IB HL Design Technology Major Project

The Drawing Board

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DT Major Project
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Design Opportunity

The drawing board has been a very useful tool for artists and designers. Earliest records of the device date back to the early 1700s (Dictionary), and its use is still existent today as one of the staples of the design field. Ironically, however, the drawing board is a product that shows a large opportunity for innovation in the design world.

Contemporary Drawing Boards:

(Artdiscount.co.uk)

(Gstatic)

(Smithdrafting)

Despite the drawing board's long history within the industry, contemporary boards are primitive and limited in their design. Instead of innovating the board however, the modern design world is moving more towards electronic drawing boards. These boards hold endless digital tools that convention al drawing boards, in some cases, simply cannot match.

(Stewart)

However some veterans of design are either not willing or cannot learn the new skills required to operate the new electronic design tools. Some designers also prefer some physical processes of design which the electronic features do not perform as well in.

Some Pros and Cons for each of the products are:

	Physical Drawing Board	**Electronic Drawing Board**
Pros	-Physical drawing tools for user aid. (Guided ruler, protractor, etc...) -Much easier to learn how to use when compared to the Electronic Drawing Board -Produces tangible copies of work. (Ex: Textures can be added to a design)	-Easy distribution of work/files -Scaling ability -Changes can be made more easily with "Undo", "Redo", "Save", and "Edit" capabilities. -Endless art and drawing tools -Ability to work in dim or dark lit areas
Cons	-Potential for physical user error -Distribution of work is less convenient -Resources required to produce physical works. (Pencils, erasers, etc...)	-Potential for software error -Glare when working in direct light -More complicated to learn how to use than the physical version -Price of these products -More delicate/ less durable products

Both products have their own unique benefits, however could there be a product that integrated the capabilities of both into one?

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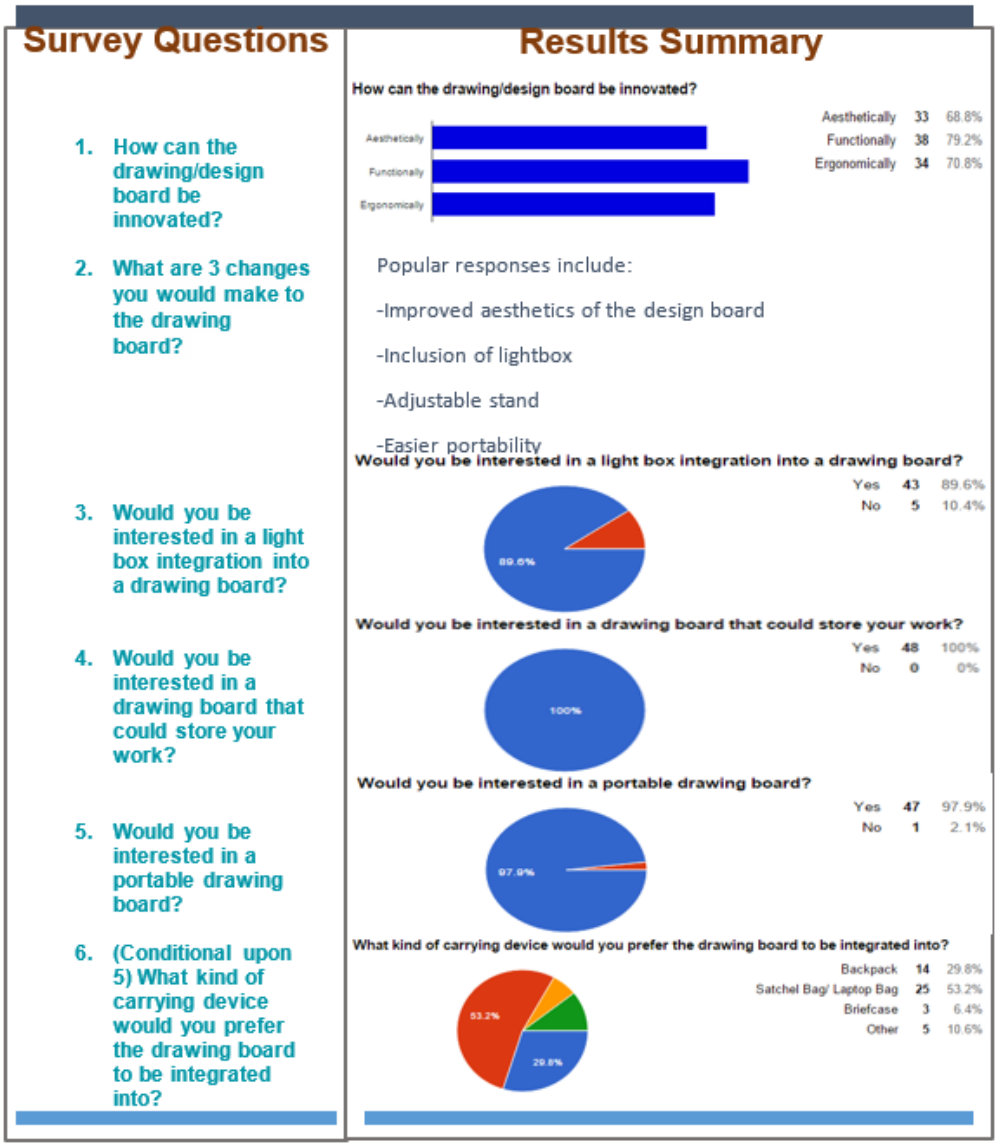
Design Problem: As a design student currently working with a physical design board, I find that designing “on the go” can be very difficult. Often times, countless additional tools other than the drawing board are required to work, including a lightbox, pencil holders, and additional storage for your work. Cases vary with every individual, but often, designers are forced to carry multiple components in order work. Additionally, as previously developed, the drawing board’s existing market shows a lack of electronic and physical capability integration. In certain cases, I would prefer having the flexibility of both capacities, but the lack of integration limit’s the user as they have to buy multiple products in order to have both capabilities. Some questions that I asked myself in experiencing my design discontent were…
Design Questions: How can elements of the Electronic and Physical Design Boards be integrated and innovated to create a superior product? How can the drawing board become more portable? How can the new, more portable design board encompass a breadth of design tools in order to prevent limitations of design “on the go”?

While all of these problems were relevant to me, I needed to ensure that other drawing board users experienced the same obstacles that I do so that I could identify whether there is a market opportunity.

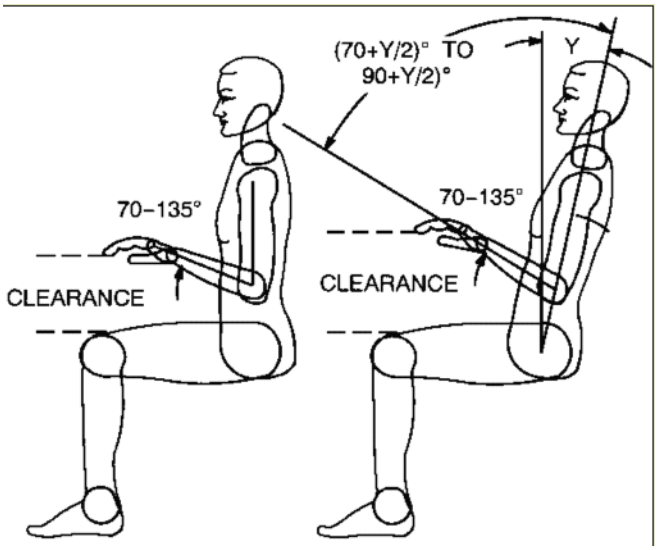
User Research:

I conducted research to understand what users want in a drawing board and what aspects they think can be improved in the product. To do this, a simple survey was conducted, targeted at design students. Forty eight responses were collected and taken under consideration.

According to my market segment of designers (prospective and rising designers), I can confirm that my peers agree with my discontents about the drawing board. 97.9% of the participants expressed that they wanted a more portable drawing board, and a large majority of participants sought a drawing board that could store and hold more design tools. The most preferred form of the portable drawing was the satchel. An interesting and important ergonomic consideration realized from the research was the “adjustable stand” element to the design, ensuring that users are comfortable at their working preferences.



To find out what the range of angles should be for the adjustable stand I decided to conduct some user biomechanical research. In ideal working conditions, “the forearm angle should be between 70+Y/2 [degrees] and 90 + Y/2 [degrees], where Y is the back angle from the vertical”, as exhibited by the ergonome in the drawing (ErgoTMC). This means that if the subject were to sit with a 90 degree posture then the angle made from the projected lines of their forarm and their spine should be beween 70 and 90 degrees. I will need to take this into consideration when building my adjustability features.



(ErgoTMC)

Other useful information from the same source emphasizes that working surfaces should have rounded edges to maintain the user’s physiological comfort.

To gain even more knowledge, I tried to get information from another segment of designers, (matured and educated designers). To do this I interviewed a design teacher at my school, Mr. H. In my interview, key issues that he brought up with the drawing board are as follows:

- The portable drawing board is really very awkward to fit into its case without clear indication of which way it should be stored.
- Inserting the drawing board wrongly can lead to the sliding rule breaking.
- There is no storage room for papers or drawing materials.
- The case is large and bulky yet very poorly constructed is not fit for purpose, gets crushed and deformed easily.
- 4 out of 10 boards bought last year have broken.
- The slide mechanism is not smooth
- The legs included for elevating the drawing board are difficult to detach and most have been lost due to them lying loose in the boxes.

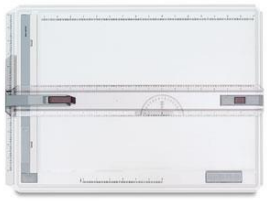
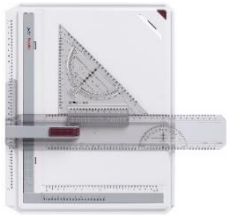
As seen above, most of the concerns brought up regard a lack of durability. This is very bad because this shortens the lifespan of the product, which is not environmentally responsible (it increases resource waste as more boards are thrown away in a shorter amount of time). Other issues listed above other than durability should be taken into consideration for my design specification, but since durability is such a prevalent issue, making my product durable will become one of the more important specifications.

<u>Key Research Findings:</u>

Users want a drawing board that

- Is portable
- Is durable
- Includes work and tool storage
- Is aesthetically pleasing
- Includes a lightboard/ lightbox
- Has adjustable working angles (A 70 to 90 degree angle from the spine to the forearm)

Market Research:

Product	Price	Dimensions	Pros	Cons
Blitz Translucent Drawing Board (A3) 	$135.75 (U.S Dollar)	16" × 21"	- Drawing board has a translucent surface that can easily be back-lit - Handle provides portability -Adjustable stand	- Simple design seems to be overpriced - External source need for backlighting
Martin Universal Design PEB Portable Drawing Board 	$116.99 $121.99 $126.99 $157.99 $167.99 $193.99 (U.S Dollar)	16" × 21" 18" × 24" 20" × 26" 23" × 31" 24" × 36" 31" × 42"	- Comes in a product family - Comes with a guided ruler - Melamine-composite drawing surface is excellent for drawing - Adjustable stand - Handle	- Simple design seems to be overpriced
Koh-I-Noor Portable Drawing Board (A3) 	$97.59 (U.S Dollar)	14 ¾" x 19 ½"	- Measurements included on board - Clips an hold paper down when being used - Railing system for the ruler - Attachment available (sold separately) - More elaborate ruler provided	- Only 2 working angles available - Not very "portable"
Rotring Rapid A4 Drawing Board 	£67.00 (British Pound)	40 x 31.4 x 5.2 cm	- Measurements included on board - Clips an hold paper down when being used - Railing system for the ruler - Triangle attachment included - Elaborate ruler provided	- Only 2 working angles available
Wacom Cintiq 22HD (A4) 	$1899.99	25.6 x 15.7 x 2.2 in	- Electronic features to enhance the design process - Sleek, aesthetic design - Multi-OS compatible system - External buttons offering quick design functions and actions - Adjustable stand	- More fragile than non-electronic boards - Very expensive compared to non-electronic boards

Dimensions are: (A4= 210 x 297 mm and A3= 297mm x 420mm)

Due to length restrictions, it is not possible to show all products that I have analyzed, so a few were chosen as examples for analysis.

After analyzing existing products on the market, I have come to discover that there are no integrated portable drawing boards. This is good news for my product, because it will be contributing something new could attract potential customers. Another finding was that all of the drawing boards existing look fairly indistinguishable, usually being flat white boards for the physical drawing boards, and flat black boards for their electronic counterparts. There is no character to the products, making them indistinguishable from one another. Regardless of the board being electronic or physical, all of the

drawing boards researched have been comprised of primarily plastic. Plastics are used because of their rapid processing in manufacture, their cheap costs, and their availability (since they are synthetic).

Market Statistics**:**

- Drawing board dimensions are typically: 16” x 21” (A3), and 12” x 15¼” (A4)
- Drawing boards average around 110 to 115 U.S dollars; my calculated average was $113.05. (There is little price difference between A4 and A3 products)
- Electronic drawing boards range from around an average $1999.95 (for the A3 equivalent), to around $1799.95 (for the A4 equivalent).

Design Brief:

Target Market: Current and prospective artists and designers, ages 14-65, who would benefit from a product that facilitates portable design.

Goal: Design a physical and electronic drawing board that is integrated into a portable device that aims to make portable design easier.

I will be making an electronic and physical drawing board hybrid that will include several design tools in order to facilitate both “on the go” and stationary design, (the portable aspect of the design will not impede on the traditional stationary design setting).

The device will be easily portable using an integration with a carrying device (such as a backpack, or satchel). The primary purposes will be to solve the previously stated issues of design “on the go”, and to create an all in one device that will satisfy more needs of the user. This means that it will have to be relatively lightweight, tough, and waterproof.

The secondary focus is the inclusion of components from both physical and electronic design boards. Currently there is a market gap of electronic, and physical drawing board hybrids; I believe that I could bridge this gap as a designer.

Lastly I will need to satisfy user demands: the product should also be aesthetically pleasing, durable, include work storage, and should include ergonomic working considerations. These were the major issues brought up in the user research so solving these issues would lead to a product that consumers would enjoy more.

I will be opting to design an A4 drawing board because in a portable setting, A4 takes up less space, will weigh less, and will be less of a hassle for the user to carry with them. This would leave more potential for the design to succeed.

Designing an integrated product is a feasible approach to me. Because there are existing products on the market which hold relevant aspects of the drawing board design, all I have to do is study the positives of each of the products on the market and filter out the negatives of each design. The greatest indicator of what these negatives or areas of improvement are comes from my user research. Therefor because I have all of the resources needed to create an innovative product, I believe that the project is feasible.

Market Specifications:

Target Market: Designer and artists

Target Audience: Prospective and current professional designers and artists.

The primary audience to this product would be both serious designers and artists. These two types of individuals would benefit the most out of this innovation as the product seeks to tackle issues most directly related to their occupations.

Prospective Designer/Artists	**Professional Designers/Artist**
Ages: 14-21	22-65
High school and college designers	Workforce designers
Live an active lifestyle going to and from their educational institutions and extracurricular activities.	Live a more sedentary lifestyle as they are more committed to their design occupations.
Have more opportunities for design “on the go” as a result of their active lifestyle.	Are more committed to design compared to prospective designers, and therefore could also benefit from the option of design “on the go”
Portability is a large concern for them	
Both benefit from a physical and electronic board integration	

Price target: $1999

I have come up with this price range through the market research I had done earlier. According to the physical drawing board prices, the average price per product is $113.05. For A4 electronic boards, the average is 1799.95. Since my design plans to integrate the two products. I decided to add the average cost of the electronic board to the average cost of the physical board. This equates to $1913. For simplicity I rounded the product up to $1999.

The target audience would be willing to pay this price as it is not an extreme difference from the price of the electronic board. Professionals are willing to pay if they take their job seriously. There are no other competitor products such as this one therefore a price cannot be based off of existing products.

To test this price, I decided to conduct a survey with 23 prospective designers and 18 professional, or high level designers. After pitching the idea to them I collected an approval survey to find out how many would actually pay the price given above. 17 out of 23 prospective, and 16 out of 18 professionals said that they would pay within the around the price given. This means that there is an 80% agreement on the price of the product, which is acceptable. It is important to note that the majority of the individuals who did agree to the price range emphasized that they would not pay much over this price.

Because of this I should limit my product to the $1999 price point. In addition, because there is a younger demographic involved in the target, increasing the price point would impact their sale

significantly. The younger demographic is not affluent, meaning they do not spend their own money, rather their parent's money, so they are less inclined to pay more.

Market analysis:

Possitively and negatively, the market for drawing boards is not very big. This is because the art and design community is very niche, and out of that demographic, not all will want or need to purchase a drawing board. A negative consiquence of this is that there is less information out there to collect in terms of statistics and prior research. This means that there is more of a risk when entering the market. Another consiquence is that there is a lower consumer population for drawing boards, meaning profit might be limmited by the number of customers that are available. Conversely, because the market is relatively small, I would be able to attain a higher market share for my product more quickly in the drawing board market relative to other markets. Additionally, because I am targeting a niche community, there is more opportunity for loyalty. There are less consumers, meaning it is easier to build a loyal customer culture. I need to do this through effective branding, ensuring that my company is a dependable, familiar company that buyers can trust. From what I have seen, there is no established name or brand in the drawing board market.

Competition:

My main competition is other electronic drawing boards. The reason why these are my main counterpart is because electronic boards simply offer more capabilities than the physical drawing boards. While physical drawing boards are unique in the physical tools that they offer such as an easy-to-use guided ruler system, electronic boards simply have more utility. My drawing board has an edge over the competition because of the added benefits of the physcial drawing boards and it's portable design.

