

MAJOR DESIGN PROJECT – THE POSTURE-CORRECTING BAG

CRITERION A - Identifying Design Need

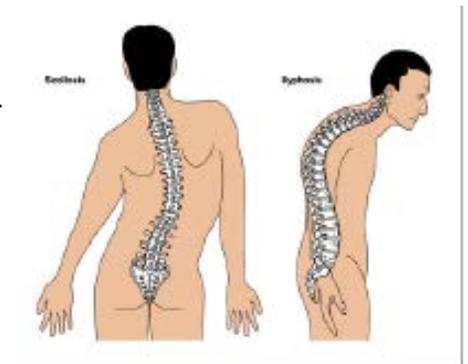


When young students go to and from school to their home, or tuition centers, they often carry around a school bag strapped to their shoulders. This school bag is crucial because it carries around all the resources needed in your learning in and outside of school. The problem is that these bags tend to be very heavy from all the resources such as books -and, now in the 21st century, laptops too. An example of this crammed backpack is shown below.



As such, these bags put massive pressure onto the growing students' backs and to compensate the weight pulling them backwards, they slouch forwards with poor posture. A study was done by PubMed, a US government agency based on public health, on 3600 students. Poor posture was detected in 38.3% of the students, with symptoms ranging from round back to protruding scapulae. (*Prevalence and Risk Factors of Poor Posture in School Children in the Czech Republic.*)

In an article called the “The Ill Effects of carrying heavy schoolbags” about heavy schoolbags’ effects, Dr. Zubeir Patel from The Health Site (a site concerned with all things health related) addresses this from the point of view of a doctor. She states that “*Carrying very heavy backpacks can lead to musculoskeletal problems, especially if children carry the bag on one shoulder. It puts extra pressure on one side, tilting the spine.*” She elaborates on the long term effects, saying that it can result in not only spine deformations called kyphosis or scoliosis (shown in the diagram to the left), but stunted or abnormal growth as well. (*Kriti Saraswat*)



She also explains that the acceptable weight limit should be around 10% of a student's body weight. Livestrong.com (another health site) states that the average weight of a 15 year old child is around 57kilos. (*Paventi*) This means that the weight they should be carrying has to be below 5.7kg. But through a quick survey done on a group of 10 middle school children of ages 13-15, it was discovered that at least 8 of them carried a schoolpack which carried more than 6.5kgs.

But this is obviously not possible, at least, from a certain age onwards when you need more than just a lunchbox and toys. This can be seen in the photo to the left, where a young Indian student is seen leaning forward from the massive pressure of the school bag

1. "Prevalence and Risk Factors of Poor Posture in School Children in the Czech Republic." The Journal of School Health. U.S. National Library of Medicine, n.d. Web. 22 Aug. 2016.
2. Kriti Saraswat. "The Ill-effects of Carrying Heavy Schoolbags." TheHealthSite.com. N.p., 25 Mar. 2015. Web. 22 Aug. 2016.
3. Paventi, Jared. "The Average Weight & Height of a 15-Year-Old." LIVESTRONG.COM. Leaf Group, 16 Aug. 2013. Web. 22 Aug. 2016.

I then **interviewed** a number of mothers with students of all age ranges to confirm the problem, as parents will be the ones who worry the most about their kids.

All the mothers agreed with the statement that school bags were too heavy and really caused a “noticeable effect” on their children’s postures. The mothers of Asian descent were especially worried because they started sending their children to tuition centers from a young age and consequently the weight in their children’s bags increased from the tuition resources. The mothers of late high school to college students, although worried, admitted that the students had either already developed poor posturing or were old enough that they knew the importance of keeping proper posture on their own.

I also performed a fly-on-the-wall observation at my school bus parking lot and at my condominium where the school bus drops off at. I observed many school kids and seniors carrying school bags to and from school, and noticed that a greater percentage of middle school students were hunching over than the other groups, and also that high school students were either hunching too, but they would constantly adjust their postures, or weren’t hunching at all.

Appropriately, the target market will be focused on students from early middle school to early high school, as that is the range at which students have to carry substantial weights in their packs as the school load increases, but it is also the range where they are not self-aware enough to correct their own posture. This range would be from ages 10-15. The target audience will be the worried parents of the young students. Since the average age of a mother birthing her first child is 26 years old according to Babycenter.com, the target audience’s age range will be 36-48 years old.

Solving this problem is ultimately for the target market’s benefit, the children’s benefit. Having a way to prevent slouching forward and poor posture would prevent the permanent and long-term musculoskeletal problems such as scoliosis and kyphosis. Dr Zubeir Patel also states that poor posture will lead to headaches, muscle pain and joint strain, so a good posture will be prevent those too. As Erika Stadler from the Refinery29 website, a women’s health site, writes, *“As it turns out, our slouchy ways can do more than mess with our musculoskeletal system, they can negatively affect the way we feel.”* She elaborates by mentioning a study at Columbia University, whereupon it was discovered that those with proper posture had a sense of greater power and control, and less stress hormones in their systems. So it would emotionally benefit the students as well, allowing them to be more confident in their school lives and less stressed out.

These effects would all come together to not only help the students focus during classes (reduced distractions from aches, greater emotional health), but also to help them in the long term so that as they grow older, they do not develop spinal deformities. A healthy posture leads to a healthier life.

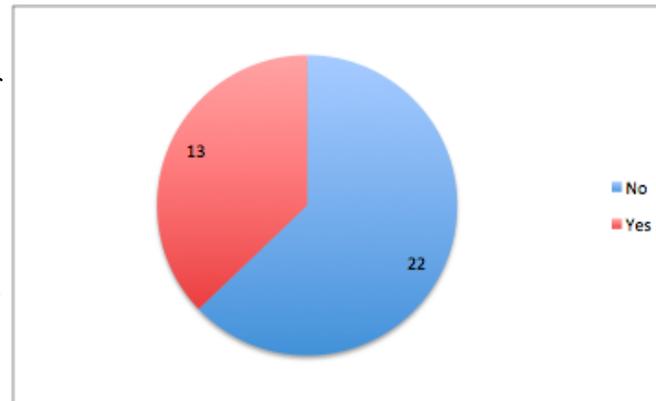
Key Findings of Market and User Research

In order to identify the define the problem further and to identify the requirements of the solution, a survey was conducted on the target audience of the parents of the target market (students from middle school onwards). This was done because the target users would not be as posture-conscious as the target audience, who would constantly worry about their children's health and safety.

After surveying 35 people of the ages 30-48 (all with students in middle or high school), the following data was found and analyzed.

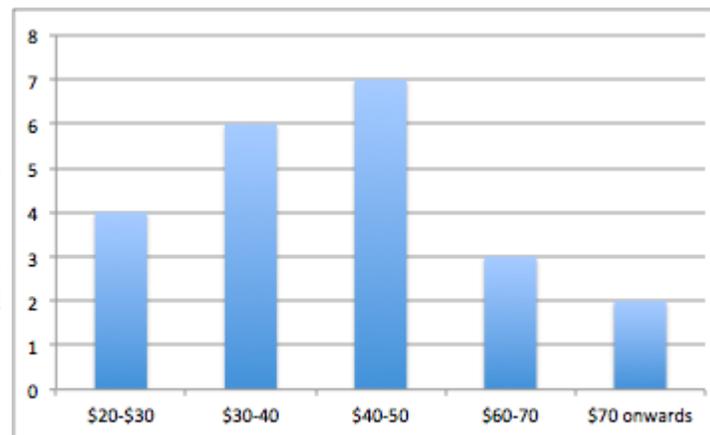
USER NEED

When asked if they were happy with their children's school bags, regarding the children's comfort, safety and health, 22 of the 35 replied that they were not happy. Of those 22, only 8 replied that they were looking for a new school bag, suggesting that school bags are not bought frequently, and the market is not very innovative. All of the 22 unhappy parents stated that the reason for their discontent was the problem of their children's postures, indicating that the design problem is indeed a concern for the target audience, and therefore makes for a viable product.



COST CONSTRAINTS

When the 22 parents were confronted with the possible solution of a posture-correcting backpack, they were asked how much they would pay for the backpack. The majority of the group (7) said that they were willing to pay \$40-50 USD. It is worthwhile to note that this survey was conducted in a condominium in a relatively well-off area, so the results may be skewed a little. But generally, around 77% of people want a bag that is \$50 or below, indicating the price requirement of the bag.



The survey showed that there was a definite need for a moderate-in-price, posture-correcting bag in a market that is not overly innovative.

PRODUCT ANALYSIS/ COMPETITION

Next, a product analysis was conducted in which similar products were analyzed for their attributes, strengths and weaknesses to see what the solution had to be alike to or better than.



Posture Transformer/Antigravity Backpack

- uses straps and cushions which force postures to be corrected, a use of ergonomics
- \$159 USD, very expensive
- looks very sleek and high tech, more appealing to the younger audience
- pack is very small, and not intended to carry anything heavy
- made of polyester fabric which is lightweight, durable and water-resistant

- adjustable straps
- multiple compartments for versatile uses

BackTPack



- pack is big, certainly very suitable for school uses, laptop fits
- doesn't look particularly aesthetically pleasing
- prices range from \$50-\$60, much nearer to the price requirement set through the survey earlier
- bags stuck to the sides to induce an upright center of gravity and therefore correct posture.
- adjustable straps
- multiple compartments for versatile uses
- made of polyester fabric which is lightweight, durable and water-resistant

I have identified aspects of the designs which are helpful for my investigation:

- the price point of around \$50 or below identified through the survey seems to be achievable, as the BackTPack is around \$50-\$60 USD.
- the pack needs to be made of good quality materials such as polyester fabric which is lightweight, durable and water-resistant.
- the posture-correcting has to be done through cushion padding and the design of straps, of which the straps have to be adjustable to be more ergonomically suitable
- has to have multiple compartments for various uses.
- pack has to be big enough to fit a laptop, in this new age where most learning is done through online sources

Anthropometric/ Size/ Performance Requirements

Next, secondary research was conducted to figure out the anthropometrics and approximate size of the backpack. Average human data was used as data for specifically younger age groups was not available.

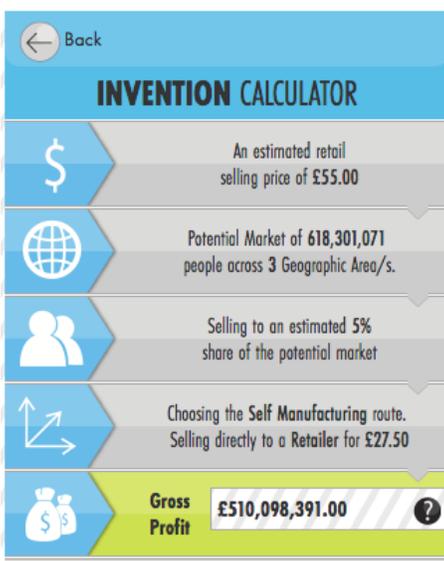
The backpack will be strapped to a person's back, so a person's average back width must be considered. Since data for average back width was not available, the average shoulder width was instead set as the limit to which the straps should be apart from each other. BodyBuilding.com, a website dedicated to all things healthy living, states that the average shoulder width is around 17-18 inches, which in metric units is approximately 45cm. This is the limit to which the straps should be set apart, especially since the students of the target user group do not all have fully developed bodies.

The backpack will also have to be able to store a laptop, as it is supposed to serve as a schoolbag, and learning is mostly done online in current times. Quora.com, a general information website, states that the biggest commercially-widely-available laptop size is 17 inches in length, which equates to around 43cm. This means that the backpack has to be a minimum of 17 inches in length to be able to carry around a laptop.

Material/Manufacturing Requirements

Then, the research for manufacturing processes and materials was done. Through the product analysis, it was discovered that the material had to be water-resistant, light-weight and durable, such as nylon canvas. Generally speaking, most bags (not exclusive to posture-correcting bags), are also made of fabrics of similar properties, so this is the requirement for the material.

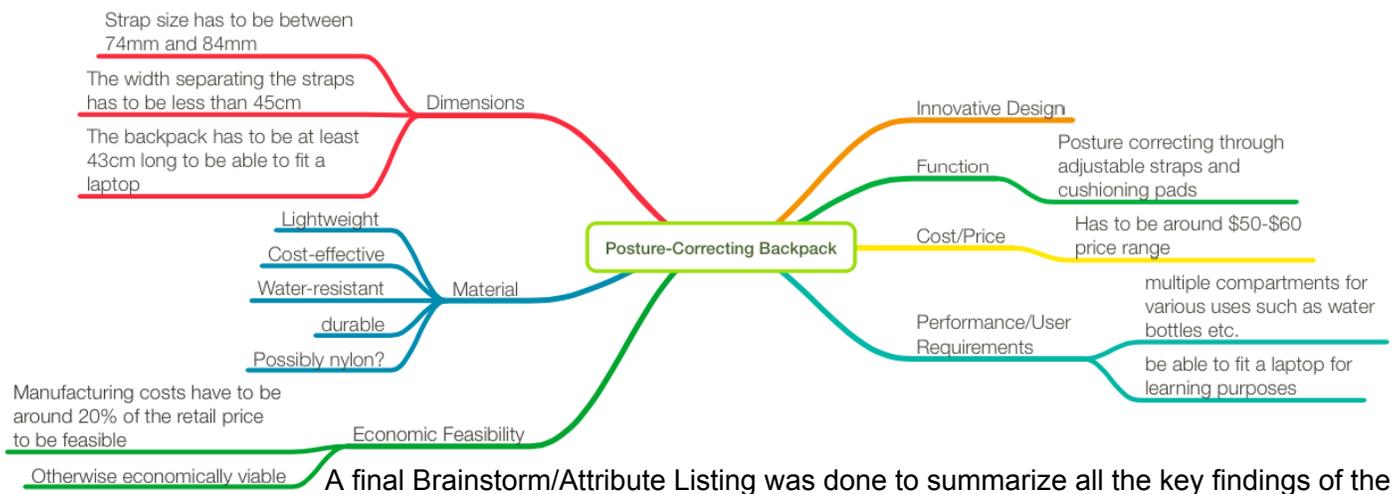
For the manufacturing process, a sewing machine has to be used as the majority of material used in the product is fabric. The type of stitching does not necessarily matter as long as the stitches are straight to allow for easier creasing on edges for a cleaner look, because most layers will be stitched more than one time together, meaning there is no worry for durability of joining method, such as using complicated stitching like lockstitching or overstitching which are more durable but more time-wasting and expensive. This way we remove the unnecessary complications and reduce time wasted and materials wasted. Seams or no seam stitching doesn't matter either as the seams will always be on the inside of the bag, which doesn't hinder performance.



