

Hozhoni Automated Art Easel

Final Report

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DISCLAIMER

Students prepared this report as part of a university course requirement. While considerable effort has been put into the project, it is not the work of licensed engineers and has not undergone the extensive verification that is common in the profession. The information, data, conclusions, and content of this report should not be relied on or utilized without thorough, independent testing and verification. University faculty members may have been associated with this project as advisors, sponsors, or course instructors, but as such they are not responsible for the accuracy of results or conclusions.

EXECUTIVE SUMMARY

The fundamental purpose of this design is to promote mobility, inclusion and enhanced quality of life of the user who are unable to move. With the help of this design they can do their artwork or anything like sketching without any need to move. Effective Mobility is the most important need of all people specially .We have proposed some in-home gravity balancing harness system that people with movement disabilities can build with limited resources. There are many people with weak muscles and other issues, which make it hard for them to stand and do their work. We have tried our best to make it as simple and easy as possible. It is most important issue and should be given importance especially in this era in which technology has evolved to a great extent. The devices until now are really old design devices. Our goal is to make an advanced device with more functioning capabilities.

This is a senior level engineering project. The goal of this project is to design a device that helps the disable people. This device will be suitable for both people with moving disabilities and people having weak muscles which make them unable to move their hands etc. Our main focus was to make the device safe to avoid any Misuse of equipment that can lead to serious injury. It helps approachability of the art to the disable people in an easier way. The shape of the device makes it more stable and leaves fewer chances for any mishap. We have tried our best to make it as comfortable and feasible as possible.

ACKNOWLEDGEMENTS

We would like to express our deepest appreciation to all those who provided us the possibility to complete this report. A special gratitude we give to our project sponsor, Ms. Terri Engel, whose contribution in stimulating suggestions and encouragement, helped us to coordinate our project especially in writing this report. Furthermore we would also like to acknowledge with much appreciation the crucial role of the staff of mechanical engineering who gave the permission to use all required equipment and the necessary materials to complete the task “Assistive device for the art studio”. Last but not least, many thanks go to the head of the project, Professor David Trevas who have invested his full effort in guiding the team in achieving the goal. We have to appreciate the guidance given by other sponsor as well as the panels especially in our project presentation that has improved our presentation skills thanks to their comment and advices.

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1 BACKGROUND

1.1 Introduction

There are many examples of assistive devices for people with manipulative disabilities. These devices enable disabled people to perform many activities of daily living thus improving their quality of life. Disabled people are increasingly able to lead an independent life and play a more productive role in society. In the case of disabled Adults, such assistive devices have been shown to be critical to their cognitive, physical and social development

This is a high level engineering project. Our goal was to design a device which can assist the disabled people. Many assistive devices for manipulation and locomotion have been made. We focused on making an assistive device which can help the disable people to perform their tasks easily.

1.2 Project Description

We made a device that can help disable to perform any task life drawing, sketching etc. as the easel is capable of holding the paper and moving up and down to adjust the height of the stand. This device or will be able to assist disable to get their work done. For this we brainstormed many ideas and designs. This device will help those disabled people to enjoy or get entertained without any motion and pain.

We have utilized the concept of a window regulator easel too in our machine to make it more efficient. Despite rapid scientific and technological progress in allied disciplines, there has been very little innovation in wheelchair design. We focused on this aspect as well. Hence the following report will describe all the designs and their comparative analysis.

1.3 Original System

This project involved the design of a completely new window regulator based device. There was no original system when this project began. Our design was to make an easel for disable people who have body issues in their hands and legs. We tried making a design to help them draw easily and make them comfortable and we found 20 designs to make and every one chooses a design to

talk about in an assignment. We chose the design of easel with a window regulator easel that can help the disabled people work on drawing by just use the switch and the machine will move the easel up and down to make the person who has an issue to reach all the points of the easel and draw on it

2 REQUIREMENTS

As the device is to be used by disabled people so the main requirement is that it must be safe to use so that they can handle it with safety. Moreover the settling time of the device must be as small as possible so that the disabled people can set it at minimum time required. It must be flexible and should not be dangerous at any cost. Moreover another requirements Is the cost effectiveness. A complete analysis of requirements was done to meet the most important of them .For that we set priority list for these requirements and worked on it to achieve the goals.

Moreover we also interviewed the customers and the clients who are the real stakeholders in this case. We listen down their requirements and decided on the basis of that.

2.1 Customer Requirements (CRs)

To find out what requirements are necessary and important for the customers we did a complete analysis and research on this process. We interviewed few disabled people who were interested in this project. We asked them what their most important requirements or needs are. Following table describes the compact interview we took from 3 of our customers.

Table 1 - Appendix A - Customer's' Requirements

Customer Requirements
Safety
Easy to store
Light weight
Adjustable
Easy to use
Comfortable
Easy to clean

Size
Saving time
Low cost

In this part of our project we integrated customers' requirements in our projects. Our objective is to make it according to the needs of the customers. While interviewing the customer everything became clear to us that the designing process must focus on the needs of the customers. If we design it according to the needs of the customers, it will give them a lot of opportunities to explore their life and show their hidden skills and make themselves feel better than laying idol.

2.2 Engineering Requirements (ERs)

Our main focus was to make the device safe to avoid any Misuse of equipment that can lead to serious injury. It helps approachability of the art to the disable people in an easier way. The shape of the easel makes it more stable and leaves fewer chances for any mishap. We have tried our best to make it as comfortable and feasible as possible.

Here is the list of the Engineering requirements we will be keeping in mind while selecting our design. Sharp parts, movable, light material, flexible, simple design, force, cleanable, easy to handle, efficient, and low cost.

