Project Deliverable D: Conceptual Design
GNG 1103F – Engineering Design
Faculty of Engineering – University of Ottawa

Team 3 F01

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Introduction

The purpose of this document is to show the next step in the design process that our team is working on. The task at hand is to develop a modular product which will remove snow and ice from the campus sidewalks at the University of Ottawa. This would be a replacement for salt which causes severe damage to infrastructure and the environment.

Using the products benchmarked and target specifications, some conceptual designs have been produced. It is important that the problem statement and consumer needs are kept in mind during the design process. Of the three subsystem concepts designed by each member, they all fit most of the target specifications and could theoretically be used. After weighing the pros and cons of each design, the most effective designs were selected for further development.

Subsystem Outlines

The purpose of the subsystem outline is to break down the three main components of our product, which will allow for the main goal to be accomplished. The goal of the subsystems is to allow for each team member to come up with conceptual designs that will be able to be evaluated and put together to form an effective final design than would otherwise be difficult to put together all at once.

As a team we have broken the design down into Heat-production, Casing, and Connectors. These three subsystems cover the main functions of the design that will be required. Heat production is the component of design which deals with transferring heat from an energy source to the snow or ice. It will discuss how the device is heated, the level to which is heated and how a user would control that. The Casing is the subsystem dealing with the outside of the design. Designs for this will include material of casing, waterproofing and other such criteria. The final subsystem is the connectors. Designs for this system will discuss how the units will transfer heat from one to another and how they will be secured together.

Table 1 covers the boundaries of each subsystem. The boundaries relate to the target specifications and metrics described in the previous project deliverable (PD C).

Table 1 - Subsystems

Subsystem	**Boundaries**
Heat production	Source of heat, heat control
Casing/outer shell	Material, waterproofing, Grip, size, strength, salt resistance, repairability
Connectors	Connecting methods, power transfer from unit to unit, modularity

Conceptual Design

Each team member created at least one conceptual design for each subsystem. The names of the concepts are listed in Table 2 and sketches for each can be found in the appendix.

Table 2 - Concepts

Name/ Subsystem	**Jeremy**	**Simone**	**Piotr**	**Jada**	**Zhili**
Connector	-Hose wire -Vertical teeth	-Computer connector -Playmat design	-Side bars with “teeth”	-Connection input -Lego connectors -Puzzle connectors	-Playmat design
Heat Production	-PTC heater -Nichrome wire -Conductive ink	-Heated by wire	-Molded heating	-Electric wire	-Wire around support
Casing	-Waterproof Fabric/Zipper	-Playmat design	-Top/bottom textured	-Textured top with ramps on sides	-Top texture -Top and bottom buckle

Design Evaluation

After generating conceptual designs, we analyzed and evaluated our designs against the design criteria. This is done using a decision matrix for comparing the solutions from the technical benchmarking process. In our rating system, we used "+"," "-, and "N/A" to show how certain concepts compare to certain criteria. A "+" represents a good score, " N/A" is a neutral or irrelevant score, and "-" represents a poor score.

Table 3 - Casing

Casing Concept/ Criteria	Waterproof Fabric/Zipper	Playmat design	Top/bottom textured	Textured top with ramps on sides	Top texture
Waterproof	+	N/A	+	N/A	N/A
Cost	+	N/A	-	-	+
Grip	+	N/A	+	+	+
Material Effectiveness	-	N/A	N/A	N/A	+
Accessibility	+	+	+	+	+
Maintainability	+	-	+	-	+
Total:	+4	0	+4	0	+5

After comparing our casing designs with a few of the most important criteria, we found the "top texture" design to be the most effective. While the other designs such as the "playmat" and "textured top" provide important and unique designs, the "top texture" design is able to reliably fit the needs of the design criteria. For this reason, we believe the best choice is to use the "top texture" as a base for our design, and incorporate ideas from other designs in the future.

