them know how to count numbers and hence keep them busy and informed.

3.4.1.2 Existing Design #2: Texture board containment

It enables the students with severe disabilities such that they will be able to differentiate between various texture feels.

3.4.1.3 Existing Design #3: Positioning pillows containment

It entails positioning pillows which are made from a strong and a washable fabric.

3.4.2 Subsystem #2: Sensory boards

Since the device will be used for teaching the disabled students how to perform various activities such as how to pull, push, twist, switch etc. a wheel chair with an appropriate sensory board can be adopted.

3.4.2.1 Existing Design #1: Sensory stimulation tray

The design involves a sensory stimulation tray whose purpose is to entice the vision and sense of touch of the user.

3.4.2.2 Existing Design #2: Audio sensory board

The design entails a sensory board with digital controls and voice prompt to guide the user on various actions.

3.4.2.3 Existing Design #3: A stand sensory board

The design has legs that can be used in regular classroom for teaching materials.

Subsystem #3: Safety

3.4.3 Subsystem #3: Safety

The device should ensure the safety of the user at all times.

3.4.3.1 Existing Design #1: Wheel locks

They ensure that the device is steady when the student is stationary on a desk.

3.4.3.2 Existing Design #2: Angled armrests

They enhance access to counters tables and desks

3.4.3.3 Existing Design #3: Brake locks

They enhance safety of the user by locking the braking system.

4 DESIGNS CONSIDERED

The team generated a variety of designs during the brainstorming process which were in line with the various customer and engineering requirements. Various aspects of design were considered and improvements made on the already existing designs. Some of the designs selected are as follows.

4.1 Design #1: Wheel chair with a desk

The device has a board which can be used for writing and eating purposes. This will ensure that students carry out their reading and writing tasks easy by placing books on this board. It also has wheels to facilitate movement from one place to another. The major challenge with the board is that it must be removed every tie the user is not using it.