My price point of $1999 is also very close to that of the average A4 electronic drawing board ($1799.95). With my unique added advantages, this means that users are getting more value for their money which contributes to why consumers might choose my product over others. The design therefore must succeed in the integration of a portable device and the physical features of physical drawing board.

User Needs (Essential requirements):

- A portable product
- A durable product
- A product that includes work and tool storage
- A product that is aesthetically pleasing
- A product that includes a lightboard/ lightbox
- A product that has adjustable working angles (A 70 to 90 degree angle from the spine to the forearm)

Design Specifications:

1 - Human Factors and Ergonomics

1.1– The product has adjustable working angles (A 70 to 90 degree angle from the spine to the forearm).
Justification: Every user has individual and unique preferences for their optimal working angles.

1.2- The drawing board surface and edge is textured smoothly.
Justification: When designing users have to rest their arms on the board, if the board surface is not comfortable for the arm, user will experience physiological discomfort.

2 – Sustainability

2.1- Design is aligned with triple bottom line sustainability concepts.

Justification: Designs must be environmentally, socially, and economically sustainable to maximize its success and optimize its impact on society.

2.2- Product is designed for disassembly.

Justification: Design for disassembly extends the product's lifespan by offering opportunities for repair. It also ensures that materials can be separated more easily for processes such as recycling at the end of the product's life cycle.

2.3- The design is appropriately dematerialized.

Justification: Environmental impact can be minimized by the reducing the amount of unnecessary material needed, hence saving resources.

2.4- The design is durable.

Justification: To eliminate unnecessary waste from disposal, the design should maximize its lifespan. A lifespan to aspire to would be 10 years.

3 Materials and Aesthetics

3.1- Design show potential for variations in pattern, material, or color on the board's exterior.

Justification: Users want design boards to include aesthetic appeals.

3.2- Design is smooth and sleek in form.

Justification: Users should be comfortable with the products appearance when utilizing it.

3.3- The materials should express a sense of quality.

Justification: Since the target audience consists of design professionals, these individuals will need a product that expresses quality.

4 Market

4.1- The product suits the needs of the target market: designers and artists.

Justification: If the product does not suit the needs of the target market, the design is useless.

4.2- The product suits the needs of the target audience: college design students, high school design students, and professional designers.

Justification: If the product does not suit the needs of the target audience, the design is useless.

4.3- The product is within the price range of $1999 or below.

Justification: The product should be in this price range as it suits the professional demographic. This price also represents an appropriate price for an electric and physical design combination.

5 Classic Design

5.1- Aesthetics and form contribute to a design that seems to be timeless.

Justification: Profit making is benefited by a product that consistently sells.

5.2- Elements of the design contribute to preventing the product's obsolescence.

Justification: Profit making is benefited by a product that consistently sells.

6 Sustainable production

6.1- Design is comprised of renewable and sustainable materials.

Justification: Sustainable materials reduce resource depletion and thus reduce environmental impact. Because these resources are easily renewed production does not suffer from an absence or unavailability of materials.

7 Commercial Production

7.1- The design ensures that commercial production is feasible.

Justification: Without a working production plan, the product cannot be assembled efficiently.

8 User Centered Design

8.1- Design is intuitive.

Justification: Product usability needs to be optimized for maximum user satisfaction.

8.2- Design is integrated into a carrying device.

Justification: Research shows that portability is a user demand; this integration accommodates for this user demand.

8.3- Electronic surface must be luminous enough to act as a light box.

Justification: User's want a lightbox in the design. The electronic surface can act as this, although considerations of brightness will have to be made in order to ensure that the surface works.

8.4- Design incorporates work and tool storage into the product.

Justification: According to research, users want work storage ability in the product. Work storage is necessary for portable design, yet access to design tools is too, therefore both storage areas should be incorporated into the design.

9 Technical Requirements

9.1- Design incorporates technological functions of the electronic drawing board and physical tools of the conventional drawing board.

Justification: To make a superior product, flexibility of digital and physical design should be incorporated, giving a designer a multitude of working options.

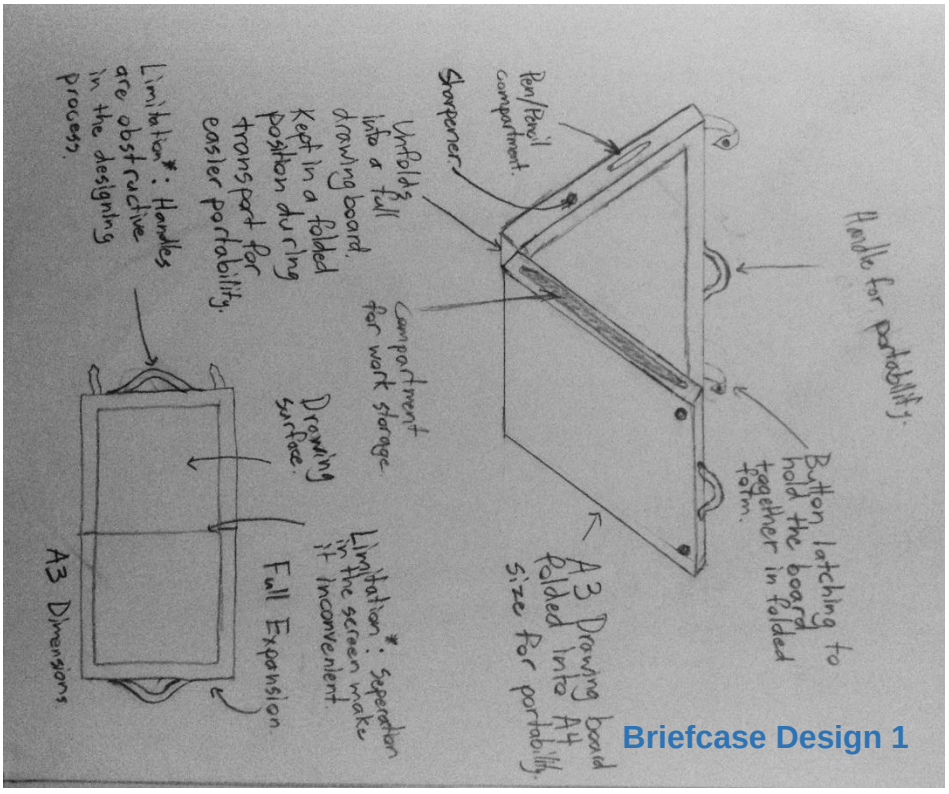
9.2- Electronic screen is capable of acting as a working surface for physical work.

Justification: When working with a traditional pencil and paper, the surface must be durable enough to resist scratching and other potential afflictions.

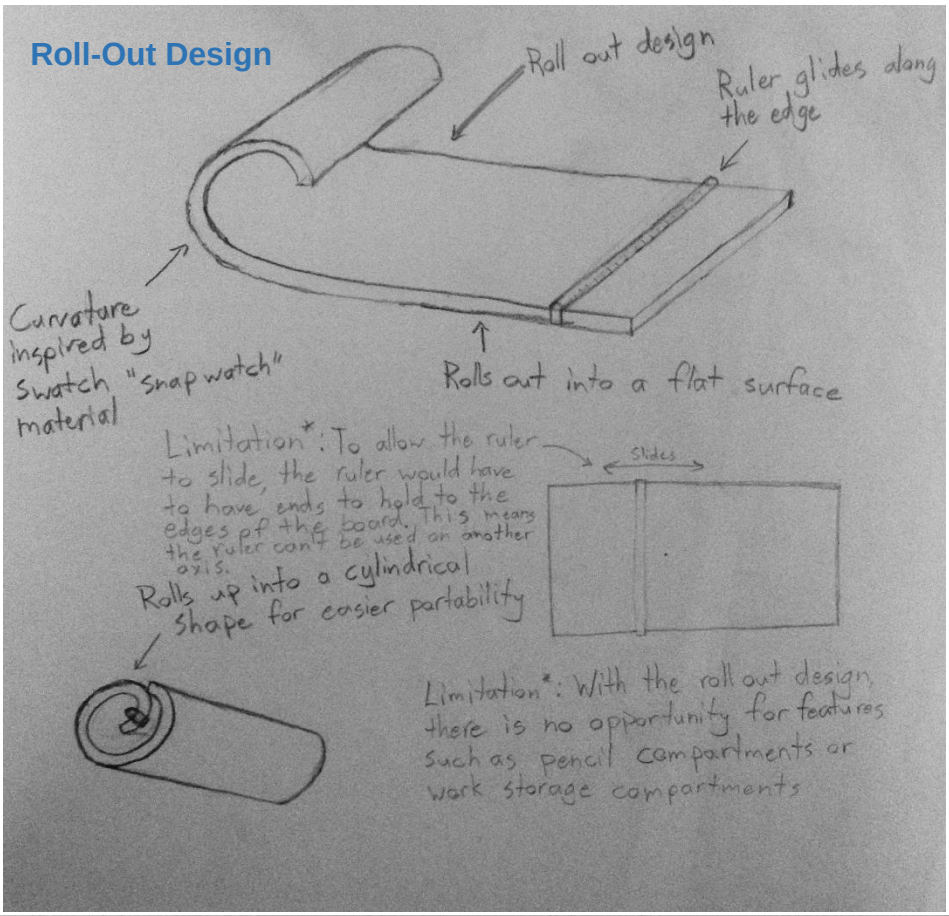
Conceptual Design

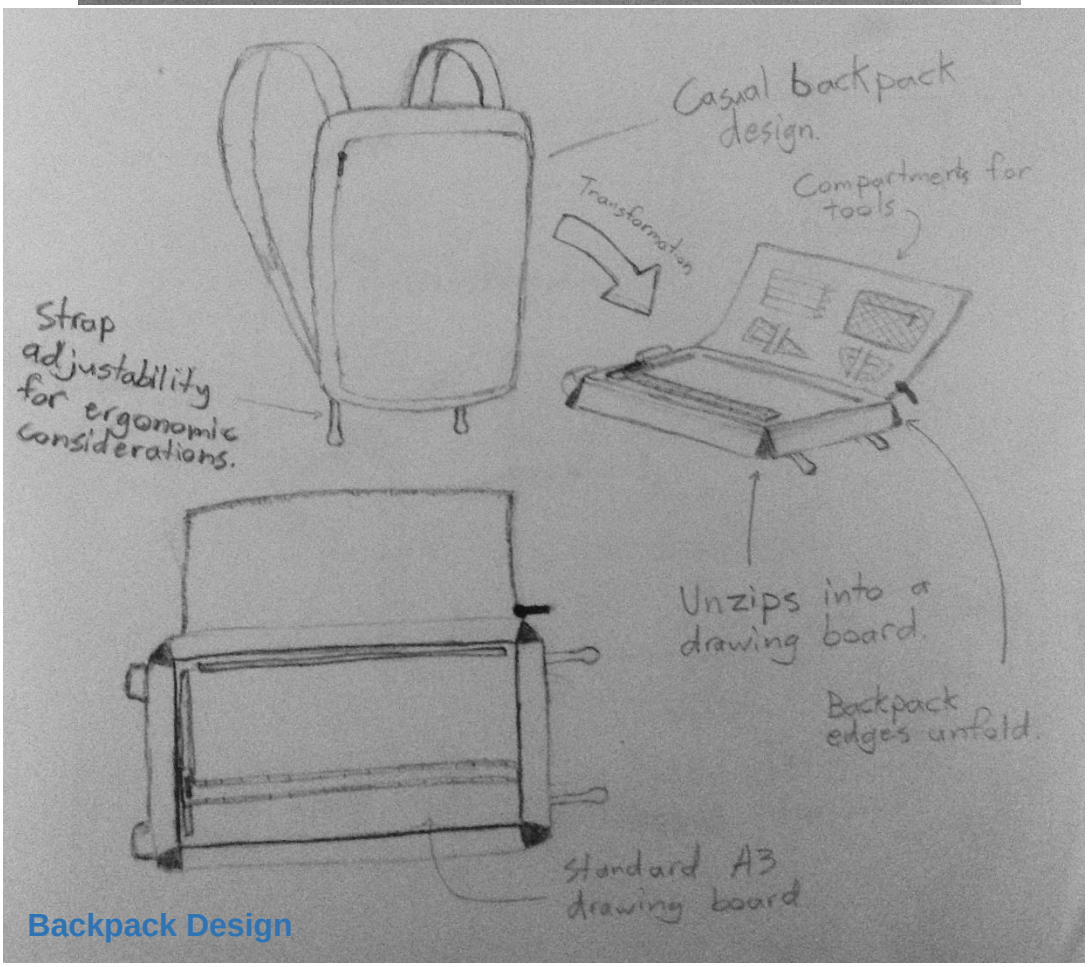
In this section, a series of six preliminary designs will be drafted. Each of these six designs will be evaluated under design specifications. Since specifications one, four and five are the only ones capable of evaluation at the sketching stage, these will be used. Additionally, each of the designs' strengths and weaknesses will be highlighted to gain a more encompassing perception of each design. Based off of the designs, three of the strongest ones will be chosen for development. More thought will go into the feasibility of each design, along with considerations that could be made in order to fulfill the design specifications. To aid reflection and visualization of these designs, small scale paper models will be made for each. Based off of the three developed designs, one will be chosen to take forward to prototyping stages. A rendered CAD model will be made for this final design.

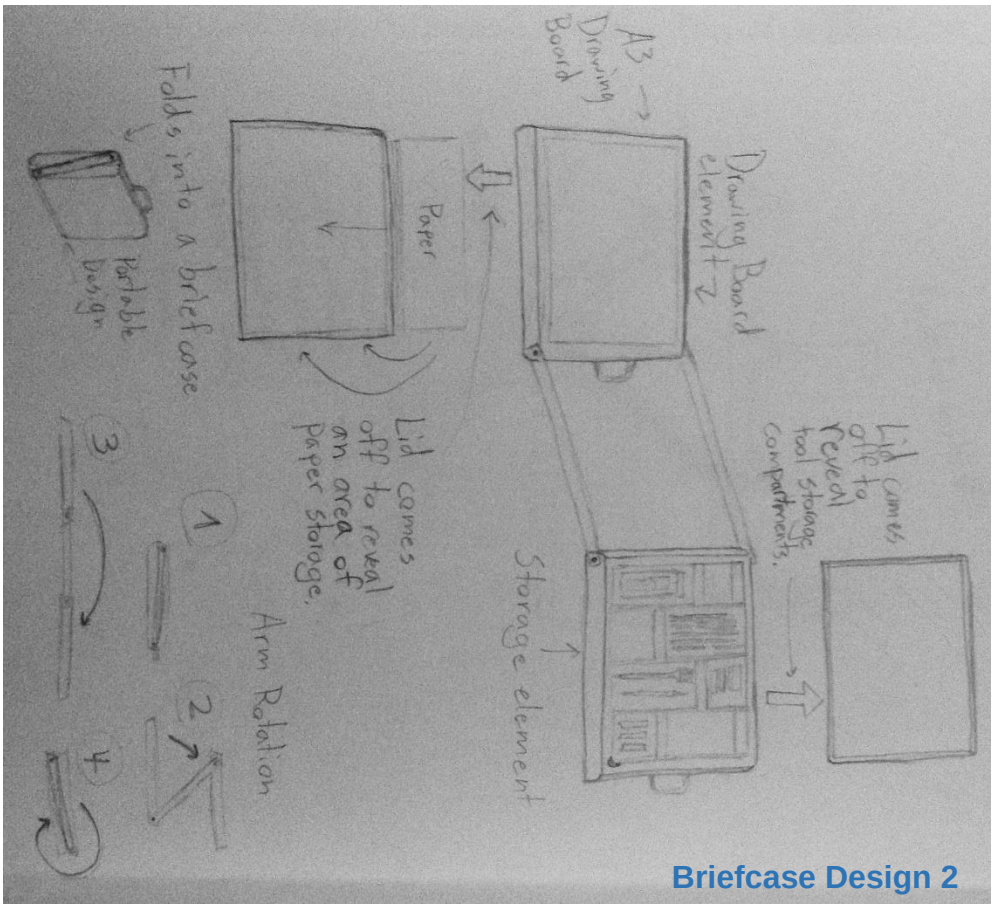
Designs:



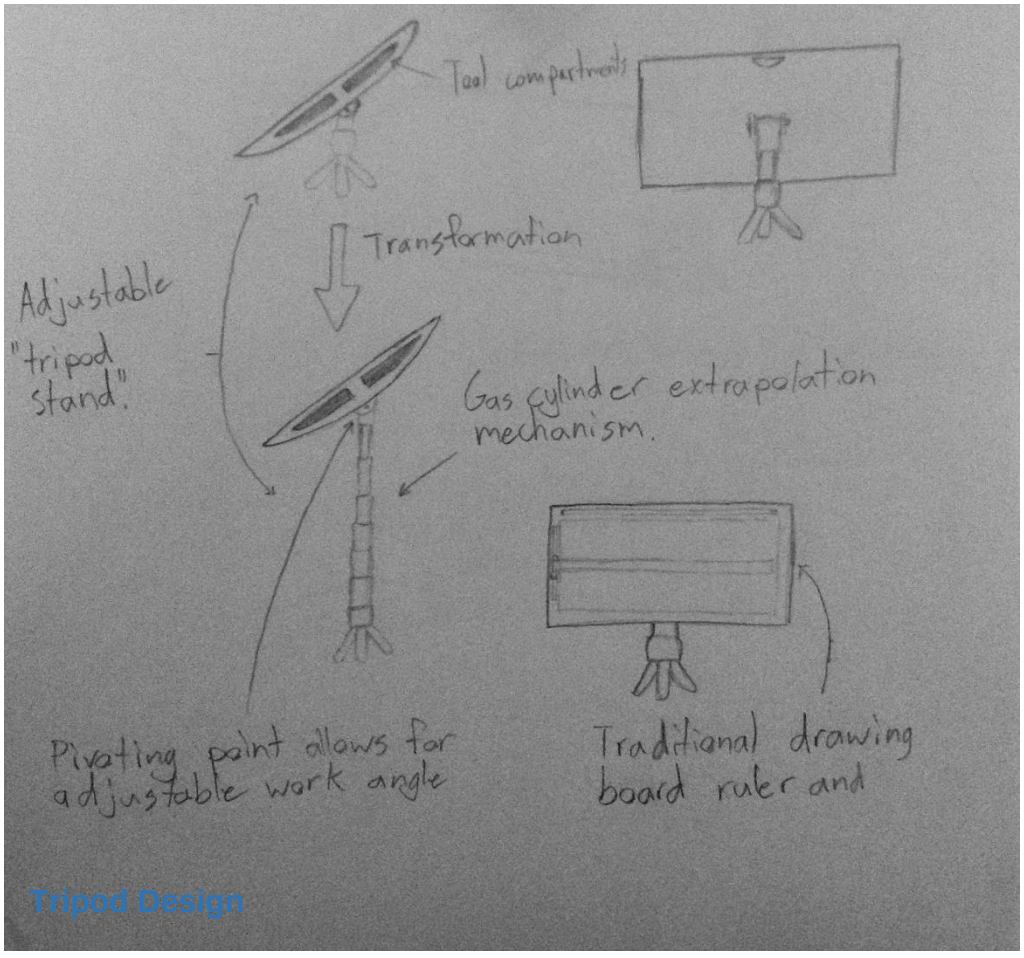
Briefcase Design 1


Roll-Out Design
Roll out design
Ruler glides along the edge
Curvature inspired by Swatch "Snapwatch" material
Rolls out into a flat surface
Limitation*: To allow the ruler to slide, the ruler would have to have ends to hold to the edges of the board. This means the ruler can't be used on another axis.
Slides
Rolls up into a cylindrical shape for easier portability
Limitation*: With the roll out design there is no opportunity for features such as pencil compartments or work storage compartments

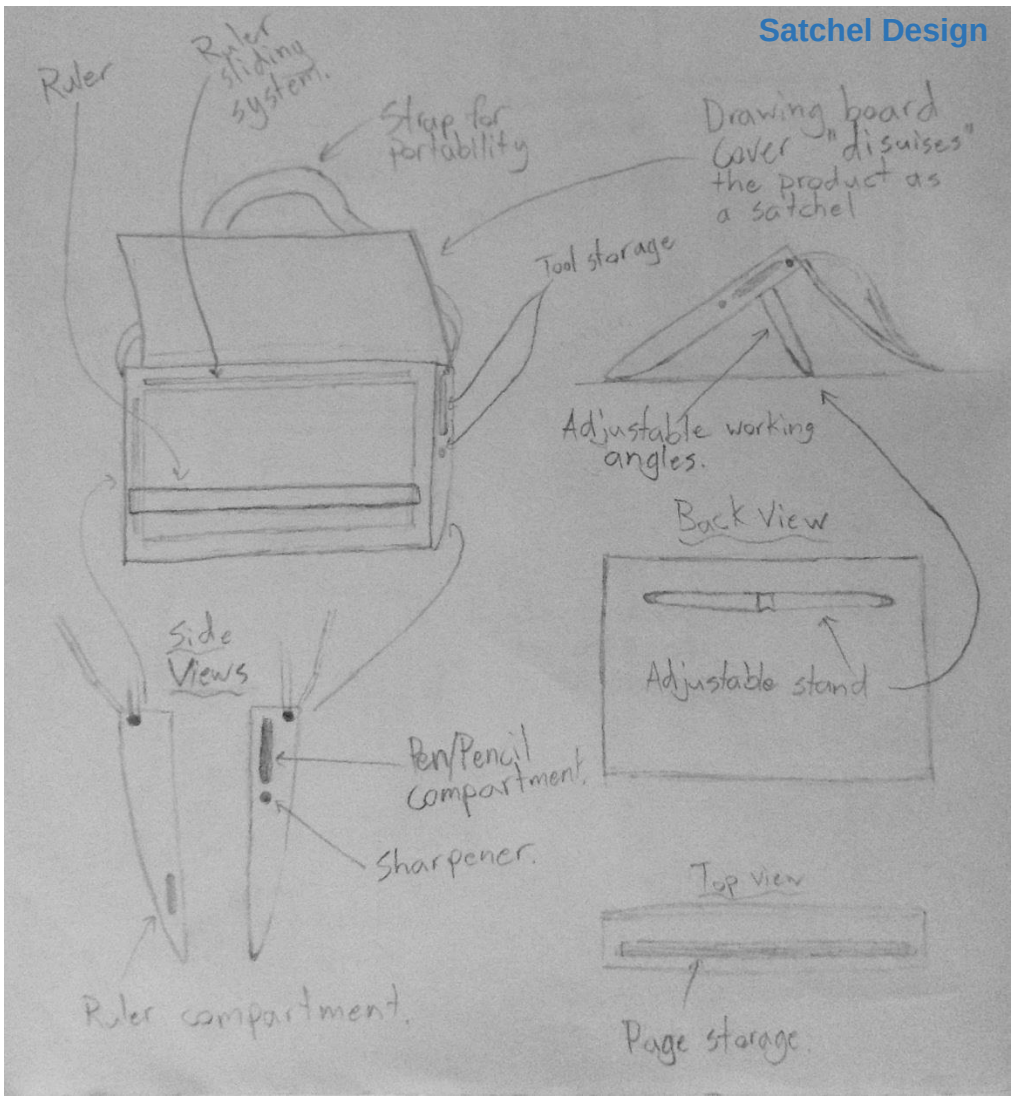

Casual backpack design.
Compartments for tools
Transformation
Strap adjustability for ergonomic considerations.
Unzips into a drawing board.
Backpack edges unfold.
Standard A3 drawing board
Backpack Design



Briefcase Design 2



Tripod Design



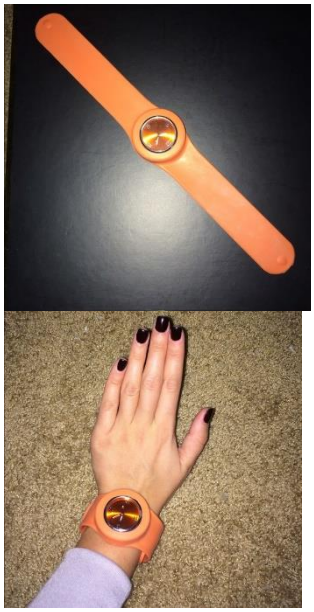
Briefcase Design 1:

This design modifies the A3 drawing board splitting it into two. The two splits are attached to one another with a hinge. The hinge allows each side to fold up into a briefcase like configuration.

Strengths: It's indistinguishability from of a suitcase gives creates a less radical design which users might feel more inclined to purchase because of their preexisting comforts with briefcase designs. The design also provides adequate special possibilities for tool storage.

Weaknesses: The design's split in in the drawing board possess some big issues with usability and design criteria. Since the design is an A3 drawing board, the split means that flat page storage is limited to A4 paper, (half the size of A3 paper), within one half of the briefcase. This poses problems for users who desire to use sheets larger than A4 in a portable design environment. The split also creates a small separation crevasse in the drawing board surface that could interfere with design processes such as drawing. As one of the design specification emphasizes electronic components in the design, the split causes additional problems for electrical connections between both sides, as the hinges are the only points of contact.

Roll-Out Design:



(Cassbowmann)

This design is based of swatch “snap watch” material, a material that can contort into a cylindrical shape but also has the ability to snap into a flat surface. A ruler, inspired by the “Martin Universal Design PEB Portable Drawing Board”, clings to the side to facilitate aid in the design process.

Strengths: The roll-out material poses a solution to portability whilst creating a unique, radical design. Additionally unique clinging ruler is an installed tool to the board, therefore potential for its loss is eliminated.

Weaknesses: The biggest weakness is the materials real life feasibility. Whilst the material works for the snap watch, there is no indication that it will work on a larger scale for a drawing board. Furthermore, the actual name of the material cannot be found which renders manufacture impossible. The design also has no potential for electronic board integration, no work storage, no adjustability, and is not integrated into a carrying device.

Tripod Design:

This design is inspired by a tripod. With a tripod base, the board can be easily adjusted vertically, can be pivoted for adjustable working angles, and can be rotated around the axis of the tripod stem.

Strengths: Because this design is meant to be stationary, the board has less limitations concerning its weight. This means that there is more opportunity to increase the board’s volume, an advantage that could be utilized to fit in more electrical components, or more space for work storage.

Weaknesses: If the board topples over, the board could be damaged, therefore the base would have to be large. With a tripod base that is large, however, the user might feel inconvenienced with the amount of space that the board is taking. For example, if the board were located on a desk, there would be less room for other items such as a computer monitor, books, or a keyboard. Another major flaw of the design is that it fails to satisfy one of the most important design specifications: 8.2- Design is integrated into a carrying device. Integrating the product into a carrying device is both one of the specifications that has inspired this project, and a specification that research has proven is in demand. Without accomplishing this, the board wouldn’t be innovating the drawing board design.

Backpack Design:

This design is one integrated into a backpack. The drawing board can be accessed by unzipping peeling the front face of the cover away. Tool storage can be accessed on the inside of the front face of the backpack.

Strengths: Unlike the other designs thus far, the backpack offers adjustability as a carrying device. With adjustable straps, the design suits a range of upper body anthropometrical measures, ranging from 5th to 95th percentile users. The inside of the back also offers a good amount of space for tool storage, a useful strength when designing. The fact that the drawing board is disguised as a drawing board also de-radicalizes the design, making it more of an established and normal design.

Weaknesses: The fact that the backpack fits, an A3 drawing board into its back means that the backpack will be rigid in structure. If the backpack is rigid in structure, users are more susceptible to physiological stress, as the form of the back is not naturally a straight line. In a biomechanical sense, the back moves slightly as the shoulder blades shift during the walking process. This would lead to

oscillating contact between areas of the back and the backpack, creating discomfort for the user. The square-like nature of the drawing board within the backpack will also contribute to the shape of the backpack. With the board as a skeleton, the backpack would be forced into a box-like form, an irregular and unappealing shape for a backpack. Finally, and most importantly, the design fails ergonomic specifications as the backpack does not offer adjustable working angles.

Briefcase Design 2:

This design was inspired by a tackle box. A design that is inconspicuous as a briefcase, but folds out to reveal a product with two sections: one with work storage and a design board, and the other with tool storage.

Strengths: The design is less radical, taking shape as a briefcase; because of this, the market audience is more likely to purchase a design that they are comfortable with. The design also allocates a good amount of space for tool and work storage.

Weaknesses: The rotation of the swinging arm to reveal the two sections could require a large amount of space. In the context of portable design this could be a very big issue. For example, if one wants to design while seated within an airplane, the designer would likely have to invade another passenger's space to be able to rotate the arm fully, inconveniencing both the designer and the other passenger. Furthermore, the design does not satisfy the ergonomic considerations in working angles.

Satchel Design:

This A4 drawing board is integrated into a satchel carrying device that considers tool storage, work storage, as well as room for electrical components.

Strengths: This design has the similar case as the other carrying device designs; the design is not radical, as it emulates the classic satchel design. This satchel design also comes with the benefit of 5^{th} to 95^{th} percentile strap adjustability, and a front satchel type cover that preserves the drawing board's surface. Finally, the board satisfies key specifications in work and tool storage, as well as adjustable work angles.

Weaknesses: Fitting work storage, tool storage, and electronic drawing board components in this one body would be hard to achieve as the components would have to be compact, fitting closely together. If a compact design cannot be achieve then the product will have to take up more volume, which would be inconvenient for users in a portable sense, as well as in an aesthetic form (the satchel would be more clunky).

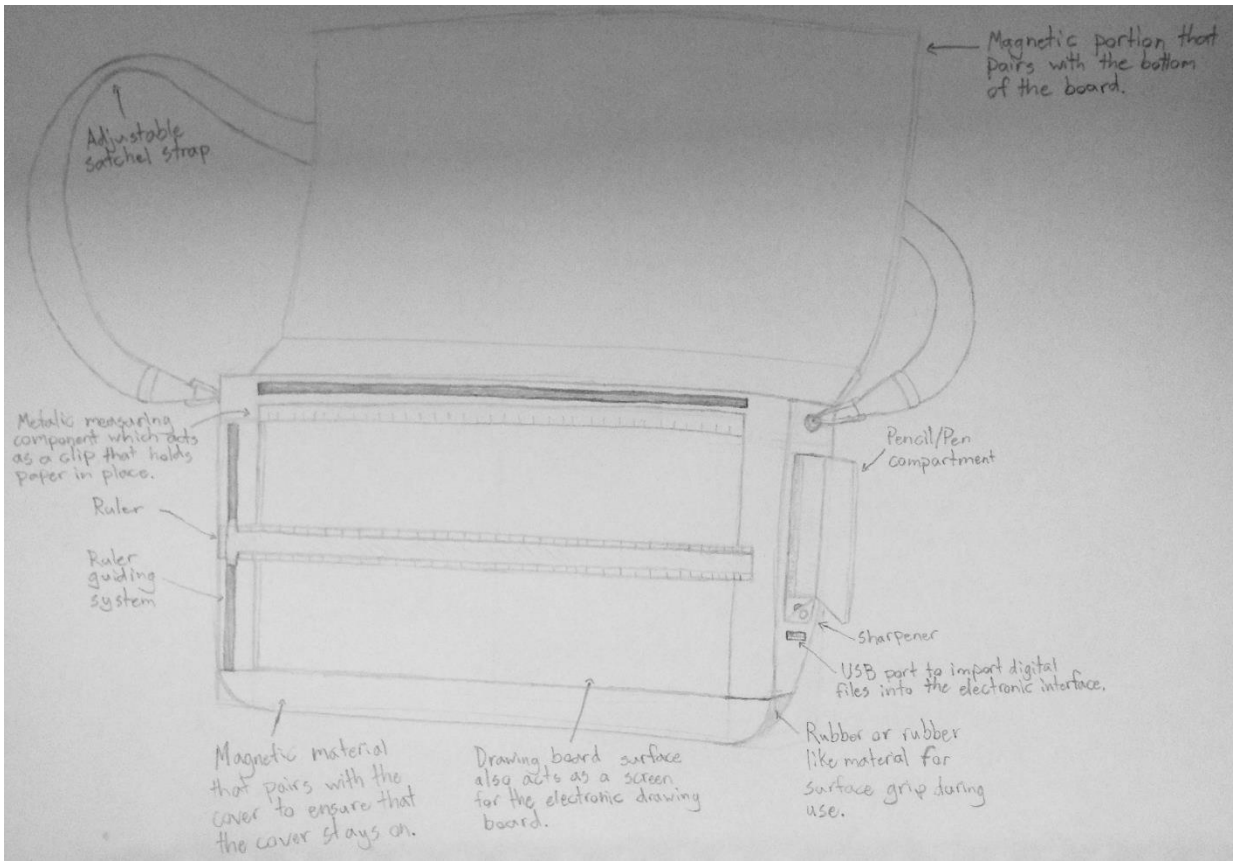
Chosen Design:

Satchel Design

This Design seems to satisfy all of the key specifications that have actually inspired this project. On top of this, the design's strengths seem to outweigh its weaknesses, which is a good sign for the product. Key strengths of the design are:

- Its non-radical design; (it visually appears as a satchel, an established, existing product).
- Its possession of work and tool storage.
- Its 5^{th} to 95^{th} percentile strap adjustability.
- Adjustable work angles

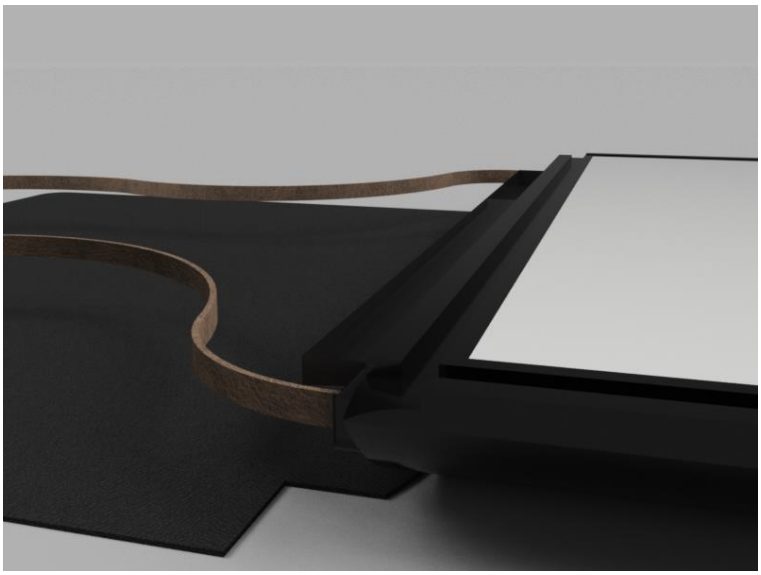
Refined Concept:

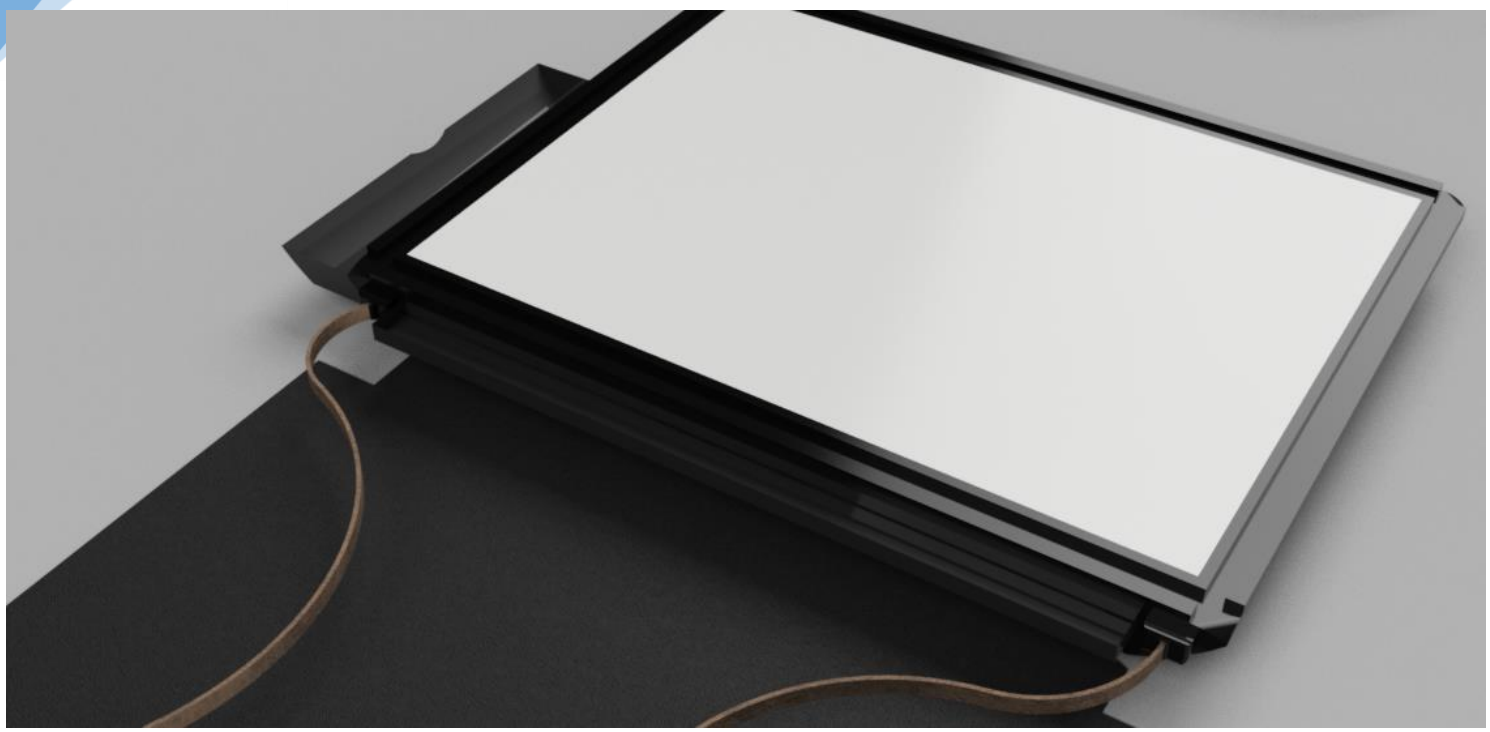


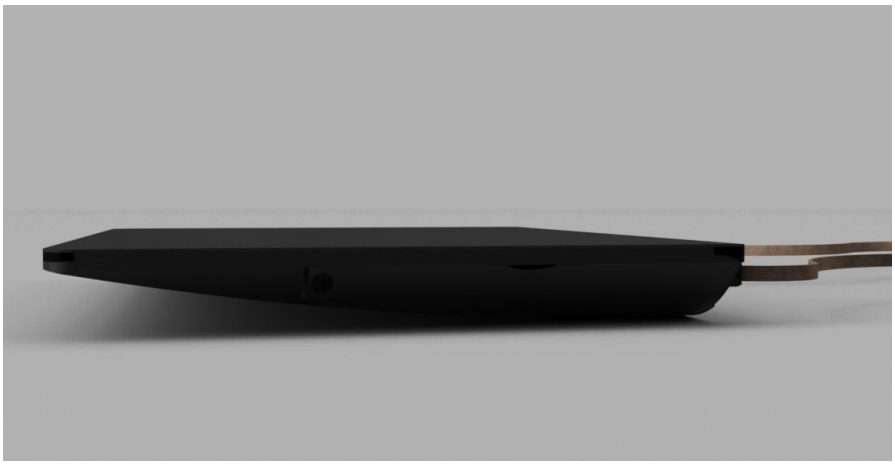
Now that I have chosen my design concept, to help me develop and better visualize my design, a CAD model will be created and evaluated.

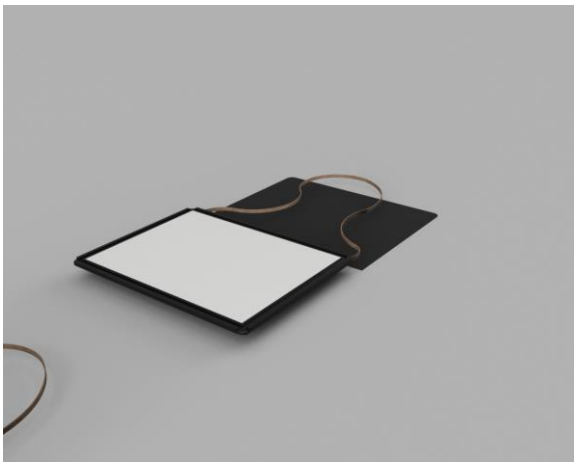
CAD Model:

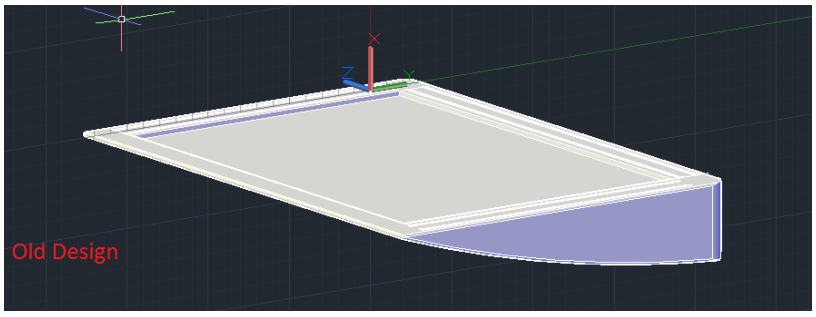
(Made in AutoCAD and Fusion 360)











In the process of creating the CAD modelling, I tried to make the model have realistic dimensions so I could use it as an aid in the process of prototyping. The process of inputting realistic dimensions highlighted some issues with my ideas. Fist of all, I would want to incorporate an electronic interface into my design, the board would be massive (volumetrically). This did not allow for the product to look sleak and aesthetically appealing as I want it to. But aesthetics were not the only issue with the interface. Thinking about the electronics made me realize how unreasonable they were in a project at this scale. As seen in the market research, electronic boards are very expensive, and as a high school designer, the institution and other funders would not be willing to give me a budged high enough to invest in these electronic interfaces. In reconsidering my design, I am making the following ammendments:

Design Specifications:

~~9.1- Design incorporates aspects technological functions of the electronic drawing board and physical tools of the conventional drawing board.~~ (The board will now only have a lightbox surface and the electronic interfaces will be removed).

Market Specifications:

Price Ranges/Limitations: ~~$1999~~

Since the board will not be including electronic components, the new price point will be significantly reduced. The price will still be more expensive that the traditional drawing board, however the main difference in price now would be the cost of the lightbox. Current market prices for lightboxes are around $40 - $70, so I will be adding this to the common $115 price of the traditional drawing board.

New Price Ranges/Limitations: $155-185

Target Audience: Prospective ~~and current professional~~ designers and artists.

Because the board is losing its electronic interfaces, I feel that this would be a major negative for professional designers and artists because these individuals are the ones more likely to need the advanced capabilities offered by the electronics. Also, as I reconsider my audience, professionals are less likely to benefit from the portable design offered by the product. These people usually occupy a job, where they do most of their designing at work in a stationary environment. I'm now going to narrow my audience to prospective high-school to college designers (14-21) who are more active and mobile in lifestyle and are more likely to benefit from the product.

To test this price range, I surveyed 24 prospective designers and artists to see whether they would pay in the range. 22 agreed to pay within these amount of money. 91% of participants therefore agreed. From the people that agreed, I asked them the exact price that they would pay. The average of these responses was close to $160. In the marketing section, if I calculate that I am able to make a reasonable profit with a price of $160, I will likely make that the price of the product.

After realizing that dimensions that might seem appropriate when thought out could be unsuitable in a 3 dimensional setting, (from my experiences with the CAD model), I decided to gain a sense of the product's new dimensions in reality, I shall make a physical model of the design. Because I live in Tanzania, modeling materials are very limited. My best option is to make a model out of foam because the material is accessible, able to be manipulated easily, and is inexpensive. To test its dimensions, I will be making a 1 to 1 model. This construction will be purely to get a sense of the way the board takes up space in the real world before I make the real product.

Unfortunately, the construction of the model was relatively poor. This is because we did not have the necessary pieces of foam that I once thought we did. On top of this, I was not using a high fidelity "blue foam", but rather a cheaper, lower fidelity foam. This means that I could not shape the board to the amount of detail that I wanted to. The foam here in Tanzania is most accessible as a reused material from packaging, therefore the foam that I used was dirty and in poor condition. To mask

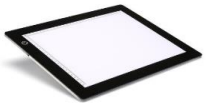
imperfection, I tried to coat the foam and glue over a layer of polystyrene; unfortunately the layer was not able to stick to the foam well. Despite all of these limitation, the low fidelity model did inform me about the dimension of the drawing board in space. I was happy at its size and could see it fitting well as the body of a satchel.

Design Development

Prototype Materials and Components:

In order to produce the prototype for my product, I will need to choose the most appropriate materials relative to the resources I have accessible to me.

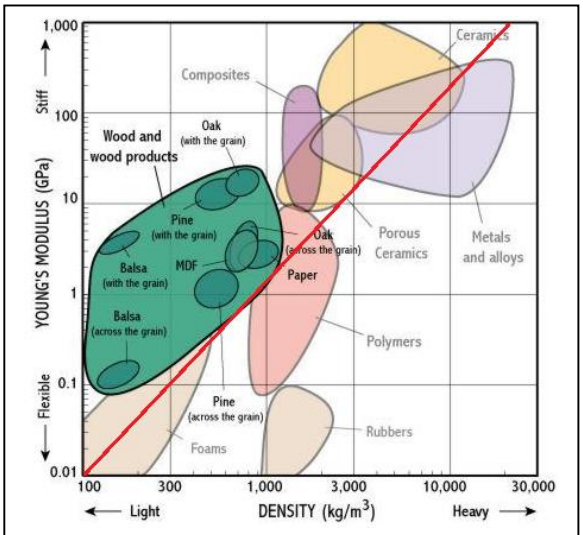
Light board: After doing a lot of research around creating a light board/box. The most promising item that I could find was the LED light panel. Unfortunately light panels that I found were not the appropriate dimensions for an A4 light box. After running into this problem, I researched A4 light boards on the market and these seemed like more promising options. Not only were they built for A4 use but they would be available to me at a fraction of the cost compared to me trying to work with the bare LED panels. I decided on this "Xcellent Global A4 LED Bright Tracing Board".



(Xcellent Global)

Battery: Since the lightboard does not have a built in battery, this means that the board would need to be hooked up to a separate power supply. According to the specifications given by the lightboard, it takes 5V. I was able to get my hands 5V, 5000 mAh rechargeable battery which would be able to power the board for 3 hours on a full charge. On par with laptop battery life, 3 hours of life should be sufficient for a lightboard. To hook up the battery to the lightboard, I'm going to solder the USB cables (Out) to the board's wiring. However, I will not touch the micro USB cable (In) because I will need it as the recharging port.

MDF: Since the body is a complex shape I will need to be using materials that can be machined and formed. My initial consideration was thermoset plastics, because they can be relatively light, meaning the user would experience a lower amount of physical fatigue. But with the schools facilities, I do not have the machinery needed in order to form a complex shape out of thermosets. After this realization, I have decided to jump straight to a material that I know my laboratory has the ability to work with. With wood, I will be able to carve out as well as subtract any unnecessary materials for dematerialization. Woods also have a relatively high stiffness compared to their density, this means that the body lighter whilst more durable than other potential material options. So even though the material is not the one I envision, it has some merits for selection. In a commercial production situation I envision using a black thermoset for reasons I will discuss in the next section; and with this envisioning, I will be using MDF as my wood because I would be painting a black color over the material. There is no point in using a more expensive wood, since the final look would look undistinguishable. With MDF, I am using the most workable, and inexpensive material available to me. MDF is also a manmade timber, recycled from waste, so its use has little to



(University of Cambridge)

no environmental consequences. Some consequences of this would be the weight of the prototype. Relative to other carrying device materials, wood is a heavy material, even with the process of dematerialization, but since this is prototype there some sacrifices in performance are necessary.

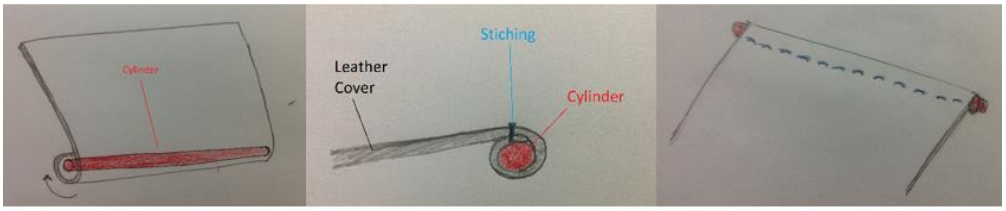
"Laud" "Modest"

(Fink)

Car Filler and Paint: When I coat the MDF I will be using a car filler which will make the wood glossy, impermeable and will remove any imperfections in the wood, which are all characteristics that I desire for my product. Impermeability is crucial to this product because the product not only holds precious work, but also a light board, and in portable situation, environmental factors such as instances of rain or snow could create problems for the product if they are not properly accounted for. I also will apply a car black paint after the filler because naturally bonds well with the initial coating. I want the design to be modest, and not too "laud" with color, so I will be using a dark pallet. Using a black body also hides scratch marks and other withering that could occur to the body, which makes the color choice great for prolonging the products lifespan, thus reducing environmental impact.

Leather: For the cover of the board, I will need a material that is aesthetically pleasing as well as impermeable. The best option to meet this requirement, in my mind, is leather. On top of fulfilling impermeability, I chose leather because is a timeless material, meaning it has remained aesthetically pleasing to a majority of people throughout generations. It will provide elements of classic design to the board, and will also suit the professionalism that I am trying to achieve. To help and support the local market, I decided to find a leather supplier within Dar Es Salaam (where I live). Upon contacting them I was offered a range of options (on the right). I chose the brown-red leather, (the second to the bottom), because I wanted a modest and "cool" color. I did not choose black because a monochromatic color scheme would be boring visually. The small color change also effective in sperating my board from the rest of the white or black drawing boards.

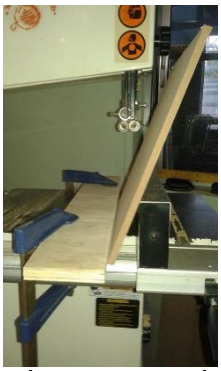
I am going to need a point to fix or attach the leather to the body of the board. So I am choosing to loop the fabric around a smooth metal cylinder, (to reduce fiction in the circumvention of the material around the cylinder), and attach the cylinder to the body. By using a cylinder the leather cover pivoted off the surface and put back on with ease. In looping the leather, I am going to stich the leather together to make a complete loop around the cylinder so that the cover is fixed.

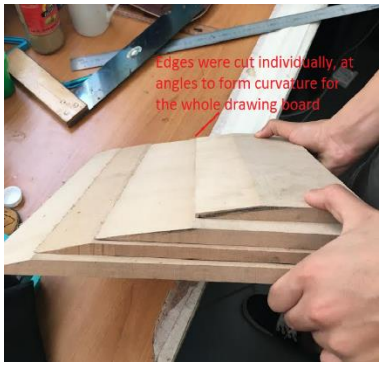


Thread: For this I will need a black, bonded, size #69 thread. I am using bonded thread because non-bonded threads tend to unravel, split and can cause difficulties in the stitching process. I'm using a black thread to match the rest of the board, maintaining the same color palette. And I am using a size #69 because it will give me an emboldened, defined stitch across the leather, without being too big of a thread size.

Strap: To make the protype I am not making my own strap; instread, I am using an old strap from an old camera that I was able to find. I am using this strap because it is cushioned and is adjustable to 5th to 95th percentiles. With both of these elements to the strap, this componet does well in incorperating egonomic consideration in my product.

Prototype Manufacturing Techniques:





Cutting: As said before the MDF body that I will be creating requires considerable amounts of subtraction in order to achieve the product that I desire. The MDF layers will all have to be cut on their edges and sanded to achieve a sleek curve. For this stage, I will be using a band-saw to cut the edges, using a system that I created that allows me to cut the wood at angles. The reason why I am cutting the layers as oppose to directly sanding the wood to a curve is so that I can save time, (subtracting larger chunks of wood is possible with the saw), and so that I have a body that is closer to the final shape that I can use as a guide for sanding. I will also be using a jig-saw for smaller subtractions as it allows my more freedom and maneuverability in my cuts. To ensure safety, I keep a mouth mask and goggles on to protect myself from saw dust and make sure that my fingers are always at least two inches from the blade.

Sanding: As previously explained, the main sanding process will be sanding the body to the smooth shape I desire. For this I will be using a belt sander as it is the only sanding device available in my laboratory currently. The belt sander also offers a relatively higher surface area for sanding when compared to alternative choices. For instances requiring smaller scale sanding such as, smoothening out smaller imperfections, sand paper or a Dremel with a sanding attachment will be used. In these processes I use goggles and a mouth mask for sawdust protection.