Sewing pins are intended to be used in conjunction with the sewing machine to initially secure different folds of fabric together and then stitch them, whereafter the pins are removed and used again for other components. In terms of cutting the fabric, a simple pair of scissors are to be used as nothing more is required.

Economic Feasibility

Finally, the economic feasibility was determined through the invention calculator, from InnovativeDesign.com. The price was entered as \$55, a number within the price range the surveyed target audience found reasonably acceptable. The target audience was entered as ages 30 onwards to around the age of 60. The market share is estimated to be around 5%, as the market is not large or innovative, and therefore is not competitive, and new businesses do not set up often in it. The final Gross Profit is shown to the right. It seems economically viable, but something to be noted is that the Calculator states that if the retail price is \$55, the manufacturing costs have to be around \$11 to be feasible.



Design Brief

Target Audience: Middle aged parents (aged around 36-48) with children ages 10-15, but the actual end user (or target market) would be the children in school aged 10-15, as they have to carry around substantial loads (around 10% of body weight due to learning resources) and are not self-aware enough to realise their poor posture while carrying said loads. A point to be taken into consideration is that the target end user are young teenagers, who decline doing anything they dislike. Therefore, the aesthetic quality of the backpack must be appealing to the younger audience. The anthropometric data used also have to be from teenage ages, as the bag will have to be ergonomic towards the end user of the teenagers.

The target market and audience for this solution are further outlined in the following marketing specification.

Design Goal: I intend to design a schoolpack that aims to reduce the pressure experienced from the weight of the pack's contents, and therefore correct the posture of students who carry around these weights everyday. I intend to manufacture a fully functional scale working prototype of this posture-correcting schoolpack to be evaluated and tested in expected conditions. This prototype should be made using similar materials and processes used in the actual batch production scale later on. This will ensure that the prototype/product will be feasible for larger scale productions.

From the market and user research analysis above, the broad requirements and the expected physical outcome were determined, represented below as Constraints and Criteria.

Constraints

- The manufacturing costs must fall below \$10 USD so that the end price is around \$55 USD
- The end working prototype must be able to be manufactured by equipment available in a school workshop, and anything non-manufacturable with the available equipment will have to be outsourced (for example, zippers or clips for closing/opening the bag)
- The width separating the straps must be less than 45cm
- The length must be at least 43cm to fit a laptop
- The prototype itself must be light
- Has to be aesthetically appealing to teenagers so that the target users will not reject using it
- Has to also be aesthetically appealing to the target audience of the parents
- The materials used and the processes used have to be as environmentally sustainable as possible without compromising other criteria or constraints, such as making it recyclable etc.

Criteria

- The design must be suited to be used by 10-15 year olds, and therefore accommodate all their anthropometrics
- The main fabric used in the bag must be lightweight, cost-effective, water-resistant and durable
- Must relieve the pressure from the load in school packs, and therefore correct the user's posture
- Must have multiple compartments for versatility
- Must be ergonomic to the student's back and shoulders

Market Specifications

Market Analysis

The invention calculator was used in the research stage to establish a general size of the potential market, but here I will narrow into specifics.

In terms of the specific market of posture-correcting backpacks, the market is very small and there are very few products available, and no barriers to entry, and therefore if my product were to be made, it would take a large market share, and would face near to none competition. Therefore in this specific sense my product should be economically viable.

In terms of the broader market of backpacks, the value of the US Market of backpacks alone is worth over 2 billion USD alone, and therefore it is a very large market. As a result, the barriers to entry are very high, as the existing companies are very big and economically efficient. As an extension, competition will be very high. The reason that the potential product will successfully compete against such companies, and the reason that it is needed, is because there are not many innovations in the bag market. Most of the products are homogenous save for their aesthetics and slight variations in strap placement. My innovative product which corrects posture is a rarity and will stand out, even though the price of my product is relatively even with the 40-50 USD price range of competing products.

The research stage has already established that the target audience are parents from ages 36-48 with children of ages 10-15, and that they are prepared to pay in the price range of 50-60 USD. Since the manufacturing costs will only be 10% of the retail price, and the retailer will take a dividend of 50% of the final price, I will earn 40% of the product's earnings, which is around \$22 per product. The invention calculator has already established before that my product is economically viable, but this analysis confirms it.

Target Market

There are only two target audiences who will end up buying the product for the target market.

Main Target Audience (Personna A)	Secondary Target Audience (Personna B)
Parents aged 36-48, with children/students ages 10-15	Children/Students ages 10 onwards
Concerned about their children's posture	Concerned about posture while at the same time wanting to look cool
Their children carry a very heavy schoolpack load daily	They carry a very heavy schoolpack load everyday
Has disposable income (i.e. middle-class and upper class), prepared to pay more for premium products	Has parents who can afford premium products (that are at least middle-class)

Target Audience

The broader market sector will be the backpack market which is a relatively big market, but the specific market sector will be the much smaller, much more niche and innovative posture-correcting backpack market. In that market the product will be aimed to the demographic segment of children/students of ages 10-15, and to the geographic segment of primarily people living in Asia, which generally has a culture of intense studying and tutoring. (therefore more weight to carry due to more books, more need for posture-correction)

User Need

The target market needs a posture-correcting backpack which the target audience (their children) will end up using and correcting their postures with. This backpack needs to be lightweight in itself, durable, water-resistant and cost-effective. It also needs multiple compartments for versatile use, and aesthetically pleasing to both the end user and the target market. Mostly importantly it has to be ergonomic and fit the end user's anthropometrics by having the straps less than 45cm apart. It also has to fit the common modern learning resource of the laptop, and therefore has to be at least 43cm long.

Competition

Through an analysis of other posture-correcting bags for children/students (in the previous Product Analysis), it may be seen that in order to compete with other products in the posture-correcting bag sector, the price has to be around \$50, the pack has to be made from lightweight, durable and water-resistant, must have multiple compartments for versatility, has to be big enough to store a laptop, and the posture correcting has to be done through cushion padding as to not hurt the user. Really, the market need for my product exists because the competitors' products do not posture-correct effectively, or their prices are too high to target a larger target market. Mitigating both of these through predatory pricing and innovative design will ensure my product's advantage over competitors.

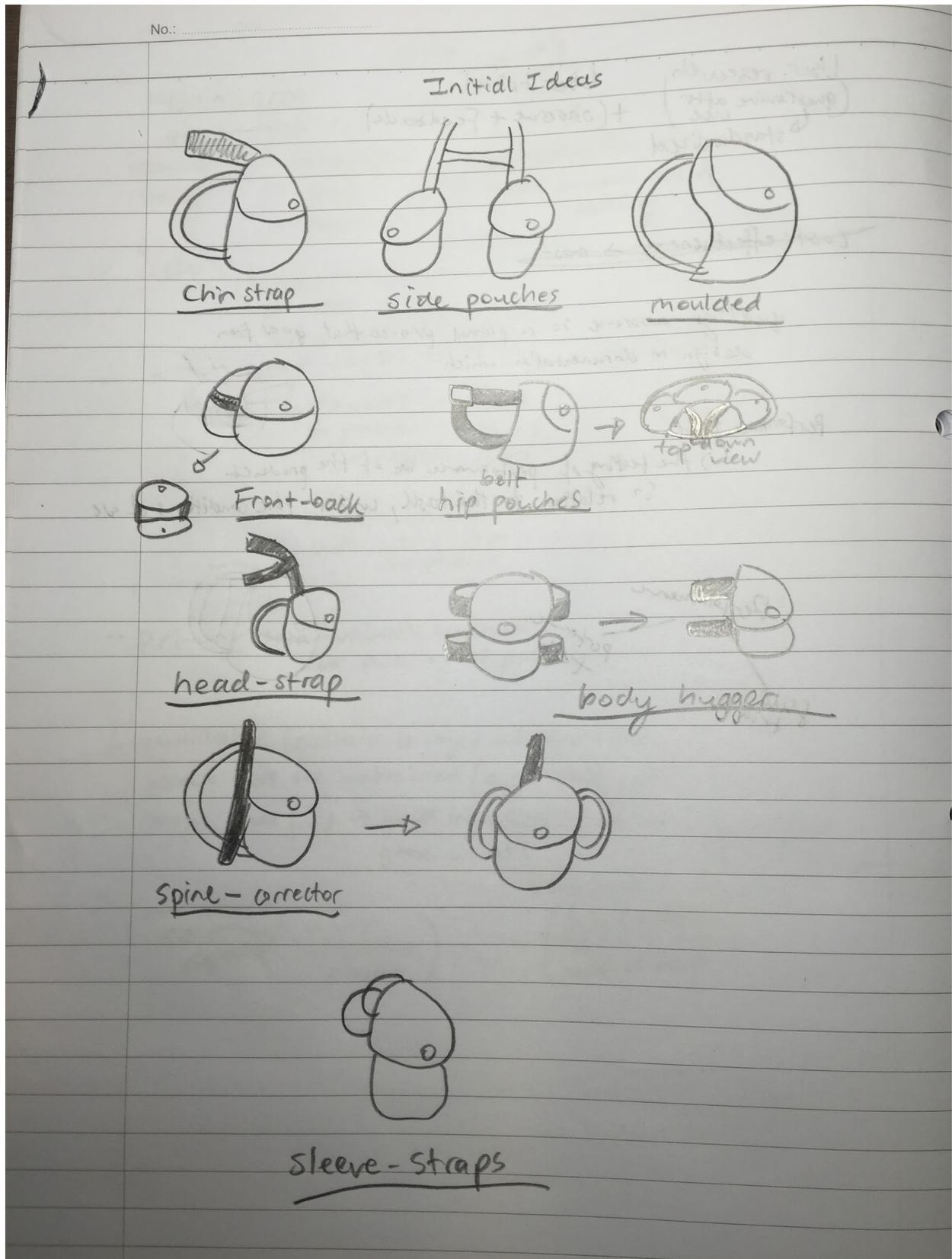
Design Specifications

	Requirements	Justifications
Function	<p>Must have some sort of cushioning or strap mechanism which reduces the amount of stress experienced by the shoulders and the back while wearing the strap, in order to correct the wearer's posture</p> <p>Must be able to carry a laptop i.e. at least be 43cm in length to accommodate 17 inch laptops as well</p>	<p>This ensures that the design need and problem of students with poor posture is properly addressed</p> <p>This ensures that in this modern world where computers are used in schools as learning resources, students will be able to carry them around.</p>
Aesthetic requirements	<p>The design must be modern and sleek, but not too complicated.</p>	<p>This ensures that there is a compromise between being visually appealing to the younger target audience and the older, middle-aged target market</p>
Customer requirements	<p>Must be easy to wash i.e. there must not be too many compartments and corners that are hard to access</p> <p>Must be light to carry by itself</p>	<p>This ensures that there is no inconvenience for the target market or audience to wash the bag.</p> <p>This ensures that there is no excess weight added on to the weight of the school resources in the pack.</p>
Performance requirements/ constraints	<p>Must have multiple compartments that are all easily accessible</p> <p>Must be durable and long-lasting</p> <p>Must be lightweight</p> <p>Must be water-resistant</p> <p>Must be able to accommodate up to 17inch laptops.</p> <p>Cushion padding must be thick enough to relieve some of the stress put on the shoulders</p>	<p>This ensures versatility of the backpack, and storage for non-school related things like lunch packs and water bottles.</p> <p>This ensures the product has a long product life and that it is durable in all conditions, and it ensures that there is no excess weight.</p> <p>These constraints make sure that the bag performs as determined by user research, by allowing storage of laptops, a key learning resource in the modern era, and by relieving the stress put on shoulders by the weight of the load in the bag.</p>
Environmental requirements	<p>The material used and the manufacturing processes must be environmentally sustainable. Whether this be through using easily recyclable or disposable fabrics such as cotton, or through using organic</p>	<p>This ensures that although fabrics are not easily designed for disassembly, the material choice is environmentally sustainable.</p>