The "top texture" is a simple design which uses strong and cheap PVC material. As one of the most commonly produced plastic polymer materials, it will be easy to purchase in large quantities. The squared texture pattern on top of the casing should last a long time, and is easy to machine into the material, as it isn't an intricate design. The grooves also provide drainage routes.

Table 4 - Heating

Heating Concept/ Criteria	PTC heating	Nichrome Wire	Conductive Ink	Wire around* support	Molded* heating
Safety	+	+	+	+	+
Large scale feasibility	+	+	-	+	N/A
Cost	N/A	+	N/A	N/A	N/A
Control	+	+	+	N/A	-
Simplicity	+	N/A	+	+	+
Total:	4	4	2	3	1

* Column encompasses multiple ideas (“heated by wire” and “electric wire” concepts)

Our team analyzed the heating concept and rated each of our designs accordingly. We thought that the PTC and nichrome wire was the most effective across our criteria. The PTC heating is power efficient, safe, and has self regulated heating. The Nichrome is cheap and controlled with a microcontroller.

As a team, we also had other ideas for heating that were not as effective such as the conductive ink, wire around support, and molded heating. The conductive ink is painted onto the surface and is not self regulated. This makes the conductive ink difficult for large scale feasibility because the ink would need to be painted onto every surface. Next, the wire around support is easy to use and safe but the cost and controllability were neutral making it not our first choice for heating. The molded heating appears easy to use but difficult to repair once installed and is neutral for large scale feasibility and cost.

Table 5 - Connectors

Connectors Concept/Criteria	Hose wire	Computer connector	Side bars with “teeth”	Puzzle connectors	Vertical Teeth*	Playmat design
Strength of connection	+	-	+	+	+	N/A
Safety for power transfer	+	+	+	N/A	N/A	N/A
Stability	+	+	+	+	+	-
Simplicity	+	+	+	-	+	+
Total:	4	2	4	1	3	0

* Column encompasses multiple ideas (“Lego Connector” concept)

The team analyzed the connectors concept and rated the conceptual designs according to criteria defined. It was decided that the hose wire, the side bars with “teeth”, and vertical teeth were the most efficient. The hose wire is safe for power transfer and simple to connect. The side bars with “teeth” can be securely connected and has good stability. The vertical teeth is a simple design and can be securely connected together.

There were also other ideas for connectors that were not as efficient, such as the computer connector, the puzzle connector and the playmat design. The computer connector did not have a secure connection. This would make the design easy to disconnect and stop the flow of electricity. The puzzle connector is not a simple design. This would make the assembly extremely time consuming and it would be expensive to create. The playmat design was neutral on the secureness of the connection, but it lacked stability, which would make it easy to move around after it was installed.

Final Design

After the concept evaluation, the team has decided to move forward with certain concepts. These are tabulated in Table 6. The sketch below (Figure 1) is the final concept the team has come up with. It is a rough idea of how the concepts presented could be combined to create one, more effective global solution.

Table 6 - Final Concepts

Subsystem	Concepts to be Developed
Heat production	Nichrome Wire or PTC
Casing/outer shell	Waterproof fabric/Zipper and Top Texture
Connectors	Hose wire, side bars with “teeth”, and vertical teeth