1. No sharp parts
2. Moveable
3. Light materials <(20lb)
4. Flexible
5. Simple design
6. No force required = 5lb
7. Cleanable
8. Easy to handle
9. Time = 2hr
10. Low cost <600\$

2.3 Testing Procedures (TPs)

For testing we did many procedures which can be listed below:

1. Decision Matrix.
2. House of quality matrix..
3. Customers' analysis.

DECISION MATRIX:

After analyzing all the designs we worked on choosing one of the designs. Here is the list of designs we did decision matrix for:











Concept										
Criteria	1	2	3	4	5	6	7	8	9	10
Design Name	Rotation Easel	Hydraulic	Adjustable Easel	Wall Stand	180 Stand	Wheelchair Stand	Easel Gear	Regulator	Easel	Chair Stand
No sharp parts	D	+	+	+	+	+	-	+	+	+
Movable		+	-	-	S	-	-	+	-	-
Light Material		-	+	-	S	+	-	-	-	+
Flexible	A	-	-	-	+	-	S	+	-	-
Simple Design		+	+	-	+	+	-	-	+	+
Muscle less		+	-	+	-	+	+	+	+	+
Cleanable	T	-	+	-	+	+	-	-	+	+
Easy to handle		S	-	+	-	+	S	+	+	+
Time		-	-	+	-	+	-	+	+	+
Low cost	U	-	+	-	S	+	-	-	-	+
$\sum -$		5	5	6	3	2	7	4	4	2
$\sum +$		4	5	4	4	8	1	6	6	8
$\sum S$	M	1	-	-	3	-	2	-	-	-

Figure 1 - Appendix B - Decision Matrix

After complete analysis we came of the result that window regulator easel is the design we will continue working with.

2.4 Design Links (DLs)

Table 2 - Engineering Requirements

Engineering Requirements
No Sharp parts
Movable
Light Material
Flexible

Simple design
Low Muscle force required = 5 lb
Cleanable
Easy to handle
Time = 2 hrs
Low Cost < 600\$

The design that we chose is window regulator easel. It is first of all safe in use. It has no much expense in designing that will be plus point for disabled people, plus it is adjustable as the person can move the canvas or the mount as per the requirements. It is not costing too much expenses and it is feasible in use. Hence this design is meeting all the requirements, which have been mentioned in ER.

2.5 House of Quality (HOQ)

We had the objective to make it cheap to satisfy customer needs. This was difficult but still we modified our design to meet the requirement. Our aim was to focus on what we are designing and to implement the ideas of the better design to our original design to make the best product possible. Through this step the team realized that the factors like power, life span, cost, weight, usability, all-weather preparedness, short setup time, non dangerous, standard components used and Level of creativity are most important to be given first importance while designing the device. HOQ helped us compare devices based on different parameters. It helped to analyze the design to be selected. This assisted us in making the decision of selecting the design. Keeping in mind all the requirements, which we had analyzed above, does this. The requirements list enclose that the design must be moveable, light in weight, flexible, easy to handle, low cost, less settling time, safe, ease of assembling etc. This list helped us a lot while designing the device. This process helped us in making functional improvements.

Customer Requirement	Weight	Engineering Requirement	No sharp parts*	Movable*	Light material < (20lb)	Flexible*	simple desing*	muscle less = 5 lb	Cleanable*	Easy to handle*	time = 2 Hr	Low cost < \$500 \$	[add or remove ER columns, as necessary]
1. Safety	5		9	6			6			6			
2. Easy to store	5		9	1	6	6				3	3		
3. Light weight	4		3	9	6	6	6			6		6	
4. Adjustable	4		6	3	9	3					1		
5. Easy to use	4		6	9	3	9	3			6	6	1	
6. Comfortable	4	6	6	3	6	6	6	9				3	
7. Easy to clean	4	1			6	3		9		6	6		
8. size	3		3			6				6		9	
9. saving time	3		3		3	6		6			9		
10. Low cost	2		3	6		9						9	
11. Shape	5		6		3				1	9		1	
12. Mobility	4	9		9		6				6			
Absolute Technical Importance (ATI)			74	185	77	121	222	60	90	123	94	89	
Relative Technical Importance (RTI)			9	2	8	4	1	10	6	3	5	7	
Target(s), with Tolerance(s)											<2 hr	<\$600	
[add or remove T/I rows, as necessary]													
Testing Procedure (TP#)													
Design Link (DL#)													
Approval (print name, sign, and date):													
Team member 1: Jarrah Albathali													
Team member 2: Abdulrahman Almarri													
Team member 3: Aly Alharbi													
Team member 4: Rakan Alhajraf													
Team member 5: Yongzhen Li													

Figure 2 - Appendix C - House of Quality

3 EXISTING DESIGNS

There are many devices in the industry and market which are designed for disable people. These devices either help them move from one place to another or they help them to pick things by moving. We have researched many devices on interest especially which have been designed for disable people. These all devices were really inspiring and creative but we were focused on naming a device, which can help the disable people to do their art without any difficulty. People with limited mobility are often unable to socialize; leading to developmental challenges later in life.

To find out the needs of these types of designs we researched many articles and visited websites. The website disabled world also gave a complete overview on how the designs must be made to feel the disable more comfortable. Furthermore the website was also a good source which helped us a lot to understand the requirements.

1. Window regulator easel

This form of easel allows the stand to move up and down to adjust the height. This will allow the users to be able to adjust the height of the stand based on where they want to draw on their drawing board. The movement allows the user to be able to access all part of the drawing board. Some of the parts are usually too high for disabled individuals to reach. However, when the easel moves up and down, they are able to reach even the top most parts of their drawing board.



Figure 3 - Window Regulator Easel

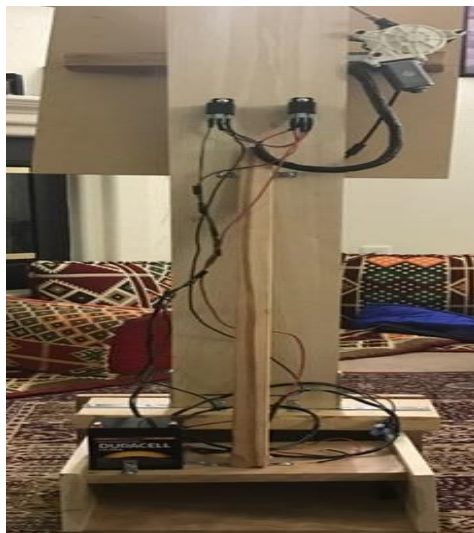


Figure 4 - Overall Design

2. Rotation Easel

The other design is rotational easel. This form of easel allows the board to move round. The user does not need to shift positions while accessing the corners of the drawing board. They only have to rotate the system and they are able to access such parts. The design has wheels that allow for this movement. These wheels can even be locked if the person is not moving. The design is also feasible and adjustable. The good advantage of this design is that it is able to reach different angels.