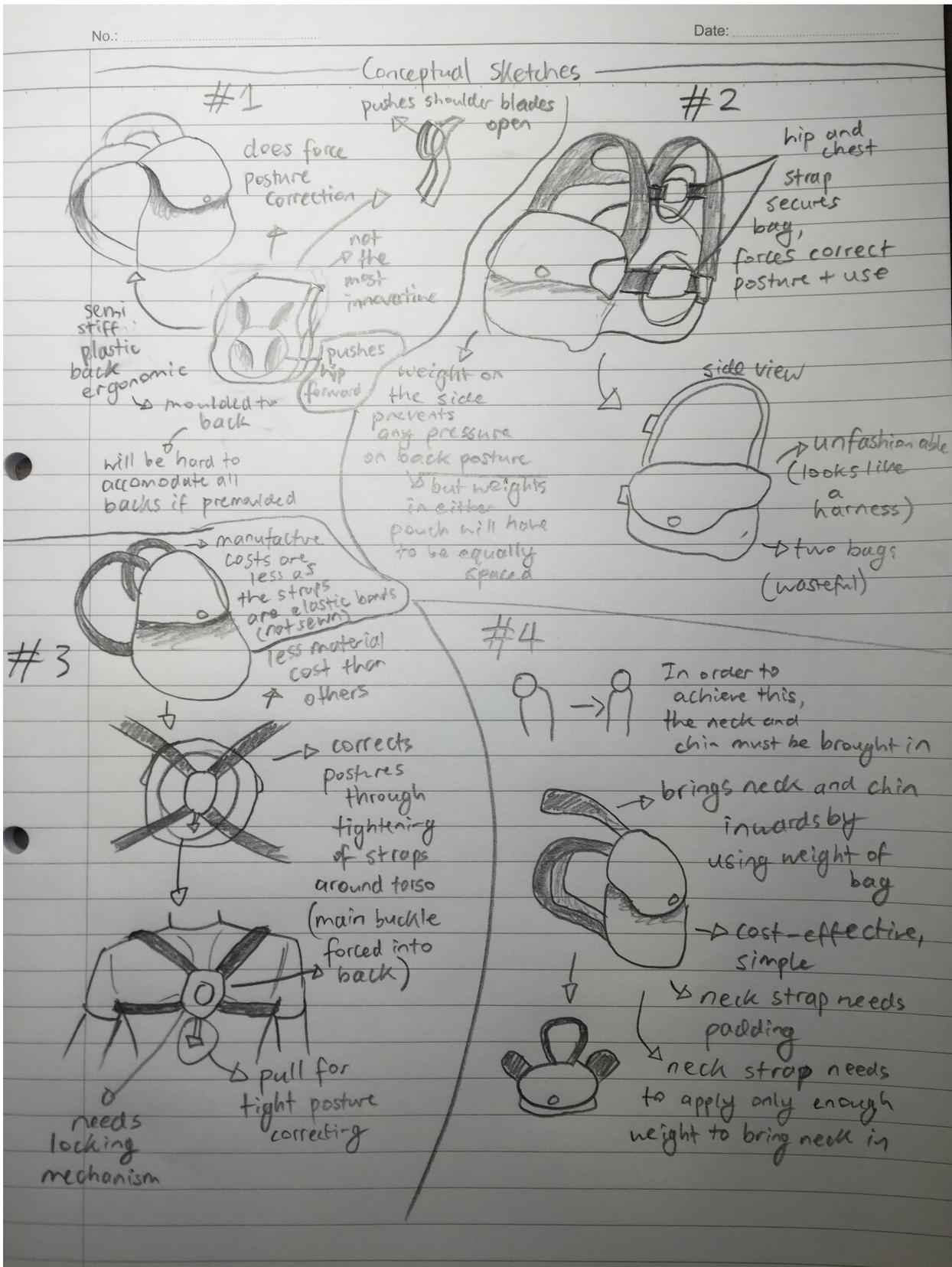
	versions of fabrics which do not pollute the environment in its production. (e.g. they don't use pesticide to grow organic cotton)	
Size constraints	At least 43cm long Straps must be less than 45cm apart from each other	This ensures the pack can accommodate laptop This ensures the straps fall on to the smaller shoulders of the young target audience.
Safety considerations	The bag must be able to support up to around 10kg (average bag weight derived from survey above) without snapping or tearing	This ensures that the bag holds together to avoid any accidents, especially if there are laptops inside.
Manufacturing Requirements	-Be able to be manufactured using school-workshop available equipment, i.e. electric powered sewing machines, but also later be able to be manufactured in CNC cutters/stitching machines for commercial production. -Minimum requirement for stitching is the single straight-line stitch, regardless of seam or no seam stitching -The cutting of the fabric must be clean-cut and not frayed (i.e. with fabric scissors or rotary cutters.)	-This ensures that the a working prototype can be produced in a school workshop, and that the techniques used can be mimicked when manufacturing in batch scale. -Layers will be stitched multiple times over in different areas so it is durable, therefore the stitch doesn't have to be super durable and elastic like a overstitch, which really just wastes time and material. Seams do not matter as the seams will always be on the interior of the bag, which does not hinder any performance or aesthetic requirements. -Clean-cutting ensures aesthetic cleanliness and appeal
Material Requirements	The material has to be relatively -light weight -water resistant -durable -have high tensile strength -have high elasticity -cost effective/ high availability -is relatively environmentally friendly (i.e. maybe it biodegrades as a natural fiber, or is recyclable easily.) -e.g. materials like nylon canvas, polyester, etc.	-This ensures that the final product is not putting any excess weight on top of the heavy school load -Water resistance and durability ensures that the product is durable in humid and wet conditions and weather, and is long lasting. -High tensile strength and elasticity ensures the bag does not tear or snap under high loads -Environmentally friendly ensures that the bag is part of sustainable design. -Cost effectiveness or high supply of the material means that it is cheaper, and ensures that the final product meets the cost constraints of \$11 manufacturing cost.
Cost constraints	Manufacturing costs have to be less than or equal to \$11, and the final retail price has to be around \$55 or cheaper	This ensures that there is a good enough profit margin for economic viability, and the retail price ensures that the acceptable price (derived from the research above) for customers is set.

Criterion B - Exploring Conceptual Ideas

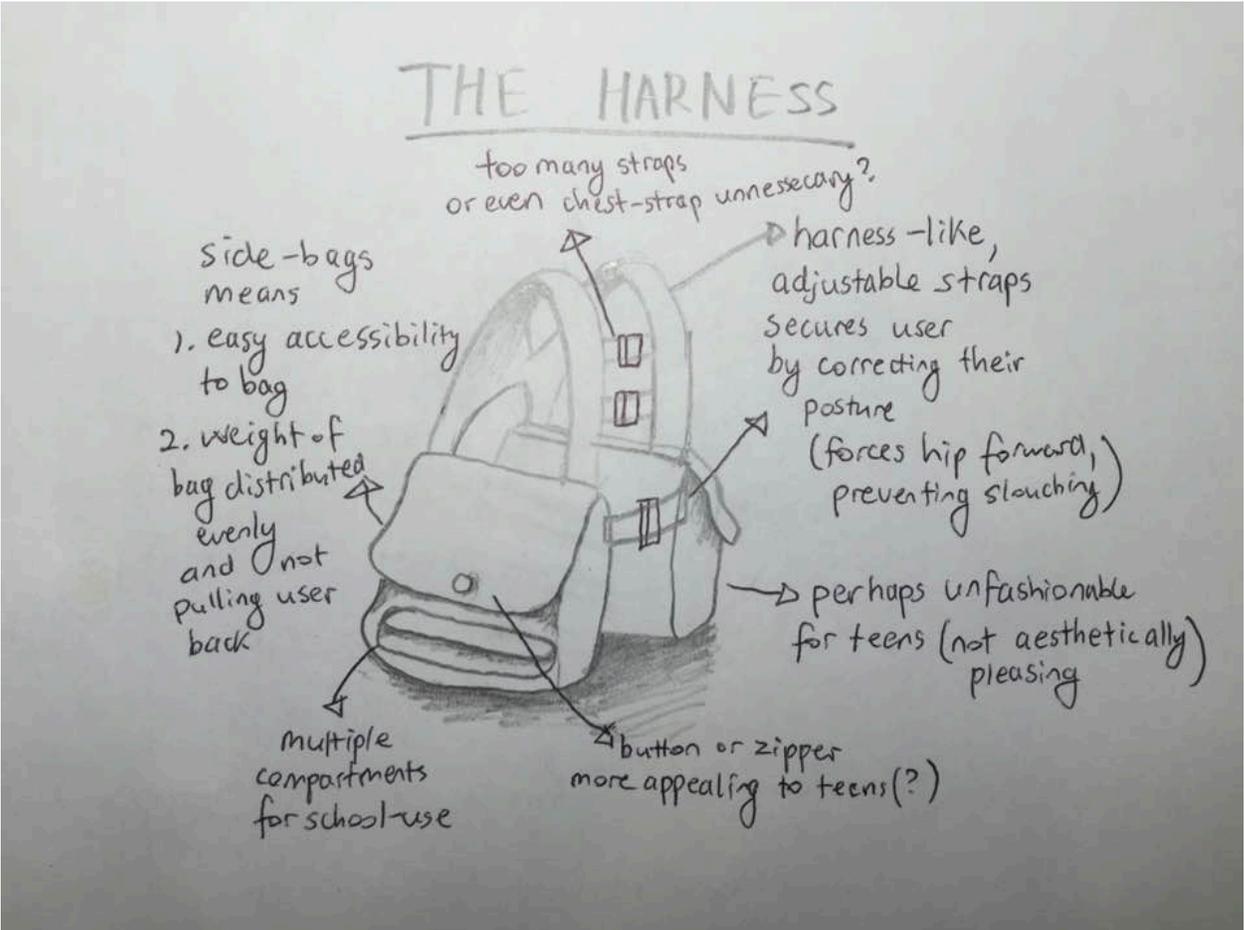
Here I will be brainstorming very basic conceptual ideas that address the design need.



Here are the 4 Ideas I have chosen to develop further:



Design #1 – The Harness Idea

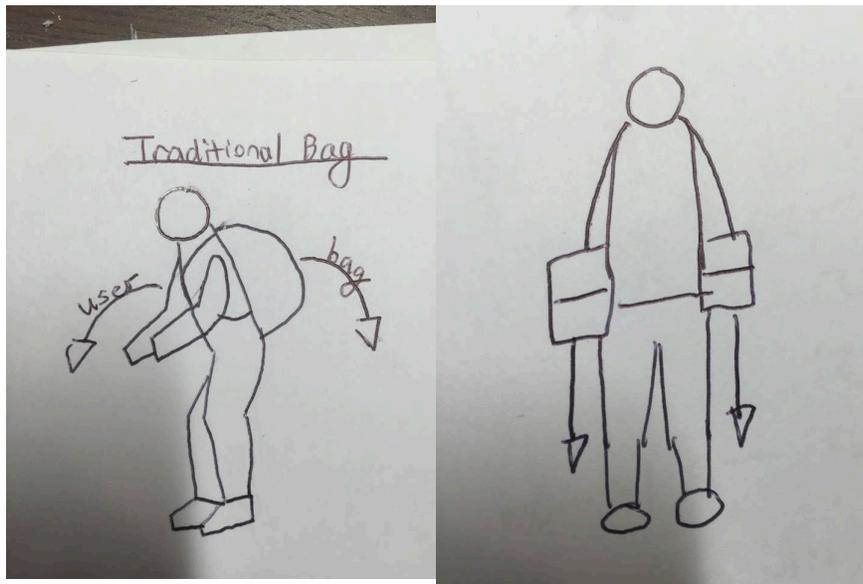


The harness idea was physically modelled using PVC foam sheets and tape to simulate the shape of the bag.



Although the bag's functionality of being a posture-correcter seems possible, the key point is that the bag has to be appealing to teenagers. This means it has to look modern, sleek and "cool", which this bag does not look like. The harness looks unwieldy and unfashionable.

The logic behind the bag's functionality is that the traditional bag weighs the user down backwards, so to compensate, the user slouches forwards.

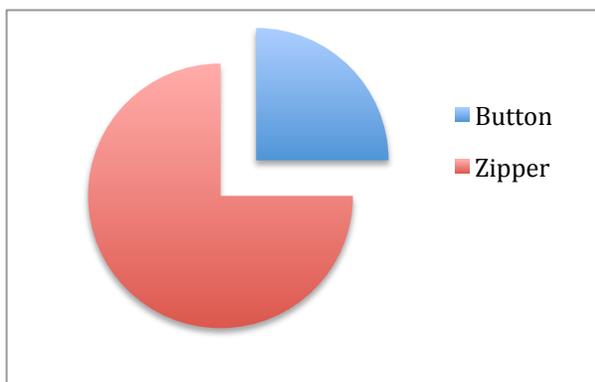


For the harness bag, however, since the bags are onto the sides, the person is merely dragged downwards, not backwards or forwards. The waist strap also prevents any slouching forwards, as bringing the hip in line with the shoulders will promote positive posture.

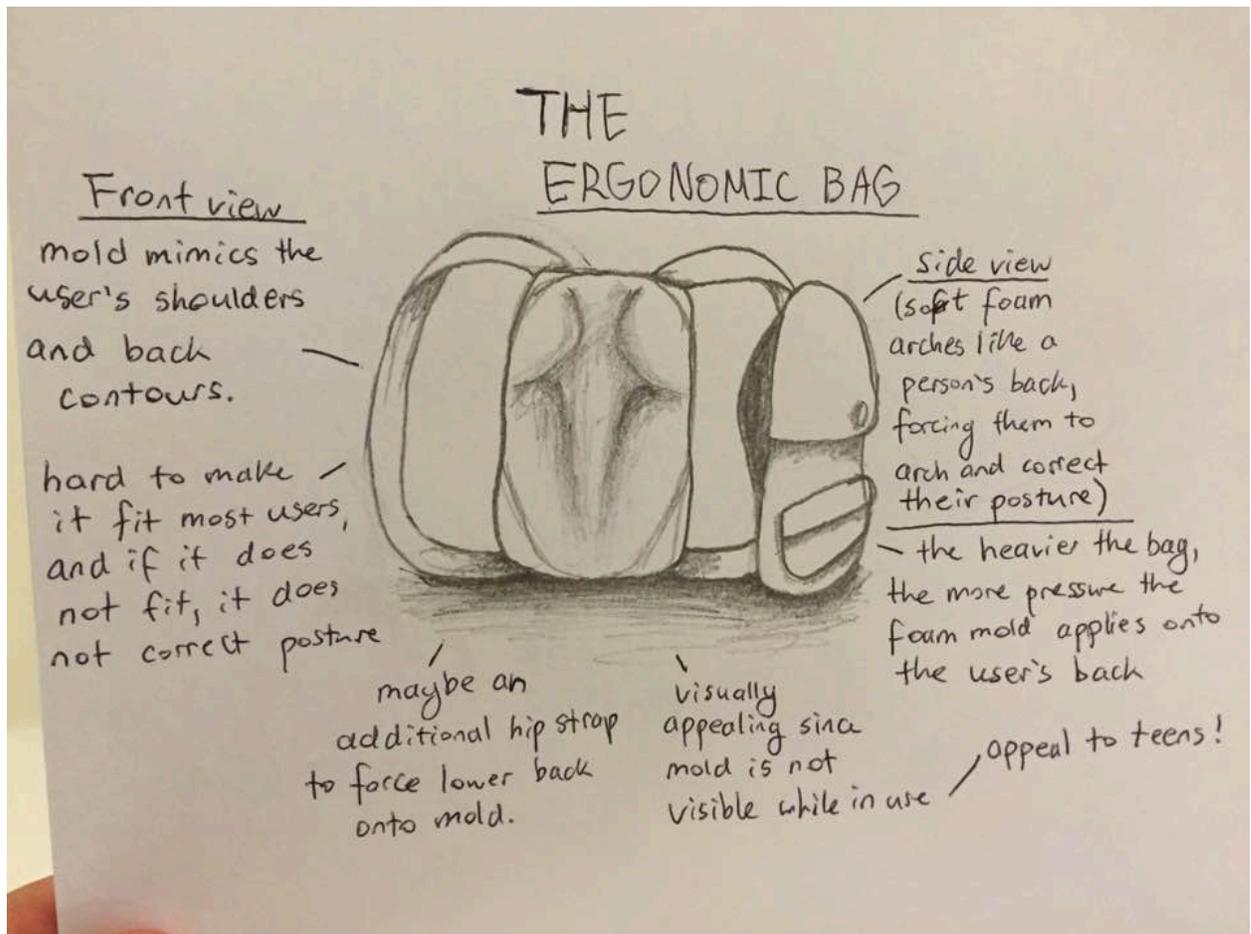
The problem with this is that the weights put in the bags on both sides have to be equal to one another, or there will be unequal forces acting on each shoulder.

A survey was also done on the Target audience age group in order to gain some user feedback.

When asked whether zippers or buttons would be more suitable for such a bag, the 75% of the teens responded that they preferred zippers, which were much easier to use, and could be hidden out of view under flaps, which meant they looked simpler and more modern.



