

axo-pak



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Jefferson University
Industrial Design '20



About Me: **Evan Page**

This isn't the part where I tell you my entire life story. Unfortunately, I don't have the amount of characters in this text box to do that and as the reader, you don't have the time for that. Maybe one day when we both have the time, we can sit down and talk about it. But what I can tell you is a little about myself and what inspired me to choose this as my senior capstone project.

First of all, before anything else, I'm a man of faith. I'm unapologetic about my faith in Jesus and whether you like it or not, you'll find Christ incorporated into my designs, because I incorporate Him in my life. And when I design, I design with a purpose. I value creativity, impact, and legacy. So when I'm designing something, sure I want it to be dope, but more importantly I want it to have a positive impact on someone. I want it to be something timeless that people can look back at 30+ years later and still appreciate it, if not love it. Something my family and friends can look back on long after I'm gone and still be proud of. When I chose to create a weight distributing ergonomic backpack for students, I was thinking about those values. Anyone who knows me knows about my passion sneakers. And ever since I stepped foot on Philadelphia University's (now Jefferson University's) campus I knew my final project was going to be a pair of sneakers. But as I grew as a designer, I began to learn just how much of an impact I can have as a designer. Thankfully by the time I entered into my senior year, I had already designed and created two pairs of sneakers. So when my professors asked our senior class what problem we were going to create a solution for, I knew I couldn't just settle for another pair of sneakers. As a church youth leader, part time educator for students in K-6th, and mentor for many young boys, I knew I wanted to design something that would have a long lasting impact on their lives.

This project is dedicated to all the kids that impact me just as much as I impact them.

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The Story



The Problem

Although students are getting smarter, their backpacks are getting bigger. You would think that with the advancement of technology, we would be able to reduce the amount of items students need to carry on a daily basis. However, despite these advancements, students are still being injured by their backpacks, especially younger students who are still growing.