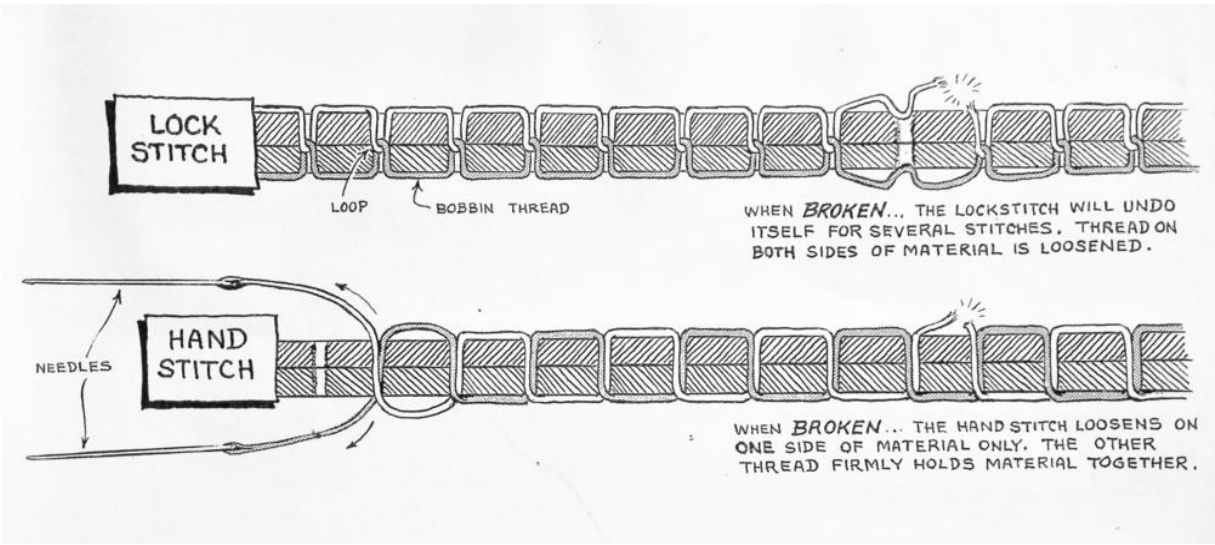
Laser Cutting: Laser cutting is an advantage technique because it can mark out guidelines on the MDF for other manufacturing techniques such as sanding or cutting. I did this by dividing the CAD model into layers of the same thickness as the MDF. With these virtual divides, I laser-cut physical guidelines onto each layer of MDF using a laser cutting machine. Laser cutting is preferred to manual marking due to the fact that machines are more precise than humans. This means that there is less room for error, helping to ensure the quality of the product. The laser cutter releases radiation, so it is crucial that you do not open the chamber whilst it is laser cutting. If the laser cutting process needs to be stopped there is both an electronic and manual override.

Soldering: Soldering is needed as a means of connecting the wiring from the battery to the wiring of the lightboard. For this process a soldering iron will be used to melt soldering wire that will bond the wires together. Soldering is a low cost, fast, and easy way to accomplish rewiring. The soldering iron is very hot so it is important to only hold the instrument by the handle to make sure you do not get burned.

Coating: Coating my drawing board comes in two steps. In preparing the car filler there are two elements to the coating: the filler and the hardener. The rule of thumb is to mix a golf ball sized volume of filler with a marble sized volume of hardener. The components should be mixed and applied quickly because the exothermic reaction between the two occurs quickly. To apply the coating, I'm using a piece of rectangular acrylic. Once the board has been coated with the filler it needs to be sanded to ensure that it is smooth. After this the black body paint can be applied over the board. The paint comes as a spray. For both coating methods, a mouth mask and goggles are needed because the particles released from sanding and spraying the materials can be harmful. Because of the nature of the filler reaction I also use surgical gloves if I need to deal with the substance with my hands.

Stitching:

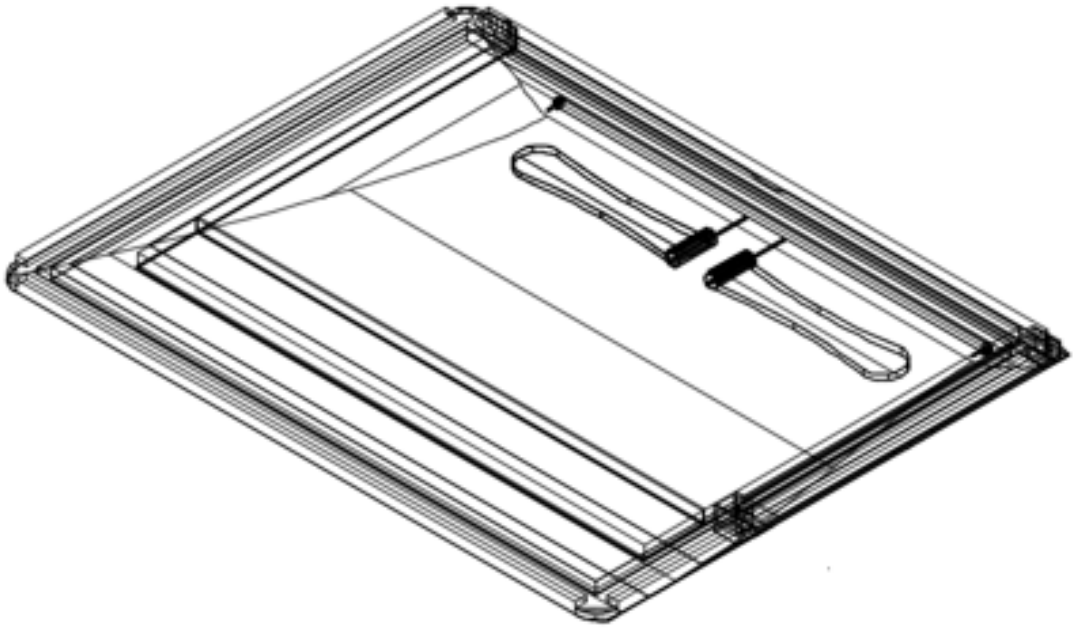
To stitch the leather I will be using a saddle stitching technique (the hand stich below). To make sure that the stitching is even I will measure out markers across the leather to indicate where I should pierce through.



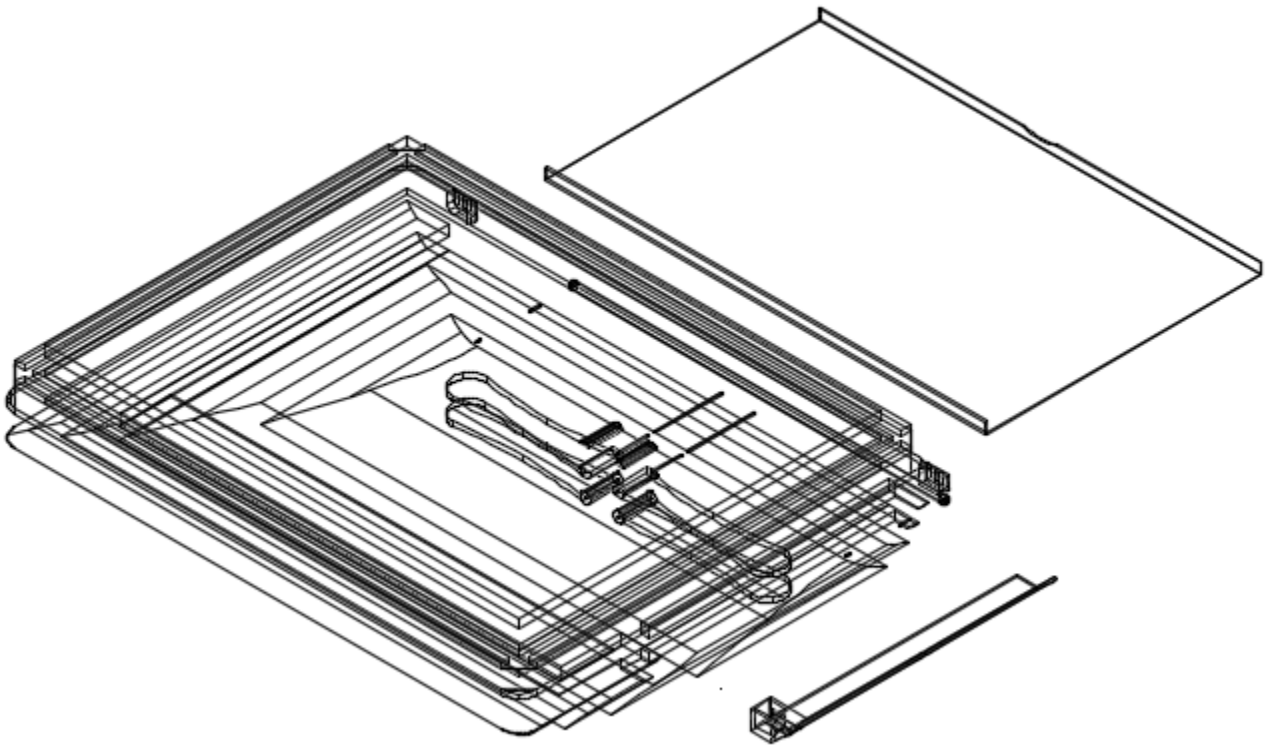
(Nylund)

Drilling: There is no stage of manufacturing where drilling is the main process. Drilling will always be used in conjunction with another process, (such as cutting with the jig saw). It is important to mention that drilling, whether it be with a hand drill or a pillar drill, needs to be done with clamps. The object being drilled needs to be stabilized to a heavy, or grounded object such as a laboratory table. This ensures that the object being drilled does not become dangerous, potentially spinning from the rapid rotation of the drill. Clamping also gives more control in the drilling process, making the job more precise. Once again, I will be using goggles and a mouth mask for saw dust.

Working Drawings:

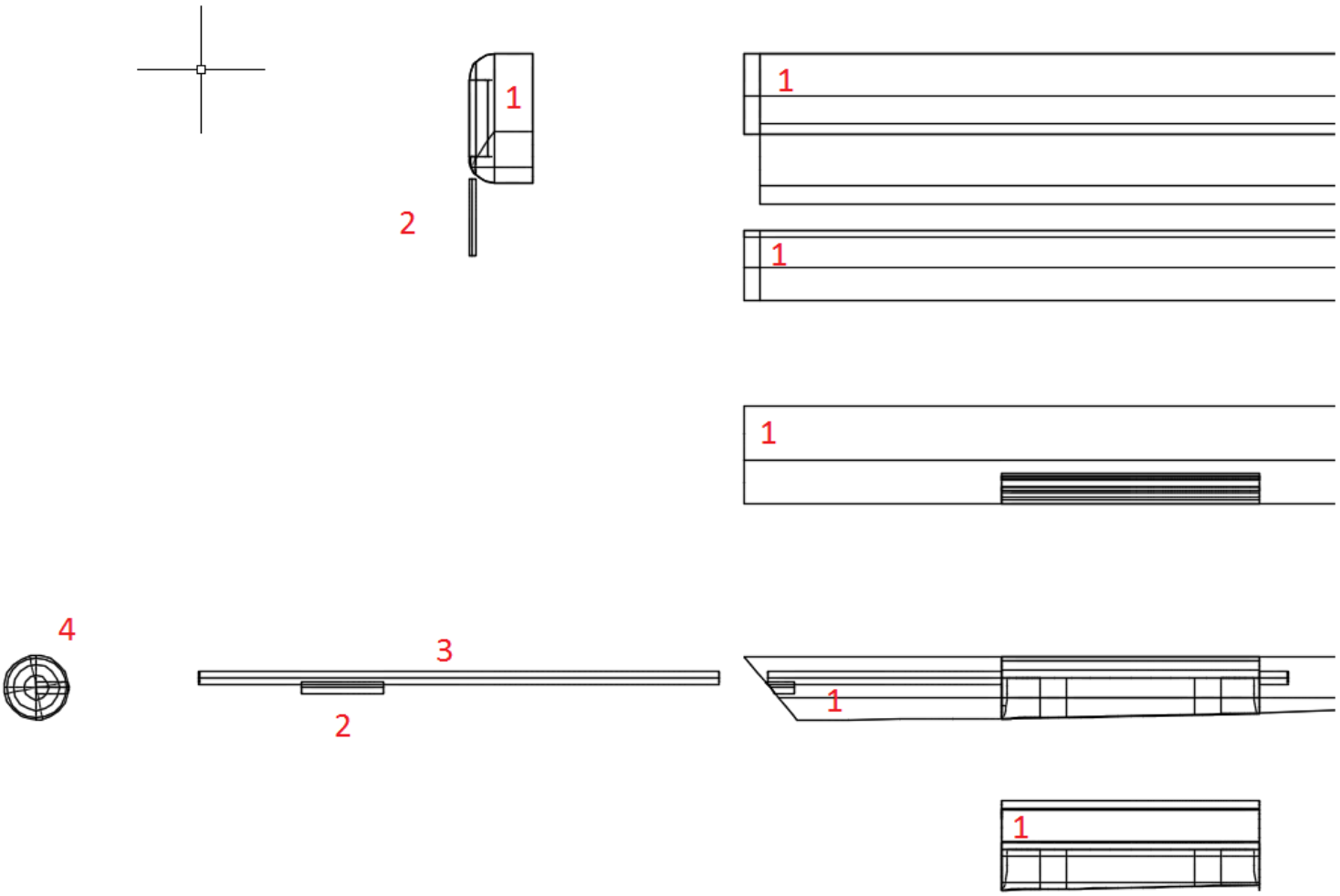


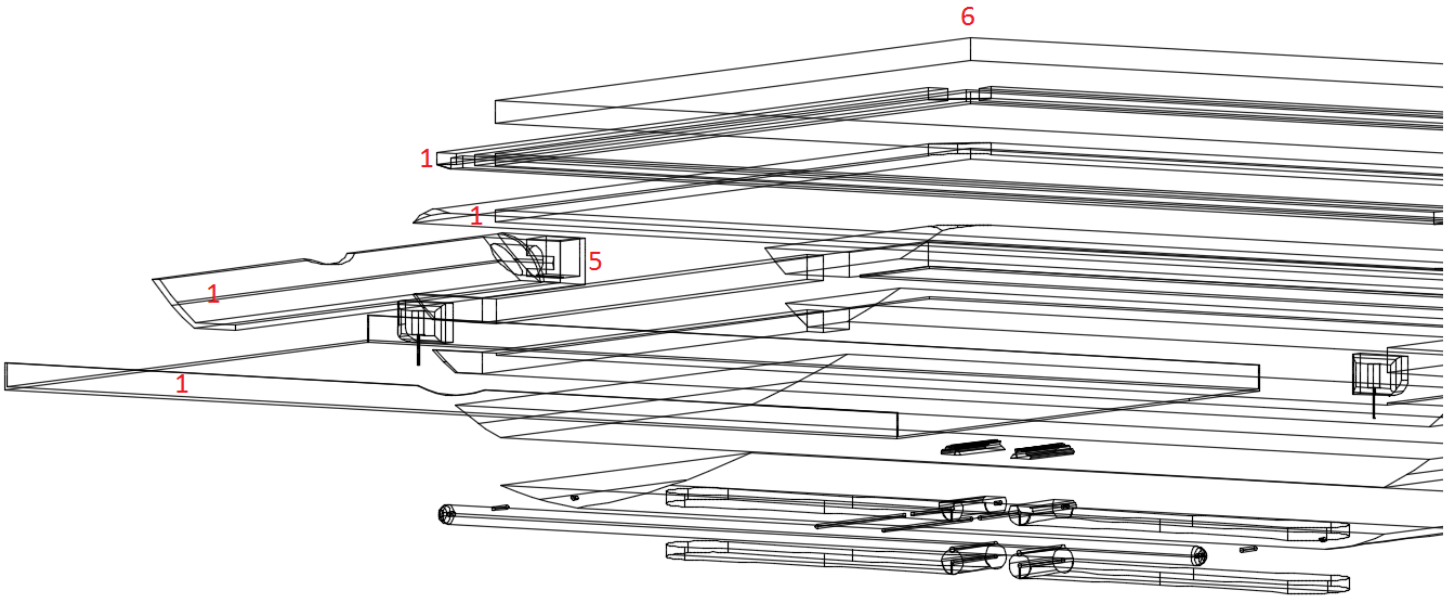
Exploded Isometric:



DT Major Project
Candidate 000215-0048

Part Drawings:





Part Number	Description
1	MDF (Machined in different ways for different parts of the board)
2	1 inch Nail
3	5 inch Nail
4	0.5 inch x 13 inch Carbon fiber rod
5	Standard American block profile pencil sharpener (8mm diameter)
6	Xcellent Lightboard (13.8 x 10.14 x 0.27 Inch)