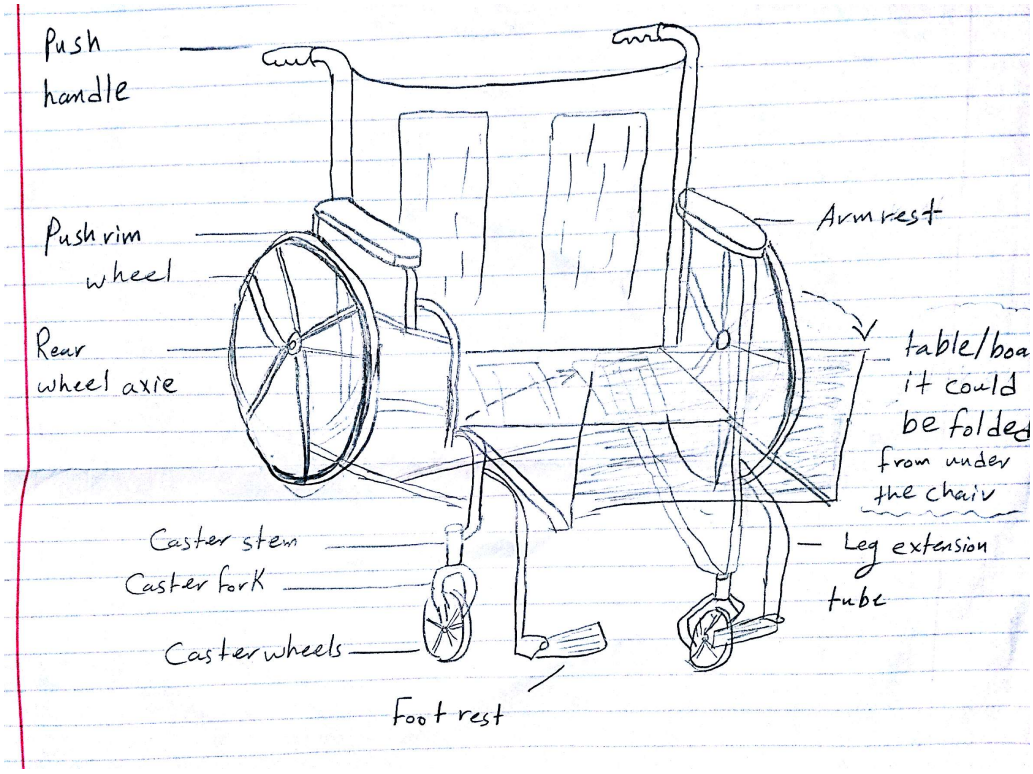

Figure 4: Wheel chair with a desk

4.2 Design #2: Lap Hugger

The lap hugger provides an appropriate upper body support and also prevents the user from leaning forward. The hugger is made up of durable foam padding covered with vinyl hence making it easy to clean. It also has a clear window for storing reading material.

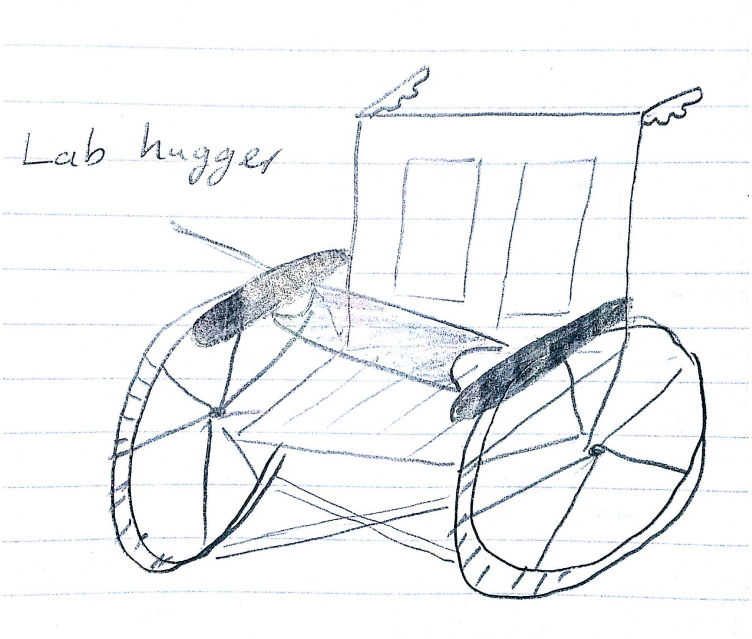

Figure 5: Lap hugger

4.3 Design #3: Foam wheel chair belt

The design comprises of a safety belt which is fastened around the waist. This is beneficial in that it prevents falls, prevents forward sliding, it has a soft breathable foam to facilitate comfort. Also, the closer can be positioned for self-releasing or even more restriction.

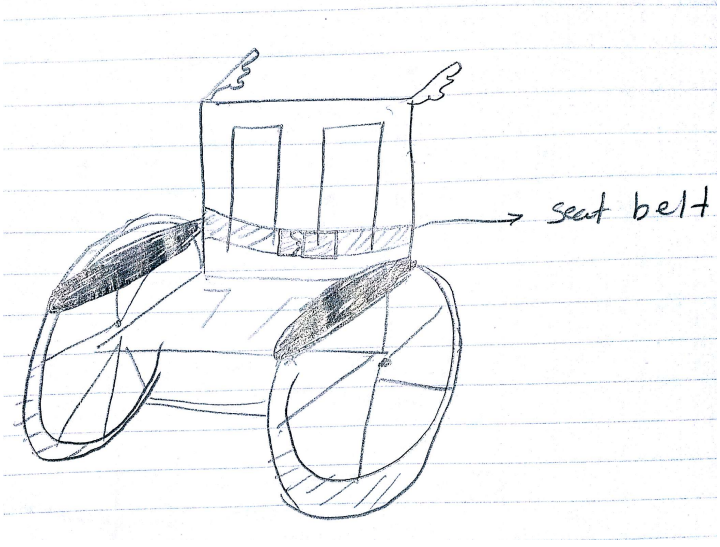

Figure 6: wheel chair with a seat belt

4.4 Design #4: A hexagonal containment

A hexagonal containment that has a door. Once the child is in, he can play around with a sensory board surrounding him.