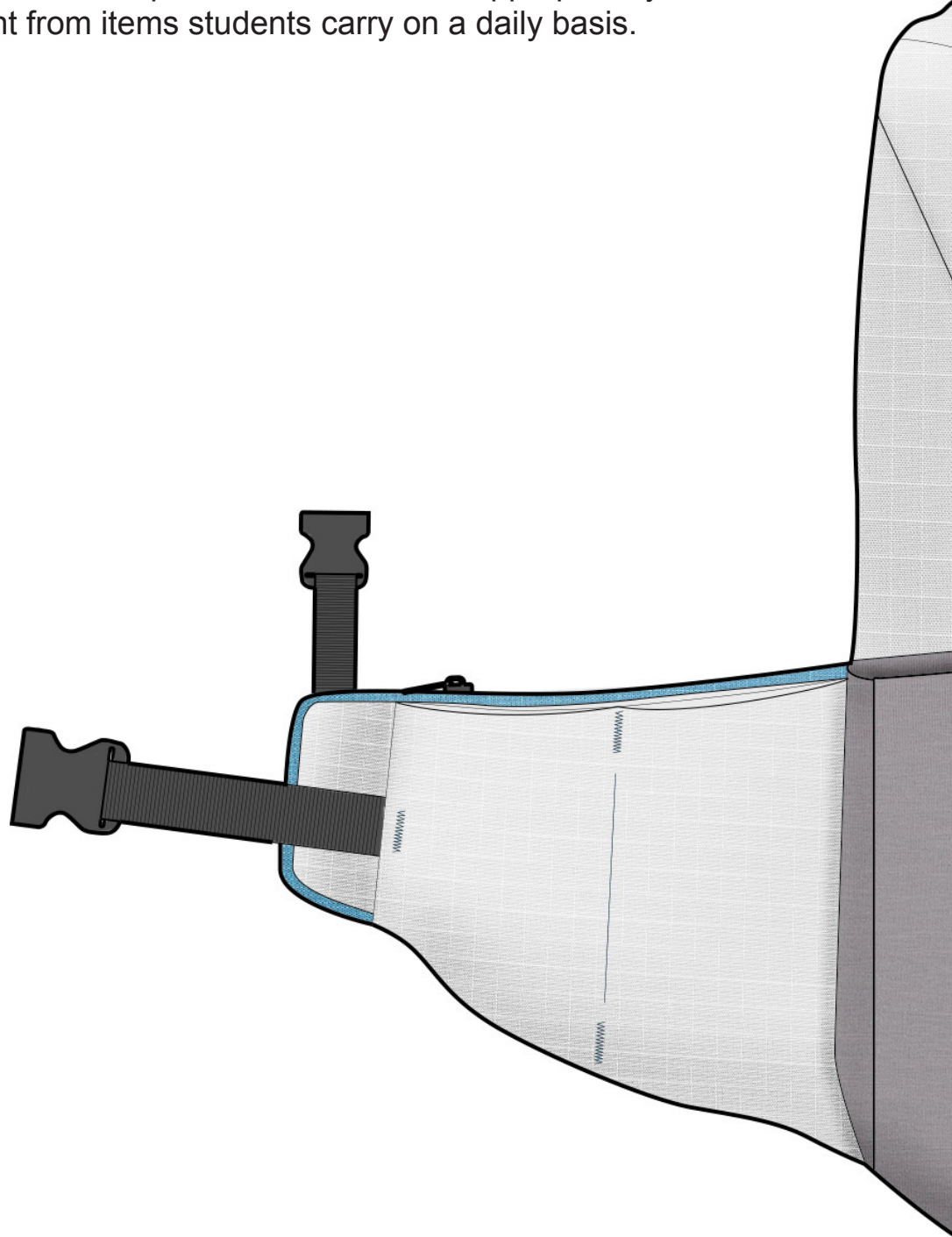


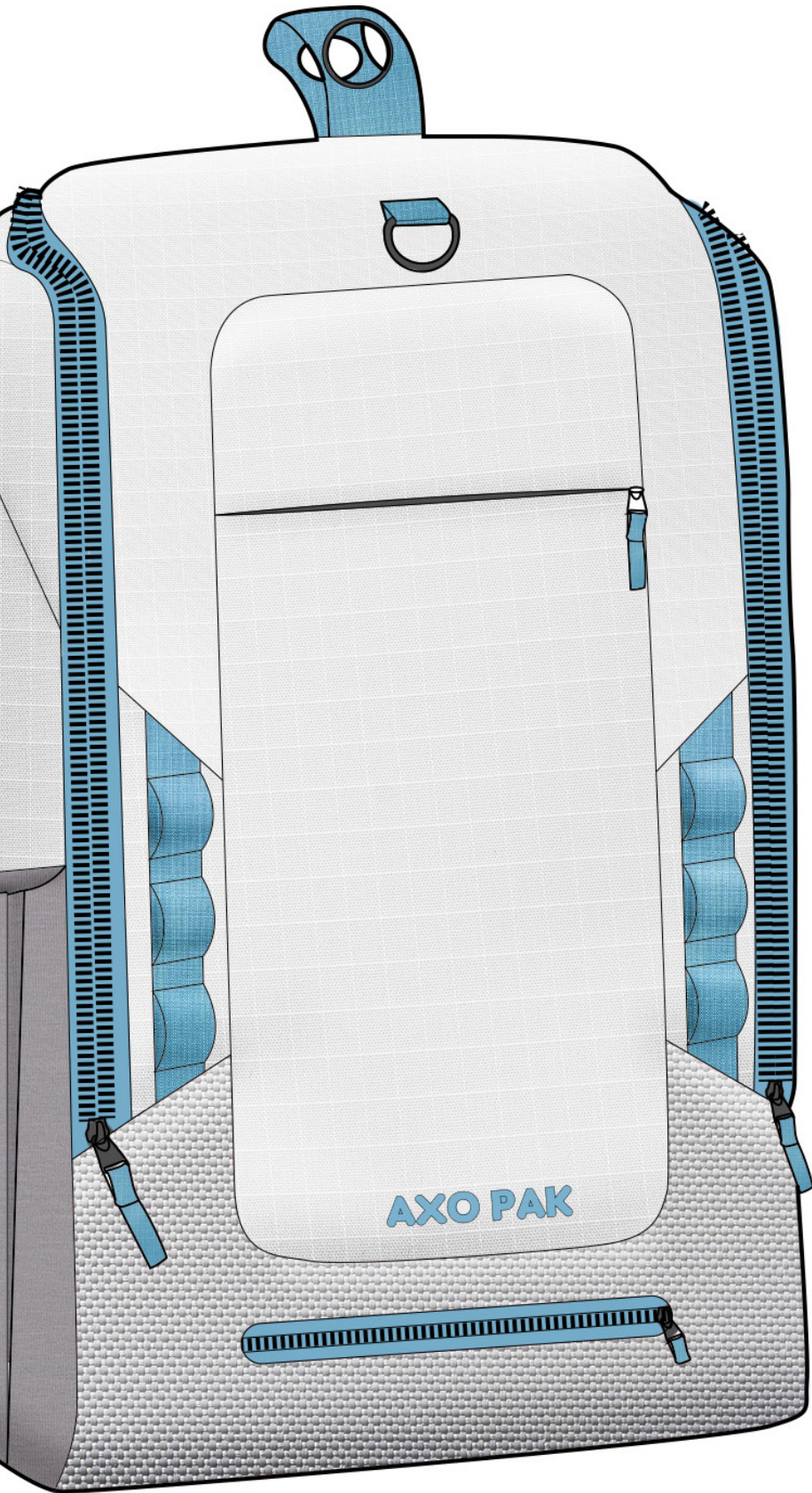
This problem isn't only affecting students, but also parents. Most parents aren't aware of how their child's backpack is affecting them individually. And the parents that are aware are worried about the long-term health of their child.



The Solution

The solution to this problem is the Axo-Pak. It is an ergonomic school backpack for students that appropriately distributes the weight from items students carry on a daily basis.