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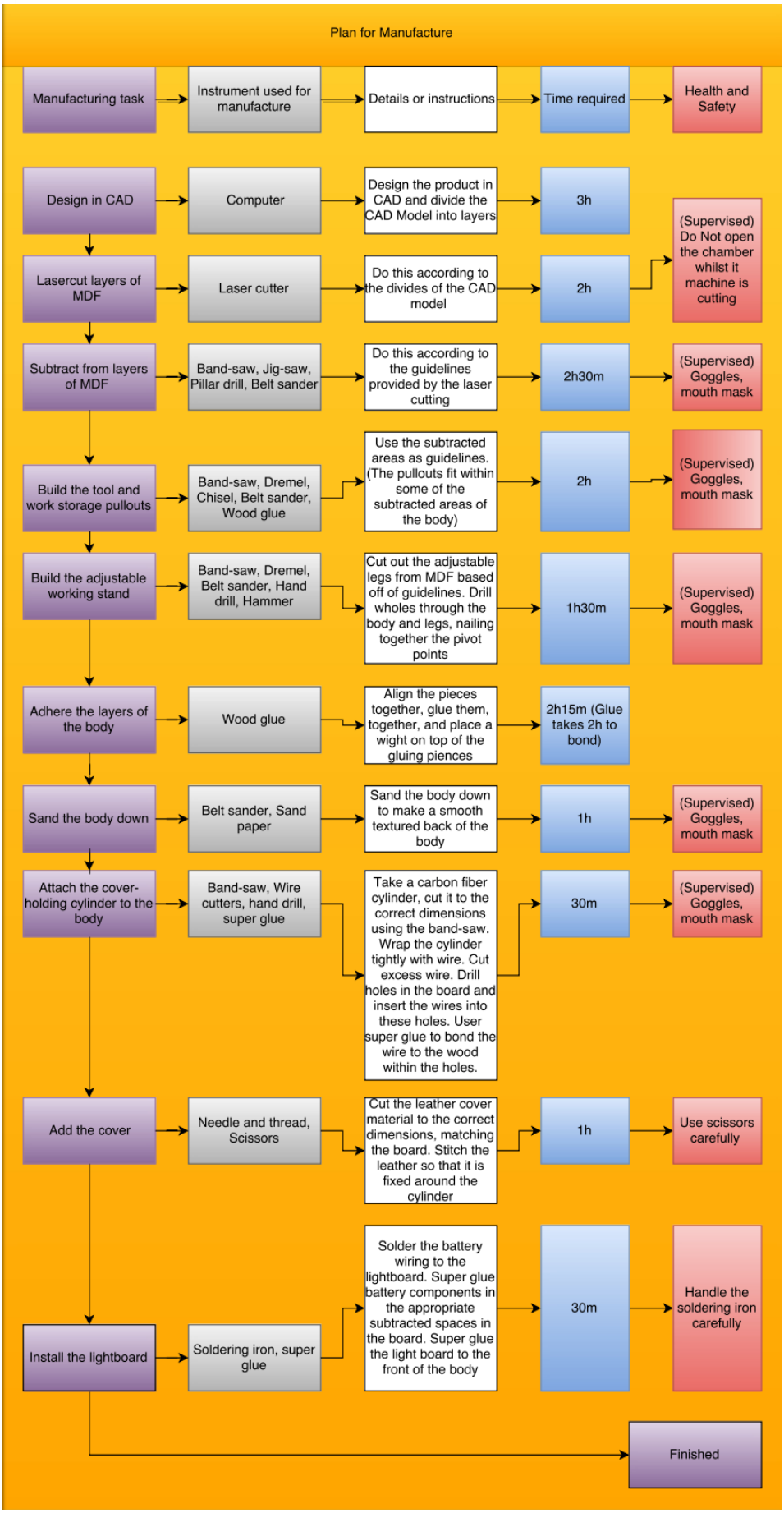

DT Major Project
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Testing and Evaluation

To test my design I decided to sample the product with individuals of my target market. Ideally I would have chosen two high school designers and or artists, and two college designers and or artists; unfortunately I was not able to find any college students to help me with my testing. I instead chose four high school students: two enrolled in IB Art and the other two enrolled in IB Design Technology. Each of the four students demoed the board for a day and in general, their experiences were positive.

Student 1:

-17 years old

-Enrolled in IB Design Technology

This student credited the innovative idea of an integrated electronic board physical drawing board capabilities. He expressed that if I were to make that idea work, he would definitely be interested in purchasing that product at the previous price point of around $1999. He was impressed with the manufactured product mostly because of the portable design aspect. He said that he often comes up with good design ideas in his car, and with a drawing board that he could take with him during transporation, this would solve his frustration of losing ideas due to the absence of portable design tools.

Student 2:

-18 years old

-Enrolled in IB Art

Much like the first student, student 2 was impressed by the idea of a portable drawing board. Feedback she gave is that the drawing board is not aesthetically pleaseing due to the MDF used saying, “It does not looked polished”, (especially on the back as seen in the picture to the right). Secondly she was not happy with the texture of the board as it was not as smooth as she would have liked it. Performance wise, she was happy with what the drawing board could offer her in her creative processes.

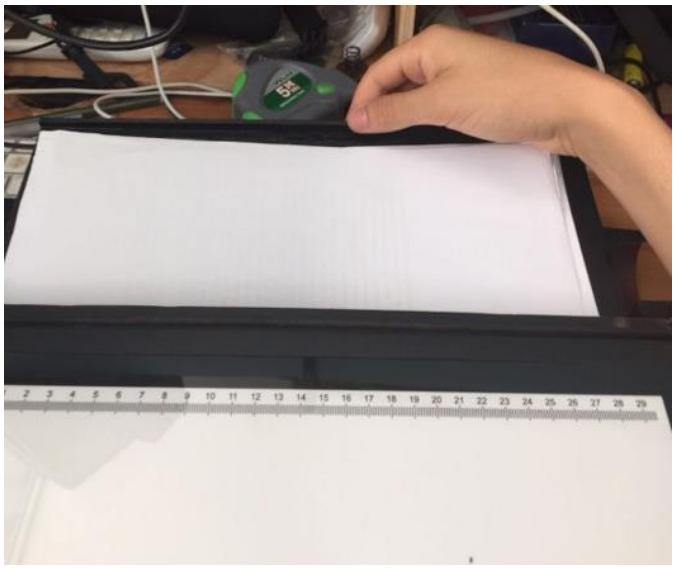
Student 3:

-17 years old

-Enrolled in IB Design Technology

Student 3 was again impressed by the concept of the design. She really liked the work storage element of the design because she expressed that she can often be dissorganized with her drawings. On the other hand dissapointed that the lighboard did not work and indicated that the adjustable stand was a little bit wobbly, so I would have to fix these elements before it would have any real success on the

market. A positive remark was that I she was given a polished version of the product, she would have used the board in the development of her major project.



Student 4:

-16 years old

-Enrolled in IB Art

Student 4 approved of my dark color palette. She said that it made the board look more professional. Once again most of the dissapointment was sourced from the lightboard not functioning properly. A new comment was that she thought that the ruler sliding mechanism should be smoother as it currently does not “glide”. It is important for it to glide because the user should be have good control in the process aligning their ruler when designing.

Through both my observations, as well as the feedback given from the user testing, I have been able to identify the weaknesses of my product.

For me the primary issues with the board are the:

- The non-functioning lighboard
  This was because of complications in wiring the battery to the lightboard. The electrical current somehow did not reach the lightboard. Perhaps the wires were not soldered properly.
- The unsmooth surfaceses of the body, (Including the the surfaces involved in the sliding ruler mechanism. In general, MDF is a relatively rough surface like most woods compared to alternative material options such as platics. Because of the nature of MDF, the surface ended up being slightly uncomfortable for users. Aditionally, as seen in the picture of the product’s back. I tried to use the car filler, but the mixture I used was inconsisent and hard to sand down evenly, hence the apperance in the picture.
- The instability of the adjustable stand
  This was likely due to a lack in precision of the angle in which the fold out. For example, if one leg is folded out to a 30 degree angle, and the other is folded out to a 27 degree angle, the board is going to tilt slightly.
- The limited angles of the adjustable stand
  Due to an inability to create my pivot points for my legs, the product is limited in ergonomic considerations as there are less options for users in terms of working angles.
- The lack of quality in the material used (MDF)
  Because MDF was my most available, machinable material, It was someone of a neccesity to use it as my material for the board. While MDF has it’s possitives in machinability, cheap cost, and

low environmental impact, it does have relatively low aesthetic appeal, structural integrity, and low tactile satisfaction. All of these contribute to a lowered psycological and physical impression on the board's quality.

- The lack in capacity of the tool storage compartment
  Due to spacial limitations of the board my tools storage compartment can only hold up to two pencils. This doesn't provide that much in terms of options for designers in a portable environment.

Market Specifications:

Target Market and Audience:

In general, my intended audience was pleased with my product. There was a lot of important feedback that I need to consider if the product were to go into production, notably concerning the adjustable stands, the lightboard, and the smoothness of the board. Despite this, the most crucial element was successful in my user testing, the concept. Users liked the lightboard and the board's adjustability, but the most favored aspect was its portability. The board will be successful in the market purely because of the solutions that it provides to designers. It is only a matter of refining the product for the manufacturing before I attain this success.

Price target:

All of the targets agreed with the price that I proposed to them, ($160), provided that the design flaws were fixed. One of my users was even interested in my previous electronic board idea with a $1999 price point. This lead I to believe that there could be potential for an extension to my product. Perhaps even a product family might be introduced.

Market analysis:

Looking at my product, there is definitely potential for success in the market. The product is unique in the features that it offers consumers. As the portability aspect seems to be the main selling point of the board, I need to use this to it's advantage when I introduce it to the market. Since a portable boards solves a lot of problems for young, active designers, I believe that the product would fit nicely in a student on-campus store. By introducing the product here, the product is sure to be relevant in an environment where consumers can give it attention, rather than in an environment where interest could easily diminish.

Competition:

Relative to my other competition, my product offers more value per dollar. Other physical drawing boards with no work storage, no lightboard, and no portable elements could easily reach price poings of 120 and above. Whilst my board is at the higher end of the price range relative to physical drawing boards, it purely offers more to the user than other physical drawing board on the market. To ensure that I have that competitive edge however, I need to make sure that my user needs are taken care of becore releasing my product onto the market.

User Needs (Essential requirements):

- A portable product
  The product completely fulfills this requirement and is likely the justification of why this product will be successful amongst users.
- A durable product

Because MDF was used, the board could easily be scratched because of the materials low hardness. In the final product, I will be using ABS, a thermoset plastic which has a higher hardness, meaning it cannot be scratched or penetrated as easily. Wood grains can also split, which is a liability with the MDF, where it is not with the ABS.

- A product that includes work and tool storage
  The work storage components function properly, however because MDF was used the sliding areas of the work and tool storage, this caused a lot of friction which caused a slight additional effort when pulling out the compartments. This should be fixed when using ABS since it is a smooth material.
- A product that is aesthetically pleasing
  The product was generally aesthetically pleasing to users, especially because of the fine quality leather of the cover, however the rough and patchy texture of the board took away from the visual "sleekness" of the board.
- A product that includes a lightboard/ lightbox
  Due to complications with the soldering the board's wires to the battery, the lightboard did not function. In my manufacturing process I can implement procedures during assembly to ensure that there are no malfunctions in the electronics such as the one that occurred when creating the prototype.
- A product that has adjustable working angles, (A 70 to 90 degree angle from the spine to the forearm).
  Because I was not able to construct the stands properly, the board was both wobbly and was limited in terms working angles for the users. This in turn affects the performance of the board in it's use, as well as it's ergonomic considerations. I think that injenction moulding could be a viable option for creating these components. Injection moulding ABS would offer the precision that I could not achieve when working with the MDF.

Design Specifications:

1 <u>- Human Factors and Ergonomics</u>

1.1- *The product has adjustable working angles (A 70 to 90 degree angle from the spine to the forearm).*
Unfortunately there were complications with creating the adjustability mechanism in the legs of the board. Originally, 4 working angles were intended; instead I was only able to have 2 angles, (in and out).

1.2- The drawing board surface and edge is textured smoothly.
Because I used wood as my body in the prototype, the surface of the drawing board is not as smooth as it would be with my commercial body material, ABS. I was, however, able to create filleted, smooth edges on the sides of the board to enhance arm related ergonomics in the working process.

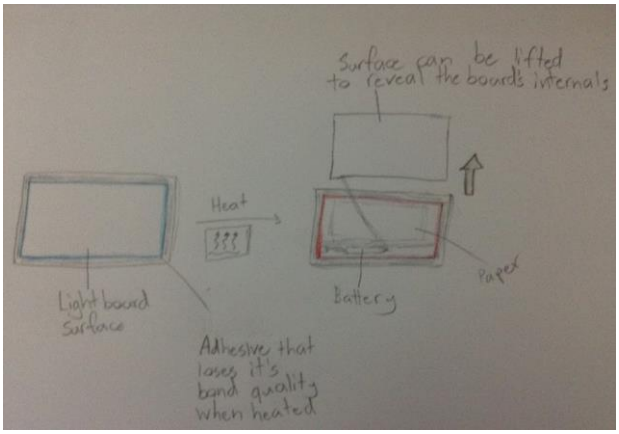
2 <u>– Sustainability</u>

2.1- *Design is aligned with triple bottom line sustainability concepts.*

To create the prototype, I used MDF which has a minimal environmental impact as it is a man-made, recycled timber. In using locally sourced MDF and leather I am promoting economic growth in a developing country, which is an economic approach to sustainability. The livelihoods of locals here are also impacted by the resources that I used; because I purchased local material, local individuals are making profit and are thereby improving their quality of life.

2.2- *Product is designed for disassembly.*

This is one element that I feel that the design lacks in. Because I want a sleek design, I have been trying to limit the amount of separations that the board has, (separations are essential for disassembly because they allow for the product to be broken up into its constituent components for processes such as recycling, repair or reuse). I am avoiding separations because they disrupt the natural flow and curvature of the board. Although I did not consider disassembly as much as I should have in my design process, I believe that the product can still be designed for disassembly. If I seal the lightboard with a reheat-able adhesive then I would be able to have access to the interiors of the board illustrated to the right.



An added bonus of designing for disassembly is the fact that during disposal, the product's components can be separated from the ABS so that it can be recycled individually. ABS is a very "recyclable" material as it maintains a high quality it after being recycled.

2.3- *The design is appropriately dematerialized.*

Because I was using MDF, I was not able to dematerialize my product. If I were to do this then product would lose too much structural integrity. With a material like ABS, which is what I plan to use for my final product, dematerialization would be possible.

2.4- *The design is durable.*

Again, because I was using MDF for my body, this limited this specification. MDF is a material that can be split, fractured, and penetrated easily. Using ABS as my material would prevent splitting and fracturing that occurs in woods, and would reduce penetration faced by the material.

3 Materials and Aesthetics

3.1- *Design show potential for variations in pattern, material, or color on the board's exterior.*

There is definitely potential for variations in color, material and pattern. The ABS that I will be using can come in different colors along with the leather used in the cover. While color has potential for customization, I do not think that implementing patterns onto the board would be a good decision. I think that patterns would ruin the professionalism of the board, which is an aesthetic that I am looking to achieve.

3.2- *Design is smooth and sleek in form*.

The form was not sleek due to limitations with sanding the car filler as well as the nature of the texture of MDF. ABS comes in a naturally smooth texture, which I will be using in commercial production

3.3- *The materials should express a sense of quality.*

The MDF used gives creates a sense of cheapness in the product, yet on the other hand, the leather used counters this with a high quality appearance. The ABS that I will be using is of the highest quality, having the most refined finishing in the injection molding process. This will keep the sense of quality of the board consistent.

4 Market

4.1- *The product suits the needs of the target market: designers and artists.*

The product currently needs improvement if it were to achieve the solutions I have given for the target market. These solutions can be seen in the "User Needs" of the In the Market specifications section.

4.2- *The product suits the needs of the target audience: college design students, high school design students, ~~and professional designers.~~ (Professional Designers have been eliminated from my target with the change in product).*

(The same as 4.1): The product currently needs improvement if it were to achieve the solutions I have given for the target audience.

4.3- ~~*The product is within the price range of $1999 or below.*~~ *The product is hits the price point $160. (The price point was changed and justified with the removal of the electronic drawing board components in the "Conceptual Design" section).*

There is no way to tell whether this product will hit the price point at this stage of my project. This specification will have to be determined in my manufacturing cost breakdown in the final section: "Marketing".

5 Classic Design

5.1- *Aesthetics and form contribute to a design that seems to be timeless.*

The leather used in this design definitely makes a significant impact on the look of the drawing board. When evaluating aesthetics, opinions are always subjective. In my opinion the leather contributes to making the board have elements of a "classic design".

5.2- *Elements of the design contribute to preventing the product's obsolescence.*

Because my product is very innovative and unique compared to the almost indistinguishable, repeated drawing board I see on the market, I do not think that my product will become obsolete any time soon. On top of this, as electronic interfaces gain more capacities, the design can be easily modified to accommodate for the push of technology. This can be done by replacing the longboard surface for new technology.

6 Sustainable production

6.1- *Design is comprised of renewable and sustainable materials.*

The Leather and the MDF used are both sustainable, renewable materials as leather comes from livestock, which naturally reproduce, and MDF is a manmade timber made from scrap wood. Thinking prospectively, the main difference between the prototype and the final product is the replacement of the MDF for ABS. ABS as mentioned before is a very good material for recycling as it has maintains a high quality. This means that less need for new ABS, reducing extraction of natural resources need to produce ABS.

7 Commercial Production

7.1- *The design ensures that commercial production is feasible*.

This specification is to be proven in the next section of "Commercial Production", however from considering possible routes for commercial production, my impression is that the design does seem to ensure that commercial production is feasible.

8 User Centered Design

8.1- *Design is intuitive.*

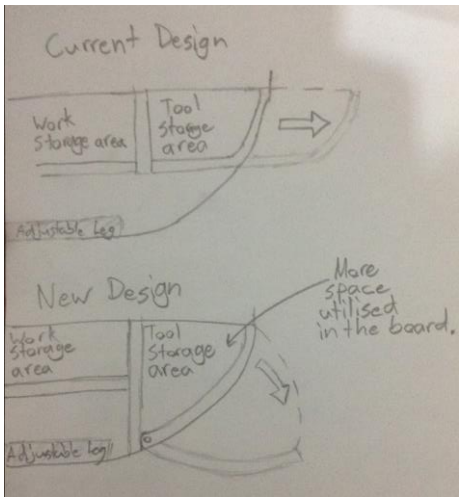
The design is very simple to use, to turn on the light box there is a clearly indicated power button, and to adjust the stands the user can manipulate the manually.

8.2- *Design is integrated into a carrying device*.

This has been fulfilled and is one of the most appealing aspects of the design.