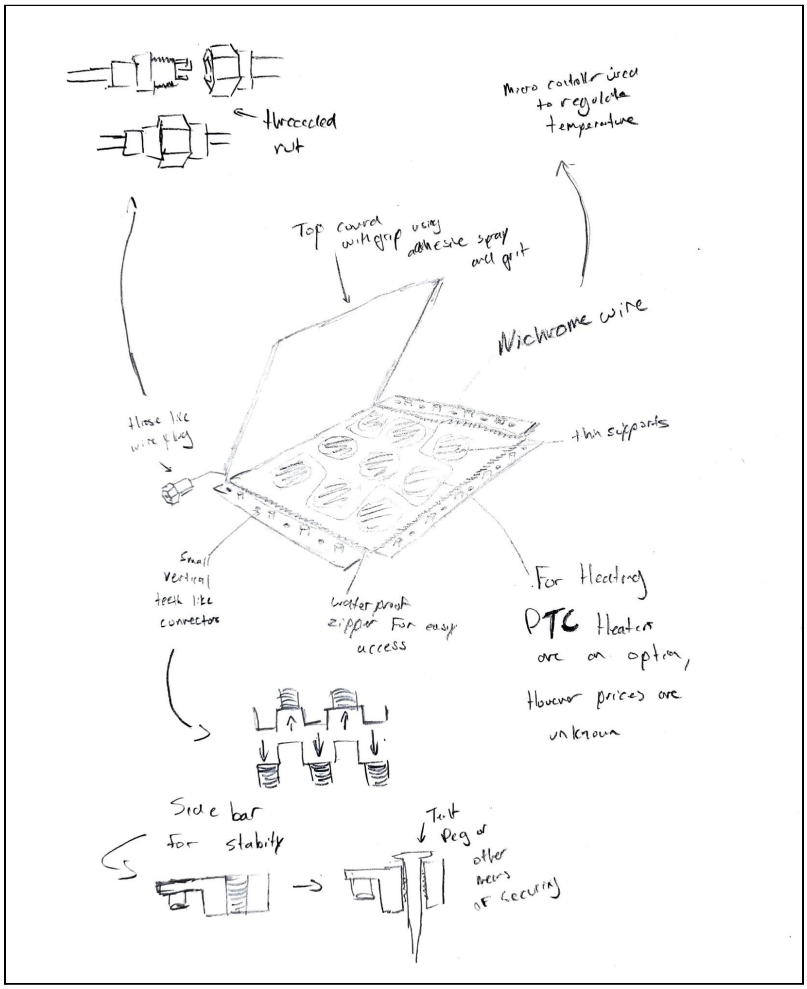


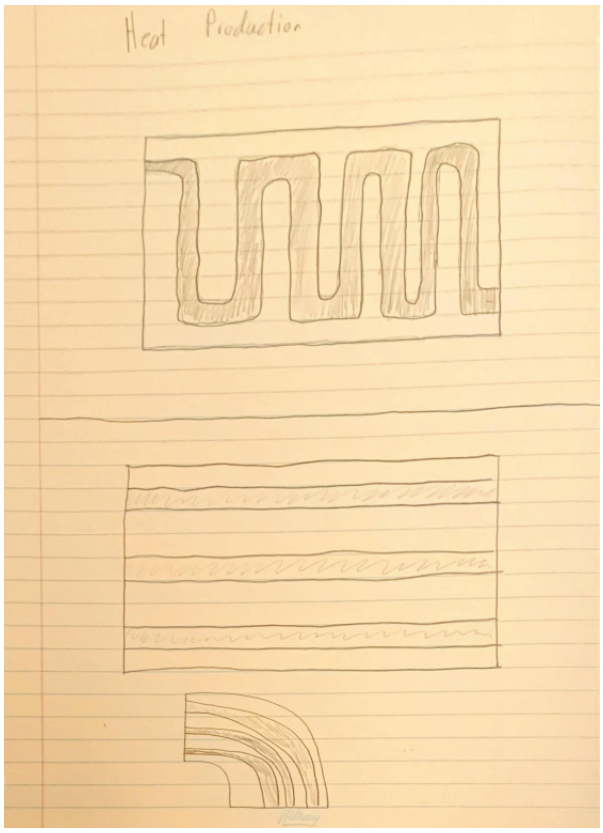
Figure 1 - Final Sketch

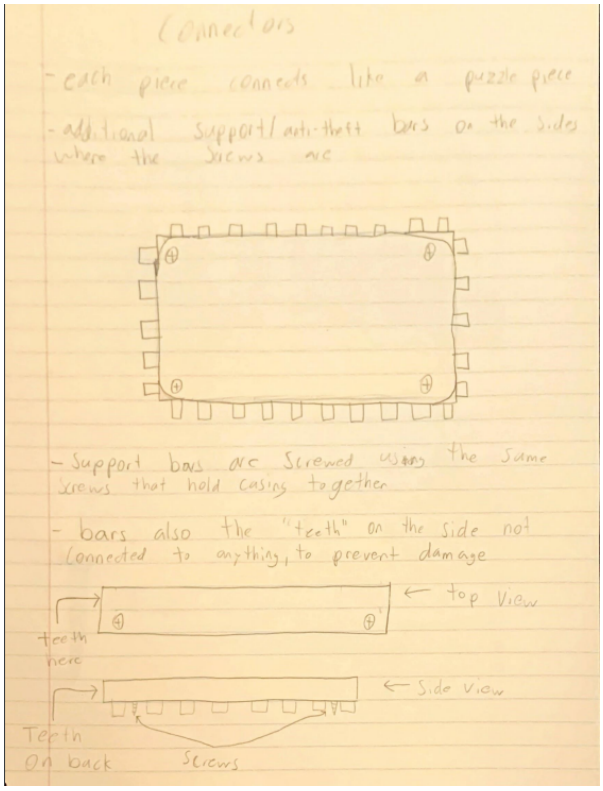
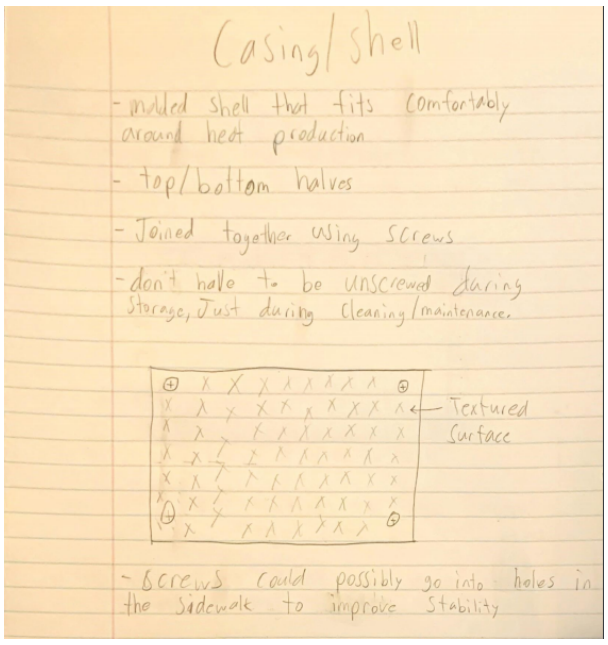
Conclusion

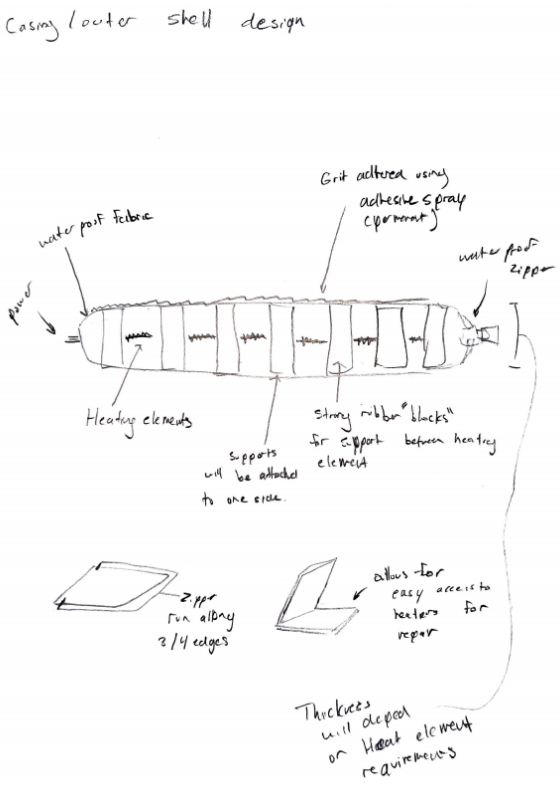
In summary, the team worked hard to bring creative solutions to the table and decide on the functional features the product will have. Looking to the future, we are excited to start on our first prototypes as well as meet with the client one on one. This will allow for our design and product to develop further.