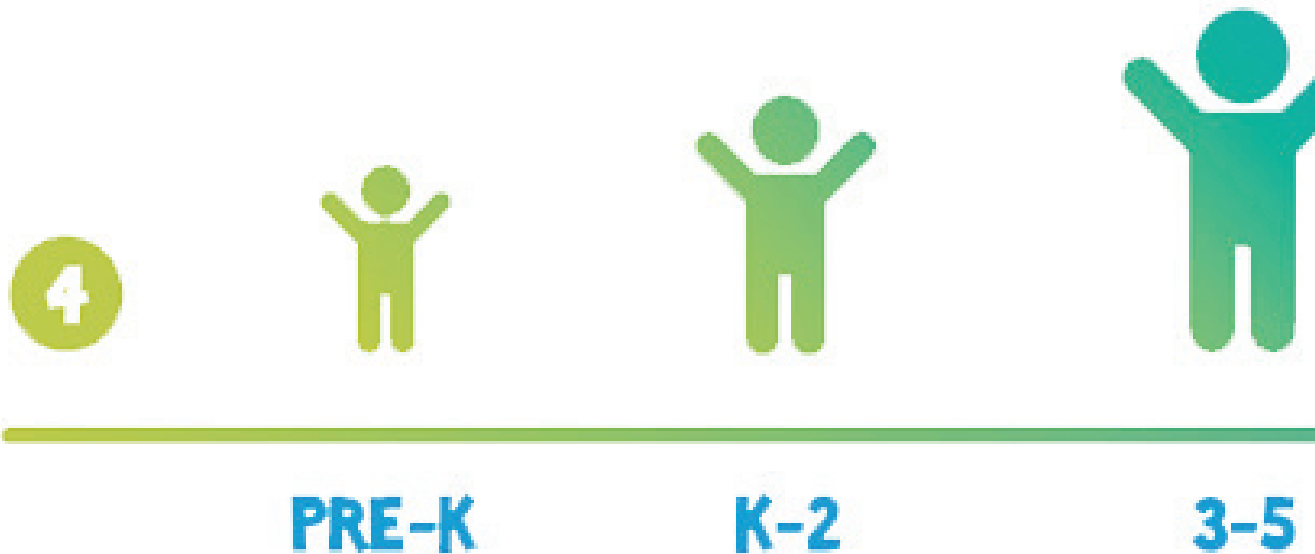
AXO PAK

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Consumer Research

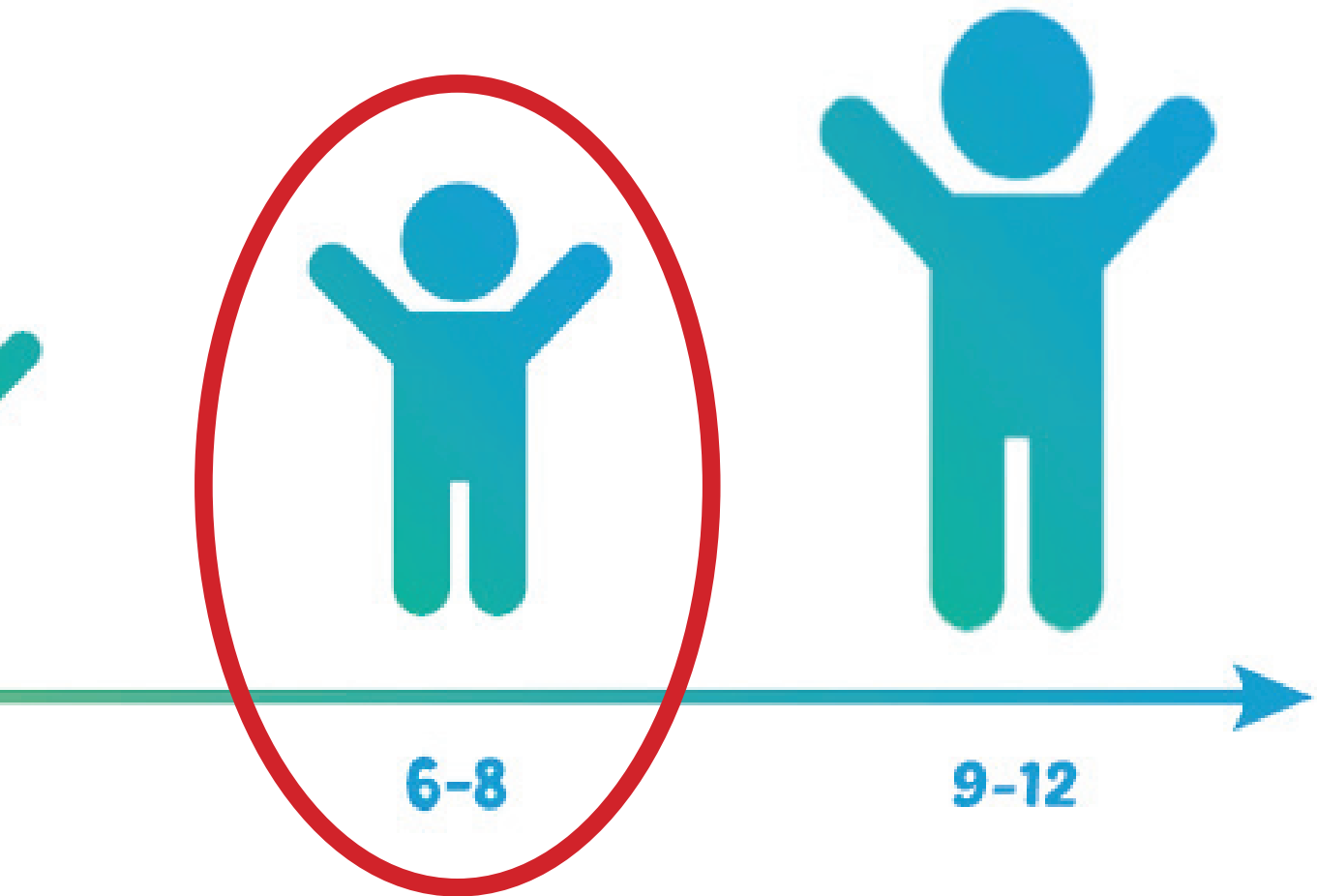


A study by the U.S. Consumer Product Safety Commission found that middle school students were 3x more likely to report back pain than other primary school students. This is due to the fact that middle school students, while still growing, carry up to 25% of their body weight, making them the most at risk for long-term injury.



Design Criteria #1

must be adjustable to fit children between ages 10-15



The Student Experience

On a daily basis, the average student:

1



Wakes up and gets ready for school

2



Leaves from home

5



Has a gym class at least twice a week

6



Participates in some sort of extracurricular activity

3



Catches the bus
or walks to school

4



Goes through a full
day of classes

7



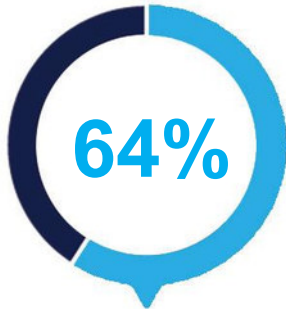
Does homework
some time in between

8



Goes to sleep

I took a survey of various middle schoolers and this is what I found:



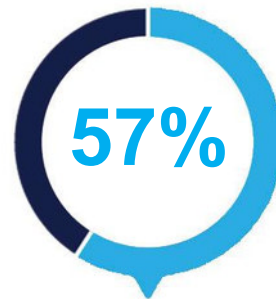
of students described the weight of their backpack as moderate to heavy



of students carried additional items in their backpack such as food, toys, electronic games, accessories, etc.

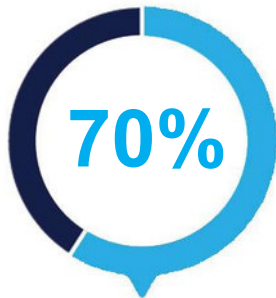


of students reported that they don't like their backpack because of issues relating to the construction of the backpack

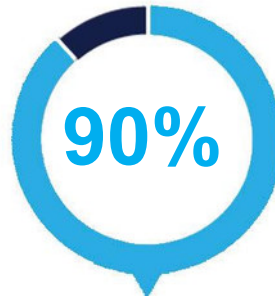


of students reported that they've experienced pain from their backpack being too heavy

I took a survey of various parents of middle schoolers and this is what I found:



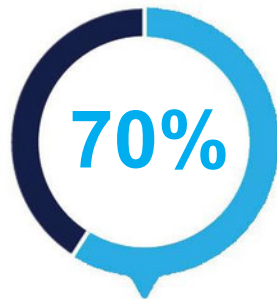
of parents reported that they weren't concerned about the weight of their child's backpack



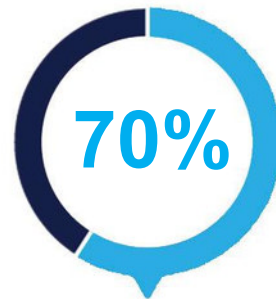
of parents were aware that overweight backpacks can lead to potential lifelong health issues



of parents reported that it is important for their child to have a good quality backpack



of parents reported that they would pay more for a good quality backpack



of parents reported that they don't hear their child complain about the weight of their backpack

So what can we do about this problem? It's not as simple as just taking items out of students backpacks. Most of these items the student needs on a daily basis. So rather than restricting students, we should enable them.



1. ID Cards are needed for access to school and transportation services.
2. Phones are needed for students as they become more independence.
3. Keys are needed for students that get home before their parents.
4. Multiple notebooks are needed to record the student's daily writings.
5. A change of clothes are needed for gym classes and/or sports programs.
6. Reading books are always a necessity for the student's literacy growth.
7. Pencil cases are needed to hold pencils, pens, markers, highlighters, etc.

Design Criteria #3

must still be able to hold all of the student's essential items



8. Students who have extra curricular activities may require extra equipment.
9. Calculators needed as students take more intensive math courses.
10. Lunch boxes are a must for students who bring their lunch from home.
11. Water bottles are another item that most students carry on them.
12. Planners are often given to students to keep track of their assignments.
13. Folders are needed to keep any papers the student may need for class.
14. Personal care items are a necessity, especially for female students.