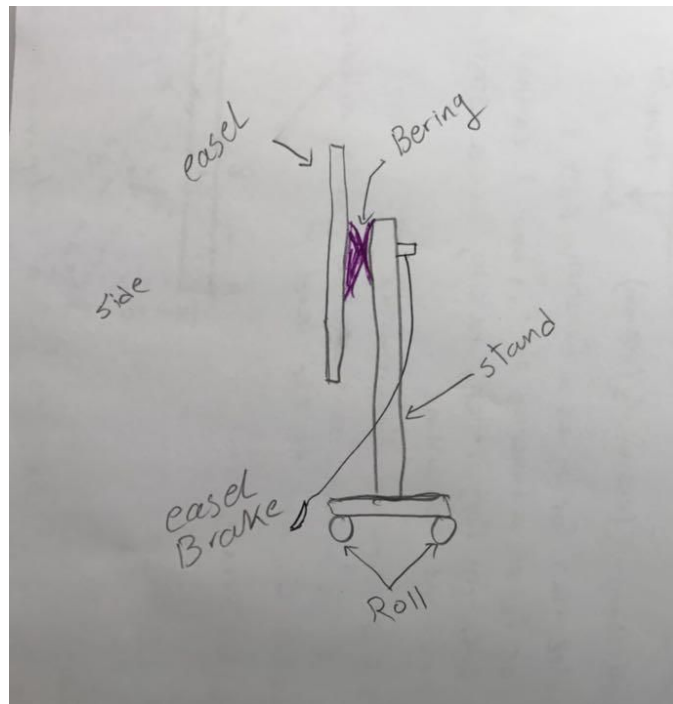


Figure 5 – Rotation Easel Design

3. Hydraulic

This hydraulic design system incorporates a hydraulic power unit, advanced circuitry and pressure transducers, which will evaluate and react to the pressures on and movements of the vehicle during access. This system incorporates the use of modern technologies for purposes of improving the access to drawing areas as well as the movement of the system as a whole. The system is quite effective and, above all, quite safe to use. It allows for effectiveness in

controlling and the abilities to be used in an effective manner.

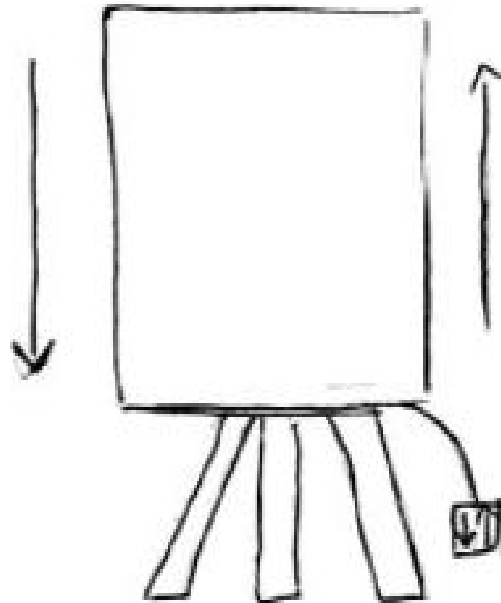


Figure 6 - Hydraulic Design

4. Adjustable Easel:

The design incorporates an easel that can be adjusted. This easel design is adjustable and moveable. It can be adjusted based on the preferences of the users. When the user needs it to be lower or at a certain angle, the easel is able to fit into these specifications. In addition, it has the ability to be folded into a smaller and portable system. It's easy to use, transportable, easy to store and allows the person to get close to the work when working on the paper or artwork. This makes it an effective design for individuals who tend to move a lot, such as movements for purposes of presentations.

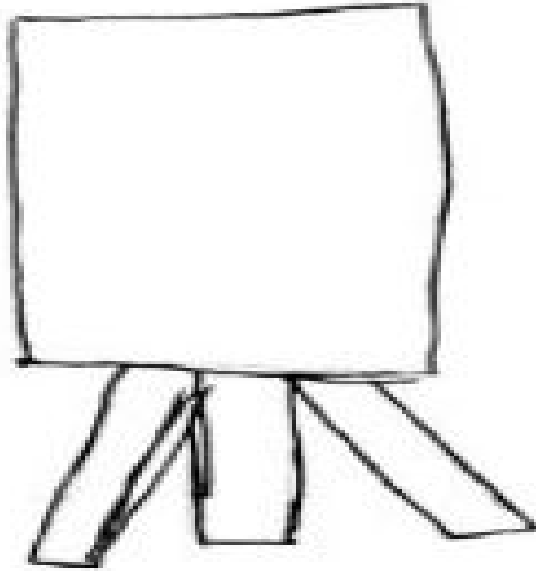


Figure 7 - Adjustable Easel Design

5. Wall Stand

The wall stand is a design that is mounted on the wall. The design incorporates the use of a rod that is fixed to the wall and that allows the user to mount his or her drawing boards. The system is considered to be effective for those with disabilities and limited mobility. This is comfortable for them to use. However, the design has significant limitations are it is not movable and cannot be adjusted based on the preferences of the users. Despite this, the system is effective for use by individuals who do not require too many movements.

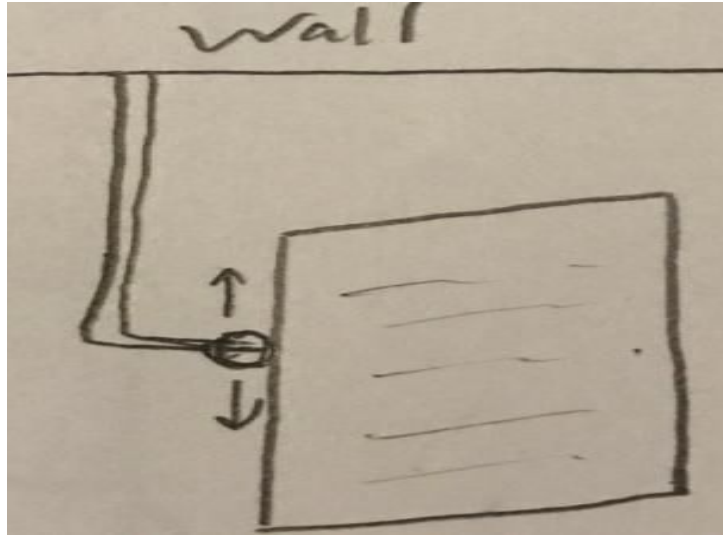


Figure 8 - Wall Stand Design

6. 180 Stand

The 180 stand usually moves effectively along its pivot. The pivot is located at the top most point of the stand. The point at which the stands and the board system meet is movable. This part can rotate either clockwise or anticlockwise to allow for effectiveness in use. This design is feasible to use and is movable. This helps the person to move the paper or rotate it as required. The design is best for some tasks, such as rotating during a presentation where people are viewing from all angles. It is effective when the user wants to shift from time to time or when they want to access different areas along the drawing board.