Appendix

Table 6

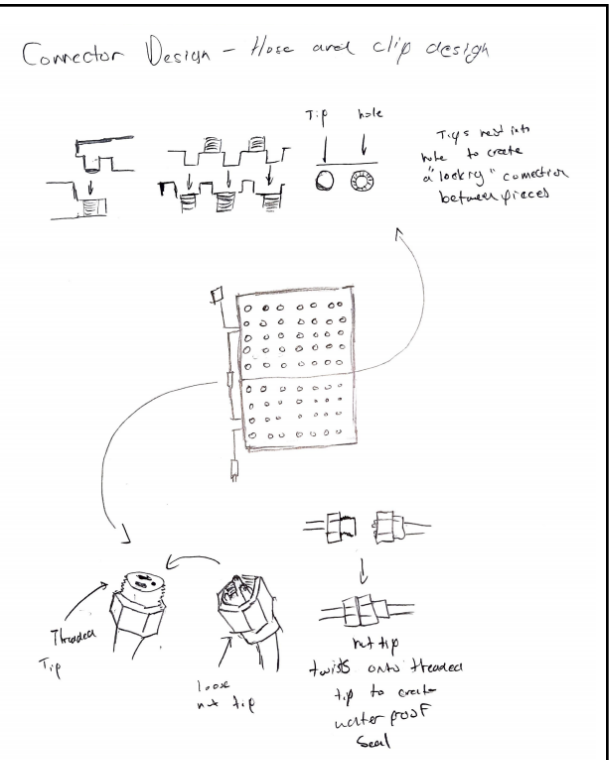
Description	**Picture**
Piotr	
Molded Heating - Casing is molded around the heating elements to leave minimal empty space - Cable/wire is connected to the next tile by being placed very close together and locked in place	

Side Bars with “Teeth” - Each tile connects like a puzzle piece, but are interchangeable - Each piece would fit tightly like this - While the tiles could be organized for wider sections of sidewalk, the main purpose of the “teeth” on the long ends of the tile are for the support bar - Support bar can be screwed into the same place where the top/bottom are screwed together, and would be able to lock together multiple tiles	
Top/Bottom Textured - Molded shell has a top and bottom half which are screwed together - An option was given during the interview to drill holes into the sidewalk. This could be done to improve the stability of the tiles - Once the tiles were placed for the first time it would be easy to consistently put them back the same way	

Jeremy	
Waterproof Fabric/Zipper - Waterproof fabric allows for electronics inside to stay safe. - Supports create a “safety blanket” for heating elements. - Zipper will allow for the case to open like a suitcase to allow for repair and maintenance. - Grit will be adhered to the top and maybe the bottom to create a grip for users. This will be done with adhesive spray.	

Hose wire
- The two segments of sidewalk will be powered by a plug inside of a hose-like end.
- Each tip will have one side of a threaded connector.
- Threaded nut and bolt connection will improve waterproofing in the power connection.