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Medical Research



**THE MAJORITY OF STUDENTS
CARRY HEAVY BACKPACKS
WEIGHING AS MUCH AS**

25%

**OF THEIR BODY WEIGHT IN THEIR
BACKPACK**

Kids carry backpacks simply because they have too many supplies that need to be brought back and forth to class. Items carried by students in their day-to-day school bags have been found to include, but are not limited to, laptops, books, pencil cases, scientific calculators, sports uniforms, gym clothes, lunch boxes, and full water bottles. Backpacks are also preferred because swapping supplies from lockers in between class could result in tardiness for class. For most students, the issue is time and convenience. Some, if not most, kids schools are big and rather than walking to the other side of the school to switch out supplies, they'd rather carry them all at once.



Design Criteria #2

must alleviate stress from added weight

DOCTORS SAY STUDENTS SHOULD ONLY CARRY

10%

OF THEIR BODY WEIGHT IN THEIR BACKPACK

When students carry more weight than their bodies can bear, this leads to added stress and injuries on the back and spine. Coupled with the fact that children's bodies are constantly growing, this additional weight can lead to long-term injuries such as chronic back pain, chronic neck pain, shoulder pain, knee pain, poor posture, etc. Studies have found that 60% of children who carry heavy backpacks experience back pain. In 2013, over 22,000 students suffered from back related injuries.








according to the U.S. Consumer Product Safety Commission



Product Research



What already exists?

Image	Name	Price	Size/Volume	Weight	Materials
	ErgoBag	\$295	Approx. 20 Liter 25 x 22 x 35 cm	Approx. 2.4lbs	fabrics that are made of 100% recycled PET bottles
	Affenzahn Kindergarten Backpack (Small Friend)	\$49.90	6.69 x 9.84 x 4.33 in. Approx. 4 liter	Approx. 0.44 lbs	Fabrics that are made of 50 % recycled PET bottles 3 PET bottles (0,5l)
	Affenzahn Kindergarten Backpack (Large Friend)	\$59.90	7.87 x 12.2 x 4.72 in Approx. 8 liter	Approx. 0.93 lbs	Fabrics that are made of 50 % recycled PET bottles 6 PET bottles (0,5l)
	Bixbee Backpack	\$49.99	15" x 6" x 12" Shoulder strap length: 28 in	Weighs 2lbs	Durable 600-denier* polyester Reflective material
	REI Tarn 18 Pack	\$39.50	15.5 x 9 x 6 inches 18 liter	1 lb. 2 oz.	420-denier nylon

Top Features

Grow-along adjustable back
Water and dirt repellent
Easy to clean
Melange effect
Wide padded hip belt (Removable)
All-round reflectors
Customizable
Stabilizing Aluminum Rail
Height-adjustable chest strap
Adjustable upper load control
Ergonomically shaped, adjustable shoulder straps
Breathable back-padding
Padded back
Drawstring to compress the content
Detachable gym backpack
Stable bottom mold

Stick-out tongue with name label
Height and width adjustable chest strap
Carry Handle
Reflectors
Soft shoulder pads
Showerproof and dirt-repellant
Easy to clean

Stick-out tongue with name label
Height and width adjustable chest strap
Carry Handle
Reflectors
Soft shoulder pads
Showerproof and dirt-repellant
Easy to clean
Coloured push-in clips
Hook-and-Loop Arms
Front pocket
Outside pockets
Secret pockets

Contoured air-mesh adjustable shoulder straps
Sliding sternum strap
Padded interior padded pocket for a small laptop (large or iPad/tablet (medium size)
Child name card holder
Plenty of multi-functional pockets
Five exterior pockets and seven interior pockets
Right shoulder strap mini pocket for lunch money
Water resistant
Reinforced base corners

Mesh-covered padding conforms to a child's back
Shoulder straps and hipbelt (w/ mesh-covered padding)
Inner hydration pocket fits a 2-liter hydration reservoir
Large mesh stash pocket on front (fits a jacket, hat and Zip hipbelt pockets
Front zip pocket, stretch-mesh side pockets, and inner mesh pockets
Safety whistle is built into the sternum-strap buckle
Front clip loop

Pros

- Most backpacks do a great job at providing styles that cater to kids
- The ErgoBag is a very ergonomic and well design backpack for students
- Most of these backpacks are made from recycled materials
- Many of these backpacks come in a wide variety of styles and color options
- All backpacks incorporate features such as padding, sternum clips, added pockets, adjustable shoulder straps, some sort of top loading system.

Cons

- Most backpacks are geared towards students in K-5th, not middle school.
- Even for the demographic that these backpacks cater to, the price points are very high.
- The REI backpack can be used to store school supplies, however, its main purpose is for children's hiking equipment.

Additional Product Research

I also decided to look into other non-school items that are ergonomically designed to help the user carry heavy loads for inspiration for my initial concept.

Back Braces



Back braces are used by various workers who lift heavy items on a daily basis to prevent or restrict painful movements, such as twisting the spine or bending forward, backward, or to the side. By reducing spinal pressure, a back brace may lessen painful muscle tension that is a common protective reaction following an injury.

Military Backpacks



Military backpacks are specialized backpacks used by military professionals. These backpacks are made from premium quality materials and hardware and are designed for strength, durability, modularity, and high activity in order to carry packs, clothing, and various supplies.

Hiking Backpacks



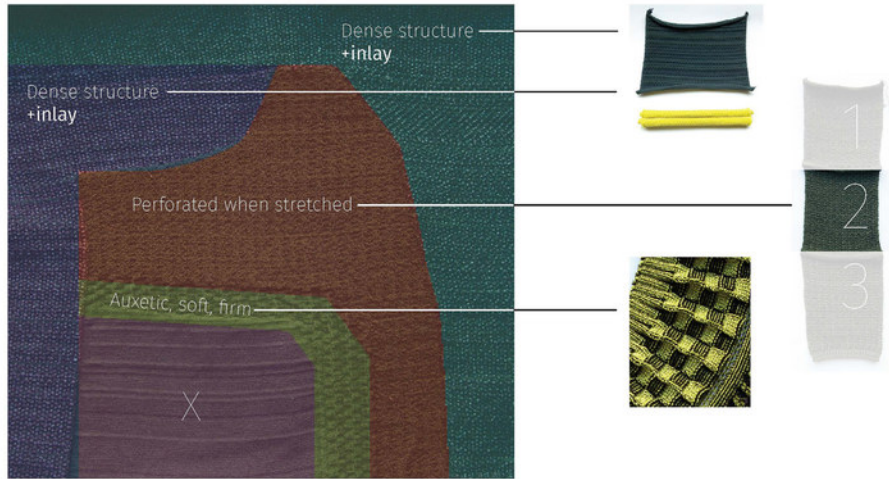
Hiking backpacks are specialized backpacks that are designed to carry large volumes of hiking supplies in the most ergonomic way possible. Features such as padded contoured straps and back, sternum and hip straps, and additional side pockets help support the user's back. Some hiking backpacks also come with a built-in internal frame which provides a closer fit, meaning more stability when traversing uneven or rugged terrain.