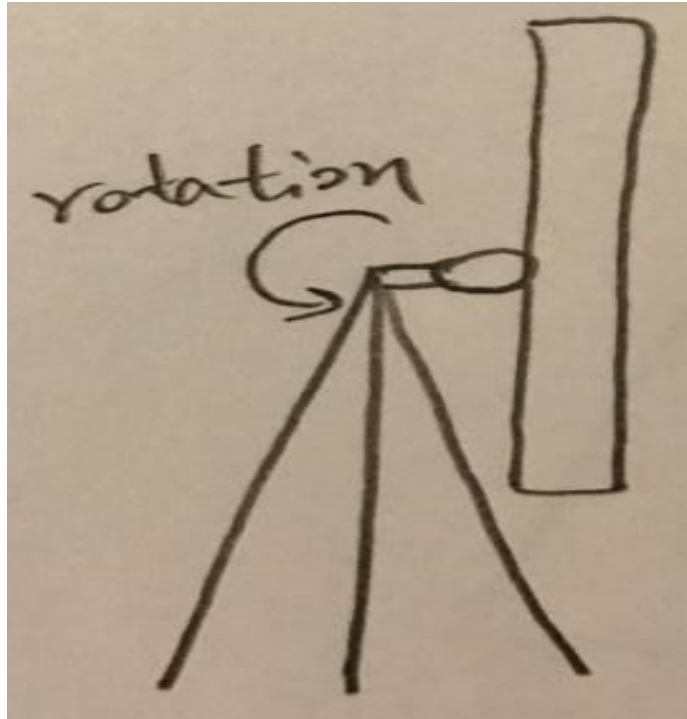


Figure 9 - 180 Stand Design

7. Wheelchair Stand:

The wheelchair stand design is a design that can be mounted on a wheelchair. The design is made in a manner that the system can be clamped on either sides of a wheelchair's armrest. This design is effective since it allows the user to get up close to their workspace. In addition, the design is easily portable and can be used anywhere. This stand is also a comfortable and easy to use design. It helps them do their work in complete ease. The design is of good quality and comfortable to use.



Figure 10 - Wheel chair Design

8. Easel Gear:

The easel gear design incorporates the use of gear systems. These gears help in moving the board on either direction, either up or down, based on the users need. This design is adjustable and can be handled up to different levels. It is stoppable and has a gear too. It's moveable and depends on the activity the person is performing. However, the design is at times difficult to use since some of the users do not have strength to move the system or operate the gear system, which makes this design ineffective especially for individuals who have limited upper body strengths.

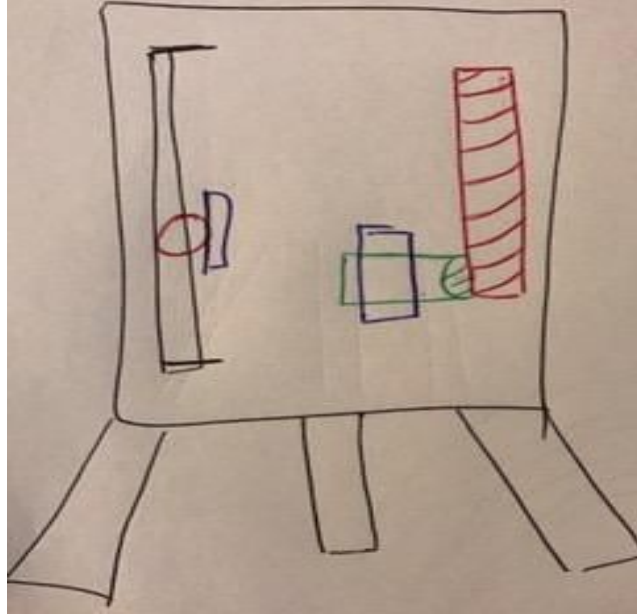


Figure 11 – Easel Gear Design

9. IPod:

IPod is an easy to use way for the disabled people to do their artwork. This can help them do their work in a comfortable way. They can just connect to an apple TV and do their own work and then print it with special printers that should be offered to them from their sponsor. This is a good design since it incorporates the use of modern technology. The technology is used in allowing individuals to access their drawing in a better manner through enhancing various aspects of the drawing.

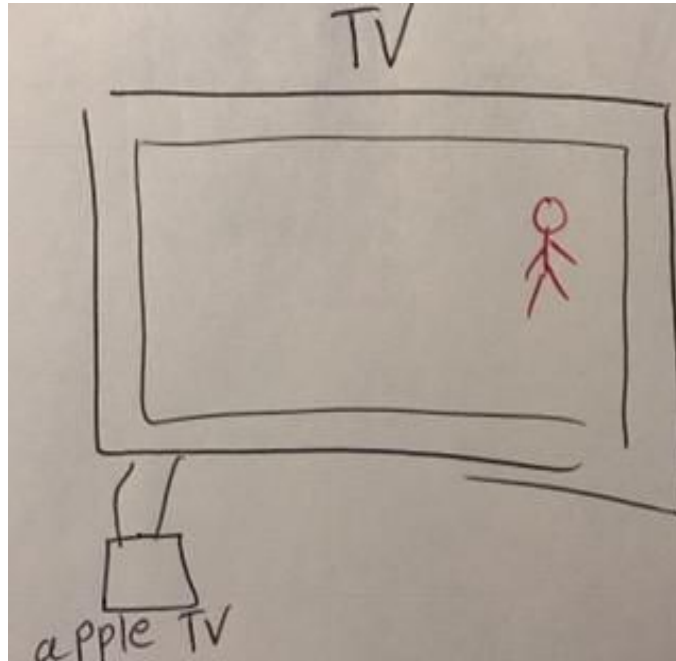


Figure 12 – iPod Design

10. Chair Stand:

The chair stand design is based on clamping the system onto a chair. This design is basically a chair with a stand of wood placed in front of it. This stand is basically attached with the chair. It is not too easy to move though. The design also allows individuals to be able to meet different objective, include the ease of movement, ease of use, and other forms of effectiveness.