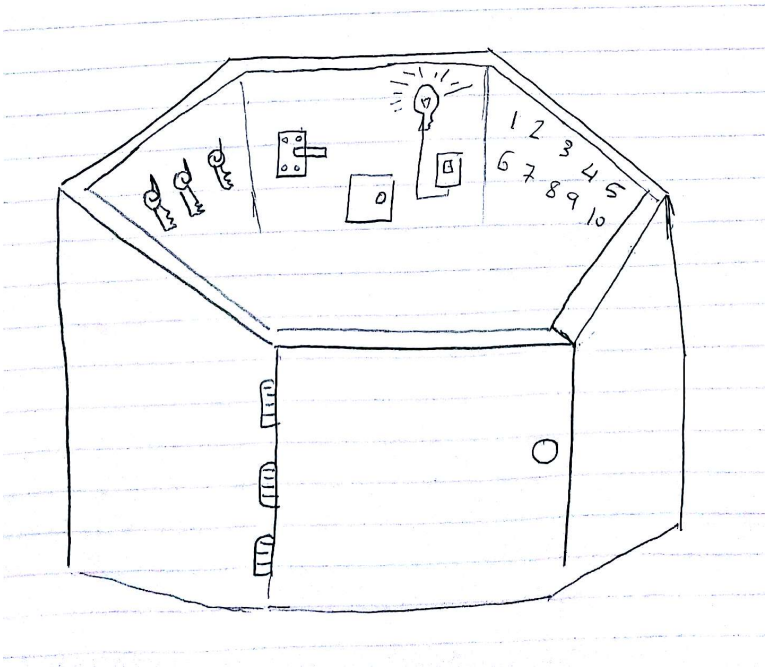

Figure 7:A hexagonal containment

4.5 Design #5: A hexagonal containment sensory board with wheels

A hexagonal containment made of word and it has door which enables the child to get in inside. Once the child touches the wall and play with the materials, the wheels will rotate. Consequently, energetic kids do not fell board because they are moving from one place to another but inside the hexagonal.

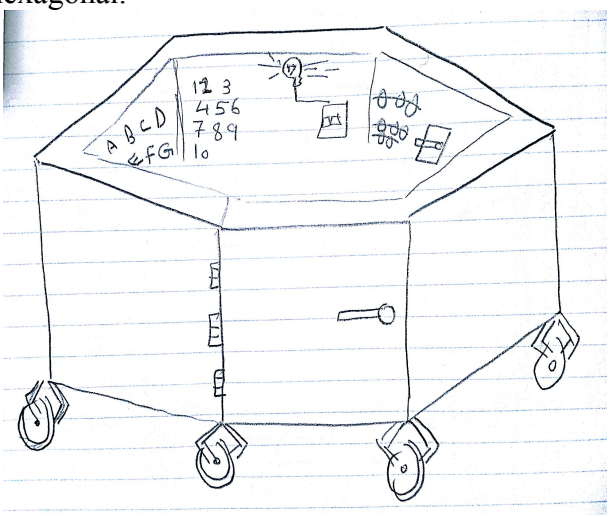

Figure 8:A hexagonal containment sensory board with wheels

4.6 Design #6: Trampoline Containment sensory board

A hexagonal containment has a door and it is made of wood. The base of it is a trampoline. This can entertain the child while he is learning the hexagonal.