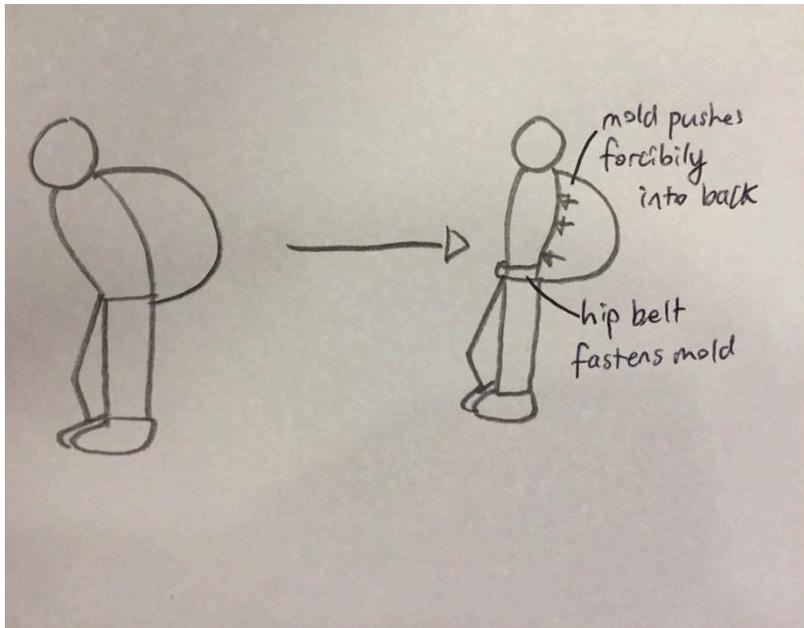
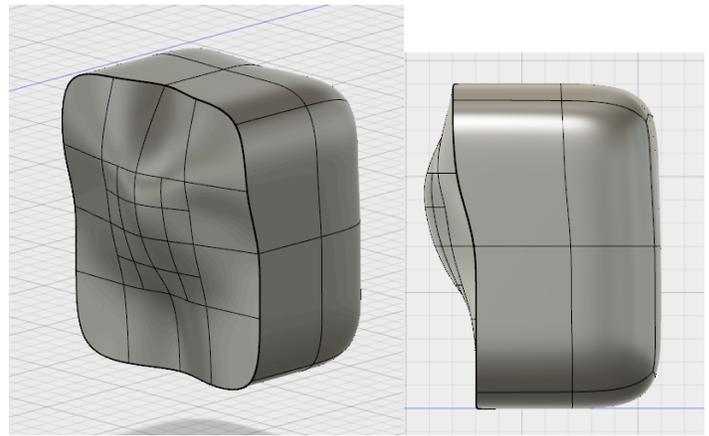
Design #2 – The Ergonomic Idea



The ergonomic bag was also modelled using clay to simulate the back-mold component of the bag.



Although the bag should be very appealing to the target audience of the teens, as the posture-corrector is hidden away while the bag is in use, the bag will be difficult to make into a reality. Not only is it difficult to find a complete average anthropometric data set for the backs and shoulders of teens online, but even when it is manufactured using that data, it will be difficult to fit to all teenagers, since the mold has to fit perfectly in order to correct posture. Additionally, people tend to grow spontaneously and drastically during their teenage years, which means that what might have been comfortably correcting posture might not fit after the user grows.



The logic with the posture-correcting element is that the mold pushes into the back, matching its contours so that the parts that need to be pushed forward to promote good posture (like the lower back and hip) are pushed forward with protruding foam, and the parts that need to go back more (like the shoulders and upper back) are allowed to relax back in the mold's cavities.

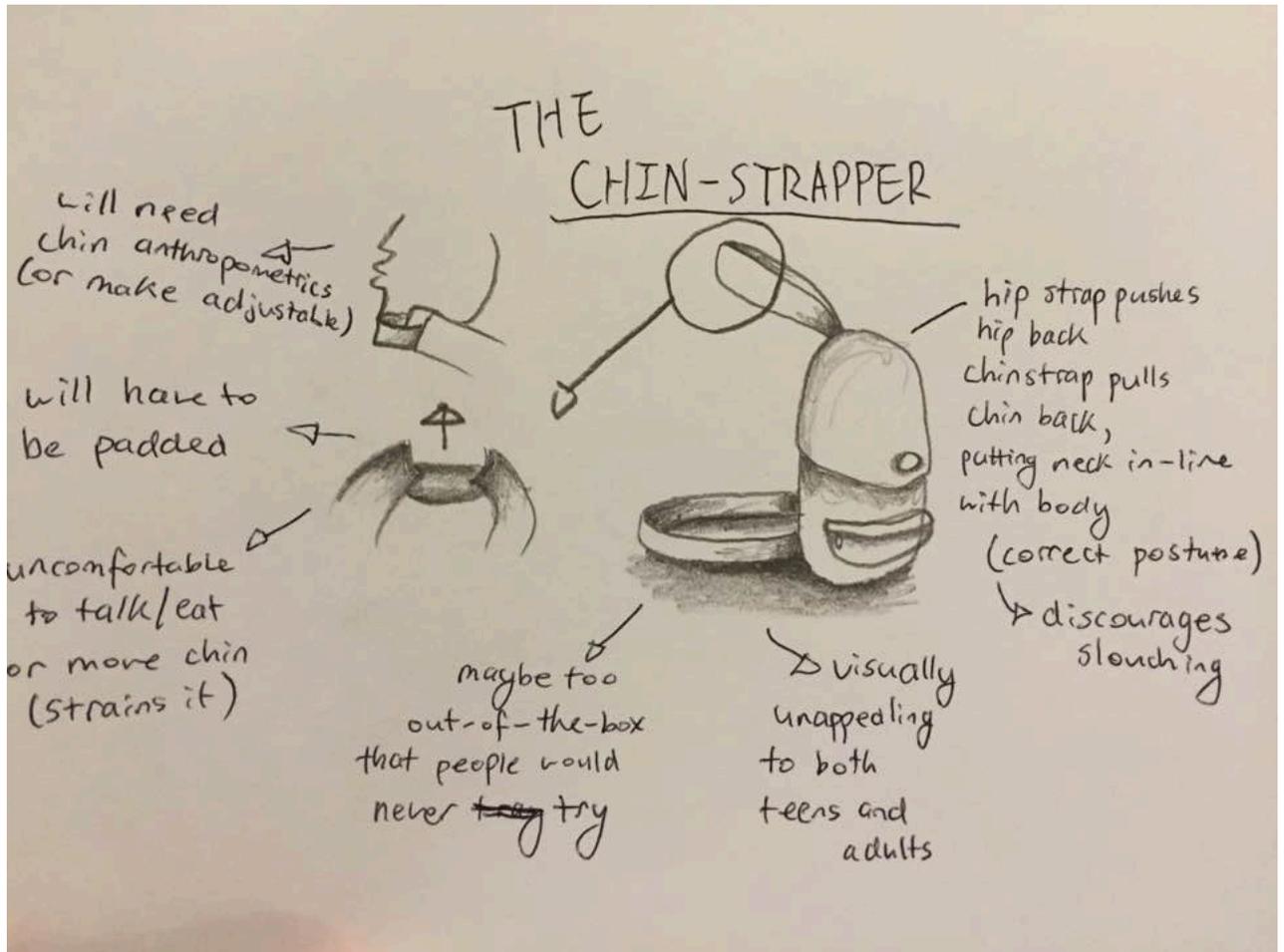
An interview was done with Juan Garcia, a father of age 36, in order to see what the target market thought about the idea.

“What do you think of the Ergonomic Bag

mold idea to correct your children's postures?”

Mr. Garcia: “While I do think that it may work for some, the solution looks like it would be **ineffective to most, if it weren't a perfect fit**. Maybe having a mold that wasn't too specific (by removing the shoulder blade cavities and such) and instead having a much **more general mold** that has maybe only an undulation in the lower back to push it forward would be more appealing and effective.” The client's feedback that the mold should be more generalised was very insightful.

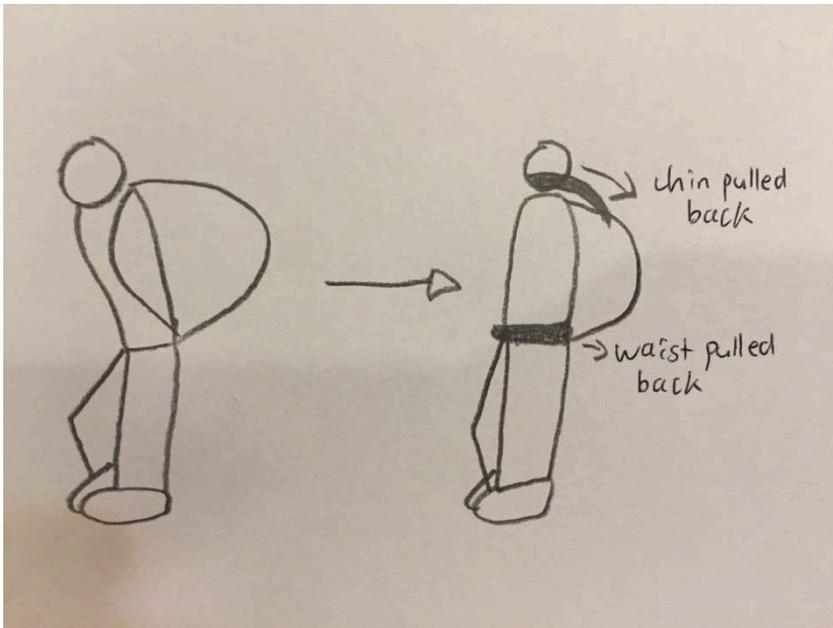
Design #3 – The Chin Strap



The above chin strap design was modelled using PVC foam sheet to simulate the appearance of the chin strap itself, as the rest of the bag would be a regular one.



This idea is very innovative but at the same time, maybe too weird and out-of-the-box that consumers will be discouraged to buy them. The chin strap makes the bag look as if it is some type of choker, which does not have child-friendly connotations. Especially for teenagers who are looking to fit in with others or look cool, having a chin strap around your neck as you use the product is not aesthetically pleasing. Additionally, although the chin strap will likely correct your posture, the chin strap creates extra strain on your neck and chin which not only prevents you from talking or eating while you carry the bag, it may lead to bone problems in the future.



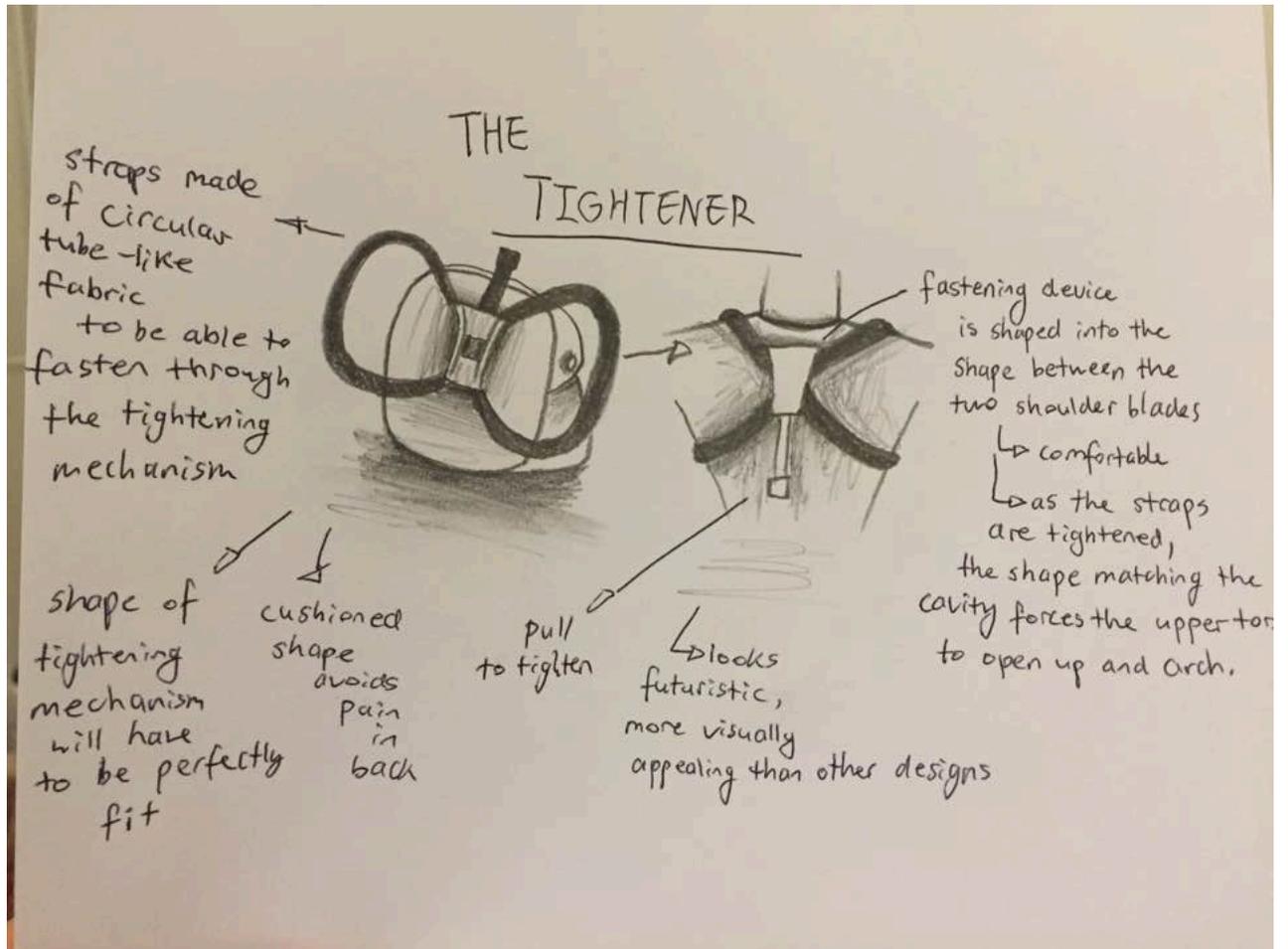
The logic with the chin-strapper is that since the chin strap pulls the chin back and the waist strap pulls the hip back, the only part that is loose and not being pulled back is the rest of the back and shoulders in between the chin and the hip. This results in an arching of the back which promotes good posture.

An interview was conducted with Julian Ross, a teenager of age 15, a member of the potential target audience.

“Julian, would you wear and/or use this bag to go to school?”

Julian: “It **looks scary, like it could choke me**. It also **doesn’t look very good** either. Also, I couldn’t even do simple things like talk or move my mouth without taking off my bag, which is **very inconvenient and uncomfortable**. I wouldn’t use this for sure. People aren’t going to buy something just because it works.”