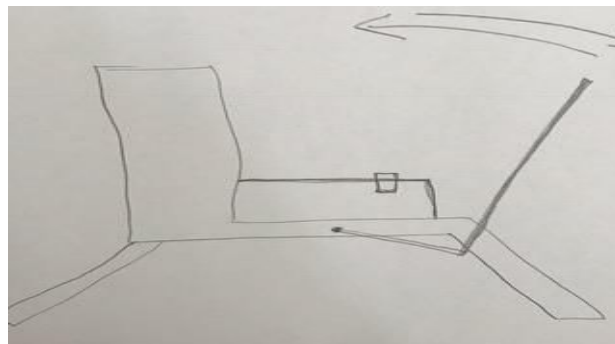


Figure 13 - Chair Stand Design

3.1 Design Research

A lot of work was done in previous years to make the disable people less dependent on others. We researched many articles and did a lot of reading to find out how much industry has developed to achieve this goal. There are many devices in the industry and market, which are designed for disable people.

These devices either help them move from one place to another or they help them to pick things by moving. We have researched many devices on interest especially which have been designed for disable people. These all devices were really inspiring and creative but we were focused on naming a device which can help the disable people to do their art without any difficulty. People with limited mobility are often unable to socialize; leading to developmental challenges later in life.

To find out the needs of these types of designs we researched many articles and visited websites.

3.2 System Level

There were several designs, which fulfill the needs and requirements of our projects. These designs have been mentioned below too. There are three system levels in this device. Following are the designs that we have analyzed in system level:

1. Chair stand
2. Easel gear
3. Window regulator easel
4. Rotation Easel

In these designs we first of all analyzed the levels to which the device can move and its accessibility. The hydraulic design is complex design. 180 design is easy to use but it can just move to a certain angle. Combination of window regulator easel and rotation easel is most suitable for this design.

3.2.1 Existing Design #1: Chair Stand:

This design was basically a chair with a stand of wood placed in front of it. This stand was basically attached with the chair. It was not too easy to move though.

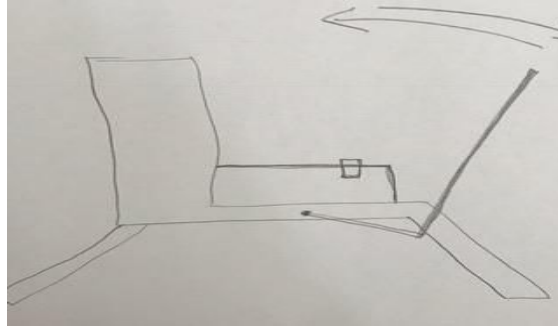


Figure 14 – Chair Stand Design

3.2.2 Existing Design #2:Easel Gear:

This design was also meeting our requirements. This design was adjustable and can be handled up to different levels. It was stoppable and had a gear too. It's moveable and depends on the activity the person is performing.

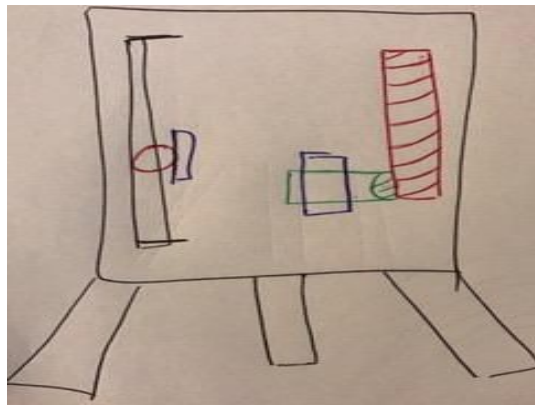


Figure 15 – Easel Gear Design

3.2.3 Existing Design #3: Rotation Easel

This design of rotational easel, which already exists, has some limitations and is not too much comfortable. It has yet to be modified to make it meet the needs of the customers.

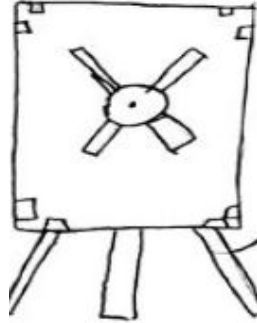


Figure 16 - Rotation Easel Design

3.3 Subsystem Level

1. Functional decomposition:

The design problem for this project was a device enabling people with very limited skills to create art. This problem resulted from discussions with people with different disabilities. The customer needs include: easy to operate, easy to cleanup, and easy to create art with limited skills. Participants in the experimental “functions” group were given the basic functions of: the device must contain, position, and dispense an art medium along with holding a paper in place.



Figure 17 – Overall Design

A window regulator easel with a switch on device comprising: stand, easel, break, tires, etc.

The window regulator easel for disabled artist is a custom made it operated by easel designed to provide complete adjustability for individuals with a physical disability. The design allows the easel to be used from a wheelchair, or by any artists. Each unit is tailored to the individual needs of the user and can be manually controlled. Because most individuals with a physical disability have a limited reach, this window regulator easel is ideal in that it moves up and down, providing a much larger workspace for the artist.

Disable people cannot control height and that is why we have the up and down movement. Also, there are wheels or balls at one end that permit easy movement, but when in use the base rests directly on the floor.

Initially our design was not movable as it was flat from the base. We modified it by adding different components. Now the machine at the back of the mount is responsible for moving the mount to different heights. It adjusts the device as per the requirements of the customers.

3.3.1 Subsystem #1: Hydraulic

Hydraulics based devices have already been used for disabled persons. These devices help them to move from one place to another.

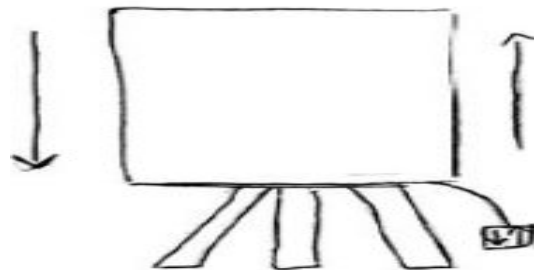


Figure 18 – Hydraulic Design

3.3.1.1 Existing Design #1: Wall Stand

It's wonderful for those with disabilities and limited mobility. This is comfortable for them to use. It uses hydraulic system to move the stand. It also helps the disabled persons to

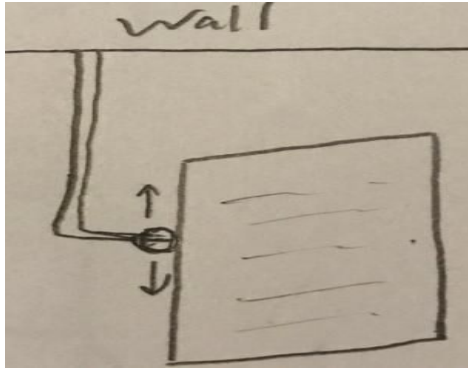


Figure 19 - Wall Stand Design

3.3.1.2 Existing Design #2: Hydraulic

These hydraulic design systems incorporate a hydraulic power unit, advanced circuitry and pressure transducers, which will evaluate and react to the pressures on and movements of the vehicle during access. This system is effective and, above all, safe to use. This design also incorporates the hydraulic system.