8.3- ~~*Electronic surface must be luminous enough to act as a light box.*~~ *(Lightboard is luminous enough for effective use).*

By testing the lightbox beforehand, I can confirm that the surface is luminous enough, coming up to 4400 lux. This is enough lighting for the lightboard to be very effective.



8.4- *Design incorporates work and tool storage into the product.*

On one hand, the work storage compartment was very effective and can hold up to about 30 A4 pages. On the other hand, the tool storage can only hold a maximum of 2 pencils or pens. To solve this, I am considering a different kind of compartment seen in the drawing to the right.

9 Technical Requirements

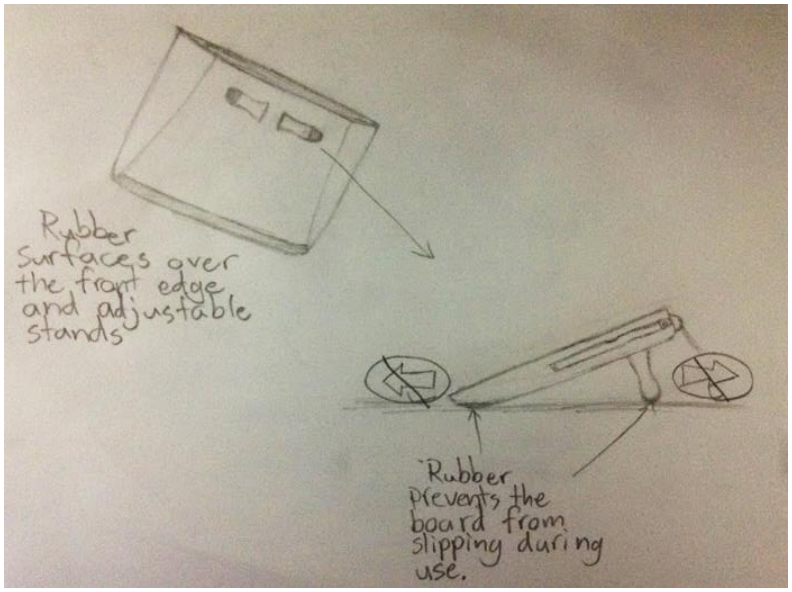
9.1- *Design incorporates technological functions of ~~the electronic drawing board~~ the lightboard and physical tools of the conventional drawing board.*

If the lightboard were to be fixed, this specification would be fulfilled.

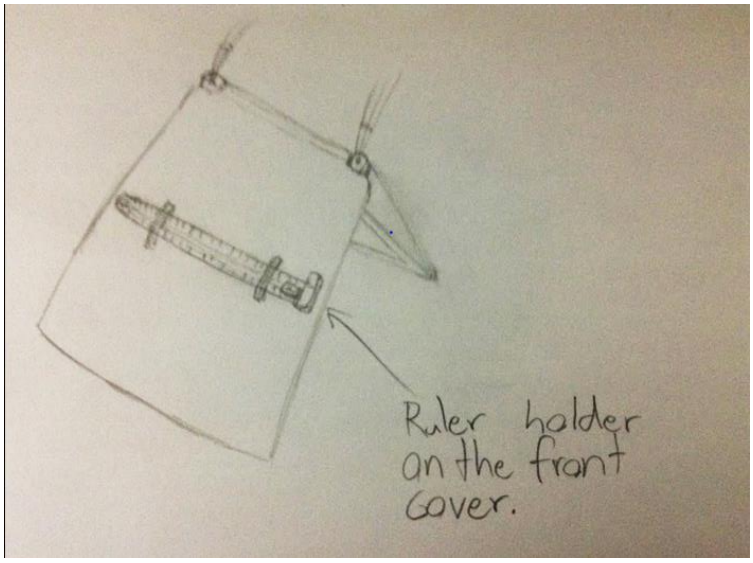
9.2- ~~*Electronic screen*~~ *the lightboard is capable of acting as a working surface for physical work.*

This specification was more applicable to the previous design as the electronic screen was a more fragile surface, whereas the lightboard is designed to be worked on. This specification is evidently fulfilled.

An aditional realisation that I had with my drawing board that was not orinigally in my specifications is that the board should do all it can to prevent itself from sliding and moving back and forth across the surface that it is on during use. To prevent sliding, I am considering implementing rubberized surfaces to the bottom of the board.



Another somewhat obvious, post-realization is that I have not out much thought into where the ruler being used is to go. In fact, the ruler was not origninally considered in my prototype. This was a large error on my part, but, optimistically, this can still be a consideration for commercial manufacturing.



Additional Images of the prototype:

Major Prototype Flaws and Solutions:

Major flaws with the prototype	Solutions for commercial production
<u>The aesthetics of the board's body</u> The product was generally aesthetically pleasing to users, especially because of the fine quality leather of the cover, however the rough and patchy texture of the board took away from the visual "sleekness" of the board.	I will use a polished, smooth ABS for the body of my board. This ABS would not consistent of the same "patchyness" and inperfections that the MDF does.
<u>Durability of the product</u> Because MDF was used, the board could easily be scratched because of the materials low hardness. Wood grains can also split, which is a liability with the MDF, where it is not with the ABS.	In the final product, I will be using ABS, a thermoset plastic which has a higher hardness, meaning it cannot be scratched or penetrated as easily. ABS also does not experience splits in grain like MDF does.
<u>The adjustable legs</u> Because I was not able to construct the stands properly, the board was both wobbly and was limited in terms working angles for the users. This in turn affects the performance of the board in it's use, as well as it's ergonomic considerations.	I think that injenction moulding could be a viable option for creating these components. Injection moulding ABS would offer the precision that I could not achieve when working with the MDF.
<u>Lack in tool storage space</u> The tool storage compartment only allows for a maximum of 2 pencils or pens. This limits the potential for design "on the go".	I have created a new type of compartment that folds out in a defferent way. This new compartment seen in the solution to design specification 8.4 offers much more space compared to the older design.
<u>The ligthboard</u> Due to complications with the soldering the board's wires to the battery, the lightboard did not function.	In my manufacturing process I can implement procedures during assembly to ensure that there are no malfunctions in the electronics such as the one that occurred when creating the prototype.

Commercial Production

Production Strategy:

Production Strategy- Outsourcing manufacture:

I have chosen to outsource production for my product, because as a small company, I do not have the monetary means to purchase equipment for my own assembly line. It is also cheaper purchase from other companies who specialize in certain manufacturing processes. Outsourcing also has some positive and negative consequences to triple bottom line sustainability. Outsourcing can be very good in promoting social and economic sustainability because it secures jobs for individuals in the manufacturing countries which promotes economic growth, quality of life, and improves livelihood. On the other hand, in these often developing countries, workers involved can potentially be treated unfairly or payed insignificant salaries. One way to eliminate this is to set forth fair trade deals with the manufacturing companies, which ensures that workers are treated fairly. Environmental sustainability might also be compromised due to loose environmental regulations in these developing countries. Although there are positives and negatives, there seem to be more positives to outsourcing as a small company.

Production Strategy- Batch Production:

I believe that batch production would be the most appropriate strategy of production in the launch of my product. With batch production, you do not commit to a continuous stream of production which might lead you to bankrupsy if no one buys the product. Instread, with batch production, the first set or batch can be made. If this batch is successful, then subsequent batchs can be made increasing in the scale of production and the units manufactured.

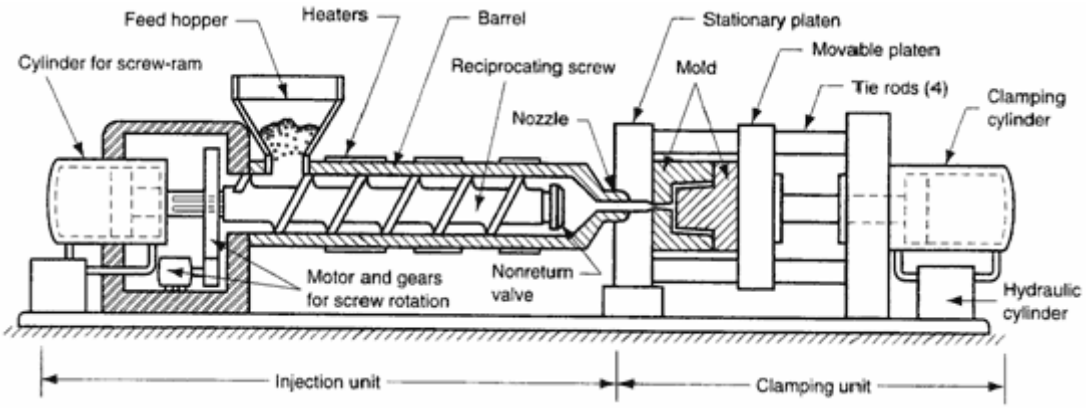
Materials and Processes:

In the cosidering my commercial production, I not only have to come up with feasible materials and process, but have to propose solutions to ameilorate previous issues that I had with the prototype.

Injection Molding:

The first and most important process involved in the commercial manufacture of my product would be injenction moulding. All of the components of the body would be made from injection moulding appart from the lightboard and the battery.

Injection Molding Machine



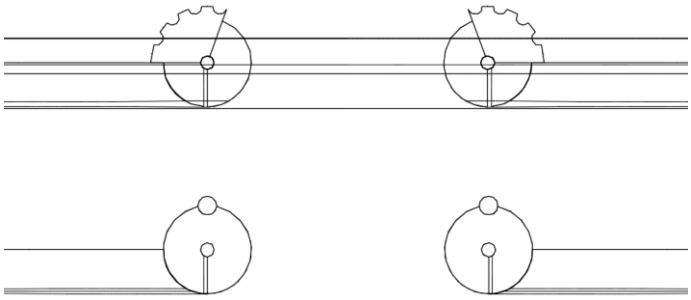
(Xcentric Mold & Engineering)

I chouse injection molding because the process offers cutomizability. Simply by changing out the mold, a wide variety different components can be made. In my case I would be making the adjustable legs, the ruler, the work and tool storage compartments, and the main mass of the board by injection moulding.

By choosing to injection mold the main mass of the board, (the body withought pullouts), I am commiting to my aesthetic considerations. The mold of the body would have no seperations, and would be one unit. Unlike some other processes injection moulding allows me to create theses complex shapes without needing to create sepatations that require bolts, screws, or nails. By avoiding things like these, the board would maintain it's natural flow rather than having all of these little fastener that would visually pollute the board's sleek intended aesthetic.

I am producing the adjustable legs through injection moulding as the mechanism that I have in mind requires a lot of precision in order to get it to work. This precision would be offered through this processes as the molds for manufacture can be extremely accurate. If the injection molding were to be done correctly, the I would avoid the issues of wobliness and limited working angles.

Likewise, the compartments have to be accurate in dimensions, however they do not reuire accuracy to the same degree. I would use injection moulding for these primarily to keep the same aesthetic througout the board's components.



A separation of the mechanism in CAD. (Hollowed board on the top and the adjustable legs on the bottom)

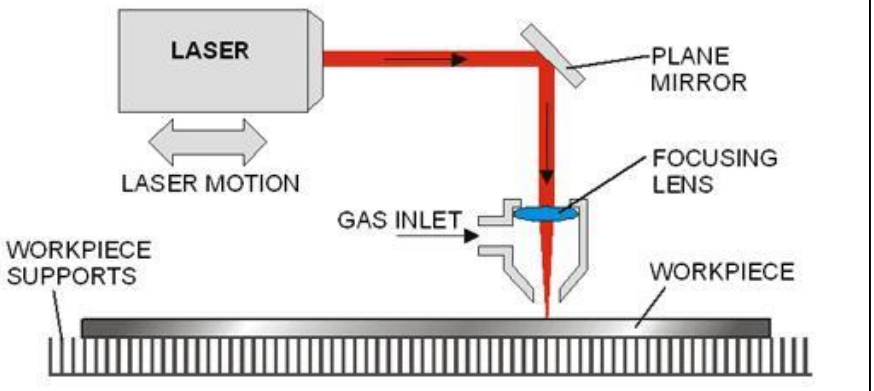
I will be using a glossy black heat resistant ABS for all of the injection molding except for the ruler, as this will need to be a clear ABS. The ABS needs to be heat resistant to ensure that it withstands more extreme environments such as high temperature locations. Under ASTM D648 testing, heat resistant ABS can defelect about 118 degrees Celcius at 455 kPa, which is a relatively high heat deflection for a plastic material (MakeItFrom). The board may have to face a lot of extreme environments in its portable role. ABS is also impermiable, so water leakage into the bord, (that could ruin electrical components and your work), will not be an issue in cases of rain or snow.

I want to give a sense of high quality, so when I outsource my injection moulding, I will be choosing the most polished finish. I do not want to end up with a similar issue that I had with my prototype, a surface that is not smooth, is inconsistent, and is visually unappealling.

Another important consideration is that I want my board to be hollowed for dematerialization. In order to dematerialize the board, the mold would have to ensure that the thickness of the ABS is always at least a quarter of an inch thick to prevent the board from losing structural integrity.

ABS is the material of choice in the injection molding process because of it's abilities as a thermoset to be molded and formed into a solid object, It's ability to come in heat resistant variations, and it's glossy visual aesthetic.

Laser Cutting:



(He)

To make the cover, the most efficient and accurate approach would be to laser cut the leather. Laser cutting can cut more efficiently and accurately than any skilled laborer could. The laser would be cutting out “Top-grain” leather as this leather is impermiable and has a nice textured look to it. This is the same type of leather that I used in my protype and both myself and users were happy with it’s appearance and performance.

To perform the laser cutting, I would have to send the company that does it, a top view vector image of my cover so that they can cut out the shape to my specifications.

Other Components:

For components such as the lightboard, the battery and the strap, their production would be separate from my knowledge as my suppliers would have their own developed and complex methods of manufacturing their products.

Manual Labors:

Some manual labor is needed at the end of the product’s assembly process as the lightboard will need to be soldered to the battery. To do this I will hire skilled and experienced laborers, because if I am obligated to keep the product to high standards, I will need a well qualified staff in doing so. Soldering as explained in the “Design Development” section, is the most preferred means of binding circutry because it is cheap, only requiring a soldering iron and soldering wire, and is somewhat easy to perform, meaning that more employees might be qualified for this.

The second munal labor is stitching the cover. To achieve a sense of quality and craftsmanship, I will be employing individuals with concrete experience in the process of stitching. I am sticking to my original specifications of a black, bonded, size #69 thread as it will give a solid stitch that will go well chromatically with the rest of the cover as well as the body of the board.

The third manual labor is simply performing tests on lightboards once the products have been manufactured. Since this is a manual labor process, it is not feasible to check every single board after productions. Humans are simply not that efficient. Instead, a selection of boards would be chosen to be tested, (for example 30 out of 100 boards). There can be no determination of the amount of boards to be tested because the count needs to be calibrated to the efficiency of the workers who are performing the task. By testing the lightboard, I am taking precautionary measures in ensuring product quality, whilst learning from my mistake from the prototype.

DT Major Project
Candidate 000215-0048

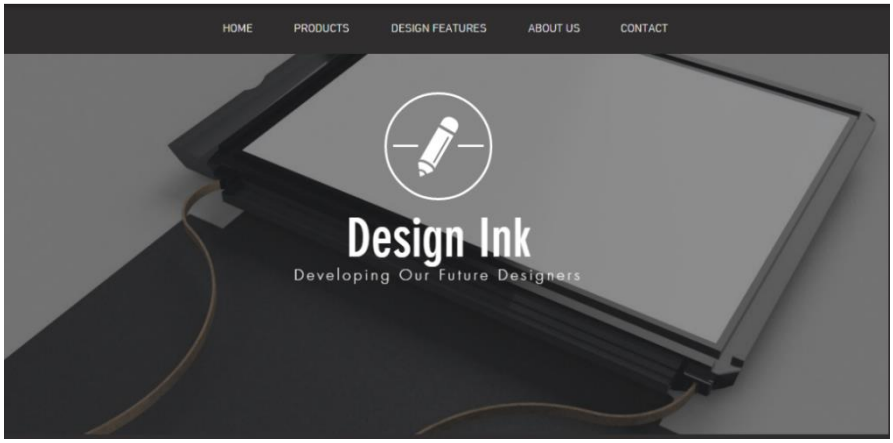
Marketing Strategies:

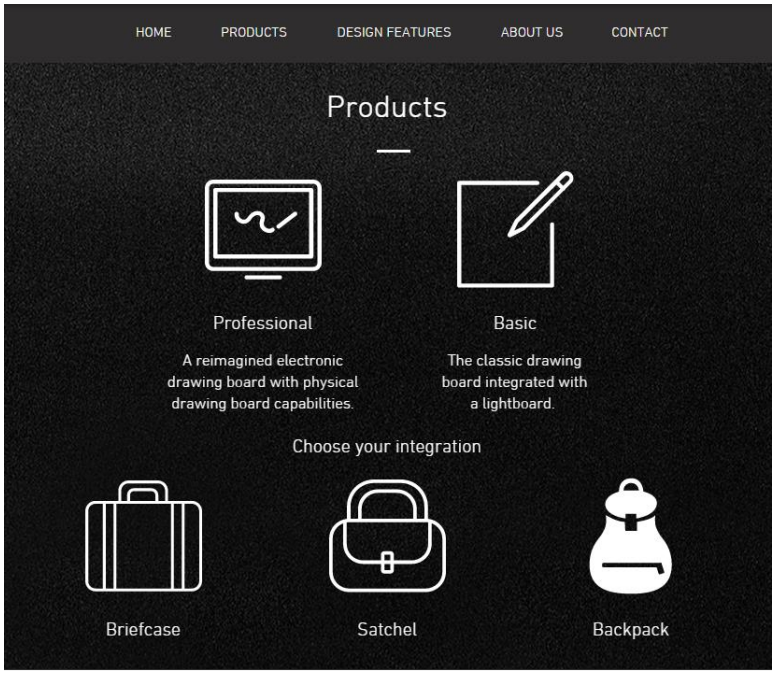
Target Market: Prospective Designers.