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Initial Development

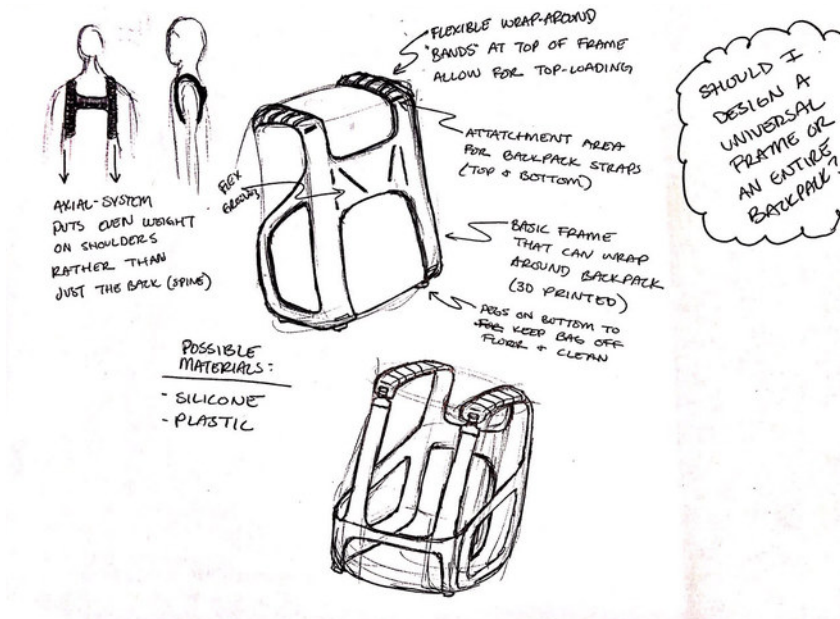


Structural Knit



An approach for structural knit was considered due to the fact that combining various types of knits in targeted locations allows for a flexible yet strong structure.

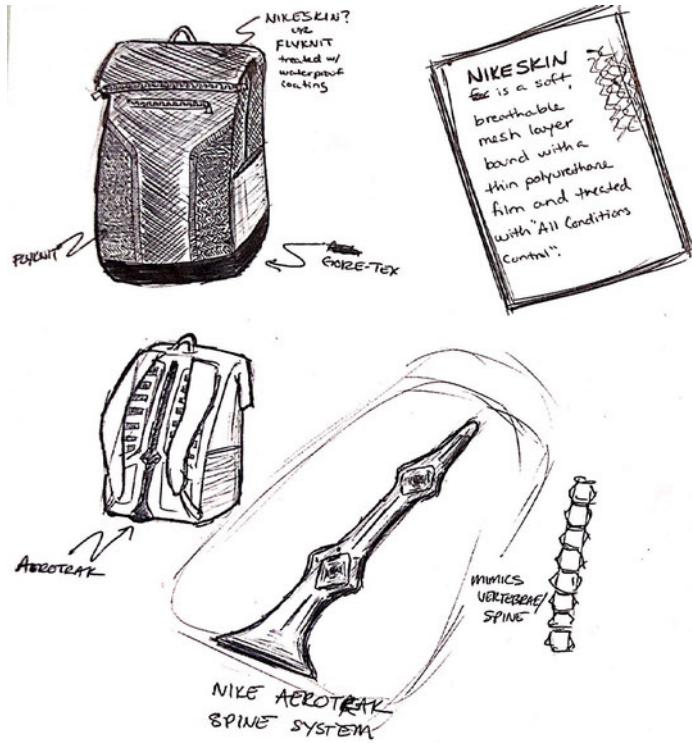
3D Printed Frame



Another option for a 3D printed frame was considered based on using strong and flexible plastic materials to create a support frame for the student's backpack.

Nike Tech Backpack

One of my favorite concepts was the incorporation of various Nike technology such as Flyknit, AeroTrak, Joyride, Pro Adapt, and FlyEase to create the ultimate backpack for students and others alike.



* Look at "Nike FE/NOM Flyknit Bra" for areas of firm flexibility

BACKPACK SECTIONS

- MAIN section that uses flexible yet firm material (like FE/NOM Flyknit)
 - "Spinal" section that uses strong yet light plastic-like material (Nike AeroTrak)
 - Back section that uses contoured cushion material (Nike Joyride or Nike A)
 - Bottom section that is strong, nonwoven, waterproof material (Gore-Tex)
 - Quick-access pocket section (can either utilize velcro or FlyEase)
- Other options
- NIKESKIN
 - ACG 4-Way RipStop
 - Knitposite



Network

In order to validate my initial concepts, I reached out to multiple professionals in the areas of industrial design and occupational therapy. I was able to hear back from most of them and get some valuable feedback that helped me simplify and refine my initial concepts.



Todd Kramer
Principal of Bluekiwi &
Designer for Bluekiwi diaper
backpacks



Mikael Avery
Occupational Therapy Practitioner
& Professor



Catherine Piersol
Occupational Therapy Practitioner
& Professor



**Sarah McNabb &
Michael Barrett**
Occupational Therapy
Students of Catherine Piersol

Professional Feedback



Todd Kramer

“Can this be some sort of educational system to show kids how to pack their bags?”



Sarah McNabb

“Children and teens tend to also wear backpacks low slung, which is due to a combination of social image. I would suggest some element to help ensure the bag is properly adjusted, even if it’s something for a parent to notice such as a line on the strap that they know should sit on the shoulder.”

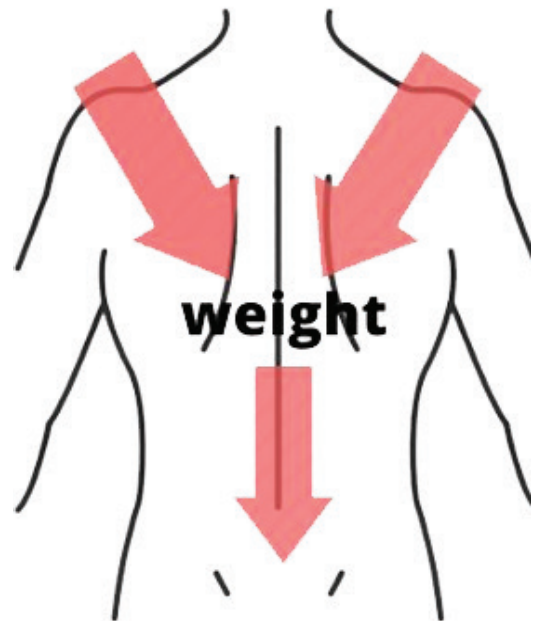


Michael Barrett

“Consider how much a child would want to use your backpack versus some cheap bag with a superhero on it from Target. Plenty of things are designed for children that they end up never using because it doesn’t draw them in, and if they don’t use it then the problem isn’t really addressed.”