3.3.2 Subsystem #2: Easel

It is a normal design of the art easel that you can find in all the places of the art for the artist who use it to draw their own drawings.

3.3.2.1 Existing Design #1:) Easel Gear

This design is adjustable and can be handled up to different levels. It is stoppable and has a gear too. It's moveable and depends on the activity the person is performing.

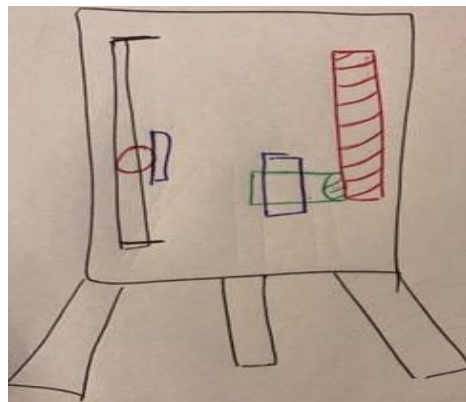


Figure 20 – Easel Gear Design

3.3.2.2 Existing Design #2: Rotation Easel

This is the design of rotational easel and is very much comfortable and easy to use. It has the bearings and the mount, which can move to 360 degrees making it easier for the patients.

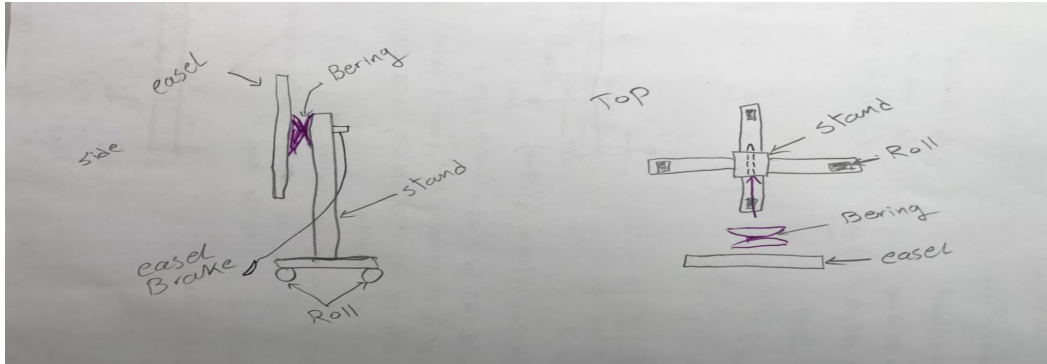


Figure 21 - Rotation Easel Design

3.3.2.3 Existing Design #3: Adjustable Easel

This easel design is adjustable and moveable. It's easy to use, transportable, easy to store and allows the person to get close to the work when working on the paper or artwork.

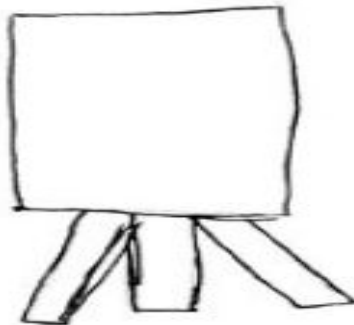


Figure 22 - Adjustable Easel Design

3.3.3 Subsystem #3: Wheelchair

Wheelchairs designs are already so common and exist.

3.3.3.1 Existing Design #1: Wheelchair Stand

This stand is also a comfortable and easy to use design. It helps them do their work in complete in easy way.



Figure 23 - Wheelchair Design

3.3.3.2 Existing Design #2: 180 Stand

This design is feasible to use and is movable. This helps the person to move the paper or rotate it as required.

3.3.3.3 Existing Design #3: chair stand

This design is basically a chair with a stand of wood placed in front of it. This stand is basically attached with the chair. It is not too easy to move though.

4 DESIGNS CONSIDERED

We considered 10 designs for short listing and converging towards one efficient design:
The list of designs is as follow:

1. Window regulator easel
2. Rotation Easel
3. Hydraulic
4. Adjustable Easel
5. Wall Stand
6. 180 Stand
7. Wheelchair Stand
8. Easel Gear
9. IPod
10. Chair Stand

4.1 Design #1: Hydraulic

This hydraulic design system incorporated a hydraulic power unit, advanced circuitry and pressure transducers, which evaluates and reacts to the pressures on and movements of the vehicle during access. This system was effective and, above all, safe to use.

4.2 Design #2: 180 Stand

This design was feasible to use and is movable. This helped the person to move the paper or rotate it as required.

4.3 Design #3: Window Regulator Easel

The design problem for this project was a device enabling people with very limited motor skills to create art. This problem resulted from discussions with people with different disabilities. The customer needs included: easy to operate, easy to cleanup, and easy to create art with limited motor skills. Participants in the experimental “functions” group were given the basic functions of: the device must contain, position, and dispense an art medium along with holding a paper in place.

A window regulator easel with a machine on device comprising: tires, stand, easel break. People can control height, tilt, and lateral position on the board. There are wheels or balls at one end that permit easy movement, but when in use the base rests directly on the floor.

5 DESIGN SELECTION

After doing complete research and analysis, we selected the window regulator easel as our selected design.