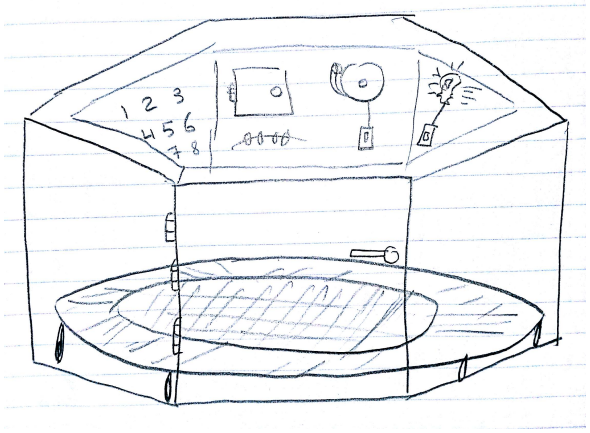

Figure 9:Trampoline Containment sensory board

4.7 Design #7: Sensory board to the wall

Sensory board that is attached to a wall. This design can enable all kids in the classroom use this available learning tools.

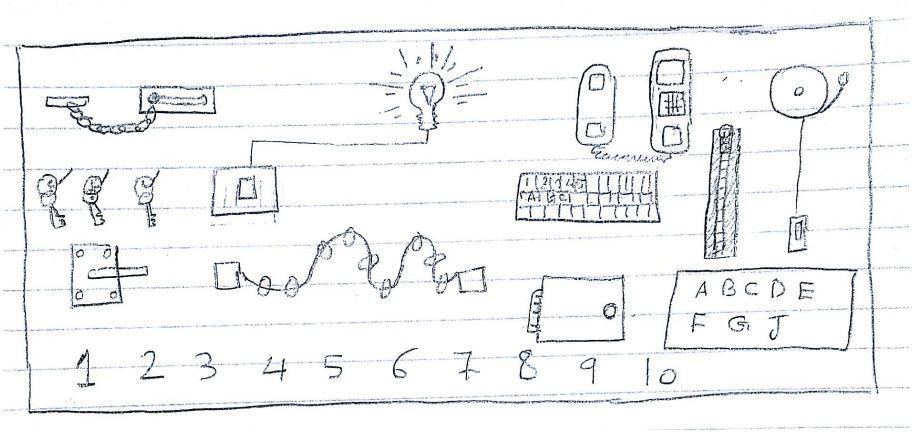

Figure 10:Sensory board to the wall

4.8 Design #8: Cubic Sensory Board

The design comprises of a sensory board which has digitalized controls. The board has a wide variety of buttons, door knobs, and some puzzles. Also, the sensory board has different lights which blink followed by a voice prompt either to caution or assuring the user of the correctness of performing a particular action. The unique about this design is that it has wheels which facilitate moving it around the class without exerting any efforts. In addition to that, we are incorporating in this design a stand that can help a disable child to get used to stand up and play with the board because of some of the kids we observed struggle when getting up. The cubic sensory board will attract them, and therefore, help them strengthen their knees.