Conventional System

In a conventional backpack system, the majority of the weight rests on the user's spine; leading to long-term back pain.

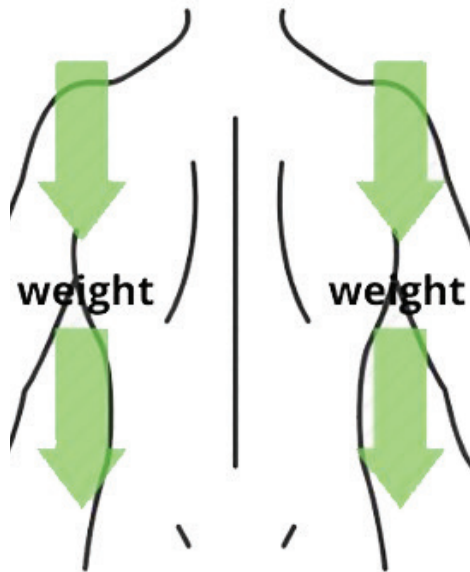


Design Criteria #4

must distribute weight appropriately along the shoulders & hips

Axial Backpack System

The majority of the weight rests on the user's shoulders and hips where it can be appropriately balanced.





After each piece of the backpack was made, all parts we combined and sewn together



Basic dimensions for the prototype were taken to cut out and assemble materials.



front view



side view



back view



User Testing

In order to test out my prototype, I reached out to the education department at the Salvation Army Kroc Center to work alongside a few middle schoolers in their Homework Zone program. There I worked closely with five students to get their honest feedback and considerations for future prototypes.



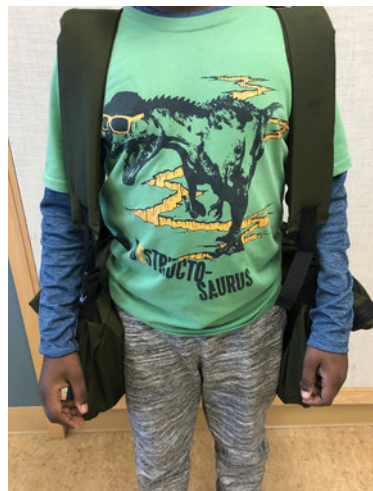
The first thing I noticed was how big many of the student's backpacks already were because of all the supplies they carried on a daily basis.



I weighed the backpacks of every student to see the average weight a typical middle schooler carries on a daily basis.



I also had students pack the prototype with the same amount of materials to test if the axial system really made the difference of weight lighter for the student.



I then had students try on the axial backpack prototype and give me their honest feedback on whether it made a difference on the weight for them and how they felt wearing it.

User Feedback

After testing my initial prototype out on a few middle schoolers, I received a lot of critical feedback.



“Lighter than my regular backpack. It’s harder to walk around in. It’s unusual.” - Semaj



“It’s about the same weight as my backpack. It’s more awkward to wear. There needs to be a strap in the middle and the pouches need to be taller so I can fit my folder easier.” - Aaliyah



“This is a lot lighter. A bit loose though.” - Brenden

Prototype #2 (Axo-Pak)

Based on the feedback that I received from the various students that tested the first prototype, I revised and altered various aspects of the backpack to better fit the design criteria I developed from my research and initial testing.

Form In Mind

Because there was a lot of negative feedback on the overall form of the first prototype, like it being very unusual to carry, I took a new approach to the backpack's form. Instead of basing the entire backpack's form on just the axial system, I combined elements from both the axial backpack and conventional backpack styles.

Inspiration From Hiking Backpacks

Key features from hiking backpacks such as the hip and sternum belt were incorporated to maximize support for the student.

Name Change

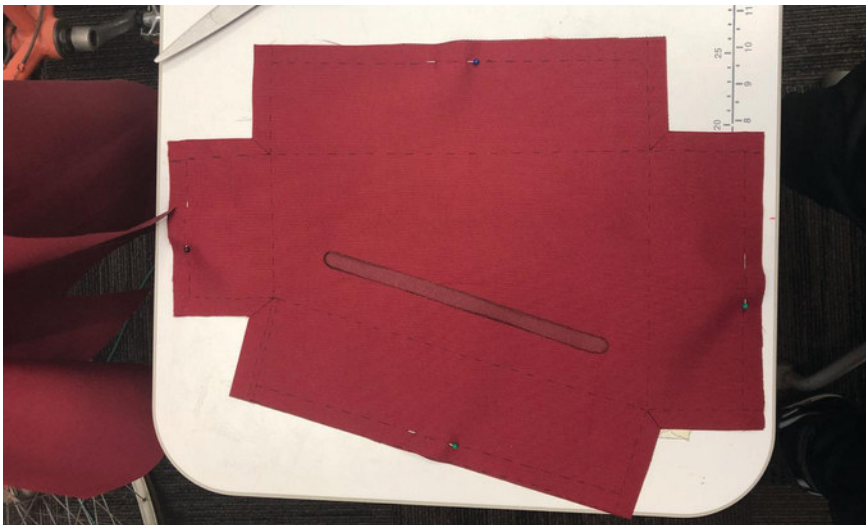
Lastly, as the backpack neared closer to the final prototype, I knew I needed to come up with a final name. Going back to my original name for the backpack (Axial Backpack), I decided to shorten the name to Axo-Pak to make it more "kid-friendly" and appeal more to my target market.





Measurements

In order to make patterns, fabric was measured and given the correct seam allowance for assembly later on.



Pattern-Making

Patterns were then cut to specific dimensions using soft goods and prototyping skills.



Assembly

After patterns were cut, they were then assembled together using bobby pins to check for the correct dimensions and desired design.

After all the dimensioning, pattern-making, and cutting, the backpack was then fashioned and assembled to fit a model similar to the size of a middle schooler.



Feature #1: Main Compartment

Although the main compartment doesn't look much like a feature, it actually serves more of a purpose than a typical main compartment that you'd find on a conventional backpack. The main compartment of the Axo-Pak is designed to be thinner, in volume, than a typical 15L backpack to reduce the amount of items the student is allowed to carry on their back.



Feature #2: Side Compartments

Still incorporating the axial system from the original prototype, side compartments were added to the main compartment to reduce the weight carried on the student's back while still allowing the student to carry the same amount of items with them. Having the additional weight on the sides allows the weight to be displaced across the sides and hips of the student.



Feature #3: Side Pocket

The side pocket is made from highly flexible material (like spandex) that sits in between the main compartment and the side compartments. It not only acts as a storage area for items like water bottles, but it also acts as a storage area for small equipment such as sneakers, soccer shin guards, baseballs, and even equipment as large as a baseball bat.