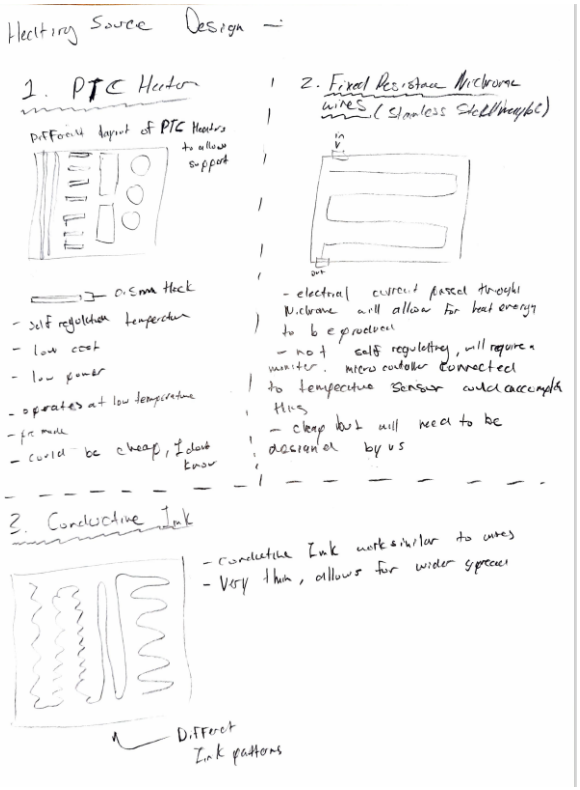
Vertical Teeth
- The two segments will be locked together purely for improvement of stability
- Teeth will nest into grooves on other segments to connect them.



PTC Heater
- Very thin sheets of printed electrical PTC heater
- Very power efficient
- Self regulate temperature
- Price is unknown but from what I understand, they are cheap
- Would need to be ordered from manufacturer
- Very safe

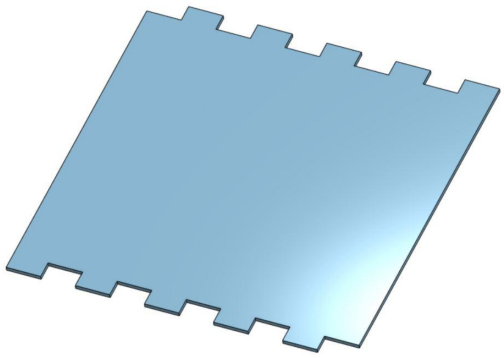
Fixed Resistance Nichrome wires
- Cheap
- Designed by us
- Controlled with a mini microcontroller to regulate temperature.
- simple

Conductive Ink
- Similar to wires (not self regulated)
- Much thinner than wires
- Ink is conductive and would be painted onto a surface.
- Electric current causes ink to create heat.



<table>
<tr><th colspan="2">Simone</th></tr>
<tr><td>

- Playmat type design to insure connectability
- The casing is solid throughout, with only room for the wires and the plug system inside
- It is sized to fit on a standard sidewalk

</td><td>  </td></tr>
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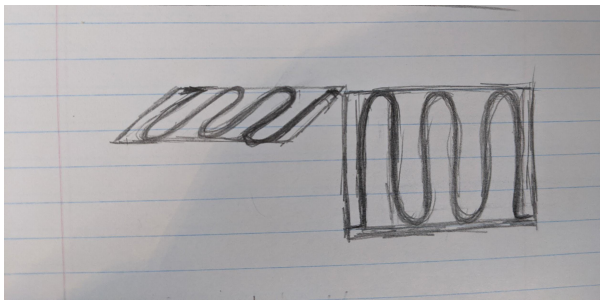
- There are heating wires throughout the inside of the mat
- They are molded to the mat to insure they don’t move

</td><td>  </td></tr>
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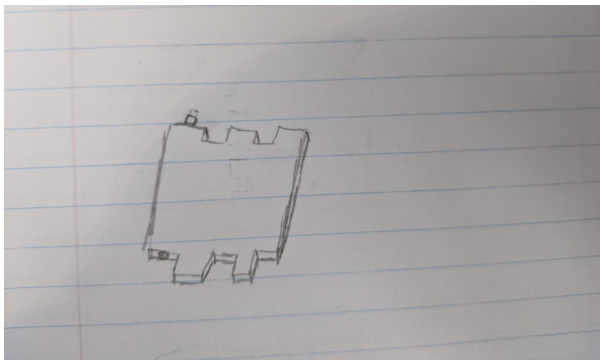
- Computer-like plug to allow the current to pass from one mat to another
- A plug is on one end of the mat and a hole to receive the plug is on the opposite side of the mat
- The teeth on the edges allow for the mats to connect and stay together