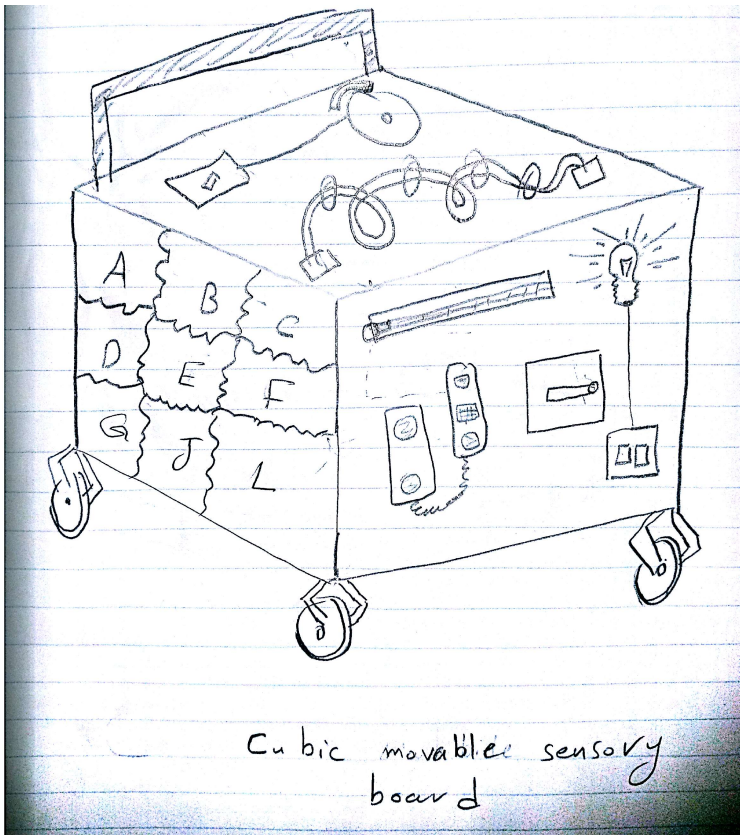

Figure 11: Cubic sensory board

4.9 Design #9: Circular Rotating Sensory Board

This design comprises of different kinds of audios that can teach disable children how to read letters, numbers, days, and months. Kids, in general, do not like to be forced when learning, so we will make this more attractive by making the circular sensory board flashing while rotating. In this case, the disable kid is more into learning because it is a game for them.

Figure 12: Circular sensory board

4.10 Design #10: A folded sensory board

The purpose of this design is also to teach disable kids life's skills such as, pulling with some resistance, pushing, twisting, switching lights on/off, and zipping. However, the significant thing about this design is that it can be folded and taken away using a handle so that kids do not play with it without their instructors' permission. Also, This folded sensory board can be turned to a desk. The unique about this device is that it can serve many things at the same time.

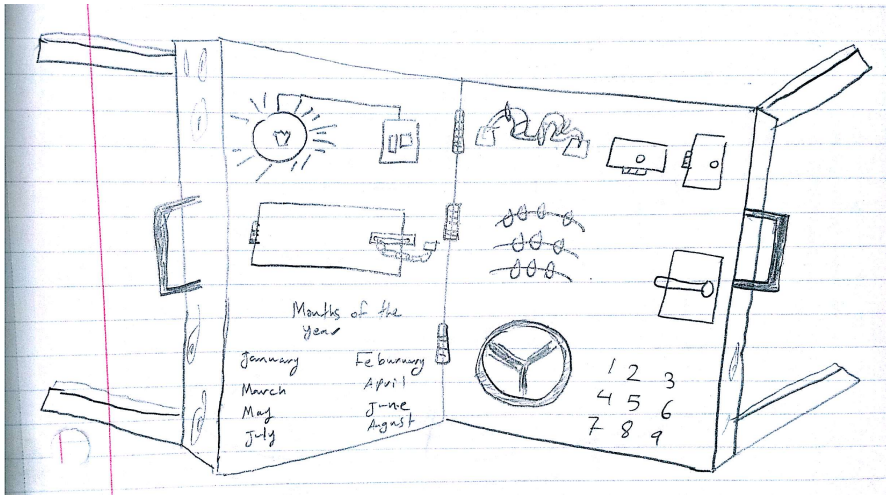

Figure 13:A folded sensory board

5 DESIGN SELECTED

In this chapter the rationale which was used by the team to come up with a final design has been discussed. Also, a description of the design has been given.

5.1 Rationale for Design Selection

In order to come up and settle on a final design, the team ensured that the selected design met all the customer requirements. Therefore the components and the design were looked into carefully to ensure that the device selected was efficient compared to the already existing ones. After deep analysis the team agreed with the eighth design since it had the highest score as presented in the decision matrix below.

Table 4: Decision Matrix

(The score of 1-10 is use, where 1 is the least effective and 10 is the most effective)

Designs:	Meets client's needs	Meets users' needs	Improves the existing designs	Total score
Design#1	8	7	8	23
Design#2	5	5	5	15
Design#3	4	5	5	14
Design#4	5	4	4	13
Design#5	5	4	6	15
Design#6	4	5	5	14
Design#7	4	6	5	15
Design#8	8	9	9	27
Design#9	6	5	6	17
Design#10	6	6	5	17
Design with highest score	**Design #8**			

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