Feature #4: Sternum & Hip Strap

Although the sternum straps were already incorporated in the first axial backpack, hip straps were also incorporated, based on inspiration from hiking backpacks, to provide additional support for the side pockets.



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User Testing



Storyboard



Brenden switches out the contents of his backpack into the Axo-Pak.



Brenden then clips the hip belt that's attached to the side compartments.



Brenden adjusts the shoulder clips to his liking for a more secure fit.



"I can run...I can jump! This thing is awesome! - Brenden

Storyboard



Arriving at his desk, Brenden pulls out all his necessary books from the main compartment.



Brenden can easily access items such as his pens and pencils from the side compartment even while sitting.



Although Brenden's next class is on the other side of the building, he doesn't need to worry about stopping at his locker since he can carry all his items at once without worrying about stress or fatigue.



When Brenden gets home, rather than taking off his backpack to access his front pocket, he simply reaches in his side pocket and quickly grabs his keys.



For my last round of user testing, I not only had students from the Homework Zone test out the new revised Axo-Pak, but I also had them take the Axo-Pak to school and use it for an entire school day!

User Feedback

After allowing a couple middle school students to test out the new and improved Axo-Pak for themselves, I quickly recorded the feedback they had for the backpack. One of the most informative responses was from Brenden:



Me: *“On a scale of 1-5, 5 being the biggest, how much of a change in weight do you feel?”*

Brenden: *“Definitely a 4.”*

Me: *“How does this backpack feel compared to your current backpack?”*

Brenden: *“Definitely lighter.”*

Me: *“How does it feel to use this backpack?”*

Brenden: *“It’s about the same as my backpack.”*

Me: *“Where do you feel most of the weight of your items?”*

Brenden: *“I don’t really feel any weight.”*

Me: *“What do you like about this backpack?”*

Brenden: *“It is comfortable and it spreads weight evenly.”*

Me: *“What do you not like about this backpack?”*

Brenden: *“It is a little bit small.”*

Me: *“Would you use this backpack over your current backpack?”*

Brenden: *“Oh yeah!”*



Final Development



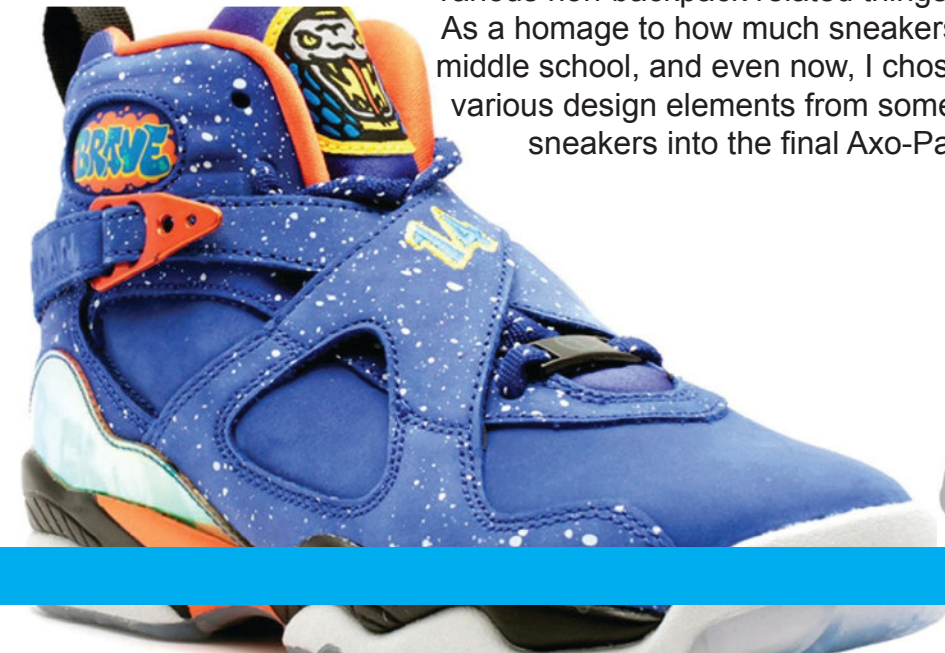
Design Inspiration

For much of the initial prototypes, I wasn't focused as much on design as I was on functionality. However, now that the functionality was flushed out, I knew I would need a flushed out design as well for the final prototype. For inspiration, I looked at all the things that make middle school memorable and exciting for students in this day and age. Things like school colors, the school mascot, school sports, school fashion & sneakers, art classes, incorporated class games such as Kahoot!, and even playing Fortnite with friends. All these things helped inspire me to create various styles and color options that I could use for the final design of the Axo-Pak.





As much as I wanted to incorporate design details that are memorable for the student, as a designer, I also wanted to incorporate design details that are memorable to me. As I reflected back on my days in middle school and what inspires me creatively even now, one thing popped in my mind: Air Jordans. Middle school was a time that I first began to follow the NBA, which in turn led me to grow my passion that I have for sneakers today. And out of all the sneakers worn on (and off) the court, the Air Jordans reigned supreme. As I started learning more and more about the design background of the Air Jordans, I learned about a man named Tinker Hatfield. One thing I noticed about him was that rather than looking at what was already designed in the field of basketball sneakers, he took inspiration from various non-basketball related things and found a way to incorporate them into his designs. In the same way, rather than looking to designs of other backpacks, I decided that I wanted to incorporate various non-backpack related things into my design. As a homage to how much sneakers inspired me in middle school, and even now, I chose to incorporate various design elements from some of my favorite sneakers into the final Axo-Pak design.