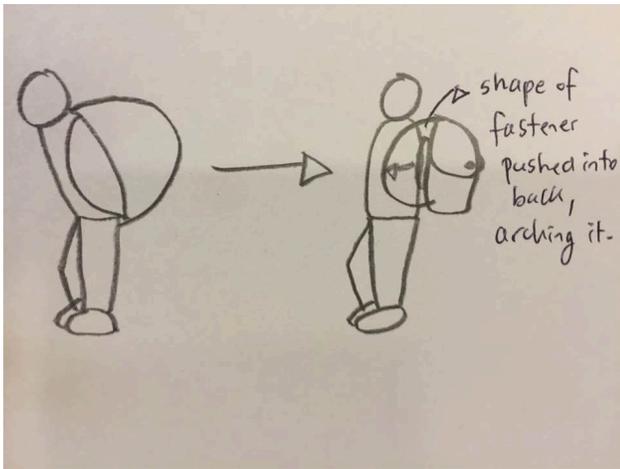
Design #4



The above Tightener mechanism attached to the bag was modelled using PVC foam sheets to simulate the appearance of it.



The idea is more appealing to the target audience of the teens, as the only difference this has in appearance to other bags is the tubular straps. The only concern is the effectiveness of the product, which is to say how well the product will correct the user's posture.

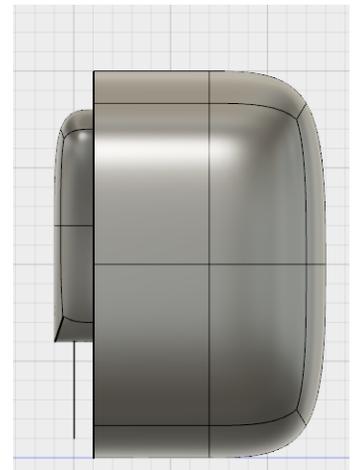
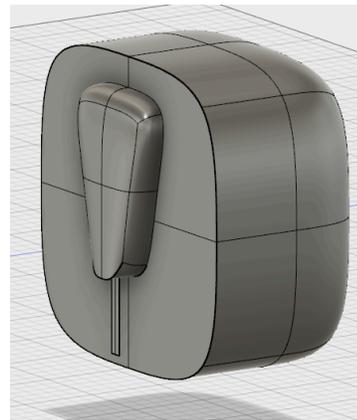


The logic is that the bag's fastening mechanism is shaped ergonomically to the contours of the middle of the upper back so that when fastened tightly, the straps will force the mechanism in between the shoulder blades to open up the back to prevent slouching. The mechanism is troublesome, as it may cause pain and discomfort even with padding on the mechanism before it even corrects the user's posture.

An interview was done with Juan Garcia, the previous interview's subject, a father of age 36.

"What do you think about this one?"

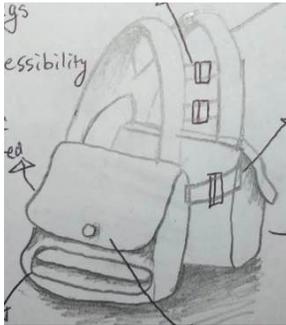
"It seems **unnatural and very painful**, especially if the straps have to be tightened a lot in order to straighten the user's back posture. The padding would certainly help, but would it be worth all that discomfort, **when the user can do without the pain and just be more conscious about the way the stand?**"



Appraisal of Designs against Specifications

In this section, each of the four designs will be compared to the design specifications. How many specifications they match will determine the feasibility and strength of the design. The specifications of size constraints, material requirements, performance requirements and cost constraints were not compared as the models are not fully scaled and neither are they made with the proper textile.

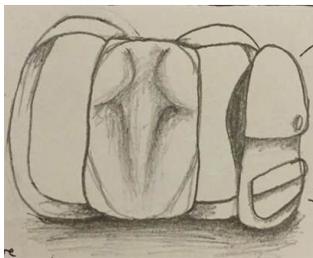
Design Number 1 – Harness Bag



This design has multiple compartments that are easily accessible, and does correct the posture of the user through the use of the straps and side-bags, can definitely be manufactured in a school workshop. The pouches are also easily accessible while the bag is equipped, and the 10kg criteria for heaviest load it can carry should be easier to meet with two pouches dividing up the weight.

The only problem that it has is that the design is not visually appealing. It does not appear modern or sleek, and instead looks complicated and militaristic, unappealing to the target audience teenagers. That will have to be considered if this design is developed later. Additionally, it is the design with the most surface area, meaning the design using the most fabric. This will translate to a relatively heavier bag than the other designs.

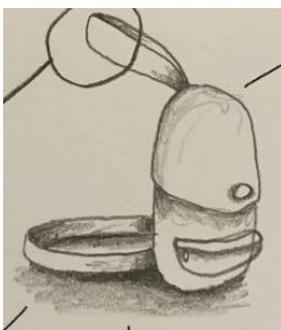
Design Number 2 – Ergonomic Bag



This design does meet the function specification of being able to correct the user's posture through the ergonomic back mold. The compartments are not as easily accessible as the Harness Bag design, but in terms of Aesthetic requirements this design is much more suited, as it looks like a regular bag when in use, and meets the modern aesthetic specification better.

The question of weight is the problem again, but this time more serious, as the material being used in the Ergonomic Bag will have to be plastic-based instead of fabric, which means this bag will be the heaviest, especially since this plastic mold has to be hard and cover the entirety of the bag to be able to posture-correct. Additionally, this raises concerns against the sustainability specification, as the whole thing cannot be recycled into virgin fabric if there is plastic involved, since it must be disassembled first. This impedes the disposal of the product.

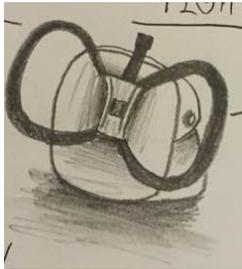
Design Number 3 – Chin Strap Bag



This design also corrects the posture of the user, but in doing so causes discomfort and stress in the neck which can lead to additional bone problems in the neck/head region. The neck is not supposed to battle the torque of a 10kg bag pulling off the back. Therefore it is the worst of the 4 designs, not being able to meet the basic functional specification of posture-correcting properly.

It also does not deliver in terms of aesthetic requirements, as it is not sleek or modern, but it does look simple. The main concern is that it is uncomfortable, dangerous and unhealthy to use and looks scary, which is obviously unappealing to teenagers. While the rest of the specifications are readily met, the two key specifications are not.

Design Number 4 – Tightener Bag



This design also corrects the posture of the user, similarly to Design Number 2, by forcing the protruding component into the back, and by extension opening up the chest and arching the back. It also has a sort of futuristic feel to it with the circular straps as tightening mechanisms, which will no doubt appeal to teens.

The concern here is that the straps cannot be cushioned very well if they are to be designed circularly like this to allow for tightening/loosening through a pulling mechanism. This means that it will be uncomfortable to use. Also, much like Design #2, there is an extra component of different material to the rest of the bag, which not only adds to the natural weight of the bag itself, but also impedes the sustainability specification, as the joining method will have to be undone and the component disassembled before recycling/disposal.

Final Chosen Design

The final chosen design will be Design Number 1, the Harness Bag, as it is the most innovative and the one I can take furthest in terms of improvements. Unlike the rest of the Designs, the posture-correcting mechanism is very logical and seems to be effective with the testing of the prototype, with its only downside being its aesthetic weakness as a bulky, harness-type bag.

Design 2 and Design 4 have too many drawbacks of being heavy due to the extra plastic molds, and being less sustainable as they will have to be disassembled because of these extra components, despite being the most aesthetically pleasing designs. Design 3 is too unusual, and doesn't meet the basic functional requirement without some seriously unhealthy drawbacks which make users develop worse spinal problems than current student's posture problems.



CRITERION C

PROTOTYPES

Using the same materials as stated in the design specifications, a working basic prototype without the use of exact dimensions was made, to test against the design specifications and to gain feedback from potential users/experts.

Black Canvas
100 % Polyester
for the exterior of
the bag

Cotton Sheets
(Soft) for the
padded straps

Hard Fleece
Netting for keeping
the shape of bag
on the inside



Cotton Straps (pre
made and
outsourced), for
bag straps

Buckles
(outsourc
ed) for
tightening
and
clipping
the
front

Using the following materials above, a prototype of the design chosen was made. The black canvas 100% polyester was chosen as the exterior material because of its original purpose as tent lining. For this reason canvas is durable and water-resistant, just the type of material I wanted. For the rest of the materials, they were not restrained to any particular design specifications, so cheap cotton and fleece were used at the very least to reduce the overall cost of production.

Firstly, the canvas sheet was cut up into individual sheets. The sheet was marked with multiple borders in order to mark where the canvas would be stitched to the other pieces of fabric, and where the hard fleece netting would support the canvas. This was done by hand, through scissors. A photo is shown below.



In the prototype, this method of cutting the fabric results in messy loose/torn pieces of fabric on the insides of the bag. This is because the scissors are not sharp enough, and therefore tear some of the fabric as it is cutting through it, resulting in lots of time wasted on the manufacturing cleaning up such loose ends. A better method would be to use a knife, or something with a sharper edge than scissors have.

Next, the hard fleece netting was stitched on the marked lines of the canvas sheets using straight line stitches on a sewing machine. The netting was kept stable on top of the canvas with the use of safety pins. This was done in order for the bag to hold its shape when there is nothing inside, a process done traditionally to all commercial backpacks through similar netting or through wire frames. This netting worked surprisingly well in keeping the bag's end shape in the prototype, and makes for great presentational/durable effect.



Next, each of the hard-fleece stitched sides of the bag was assembled inside out first, in order to flip it inside-out once the product was finished in order to create cleaner edges on the outside.

This was done using done three-point zig zag and straight line stitches. The zigzag stitches were used to initially fasten the strips of canvas together, and the straight line stitches were used to create the edge that would be the outside edges of the bag when turned inside out.



Once this was achieved, the bag was turned inside out, as shown below.

This process was repeated for a second bag, after which the cotton straps which were pre-made were stitched as the straps of the individual bags. Then the cotton straps were put through the buckle mechanism, at which point the buckle mechanism was attached to the bag straps. A back padding strap was made as well, and promptly attached on.



And thus, the prototype was finished, as shown below, on a user testing it.



The prototype does fit most of the design criteria, but is also not finished, as the closing mechanism of the bag has not been trialed yet, and neither has the multiple compartment aspect of it.

The bag itself is very light, made with a very durable and water-resistant fabric, as required by the design specification. It has also been made with relatively cheap manufacturing costs (as ensured by simply using a sewing machine and cheap fabrics aside from the canvas). Is it at least 43cm in width too, able to accommodate a laptop. The black matte color also makes for a very modern-looking bag, although the design itself is not so aesthetically pleasing.



It was tested for the ease of washing, and it was very easy to wash, with not many corners that are hard to reach. A simple rinse with soap was all it took.

It was also tested for the amount of weight it could carry. The bag could carry at least 10kg weight as suggested in the design specifications.

It was finally tested for its purpose, which is to correct the posture. With self-testing and user-feedback, it was gleaned that although the bag worked in achieving prevention of slouching, it could be designed better for more effective posture-correction.

A common feedback was that there should be a hipstrap, in order to force the user's hips in line with their chin. This would result in proper posture, and not just prevent slouching. In the final prototype, this strap will be added, but a discreet version of it, so as not to sacrifice the aesthetic integrity of the current model.

Another feedback was that the weight in each of the bags could go anywhere, forward and back, making the user slouch or get pulled backwards. The general consensus was that the bag should make you lean backwards a little bit, in order to discourage slouching further. In

response to this, the final bag will have its compartments slanted downwards at the back of the bag in order to force the contents of the bag to go backwards.

When tested for the comfort levels with some weight in the bags, the straps created a lot of stress on the shoulders. Instead, a padding system could be introduced in which the cotton padding used on the back of the bag straps were used in the shoulder straps, as traditional bags do.

Justification of Materials/Components

Component/Material	Justification
Black Canvas 100% Polyester for the exterior of the bag	<p>-Black canvas has a relatively high tensile strength, meaning in the use of a bag, the straps and bag itself can stretch with the weight of the bag snapping/ripping the fabric. It is also extremely durable, allowing the bag to withstand high amounts of weight without tearing.</p> <p>-Black canvas is also water-resistant. This is because of the thermo-plastic emulsion during the production process which prevents some moisture absorption. Not only does this allow the bag to protect its contents, but it also prevents the bag from absorbing too much water and therefore becoming much heavier in humid/rainy conditions.</p> <p>-Black canvas is also a matte-fabric, and along with the black color of it, it presents a sleek, modern feel that would likely appeal to the image-conscious target audience of the teenagers.</p> <p>-Supply of black canvas is also very accessible, as black canvas is imported all over the world to arts-and-crafts shops, much like all common fabrics are. This means the cost of black canvas wont be so high because it is in such high suppl.</p> <p>-Cost of black canvas is relatively expensive at \$30 per square meter, but for the physical properties it gives and the high quality matte-look, it is worth it.</p>
Cotton Straps for straps of bag	<p>-Cotton straps are very cheap since synthetic cotton is inherently cheap, at around \$3-\$5 per meter, and is supplied in abundance globally in arts and craft shops.</p> <p>-These cotton straps are durable since cotton is very durable.</p> <p>-The concern would be that the cotton is water-absorbent, but that is only with natural cotton. With synthetic-cotton straps, the plastic emulsion helps combat the water absorption, meaning less water weight and more secure grip on your body frame.</p> <p>-Cotton is also very inelastic, tearing under high lodas. But this is not a concern. The reason most bags use these cotton straps is because the straps themselves do not have to be as elastic as the bag material, as</p>

	<p>they are only supporting the weight equally on two shoulders.</p> <p>-Also cotton is the only available bag-strap that could be outsourced in my area</p>
Buckle Mechanism for fastening	<p>-Only available fastening mechanism that could be outsourced</p> <p>-Buckle ensures easy and accessible joining/unfastening, and is made of a very cheap plastic, and therefore it very cheap.</p> <p>-Buckles are also very easy to operate.</p>
Cotton Padding for ease of pressure of the weight in the bags	<p>-Not only is this cotton padding produced in very thick layers, allowing for more mitigation of the weight of the bag on the shoulders and more comfort for the user. Cotton is also very air permeable, which means it is very soft and comfortable, and will to an extent mould to the user's shoulder form. This adds to the ergonomic comfort of the bag</p> <p>-This type of cotton padding is a composite of cotton and a number of different synthetic and natural fibers, meaning that it is not as expensive as natural cotton, and hence is cheap. This is in high supply globally in arts-and-crafts shops.</p> <p>-Although this type of padding may absorb more water since it has more cotton content, it should not matter as the padding is covered by a nylon canvas layer, protecting it from absorbing water weight and becoming heavier.</p> <p>-It is also the only type of padding available in my local arts-and-crafts shop</p>
Hard Fleece Netting for keeping shape the bag's exterior shape	<p>-Hard Fleece Netting was primarily chosen because this netting is hard, and has a high stiffness even as a flat sheet. This means that the shape of the bag could be kept even when the bag was not in use through this netting on the inside.</p> <p>-The netting also provides a slick feel on the inside of the bag, covering up all the frayed ends of the fabric and allowing for easier inserting or removing content in and out of the bag, with a much more aesthetically pleasing interior of the bag.</p> <p>-The netting is also water-resistant due to its synthetic origin, meaning it provides a second layer of water-protection from the contents of the bag</p> <p>-Hard Fleece Netting is also very cheap and in high supply globally, as it is with most fabrics.</p> <p>-This netting was chosen over wire mesh netting on the outside seams of the bag because then the entire manufacturing process would have to add a seam on the outside of the bags, wasting more material and time, and metal would have to be placed within these seams, increasing the natural weight of the bag.</p>