Target Audience: Student's in high school and college (ages to 14-21).

Promotion:

Since my target market is a young demographic, I need to make sure that my promotional strategies are centered around them. The internet is the most commonly used media for today's youth, therefore promotion through it would be effective in capturing the largest audience of consumers possible. To put this into perspective, according to a 2012 survey, 95% of American teens use the internet, so internet promotion provides a lot of exposure (Pew). I would likely design a website and pay for advertisement space on popular social media websites such as Facebook. I used the web design tool "Wix" to create a website. This website home page captures the audience with the simple but memorable logo, the company name, and the company slogan; having these three simple elements right as you enter the website is very effective at engraving the company into the users' minds. Three simple pieces of information are less easily forgotten, and will likely leave an impression with them for longer.





In addition to advertising the product on a website, I need to consider penetrating real life environments where the product is relevant. The general opportunity to do this is at college and school fairs or events where I can hand out pamphlets or brochures to students. Handing out pamphlets is advantageous in this type of setting because there is a relatively high concentration of students and teachers, where the product can gain a high amount of exposure. Pamphlets relatively easy and cheap to produce, meaning they can be produced in abundance, hence running the advertisements should not be a problem. In some cases, at these events, a booth could be installed to give students a hands on experience with or a showcase of the product.

Place:

Many larger schools and college have on campus shops. If the product were to be sold at these places that would mean that students could have easy access to it and more students are likely to purchase the drawing board.

Outside of campuses however, the product could be sold at art and design retail stores. These are chosen specifically because of their ability to attract a demographic that encompasses the target market.

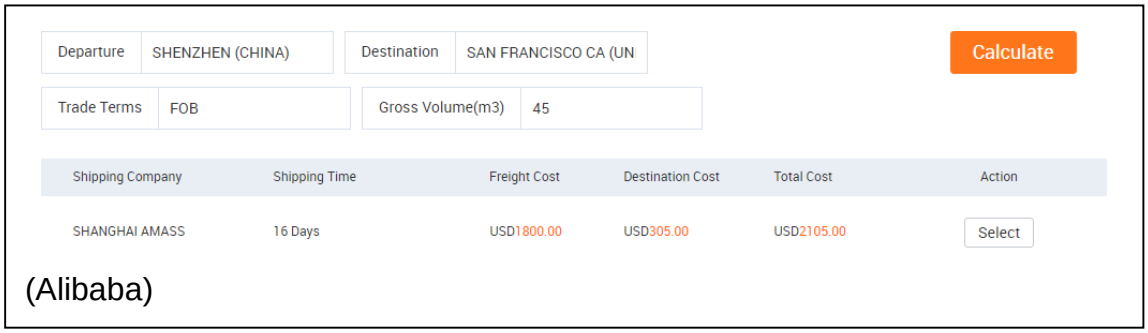
(Stanford University)

Lastly, the product would be sold online as previously discussed. The product would be sold on the company website, however it would also be beneficial to sell the product on a popular online retailer such as Amazon.com who already has a lager consumer population, making it easier for the product to be exposed.

Price:

Currently I have the pricing set in the range of $155-185, but a specific price needs to be established before it enters the market. First I need to compute my manufacture and costs to determine a break-even point.

I have used Alibaba, (an international corporate retailer), to find a supply for the lightboards. I have found a company (Huion) that will charge $9.99 per unit in an order of 10,000 units. The cheapest shipping will charge $2105 for a 16 day maritime cargo shipment which means that the cost per unit would be $2105/10000, equating to $0.21 per unit (rounded to the nearest cent). The shipment would be going to the San Francisco port because I envision my company being located in that area. There is a large design and art community there, as well as a proliferating design industry as well. Total costs each lightboard unit would be $10.20.

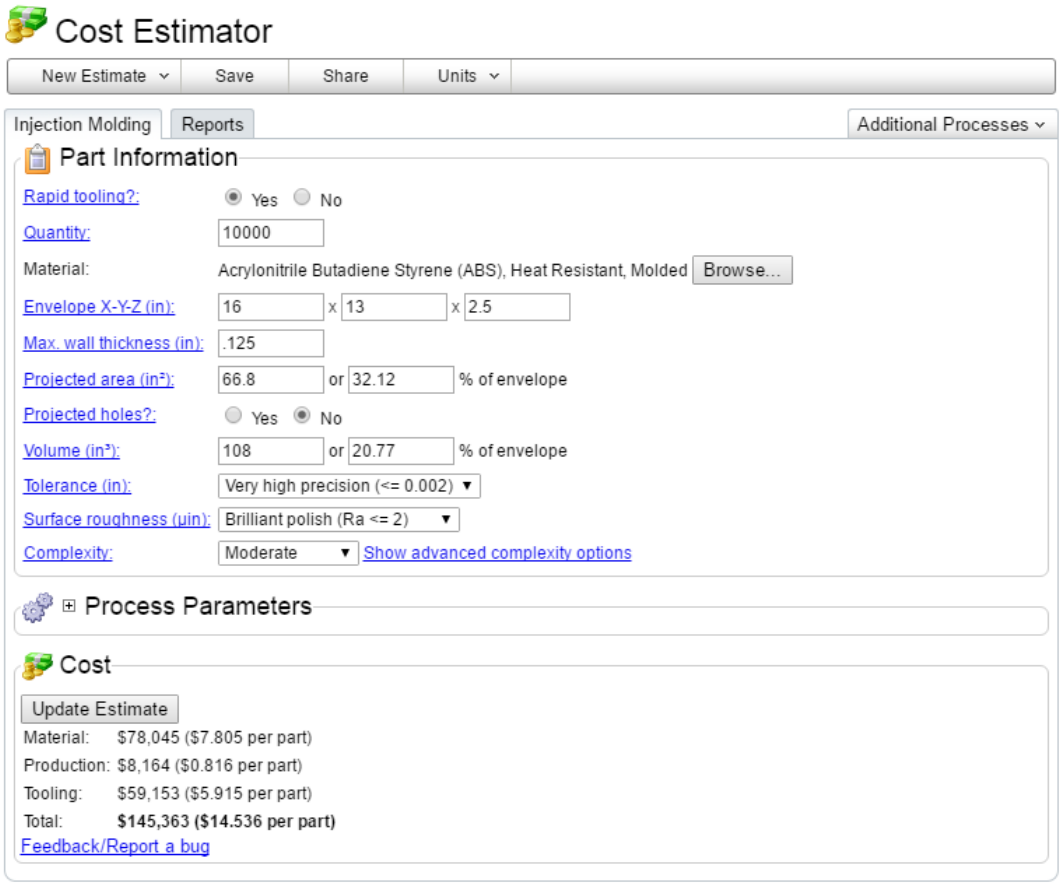


(Alibaba)

The body of the board would be injection molded. To estimate the cost to produce this, I decided to use the company “CustomPartNet”, and their tool “Cost Estimator” which is used to predict the cost of certain manufacturing processes such as injection molding. From the CAD model, I calculated all of the inputs that the “Cost Estimator” needed. If I were to use heat resistant ABS with the highest polish and the highest precision, (to ensure product quality), each unit would cost $14.54 in a batch of 10,000 at a rapid production scale.

For each of the pullouts (the tool storage and work storage) to be injection molded at the same setting as the body, it would cost $4.36 per unit (this includes both pullouts).

Cost to injection mould the main body



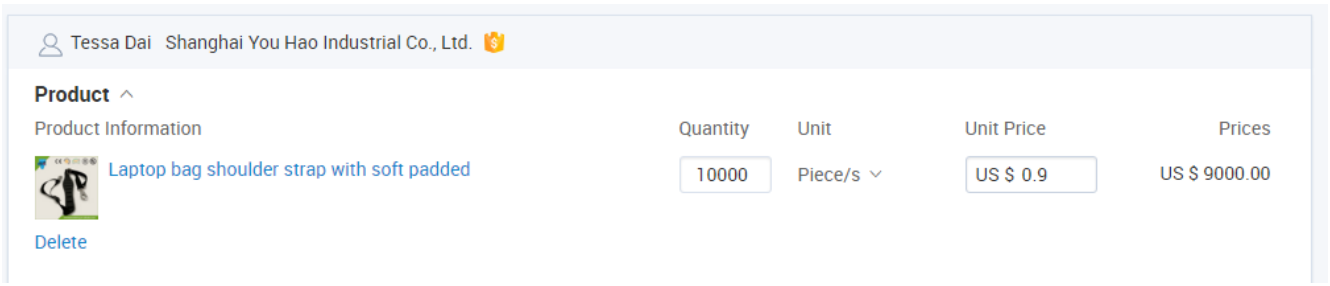
(CustomPartNet)

For the gliding ruler which includes the clinging mechanism, the cost is estimated to be $2.83 per unit. This adds up the cost of injection molding, and component parts such as screws and springs.

According to CustomPartNet has a supplier located in the bay area (where my company would be established), so shipping costs would be too small to account for at this scale.

To injection mold the adjustable stands it costs $5.37 for both of the legs.

For the straps of the board I have also found a supplier that chares $0.90 per unit. The straps are padded, reducing user fatigue. To ship these it costs $147.85, so (rounding down) about $0.01 per unit.



(Alibaba)

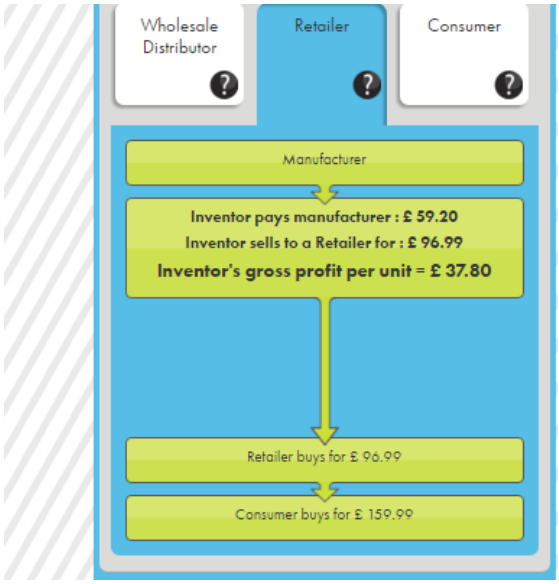
For the leather used for the cover, I'm deciding to use the same supplier that I used for my prototype: Dolsen Interiors. Although, they might not be the most cost effective supplier, I have already created a relationship and trust with the company. This will definitely have a positive influence in deal making with them and will launching my product's manufacture easier. Making an agreement with a company here in Tanzania also promotes economic growth in a developing nation. This promotes both economic and social sustainability. The company has agreed that they can laser cut out custom sheets for my board which would cost $11.45 per unit.

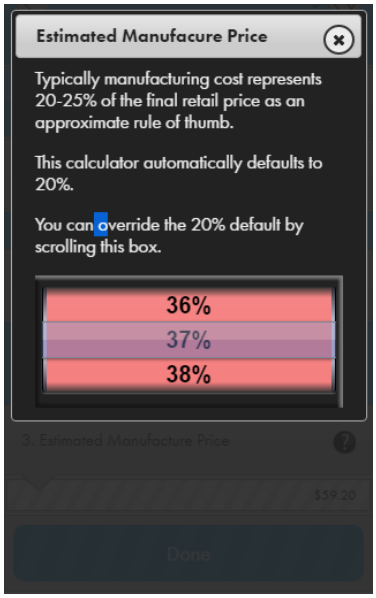
For the rubber sheeting used as the non-slip slip surface at the bottom of the board, found a Chinese company (Deke) that will charge $0.1 per unit, and an additional $0.01 in shipping.

Lastly, considering the Huion lightboards, I was able to find a rechargeable USB battery that lasts 10.5 hours, costing $1.2. Other wiring expenses including the recharging cable costs $3.9. To ship these components it would take $0.03

To assemble all of these components, it would take a maximum of 15 minutes of manual labor. According to California law, $10 an hour is the minimum wage, but if I am to practice social sustainability, I will implement the $15 "fair wage". This means that for each product, I am adding $3.75 per unit in manual labor for the assembly of products in San Francisco.

Accounting all costs of production, each board would cost $58.65. To determine the amount of profit I will be making, I will use the product price of $160 that was determined earlier on by the market survey. The $160 would be the cost of the product at the retailer. This means that this price would include the retail markup. To calculate the amount of profit that my company would make per unit I will need to exclude the amount of profit that the retailer will make.





(Innovate Product Design)

To calculate my profit I am using the "Invention Calculator". There are some important additional factors that the tool takes into account that will need to be mentioned in order for the profit to be understood. Firstly, it requires me to input geographic locations for my market. For this I have chosen the more economically developed regions where more people are more likely to be studying design: Northern Europe, Western Europe, Canada, the US, and the UK. Secondly it requires me to predict my market share. For this I am estimating a 5% share in the drawing board market, which is a worst case scenario because the drawing board market is not extremely large.

With all of these consideration, I will be making $37.80 per unit, as the manufacturer selling directly to the retailer. The "Invention Calculator" displays a British pound symbol, however this is an error by the calculator; all units are in U.S dollars. On the "Inventor pays manufacturer" line, the price displays 59.20 instead of the $58.65 that I had originally determined. This is due to the nature of the input system of the calculator. Instead of giving me an option to put in my value manually, it instead prompted me with the black box on the left. I was only able to input the manufacturing cost as a percentage of the final retail price ($159.99).

The retail price would be $159.99 instead of $160, because psychological, to the consumer, the former is valued less than it actually is when compared to the latter, even though there is only a 1 cent difference.

Due to the high profit that I am making, as well as the relatively low market competition in drawing boards, the tool predicts that my gross profit $156,138,525.33. Of course this number is optimistic, assuming that business operates efficiently and effectively.

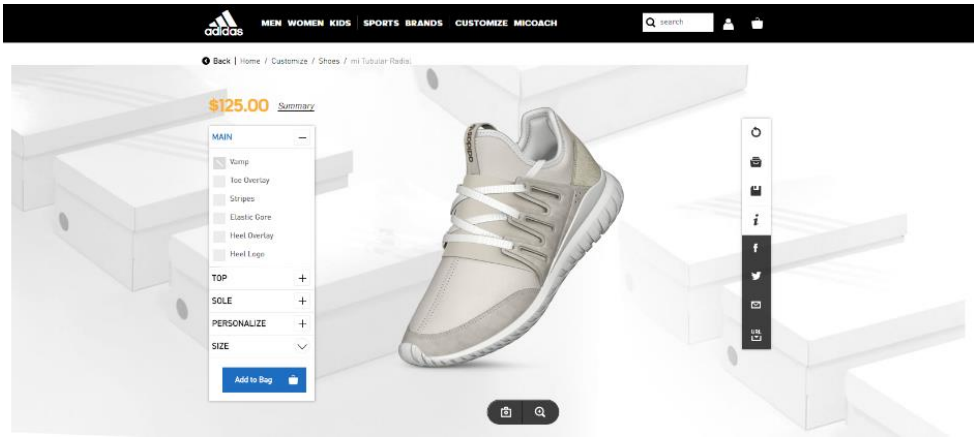
Product:

Currently, there is no popular drawing board product that is geared towards my sector of the market. Because of this, I have a competitive advantage in penetrating the market. The design shows unique qualities in the nature of its portability, which suit's the markets relatively active lifestyle compared to other age demographics.

As previously showcased in the website image, as the product grows, there might be demand for a product family. The product family I envision is very customizable because on one level you can choose whether you want a board with an electronic interface, or the simpler and cheaper version with a light board, but on another level you have options on what type of portable device you would want. Everyone is different so including this customizability allows users to find the niche that fits them. For the lightboard drawing boards, if the manufacturing costs are similar for the boards with different portable

devices, I would like to keep the prices consistent to each other. With the “Professional” electronic versions I would also like to keep the same prices between that set of products, with the prices being raised from the “Basic” versions. I might consider selling the “Professional versions at the price I originally had for my product, (between $1999 and $2499), however the profit would have to be recalculated to determine if there is reasonable profit.

To heighten and enhance potential customizability, the website could also include more options such as material, colors, or patterns. One way that this could work is to have a real-time, on screen product visualization from which you can make choices from. Many companies, especially specializing in apparel, do this such as Adidas.



(Adidas)

Promotion Plan:

Generate interest

- To create interst for the product, I need to create contacts with high school and college administration so that I can introduce this product to design students. Students are the majority group in the target market of "prospective designers" so focussing on spreading interest among them would be benifitial. I would also launch my website so that people are interested can gain more information on the product.

Gain money for product's launch

- There are many resources allowing a small company to get funded. Options to consider are listing the company on the stock market, working with an investement company such Y Combinator (who in addition to monetary funds, offer additional services), or opening a Kickstarter fund (which would be more relevant, and would create more exposure for my target market, since Kickstarter is web-based)

Introduce product to the markt

- The product would be introduced to the market at a select few retailers. Mainly art and supply stores as well as on-campus student shops.

Enhance advertisement campaign

- Advertisement space would be pursued on social media websites such as Facebook, Twitter, and Youtube. Production of panflets would increase as more interest is given to the product at school events and fairs. The product would also be listed and advertised on Amazon.com

Increase sales

- If the product does well, my company could approach a larger art and design retailers such as Blick or Michaels, and even retailers outside my intended geographic market.

Introuce a product familly

- With the same adspace on the internet and with panfets, a product familly will be introduced and advertised, suiting more consumers and increasing sales. The product's website would be updated to inform users about their new options and opertunities of purchase.

Introduce mass customization

- Following the product familly, mass customization would be introduced. The website would need to be developed heavily to support a customizing system, such as the ones on websites such as Adidas or Nike.

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