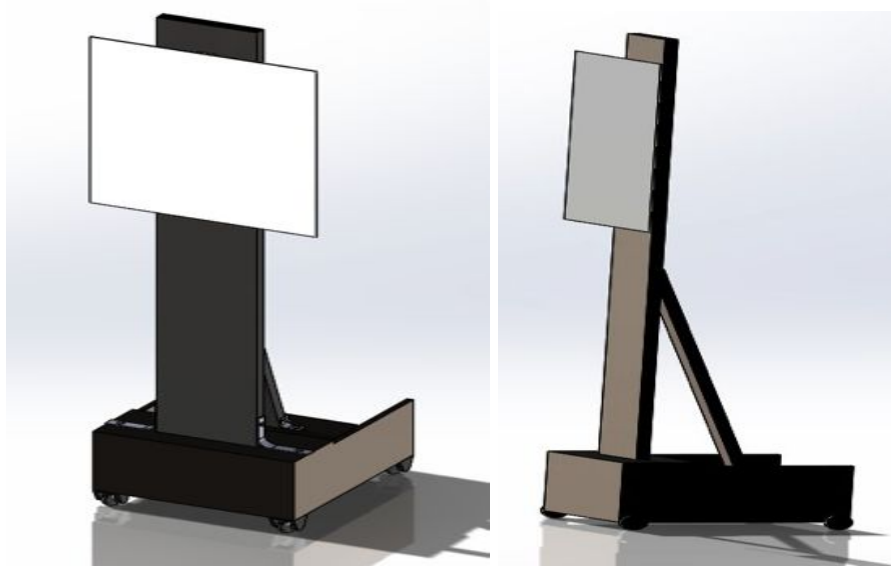


Figure 24 - CAD Models: Design Selected

5.1 Rationale for Design Selection

The reason why we selected this design is that

- it is lightweight .
- It has a built-in carry handle that makes it easy to take to anywhere.
- Moved up and down to adjust height.
- This saves the time from having to constantly pick up the piece to turn it to the area the person wants to work on.
- Easy to operate and maneuver.
- It adjustable and enables to elevate the artwork work to any needed different heights.
- It can move the piece in a complete full height for the person to draw standing.
- It's wonderful for those that have disabilities and limited mobility. The different elevation brings the work closer to the person, instead of having him to lean forward. Plus, it can help the person's hand, wrist, and neck and back avoid stress and strain.

5.2 Design Description

The design problem for this project was a device enabling people with very limited motor skills to create art. This problem resulted from discussions with people with different disabilities. The customer needs included: easy to operate, easy to cleanup, and easy to create art with limited motor skills. Participants in the experimental “functions” group were given the basic functions of: the device must contain, position, and dispense an art medium along with holding a paper in

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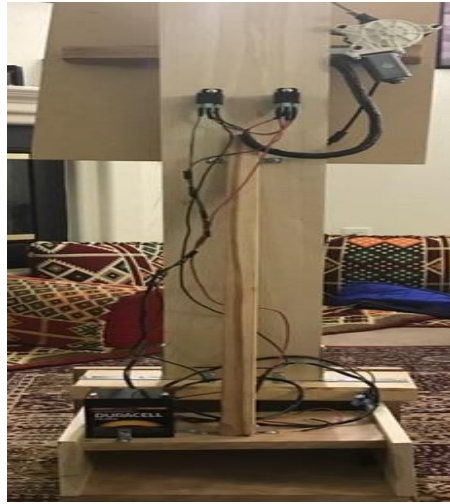


Figure 25 - Design

A window regulator easel machine on device comprising: tires, stand, and easel break. The regulator easel for Disabled Artist is a custom made it operated by easel designed to provide complete adjustability for individuals with a physical disability. The design allows the easel to be used from a wheelchair, or by artist. Each unit is tailored to the individual needs of the user and can be manually controlled. Because most individuals with a physical disability have a limited reach, this regulator easel is ideal in that it electrically moves up and down, providing a much larger work space for the artist.

People can control height through the window regulator easel, tilt, lateral position on the board. There are wheels or balls at one end that permit easy movement, but when in use the base rests directly on the floor.



Figure 26 -Design

The design images above show the completed device. It shows the effectiveness in movability of the device, where it can be moved up and down, moved in different directions by dragging it and the wheels allow for ease of movement, and can effectively rotate to face different sides.



Figure 27 -Device in Use

6 PROPOSED DESIGN

From all above designs the design, which we proposed after research and benchmarking, is window regulator easel. This is a chair having machine in the top of the easel so that it can move easily. Once a canvas is loaded onto the device, the rigid frame holds the system in place as the entire device is raised to the appropriate level by the Reliant lift. There is a power source too. It is necessary to design the power supply side efficiently.

The system has a window regulator. This easel allows the system to move up and down for purposes of accessing the whole workspace for the users. The design is show in the figure below:



Figure 28 - Design

The system is connected to the base of this system. With the help of this people can make paintings of any size because it allows access to areas of a canvas that a disabled would not otherwise be able to reach unaided.

7 IMPLEMENTATION

7.1 Design of Experiments (DOE)

There are various variables that the team tested, including the durability of the materials, the height adjustment, the rotation abilities, and the movement of the whole system using the wheels. Based on these tests, the design was concluded to function as expected. The designed moved up and down effectively, rotated as it was expected, and moved in a good way suing it wheels.

From the analysis and results, it implied that the system meets the standards set as well as the customer requirements. In addition, this implied that the design could be implemented and produced in large scale for purposes of being used by the intended individuals in improving their arts and other activities related to using the design.

7.2 Manufacturing

The manufacturing of the system was based on the sketched and designs made. The sketches included the measurements and requirements for every part of the system. Based on this, the team collected all the materials and cut them into the required sizes. Other materials were

modified for purposes of fitting into the system. Once all the parts were ready, the team assembled them together to come up with the finished system. The system was then tested for is functionality and any form of errors were looked in before finalizing on it and finishing up all the final touches, such as the paintwork.

The manufacturing process can be viewed from the below images:





Figure 29 - Manufacturing

The resources needed are shown in Bill of materials below:

Table 3 - Appendix D - Bill of Materials

Bill of Material		
Team 27 Hozhoni Art-B		
Material	Cost	Quantity
Battery	76.24\$	1
Tires	15.92\$	4
Electrical Stuff	106.05\$	3
Window Regulator	195.72\$	1
Screws	20.38\$	3
Easel	13.47\$	1
Wood	49.3\$	10
Corner Brace	40.30\$	12
Total Cost	517.38\$	
Remaining	982.62\$	

7.2 Design of Experiments (DOE)

There are various variables that the team tested, including the durability of the materials, the height adjustment, the rotation abilities, and the movement of the whole system using the wheels. Based on these tests, the design was concluded to function as expected. The designed moved up and down effectively, rotated as it was expected, and moved in a good way using its wheels.

From the analysis and results, it implied that the system meets the standards set as well as the customer requirements. In addition, this implied that the design could be implemented and produced in large scale for purposes of being used by the intended individuals in improving their arts and other activities related to using the design.

8 TESTING

We tested our design to make sure that our physical model fits with design requirements or not. It was to be firstly checked thoroughly by our team, and then we will be able to offer some disabled citizens to use our device and give us feedback. We were really excited when entered in testing phase of our final product finally. Testing of our product was totally based on basic design requirements on which the product was fabricated i.e.

All of the above mentioned requirements are to be met by our final product and furthermore customer and engineering requirements must be fulfilled at any cost.