Justification of Manufacturing Techniques

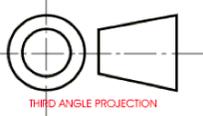
Manufacturing Technique	Justification
Stitching (zig zag and straight line)	<p>Stitching using a sewing machine is not only cost effective and fast compared to hand-sewing, but it is also very cheap as the only manufacturing cost it incurs is the spool of thread it uses.</p> <p>Straight-line and zig zag stitches were used, zig zag for initial securing and straight line for fastening/double securing layers.</p> <p>There was no need for complicated stitches like over stitching or lock stitching, because although they are more high quality joining methods with more durability and elasticity than regular stitches, they waste a lot of time, and the sewing machine used has to be equipped with the setting for these stitches. Because the layers are already being secured twice together (once through zig zag and another through straight line), there is no need for the extra durability. Hence the simple stitching.</p>
Cutting Using Rotary Cutter	<p>The fabric will be cut with a rotary cutter instead of scissors to remove the unnecessary messy threads that stick out when the fabric is torn with the non-sharp edge of the scissors. This will ensure that no frayed ends of the fabric will get caught in the closing mechanism of the bag.</p>

Final Design Proposal

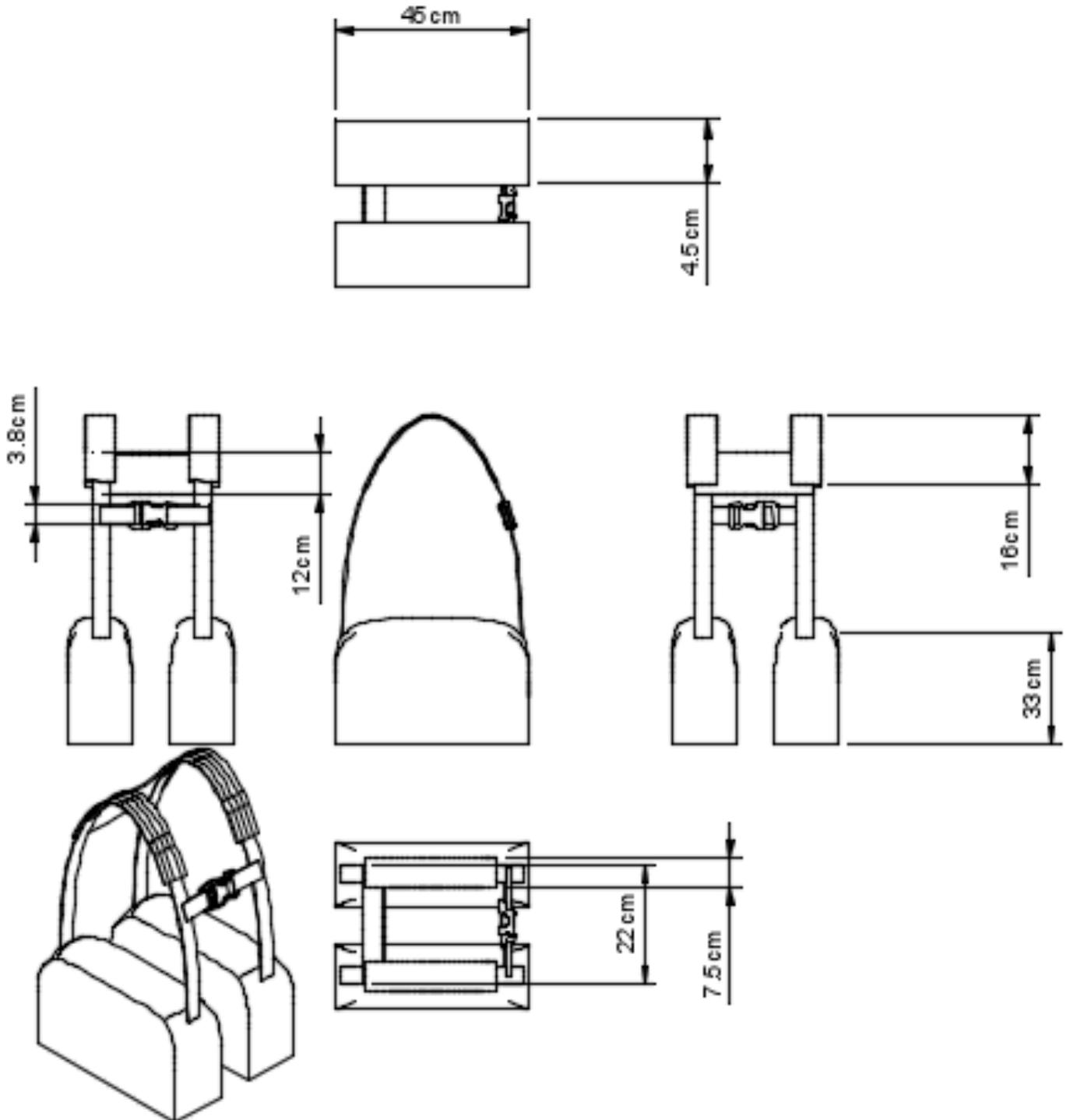


Parts List (all measurements in mm)

Part No.	Part Name	Material	Quantity	L	W	T/H	Process
1	Buckle Strap	Acetal (outsourced) and cotton	1	290	38	1	Straps were put in premade buckle, then sewn on to the Bag Straps on either side
2	Bags	Polyester Canvas and Hard Fleece Netting	2	440	290	50	Cut sides using sharp knife, then netting was sewn on canvas, then the canvas sides were sewn together into bag and turned inside out
3	Zippers	Cotton and Brass (outsourced)	2	400	30	1	Cut to length with knife, then sewn on to canvas strips layered with cotton padding and then sewn on to the rest of the bag
4	Bag Straps	Cotton	2	1050	38	1	Cut with knife, then sewn on to bag
5	Shoulder Padding	Polyester Canvas and Soft Cotton Sheets	2	305	75	3	Cotton sheets and polyester canvas was cut out using a knife, then polyester was wrapped over the cotton and creased, then sewn to secure. The pads were then sewn onto bag straps
6	Back Padding	Polyester Canvas and Soft Cotton Sheets	1	265	115	2	Cotton sheets and polyester canvas was cut out using a knife, then polyester was wrapped over the cotton and creased, then sewn to secure. The entire pad was then sewn onto bag straps

Name: Jun Oh Koo	Date: 20/11/2016		Scale 1:4	Drawing No. 1
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Orthographic Projection



Plan of Production Gantt Chart

Days			1			2		
Hours			1	2	3	1	2	3
Process	Equipment	Risk Assessment						
Mark outline on sheets of fabric that need to be cut out, and the spaces that will be sewn onto other pieces	Chalk	No risk involved.						
Cut out pieces of respective fabric, and cut lengths of bag straps and zipper needed	Sharp Fabric Knife	Stay cautious of the sharp blade of the knife, placing it gently down in a stable location when not in use						
Using a pin to secure the materials together , sew the Hard-Fleece netting pieces onto the outines on the Polyester Canvas Sheets	Safety Pins Sewing Machine	Stay cautious of the safety pin, making sure the point is always away from you. Stay cautious of the needle as it is sharp and very fast while the sewing machine is in use.						
Using a pin to secure the materials together, sew the edges of now-layered Polyester canvas sheets together, and turn the bag inside out once finished	Safety Pins Sewing Machine	Stay cautious of the safety pin, making sure the point is always away from you. Stay cautious of the needle as it is sharp and very fast while the sewing machine is in use.						
Using a pin, sew t he zipper onto the edges of the open-end of the bag	Safety Pins Sewing Machine	Stay cautious of the safety pin, making sure the point is always away from you. Stay cautious of the needle as it is sharp and very fast while the sewing machine is in use.						

Sew the cotton bag straps to the bag ends	Safety Pins Sewing Machine	Stay cautious of the safety pin, making sure the point is always away from you. Stay cautious of the needle as it is sharp and very fast while the sewing machine is in use.							
Wrap the canvas sheets around the cotton padding, and crease. Then use pins and a sewing machine to sew the shoulder and back padding pieces.	Safety Pins Sewing Machine	Stay cautious of the safety pin, making sure the point is always away from you. Stay cautious of the needle as it is sharp and very fast while the sewing machine is in use.							
Sew the padding pieces onto the bag straps	Safety Pins Sewing Machine	Stay cautious of the safety pin, making sure the point is always away from you. Stay cautious of the needle as it is sharp and very fast while the sewing machine is in use.							
Put the remaining strap pieces into the buckle mechanism, and sew the buckle strap onto the bag straps	Safety Pins Sewing Machine	Stay cautious of the safety pin, making sure the point is always away from you. Stay cautious of the needle as it is sharp and very fast while the sewing machine is in use.							

CRITERION D

EVALUATING MAKETING SPECIFICATIONS

Specification Point	Strategy of Testing	Testing Results	Evaluation against Specification	Success Score (0-2)	Market Analysis	I will find out whether the features the product offers are available in competing products, and will also research whether the production methods and materials used (i.e. polyester and sewing) is the appropriate in terms of sustainability and time and cost to effectiveness.	After investigating existing posture correcting bags, I found that the features which the product offers now, although they do exist, are not common on every single bag, and often bags have only one key feature, rather than the designed bag which includes various different features. This would create a larger demographic of parents due to greater features and functions. Researching manufacturing techniques, I found sewing to be rather sustainable and not very wasteful, the only problem being the cost of the high quality material used for manufacture. In terms of economic viability, the Invention Calculator was used to redetermine the costs of production and retail prices, in the market research section, and it was concluded that it was economically viable.	The results that have been gathered explain that this specification point has been achieved. This is because the product takes into account the target market, choice of manufacturing techniques that would suit its production method, and also takes into account how the product differs from other existing products in the market.	2
Target Market The target market includes single parents or couples (ages 36-48) who are concerned for their children's (age 10-15) health and safety, and are worried about their posture deteriorating from the heavy bag weight.	To send images of the posture-correcting bag to different parents and let them trial the product on their children.	After sending pictures of the bag to a variety of different parents and allowing them to trial the product, their overall perspectives were that the product was attractive and would like their child to use it right away.	Feedback from both parents suggests that the product has a suitable target market. This can be seen as parents commented that the posture-correcting bag would be a suitable fit for correcting their children's postures.	2	The design brief is viable, because the product has a large market. Due to the large demographic of parents worried about their children's posture (especially in my local region where it is common to send kids to tuition centers from a young age, increasing the bagload), there is definitely a market for the product. Regarding competition, the product should offer a relatively cheaper price, high quality water-resistant material like canvas, etc.	I will find out whether the features the product offers are available in competing products, and will also research whether the production methods and materials used (i.e. polyester and sewing) is the appropriate in terms of sustainability and time and cost to effectiveness.	After investigating existing posture correcting bags, I found that the features which the product offers now, although they do exist, are not common on every single bag, and often bags have only one key feature, rather than the designed bag which includes various different features. This would create a larger demographic of parents due to greater features and functions. Researching manufacturing techniques, I found sewing to be rather sustainable and not very wasteful, the only problem being the cost of the high quality material used for manufacture. In terms of economic viability, the Invention Calculator was used to redetermine the costs of production and retail prices, in the market research section, and it was concluded that it was economically viable.	The results that have been gathered explain that this specification point has been achieved. This is because the product takes into account the target market, choice of manufacturing techniques that would suit its production method, and also takes into account how the product differs from other existing products in the market.	2
Target Audience The target audience would include the children (ages 10-15) of the target market, students who are at that age where they are old enough to have heavy schoolbags but too young to care or worry about their posture.	I will speak to various students of the ages 10-15 on their opinion of my product, and whether they would use it. This will confirm whether the target audience is correctly set.	After speaking to various students, majority of the them were not really interested in this product. After showing them some pictures of the product and gaining their feedback, I learnt that there is a potential market for the product as they said that they would willingly use the product if it looked more aesthetically pleasing, and less like a harness.	It can be seen that since the target audience are not very interested in the bag designed after marketing the product towards them. However, this is common with products which parents buy out of concern for their children, like braces. The children tend to disapprove of the product.	1	The design brief is viable, because the product has a large market. Due to the large demographic of parents worried about their children's posture (especially in my local region where it is common to send kids to tuition centers from a young age, increasing the bagload), there is definitely a market for the product. Regarding competition, the product should offer a relatively cheaper price, high quality water-resistant material like canvas, etc.	I will find out whether the features the product offers are available in competing products, and will also research whether the production methods and materials used (i.e. polyester and sewing) is the appropriate in terms of sustainability and time and cost to effectiveness.	After investigating existing posture correcting bags, I found that the features which the product offers now, although they do exist, are not common on every single bag, and often bags have only one key feature, rather than the designed bag which includes various different features. This would create a larger demographic of parents due to greater features and functions. Researching manufacturing techniques, I found sewing to be rather sustainable and not very wasteful, the only problem being the cost of the high quality material used for manufacture. In terms of economic viability, the Invention Calculator was used to redetermine the costs of production and retail prices, in the market research section, and it was concluded that it was economically viable.	The results that have been gathered explain that this specification point has been achieved. This is because the product takes into account the target market, choice of manufacturing techniques that would suit its production method, and also takes into account how the product differs from other existing products in the market.	2