</td><td>  </td></tr>
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<tr><th colspan="2">Zhili</th></tr>
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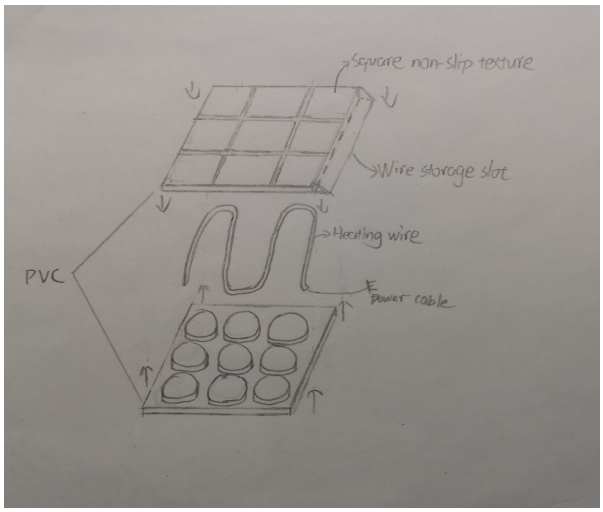
- Heating wire fixed on circular support
- Square concave texture on the top surface
- Hollow slope attach on right side to storage power cable
- Top and bottom Ncase is made of PVC material
- Case is held together by circle buckles

</td><td> 
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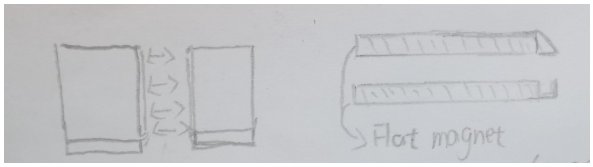
- Mats are connected by flat thin magnet

</td><td> 
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<tr><th colspan="2">Jada</th></tr>
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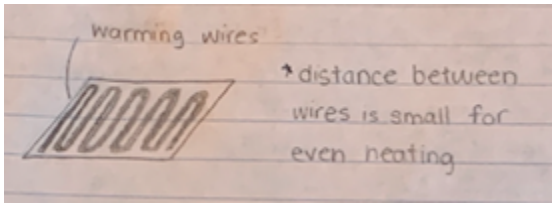
- Heating wires throughout the inside of the mat
- The wires are molded to the mat
- The distance in between the wires is small for even distribution of heating

</td><td> 
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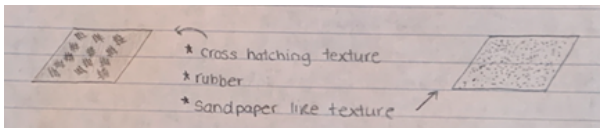
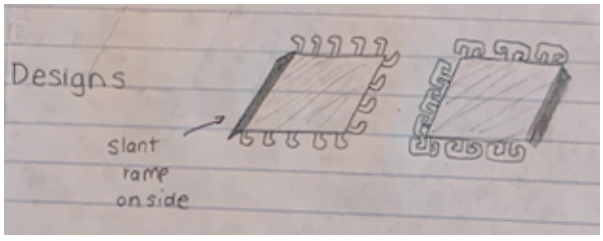
- Cross hatching texture and a sandpaper like texture on the top of the mat for grip
- Casing could be made of rubber
- Side of the mat has a ramp on one side (2 sides if it is an end piece)

</td><td> 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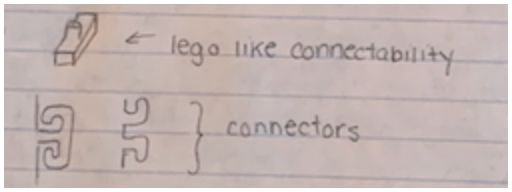
- The connectors between the mats have a lego and puzzle like connectability - The lego like connectors would work like one piece goes on top of the other - The puzzle like piece will just be pressed together	
Final Design	
The final design is found in the Final Design section of the document. This design is a visual representation of the designs that we felt were strong.