So to check all, our team tested the final product in parts by individual members in the following way:

- We all together tested our final product regarding its all basic design requirements.
- We checked the chair stand, by resting on it and use its associated functions.
- We worked on easel, just to check its smooth operation and make sure that input force must remain low.
- We worked on window regulator easel, just to ensure proper upward and downward movement with user action.

Table 4 - Test Results

Tests	Results	Problems Encountered
Chair stand	1. Height Adjustment	Feeling uncomfortable if used for long time.

		Some person might be bulky, so causes problem.
Easel gear	1. Smooth operation 2. Low input force	Disable citizens might not operate it effectively
Window regulator easel	1. Proper translation 2. Locks adjustment	Range of motion might be problem for someone
Overall operation / working	1. Proper working 2. Good user interface 3. Fully control operation by user	Overall good, but sometimes it might be ineffective for some disabled persons that are more weak

Finally we as team tested our final product regarding its overall operation or working e.g. our product must respond accordingly by user input. We checked it regarding all aspects in such a way that our one member used it as user (considering himself as senior citizen showing low muscle power) to control all of the functions to meet his demands for making his art on sheet i.e. fitted on easel.

Summarizing the results obtained from our testing, i.e.

- All Basic requirements e.g. low cost, easy to use, light weight etc. are totally satisfied design requirements.
- Chair Stand, Easel functions are quite good to some extent and can be considered as satisfied design requirements also.
- Easel gear did satisfy design requirement.
- Some joints or wiring position would not cause problems during any action. So they are said to be ambiguous design requirements.

9 CONCLUSIONS

Our design was simple yet efficient. Since assistive device often are a frame in the rehabilitation process, the need for a better understanding in the prescribing process, use and utility of assistive devices is of utmost interest to the profession. There are a lot of unanswered questions in the field and one should benefit from more studies dealing with both user experiences and underlying factors making a difference in outcome. Moreover, we think we did a good job on our project that got liked by the instructor, sponsor, and customers. Finally, we designed the project

that met all the course requirement with a high level of work and professionalism that made the project succeed in all aspects.

9.1 Contributors to Project Success

All of group members were supportive and hardworking. Everyone's contribution is highly appreciable. For the project to reach a successful conclusion we need to be working well together for a common purpose. Leading a team successfully involves learning about each individual's skills and personality in order to get the best as a whole. Our team is having a complete package of an organizer, communicator, leader and a creative thinker and I think we can well maintain project composure.

9.2 Opportunities/areas for improvement

The design is perfect until now but it can be further improved later on integrating more ease and designing. The more it is comfortable the more perfect it becomes. Areas of improvement includes that the device can be modified in a way where the person can draw even by laying on his bed. This will be more feasible for the disabled people. This will help those ones too who are unable to sit due to some spinal cord or backbone injury.

10 REFERENCES

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- [2] Carlisle, Rodney (2004). Scientific American Inventions and Discoveries, p. 266. John Wiley & Sons, Inc., New Jersey. ISBN 0-471-24410-4.
- [3] Samuelsson, Kersti, and Ewa Wressle. "User satisfaction with mobility assistive devices: An important element in the rehabilitation process." *Disability and rehabilitation* 30.7 (2008): 551-558.
- [4] Borg, Johan, Stig Larsson, and Per-Olof Östergren. "The right to assistive technology: For whom, for what, and by whom?." *Disability & Society* 26.2 (2011): 151-167.

APPENDICES

Appendix A- Customer requirements

Table 1 - Appendix A - Customer's' Requirements

Customer Requirements
Safety
Easy to store
Light weight
Adjustable
Easy to use
Comfortable
Easy to clean
Size
Saving time
Low cost

Appendix B- Decision matrix











Concept										
Criteria	1	2	3	4	5	6	7	8	9	10
Design Name	Rotation Easel	Hydraulic	Adjustable Easel	Wall Stand	180 Stand	Wheelchair Stand	Easel Gear	Regulator	Easel	Chair Stand
No sharp parts	D	+	+	+	+	+	-	+	+	+
Movable	+	+	-	-	S	-	-	+	-	-
Light Material		-	+	-	S	+	-	-	-	+
Flexible	A	-	-	-	+	-	S	+	-	-
Simple Design		+	+	-	+	+	-	-	+	+
Muscle less		+	-	+	-	+	+	+	+	+
Cleanable	T	-	+	-	+	+	-	-	+	+
Easy to handle		S	-	+	-	+	S	+	+	+
Time		-	-	+	-	+	-	+	+	+
Low cost	U	-	+	-	S	+	-	-	-	+
$\sum -$		5	5	6	3	2	7	4	4	2
$\sum +$		4	5	4	4	8	1	6	6	8
$\sum S$	M	1	-	-	3	-	2	-	-	-

Figure 1 - Appendix B - Decision Matrix

Appendix C- House of Quality

Customer Requirement	Weight	Engineering Requirement	No sharp parts*	Movable*	Light material < (20lb)	Flexible*	simple desing*	muscle less = 5 lb	Cleanable*	Easy to handle *	time = 2 Hr	Low cost < 500 \$	[add or remove ER columns, as necessary]
1. Safety	5		9	6			6			6			
2. Easy to store	5		9	6	1	6	6			9	3		
3. Light weight	4		9	9	9	6	6			6		6	
4. Adjustable	4		9	6	9	3	9	3			1		
5. Easy to use	4		6	6	3	6	6	3		6	1		
6. Comfortable	4	6	6	3	6	6	6	9				3	
7. Easy to clean	4	1			6	3	9	9	3	6			
8. size	3		3			6			6		9		
9. saving time	3		3		3	6		6			9		
10. Low cost	2		3	6		9						9	
11. Shape	5		6		3			1	9			1	
12. Mobility	4	9	9			6			6				
Absolute Technical Importance (ATI)		74	185	77	121	222	60	90	123	94	89		
Relative Technical Importance (RTI)		9	2	8	4	1	10	6	3	5	7		
Target(s), with Tolerance(s)										<2 hr	<\$600		
[add or remove T/T rows, as necessary]													
Testing Procedure (TP#)													
Design Link (DL#)													
Approval (print name, sign, and date):													
Team member 1: Jarrah Albathali													
Team member 2: Abdulrahman Almarri													
Team member 3: Aly Alharbi													
Team member 4: Fakan Alhajraf													
Team member 5: Yongzhen Li													

Figure 2 - Appendix C - House of Quality

Appendix D- Bill of Material

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