<p>User Need</p> <p>Existing posture-correctors do not fulfill their purpose very well and may not offer features such as laptop storage, the ability to actually correct posture with padded straps etc. Therefore there is a need for a posture correcting bag which fulfills the intended purpose, while being cheaper and higher quality.</p>	<p>To test this point, I will perform a physical test to see whether the product actually does correct posture with the intended amount of weight inside it, whether it can withstand the maximum weight in the design specifications, and whether the material is water-resistant and the product easy to use/transport. I will also send a survey out to the public (parents who have children who are students ages 10-15) to see whether the product fulfills their needs.</p>	<p>After meeting with a parent who has a child of the intended age group (age 15), it can be seen that the product is able to correct the child's posture quite well, even with the intended product's maximum weight of 10kg. In terms of water-resistance the polyester canvas was an appropriate choice. However, a few feedback points were that it was hard to choose school materials to balance out the weight in either side of the bag, and that it was not easy to put stuff in or take stuff out while on the floor, and they had to put it on first, making it somewhat inconvenient.</p>	<p>From the results shown in the physical test and user trial, it can be seen that the product does fulfil the user's need and has therefore achieved the needs of a parent as well as the child, though not perfectly, as can be seen through some of the more negative feedback of loading/unloading the bag being sort of inconvenient.</p>	<p>1</p>	<p>Competition</p> <p>Through an analysis of Another posture-correcting bag and other specifications it has been found that, in order to attract users, the product must be equipped with functions that they desire and which some other products in the market do not offer, e.g. a higher quality water-resistant material, laptop storage, the ability to actually posture correct, be accessible through lower prices etc.</p>	<p>In order to test this point, I will visit bag stores physically and online to see if the designed product compares with others in professional shops and if it's form, function and cost meet or exceed professionally designed alternatives. Furthermore, I will also investigate whether the features of the product meets the needs of the user, especially the price.</p>	<p>After visiting several different bag stores within Singapore and online sites selling bags, I was able to conclude that the bag designed has similar functions to that of an ideal bag at a bag shop (such as the ability to be weather-proof, portable etc...), however, one difference may be that the designed product has many functions combined into one. Comparatively, other products would have such functions however they are much more limited and do not have more than roughly 3 functions per product.</p>	<p>I was able to evaluate the specification of competition by comparing the designed product to existing commercial products. It may also be seen that according to the tests run whilst comparing other bags, the market specification point, similar to competition has been achieved. The product fully fulfills its specifications as it has a combination of features not seen in any other bag.</p>	<p>2</p>
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EVALUATING AGAINST DESIGN SPECIFICATIONS

Specification Point	Strategy of Testing	Testing Results	Evaluation against Specification	Success Score (0-2)
<p>Aesthetic Requirement</p> <p>The design must be modern and sleek, and not too complicated in order to be appealing towards the target audience of the teenagers.</p>	<p>I will conduct an interview with my client to see if this point is fulfilled.</p>	<p>After reviewing the product, the client explained that the bag was somewhat modern and sleek due to the matte-shine of the canvas material and the black color, but the buckles and straps made it look cumbersome like a harness.</p>	<p>From the interview, it may be seen that my client partly agrees that the design is sleek and modern due to the material used, but partly disagrees due to the design.</p>	<p>1</p>

<p>Functional Requirement</p> <p>Must have some sort of cushioning or strap mechanism which reduces the amount of stress experienced by the shoulders and the back while wearing the strap, in order to correct the wearer's posture</p> 	<p>This can be tested via a physical test or user trial.</p>	<p>After many user trials, it can be seen that there is enough cushioning on the strap mechanisms to reduce the amount of stress experienced, and that the bag works to correct posture.</p>	<p>The user trial results agree with the specification fully</p>	<p>2</p>
<p>Functional Requirement</p> <p>Must be able to fit a laptop. This is due to the modern age introducing technology to education, and this product should accommodate this transition fully. Therefore the length must exceed 43cm.</p> 	<p>I will conduct a physical test.</p>	<p>Most laptops were able to fit into the bag, and the length exceeded 43cm.</p>	<p>The specifications are met fully.</p>	<p>2</p>

<p>Environmental Requirement</p> <p>The material used and the manufacturing processes must be environmentally sustainable. Whether this be through using easily recyclable or disposable fabrics such as cotton, or through using organic versions of fabrics which do not pollute the environment in its production. (e.g. they don't use pesticide to grow organic cotton)</p>	<p>General review of production process, and physical testing of materials used.</p>	<p>During the testing, it was found that the production process composed mostly of sewing using a sewing machine was generally environmentally efficient, with no large use of electricity. The bag can also easily be disassembled. The materials used on the other hand, were not so environmentally friendly. Aside from the straps which are made from cotton (which is biodegradable and easily disposable), the rest of the bag is made from synthetic plastic-based fibers or actual plastic such as canvas polyester, which are not biodegradable or disposable easily.</p>	<p>The specification were not met fully, only the production process was efficient but the materials used were mostly harmful to the environment.</p>	<p>1</p>
<p>Size constraints</p> <p>At least 43cm long</p> <p>Straps must be less than 45cm apart from each other</p>	<p>Physical Test</p>	<p>The length is indeed at least 43cm long and the straps can be adjusted in width.</p>	<p>The specification was easily met fully.</p>	<p>2</p>

				
<p>Safety Considerations The bag must be able to support up to around 10kg without snapping or tearing</p> 	<p>Physical Test and user trial</p>	<p>The client using it was able to store at least 10kgs of weight in the bag without it tearing or snapping, as the stitching was strong and the material of the straps and bags durable and elastic.</p>	<p>The specification was met fully.</p>	<p>2</p>
<p>Manufacturing Requirements Be able to be manufactured using school-workshop available equipment i.e. sewed and stitched together but also later on be produced at a larger scale in batch production</p>	<p>General review of production process, observation</p>	<p>The manufacturing process used was mainly cutting with scissors and using a sewing machine for stitches. This process should be easily accessible to a school-workshop and also easily movable to a larger scale of production such as batch production.</p>	<p>The specification was met fully.</p>	<p>2</p>

<p>Material requirements</p> <p>The material has to be relatively</p> <ul style="list-style-type: none"> -light weight -water resistant -durable -cost effective -high tensile strength/elasticity 	<p>Physical test</p>	<p>Though canvas polyester is not a relatively lightweight material, the bag makes for a light design. Canvas is also not very cost effective as it is a very high quality and expensive material.</p> <p>Canvas polyester is also water resistant (as it is used regularly in outdoor tents) and durable.</p>	<p>The specification was only met partially as the canvas polyester met only 2/4 material requirements. Although, to be realistic, there isn't a fabric which meets all those criteria fully.</p>	<p>1</p>
<p>Cost Constraints</p> <p>Manufacturing costs have to be less than or equal to \$11, and the final retail price has to be around \$55 or cheaper</p>	<p>No way to test</p>	<p>Though the Invention Calculator was used in order to approximate this design specification, the actual manufacturing costs cannot be approximated fully. This is because although the cost of materials can be used to calculate a value, the cost of labor or electricity to run machines cannot be.</p>	<p>No score</p>	<p>N/A</p>

SUGGESTED IMPROVEMENTS

There are many improvements which could be done to the bag, as there are many points of feedback received from user trials and various testing methods stated above.

Firstly, the appeal to the Target audience of teenagers of ages 10-15 through a modern and sleek design should be improved. Although an effort was made in making the material used modern and sleek looking (which it does through the matte black), and the use of simple geometries, the general design of the product is lacking in any aesthetic appeal, especially to those of younger age. The younger clients the bag was tested for the Aesthetic Requirements specification on remarked that the bag's cumbersome harness-like design was a bit of a problem, and I concluded that the marketability would be a problem. Also, when testing against

marketing specifications, the young target audiences, upon seeing photos of the product stated that they would be more interested if the aesthetics were cooler, and less bulky. A change that could be made to increase this appeal would be the availability of customization to the bag when it is released into the market. The aesthetic of the bag comes from the design, and as a result cannot be edited since that would take away from the function of it, except maybe to introduce another fastening mechanism other than a buckle, maybe velcro, but this would only be a subtle difference. The customization option would allow the bag to come in many different color combinations and with logos or symbols, which not only would be considered “cool” in the younger generations, but the access to choice would mitigate the problem of aesthetics being a subjective matter.



Next, the bag does not meet the environmental or material requirements specifications fully. The straps are fine because they utilise cotton, which is easily bio-degradable or even disposable, not to mention cheap. The general review test revealed that the problem lies in the material of the bag pouches themselves: canvas polyester. Canvas polyester is expensive, and since it is composed of synthetic polyester fibers, it is not easily disposable or biodegradable. Additionally, canvas polyester is not inherently lightweight, since it tends to be a relatively dense material. To mitigate this, a different material can be used. There are bio-degradable, water-proof, durable and lightweight cotton fabrics available in the market. The issue is that from the perspective of a student like mine those kinds of high quality, specifically-engineered cotton fabrics are very hard to access, and also the fact that cotton is very inelastic. If this were to be the product of a commercial business, on the other hand, this would be a different matter. The only criteria which cannot be mitigated is cost, because a high quality fabric cannot be cheap.



Last but definitely not least, the bag testing made me realise that the bag has many frayed ends, that during the testing itself impeded the functionality of the zipper of the bag. This must be mitigated through a cleaner and different cutting method instead of scissors, such as rotary cutters. Also, many tears in the corners of the bag fabric were noticed as the bag was continually tested for its load specification of up to 10kgs. This would have to be mitigated through a much stronger stitching method such as over stitching or lockstitching, both of which I had overlooked previously thinking that it was unnecessarily complicated and wasted time.

REVISED SPECIFICATIONS – MARKET SPECS

<u>Existing Specifications</u>	<u>Problem</u>	<u>Improvement</u>
<p>User Need Existing posture-correctors do not fulfill their purpose very effectively and may not offer features such as laptop storage, the ability to actually correct posture with padded straps, etc. Therefore there is a need for a posture correcting bag which fulfills the intended purpose, while being cheaper and higher quality</p>	<p>The testing I did against this specification, which was the survey of the target market of the parents and physical testing of the product, to see if it matched user needs was only half successful, as the product was faced with an issue: It corrected posture well, but only if the weights were balanced on each side. This meant that it was very difficult to choose loads to balance out each side.</p>	<p>The specification has to be tweaked to be more detailed. Just because the posture-correcting works under certain conditions doesn't mean it isn't meeting user need. The actual user need is that not only does the product posture-correct better than competitors (which in this case it does, but in certain conditions), but it is also cheaper, higher quality, and has a lot more additional features/properties including water-resistance, high durability and tensile strength affording up to 10kg load lifting. This is because competitors do not have all these features plus the ability to posture-correct.</p>

REVISED SPECIFICATIONS – DESIGN SPECS

<u>Existing Specifications</u>	<u>Problem</u>	<u>Improvement</u>
<p>Aesthetic Requirement The design must be modern and sleek, and not too complicated in order to be appealing towards the target audience of the teenagers.</p>	<p>The problem is that the target audience stated that the bag is not appealing to them, as it looks bulky and not "cool" in the testing stage.</p>	<p>The specification has to be changed. The design is inherently bulky and harness-like in aesthetics because the form is following the function. To change it to look "cool" the function would have to completely change. The specification has to go from the aesthetics appealing to the teenagers in the target audience to the aesthetics just looking appealing in general. The bag looks militaristic and has this sort of neat, tight-packed aesthetic which is appealing aesthetically, just maybe not to teenagers. Or maybe perhaps the specification could change to being a simple color so that it can later be customised in color when commercially produced, leading to product family growth etc.</p>

<p>Environmental Requirement</p> <p>The material used and the manufacturing processes must be environmentally sustainable. Whether this be through using easily recyclable or disposable fabrics such as cotton, or through using organic versions of fabrics which do not pollute the environment in its production. (e.g. they don't use pesticide to grow organic cotton)</p>	<p>The testing method of the general overview revealed that although the manufacturing methods were alright sustainability wise, the majority of components were made with Nylon Canvas, a synthetic fiber which cannot be disposed easily.</p>	<p>The specification has to be tweaked so that the requirement is not that materials must be easily recyclable or disposable but that the product must be designed for disassembly for allow for easier recycability or disposability.</p> <p>Nylon canvas cannot be swapped out because it is the most suitable material for prototype production, bearing many characteristics which are part of the user need. Knowing this, the only aspect that can be done to improve environmental friendliness is through design for disassembly. So making the design less-stitch intensive, separating different materials in the design itself to make for easier detaching and disposal thereafter.</p>
<p>The material has to be relatively</p> <ul style="list-style-type: none"> -light weight -water resistant -durable -cost effective -high tensile strength 	<p>The testing method of the physical testing revealed that although the Nylon Canvas was water-resistant, durable and had high tensile strength, it wasn't cost effective or that lightweight.</p>	<p>Realistically speaking no fabric can hold all these physical and mechanical properties at once. Therefore the specification must be changed to the material having as most of the 5 characteristics at once as possible, so that it maximizes on the material choice of the bag.</p> <p>This way, the best choice of Nylon Canvas actually successfully match this specification.</p>

CRITERION E

Justification of Materials and Components

An analysis of the required properties of each component/ material is provided below. The general property required for the fabric material forming the bulk of the bag is a durable fabric with extremely high tensile strength (like the nylon canvas used here) so as to be able to stretch and not deform with loads within the bags. To be functional it does not have to be water-resistant, but water-resistance is desired to increase the versatility of the bag in many different climates/weathers. This applies for all the components of the bag.



The inside of the bag has to be lined with a hard mesh-material (such as hard-fleece netting) so that the shape of the bag is kept without the presence of content within the bags. This ensures that the aesthetic quality of the bag is preserved when not in use (i.e. a sleek and flat bag instead of crumpled and messy).

The padding of the bag straps has to be made with a thick, soft fabric like cotton to ensure the load does not provide much discomfort to the user.

This analysis of critical properties will allow me to select a suitable material for which to use in the industrial production.

Multiple tables has been created to compare the various material options against the critical properties, sustainability to the environment (ie biodegradability, recyclability), availability of the material in South East Asia and cost. The suitability for CNC or assembly-line manufacture has not been considered as most if not all fabrics have the same feed speed and is suitable for machining in from all directions.

Each material will be rated against the categories in the table to help me decide the most suitable material to take into industrial manufacture of the product. Each individual category will be marked out of 10, and the highest final score will be the most suitable.

General Bag Fabric

Material	Critical Properties	Sustainability	Availability	Cost (high score =lower price)	Final Score
Nylon Canvas	9 (Both very high tensile strength and water-resistance)	5	9	6	29
Silk	6 (very high tensile strength but not water-resistant)	8	9	4	27
Polyester	5 (water-resistant but less tensile strength)	5	9	9	28

For the general bag fabric, the Nylon Canvas used in prototyping seems to be the most suitable. This is because although Nylon Canvas is a synthetic fiber and might not be the best when it comes to sustainability, the score for critical required properties is very high because it has a high

tensile strength. The thermo-plastic emulsion used to manufacture Nylon Canvas makes it very water-resistant too.

Though the silk was very high in tensile strength, silk is very water-absorbent and thus cannot be used, and the opposite is true for polyester. Though polyester is very cheap, it does not compensate for the lack of tensile strength it possesses.

Bag Strap Padding Fabric

The desired property of softness was quantified using the air permeability of the fabrics.

Material	Critical Properties	Sustainability	Availability	Cost (high score =lower price)	Final Score
Cotton	6 (not water-resistant and soft)	9	9	6	30
Wool	9 (water-resistant and soft)	9	9	6	33

For the bag strap padding fabric, the Wool seems most suitable since it is less water-resistant than Cotton, and all the other properties are the same ranking, because they are both biodegradable and widely available and cheap. The water-resistance will help so that the straps do not get too heavy with all the waterweight absorbed.

The netting for the inside of the bag was left as Hard Fleece Netting for industrial production as well, as it is the cheapest and most available hard-netting material.

Justification of Manufacturing Techniques

Production Scale Chosen: Batch-Production

Reason of choice: The bag is to be manufactured as a batch-produced good, so that the target market of the parents of students of the South East Asian region can be targeted. It will not be assembly-line, mass or continuous production, however, as the market for posture-correcting bags is still quite small and niche, which means setting up a bigger scales of production will be very risky and very costly.

If the product ends up being very successful, and the market for posture-correcting bags grows, the production scale can be increased, increasing profits as economies of scale decreases the variable cost for each product manufactured.

This is because although Nylon Canvas is a synthetic fiber and might not be the best when it comes to sustainability, the score for critical required properties is very high because it has a high

Industrial Manufacture -- Sewing Machine and Scissors
In the previous section, I tested out the prototype with various users. After continuous testing, the corners of the bag started to tear, and this happened due to the stress that the fabric

was experiencing because of the weight of the load in the bags.

In addition to this, the zipper kept getting caught on frayed ends of the fabric inside and outside of the bag, and nearly malfunctioned a couple of times.

I had used a normal sewing machine with normal single thread lock stitches to sew the fabric, and a simple pair of scissors to cut the fabric.

As can be seen, the basic sewing machine stitch and scissors would not be suitable for industrial manufacture, as a higher quality product should be expected commercially.

Therefore, to improve the durability of the bag fabric and to modify the bag fabric for industrial manufacturing, I will research the various types of industrial sewing machines, stitches and clean cutting methods.

For Sewing

Industrial Machine	Method of control	Price	Production Scale
	Electric	-Setup Costs are lower, but much slower	Suitable for Batch Or One-off because the production is relatively slower than CNC sewing machine.
	CAM (computer software)	-Setup costs are high, but very time efficient	Suitable for Mass or Continuous Production as it is automated by software and is very fast/precise.

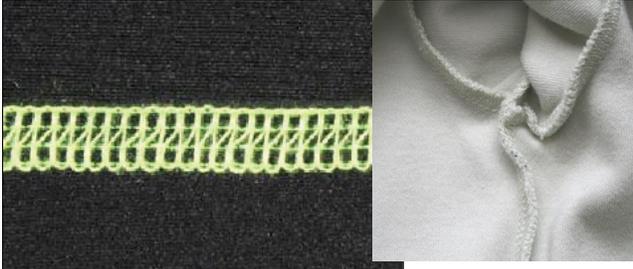
The Lockstitch Sewing Machine is most suitable, as the initial scale of production will be batch. CNC Sewing machine can be used after the production scale is increased if the product is successful and the market sector grows.

For Cutting

Industrial Machine	Method of control	Price	Production Scale
<p>Rotary Cutter</p> 	Manual or Electric	-Setup Costs are lower, but much slower	Suitable for Batch Or One-off because the production is relatively slower than CNC sewing machine.
<p>CNC Cutter</p> 	CAM (computer software)	-Setup costs are high, but very time efficient	Suitable for Mass or Continuous Production as it is automated by software and is very fast/precise.

The same logic applies here with both of these clean cutting (non-frayed edges) methods. The rotary cutter, whether manual or electric, will be suitable for use in our batch-production.

For stitching

Stitching Method	Details
<p>4 Needle 6 Thread Coverstitch</p> 	<p>Very strong stitching method which provides a lot of elasticity and hence tensile strength, which is also very durable and suitable for stitching canvas materials.</p> <p>Relatively cheaper than flatlock stitching</p> <p>Coverstitching creates serged/overlocking seams on the back of the fabric as shown in the white fabric photo to the right.</p>
<p>Flatseamer/flatlock</p> 	<p>Very strong stitching method which provides a lot of elasticity and hence tensile strength, which is also very durable and suitable for stitching canvas materials.</p> <p>Relatively more expensive than Coverstitching.</p> <p>Creates flat seams since seams are butted together and flat layers of fabric are joined by thread. Hence no seam allowance. (shown to</p>

	the right with white fabric) This can be desirable in products such as pants which should not chafe, and removing the seams makes it more comfortable.
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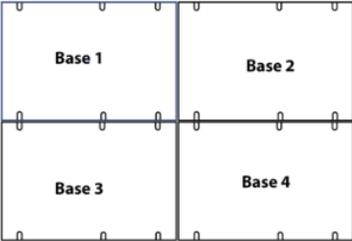
The most suitable stitching method for Industrial Production is Coverstitching. This is because not only is coverstitching cheaper, the supposed “advantage” of flatlock stitching of having no seam allowance is not needed for bags, since the seams created do not create a disadvantage in the context of bags. In fact, the seams help the bag keep its shape better when not in use, while also providing extra durability.

Design Modifications Required for Commercial Production

The detailed design for the working prototype must be modified now to be compatible for commercial production.

Nesting components (Rotary Cutter)

If the product were to be manufactured commercially, the sustainability and cost-efficiency aspects of the materials used must be considered.



Hence, the components would have to be nested together in the fabric to reduce the amount of fabric wasted. Luckily, all of the bag’s fabric components are rectangular in shape, making for easier tessellation and therefore easier nesting, which leads to leaner production.

Since the tool being used to cut the fabric is a rotary cutter instead of a CNC cutter, there is no limitation of dimensions per sheet of fabric, and hence there is no way to calculate the wasted area per bag manufactured.

Standardisation

By using mostly the same material for most of the product (in this case Nylon Canvas), it makes for more efficient production, as manufacturers can take advantage of economies of scale when bulk purchasing nylon canvas.

Components are also semi-standardised as my product is completely symmetrical down a vertical axis, meaning the straps, padding or bags manufactured can be used/replaced with the components of either side, resulting in less waste.

Additionally, since the manufacturing methods are standardised (cutting out the fabric using rotary cutter then stitching it together using the Lockstitch sewing machine) and used for the entirety of the bag, set up costs for commercial production can be reduced.



Stitching

Although it was determined that the over stitching was the most durable, elastic and suitable stitching method for the bag itself, there is no need for over stitching on the inside of the bag to secure the hard fleece netting to the nylon canvas. The 4 Needle 6 Thread over stitch complicates disassembly as the stitch is very hard to remove, and therefore hinders recyclability and efficient use/less waste of materials. Therefore, on the inside of the bag where it is not needed, the hard fleece netting will be secured using a simple straight stitch. This way, the manufacturer can recycle defective products easier, and the product is more environmentally sustainable commercially, and most importantly manufacture is marginally easier and faster this way.



Design Modifications --- Design for Disassembly



Continuing with the removal of unnessecary design choices, although the strap of the bags look very neat and sleek, there is no need for there to be a stitch running down the middle of the strap as long as the padding inside fits the strap perfectly. This only slows down production and makes it harder for design for disassembly, as the padding will be difficult to separate from the nylon canvas to be recycled if secured by stitching. Therefore this stitch needs to be and can surely be removed.

Criterion F

MARKETING STRATEGIES

I will use the 4 P's of marketing to identify suitable Marketing strategies.

PRICE

-The use of cost-plus pricing should be a given. (cost plus pricing being all direct material and labor costs added to overhead costs, and add it to a markup percentage to calculate the price of the good) This is because cost-plus pricing ensures that there is always a profit margin and that all operating costs are covered, past the break-even point, so that there is an incentive for the manufacturer to continue. To calculate the costs:

Cost of manufacturing:

Nylon Canvas is used for both pouches, both shoulder padding and the back padding.

$$\text{For 2 Pouches} = 2 * (2*45*33 + 2*4.5*33+45*4.5) = 6939 \text{ cm}^2$$

$$\text{For 2 Shoulder Padding} = 2*(2*7.5*32) = 960\text{cm}^2$$

$$\text{For 1 Back Padding} = 2*22*12 = 528\text{cm}^2$$

$$\text{Total Nylon Canvas area} = 8427\text{cm}^2$$

$$\text{Total Cost: } 0.8427 * 35\$ = \$29.50$$

$$\text{For Hard Fleece Netting} = 6939 \text{ cm}^2 \text{ (same area as pouches)}$$

$$\text{Total Cost: } 0.6939 * \$5 = \$3.50$$

For Cotton Straps =

$$38\text{mm} * 200 + 38\text{mm} * 20 = 836\text{cm}^2$$

$$\text{Total Cost: } 0.0836 * \$4 = \$0.33$$

For Soft Cotton Padding =

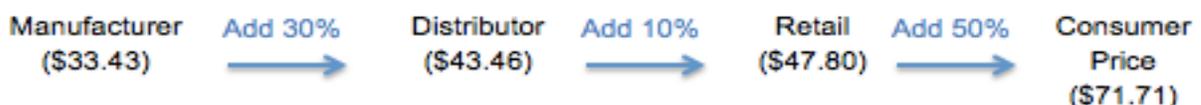
$$\text{(same as back and shoulder padding)} = 22*12+2*7.5*32= 744\text{cm}^2$$

$$\text{Total Cost: } 0.0744*\$2 = \$0.10$$

$$\text{TOTAL COST OF MATERIALS : } 0.1+0.33+3.5+29.5 = \$33.43$$

Since we cannot calculate labor or overhead costs of the "factory", we will use the total cost of materials as overall manufacturing costs.

Considering this, we use the Invention Calculator formula for calculating distributor and retail price.



Although the final Consumer Retail price is not within the initial marketing specifications of \$55, penetration pricing is still being used. This is because the average posture-correcting competitors' products range from \$70-\$150 onwards. By keeping the price relatively low, I can attract more costumers.

Additionally, if the product grows to be successful and batch sizes increase, the economies of scale would induce a significant decrease in operating costs, increasing the profit margin.

PRODUCT

-The changes which can be applied to provide more marketing appeal for consumers in the existing market and other market sectors will be considered. This gives an opportunity for the building of a product family, which branches across different market sectors while having the same or similar physical characteristics/materials. Color : the color of the product could be changed to accommodate different demographic or geographic sectors. It was initially made black because it looked sleek and modern, which is appealing towards the younger target audience. Apparently blue is also a favorite color amongst teenagers. But allowing for an entire range of colors will appeal to the greatest number of teenagers. The bag will stay one solid color to maintain the modern look. For potential older demographics looking to use the bag, more organic/ornate patterns or colors can be added to the bag to appeal to them.

Size: the size of the product could be provided in a wide range to accommodate for the fluctuating body sizes of growing teenagers. Although the bag is already adjustable (but at a very small percentile range from the center), a mix of range of sizes from 5th to 95th percentile and adjustability will ensure the product's inclusiveness of almost everyone in the target audience.

Material/Function: for different geographical market sectors which vary in climate/weather, the material could be adjusted to be more suitable for the respective atmosphere. The nylon canvas material was selected due to most of the target audience being in South East Asia, where climates are generally hot and humid all year round, hence, the water-resistance. But in colder, drier climates where users may need to keep their bag contents warm or such, the material can be replaced with a more water-absorbent but also more heat insulative material.

Place

Next, I will identify the potential places the product could be sold.

Generally, the product itself is not that versatile, and is targeted towards a relatively niche audience within the big market of bags.

Online Commerce: the internet has had an increasingly larger role in markets recently, due to the convenience and accessibility of internet shopping. Websites such as Amazon or Ebay which sell a wide range of products to consumers of virtually all demographic/geographic market sectors globally will be suitable.

1. Online Commerce Stores such as Amazon
2. Stationary/school-gear shops

Stationary/School-gear shops: Since the product is aimed towards students with bad posture, stationary shops or school-gear/uniform shops should be suitable in targeting the intended target audience. Or even the target market, since they are the ones usually buying stationary and uniform for their children before school.



Promotion

I will now consider the promotional methods of the product

Product Name: The name has to be memorable, and reflect the function and purpose of the product. The name and logo is especially key for specialised products like mine which are not considered “common” or “normal” in the bag market, and helps attract new consumers. “Straight-Sack” is a 2 syllable, catchy alliterative name that will undoubtedly be memorable as it communicates its modular function very easily: it will make you stand “Straight”-er.

Product Logo: The logo is important as it allows consumers to identify my brand, and catch their attention. The logo was kept minimalistic and modern, just as the bag is, in order to appeal towards the younger audiences, but at the same time has a rustic appeal to it. This logo can be stitched onto the outsides of the sacks of the product.

Brand Identity: This is important since it is how people perceive your brand. The unique-ness of this bag even in the posture-correcting bag sector means that it will have product differentiation and an advantage over competitors, and more importantly means that consumers will have a more special/memorable experience with my brand. This will then build my brand loyalty, and attract even more consumers.

Promotional Methods

1. School Magazines – back-to-school magazines and such which advertise various school gear that you might need, and since the target readers are teenager students, it will be suitable to advertise my product with.
2. Social Media – social media plays a big part in advertising, especially sites like Facebook and Youtube, where hundreds of millions browse each day. This is suitable since this social media sites are frequented by mostly teenagers, my target audience.

PROMOTIONAL PLAN

Finally, the promotional plan will be outlined

1. **Market Research:** Identify the target market and target audience, and through that create user profiles, which includes details like age, gender etc. This will help identify their needs and requirements for the product. Also identify the price range the consumers are willing to pay for.
2. **Gain Funding and Support:** This can be done through sites such as Kickstarter.com, where anyone can start funding a project based on their interest in it. Use this to fund the initial capital (lockstitch sewing machine, rotary cutters, etc.)
3. **Introduce Product to Market:** Start batch-producing the product, and selling to retail school gear stores and stationary shops so that your target audience/user is introduced to it, a batch of ~50.
4. **Setup for commercial manufacture:** Bulk buy materials to make use of economies of scale, and here there is no need to buy CNC cutters or sewing machines as the production scale is
5. **Increase Sales Opportunities:** To do this, advertising must begin, in Social Media platforms such as Youtube or Facebook, and School Magazines.
6. **Increase Product Family:** This will be done by providing customization through a range of sizes and colors and designs, aimed at different demographics.
7. **Increase Channels of Distribution** – This can be done through international channels such as Amazon, which will continue to grow the company/product, and advertise it even further.