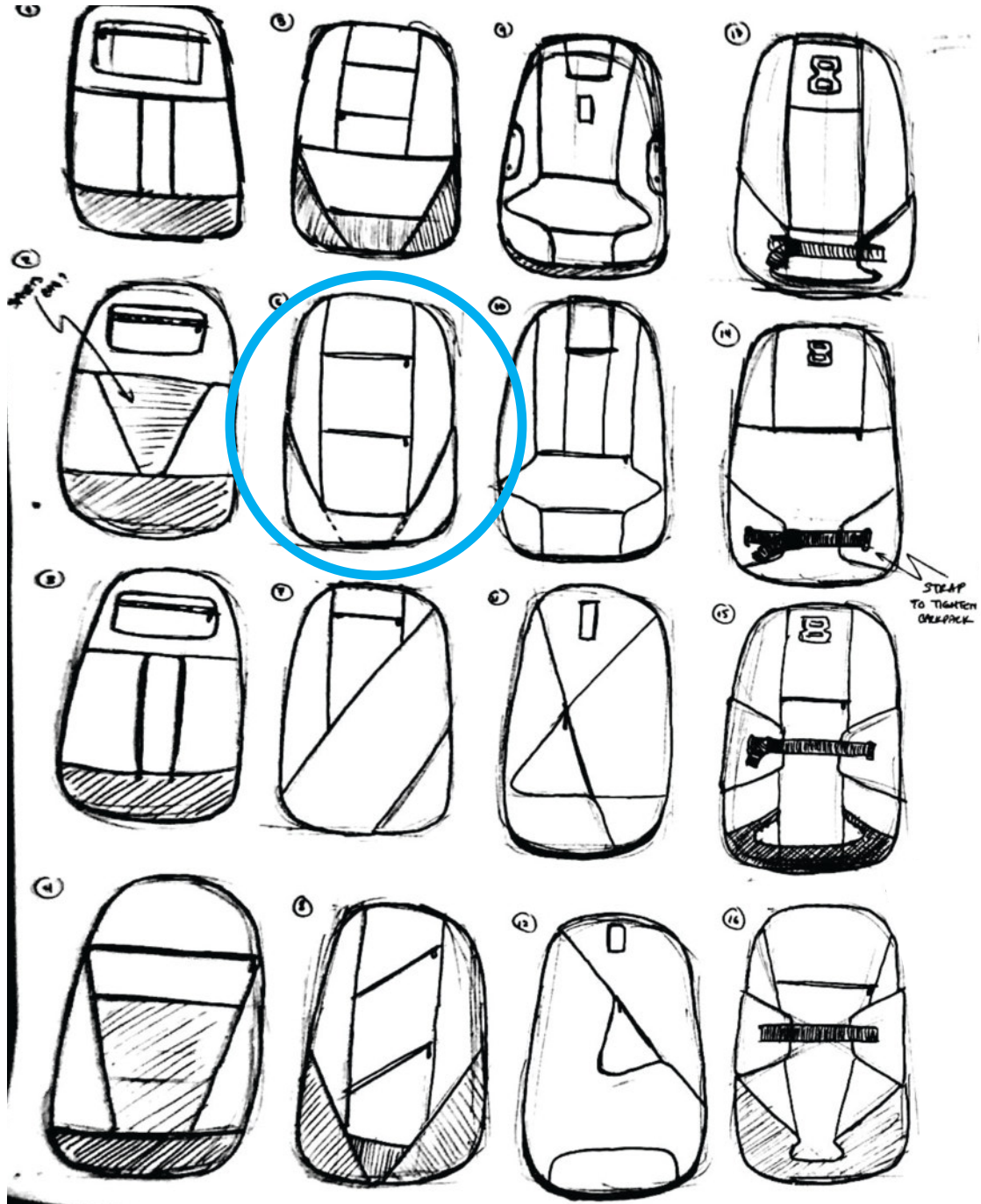
Air Jordan 1



Air Jordan 3



Air Jordan 4





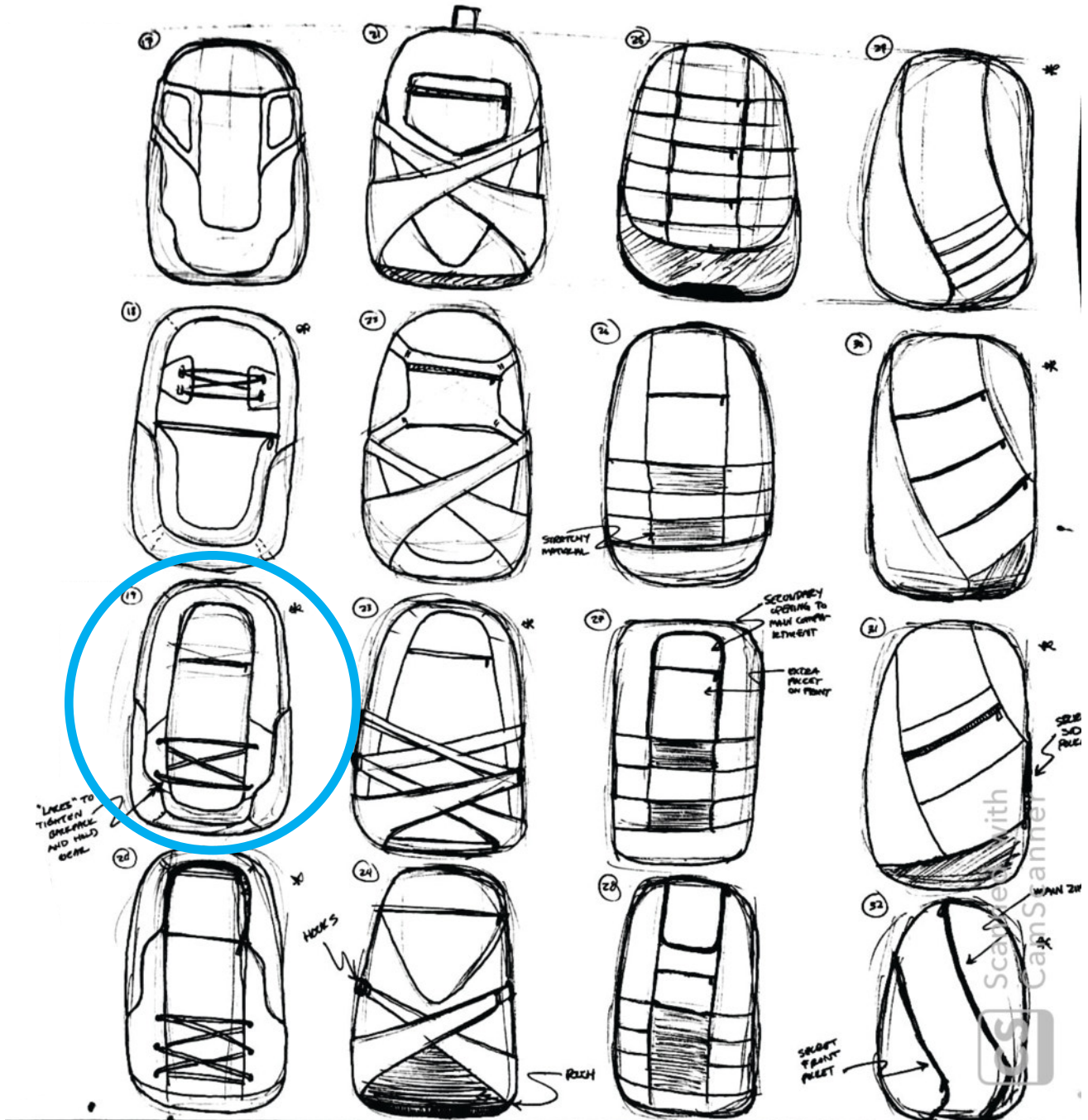
Air Jordan 8



Air Jordan 11



Air Jordan 12

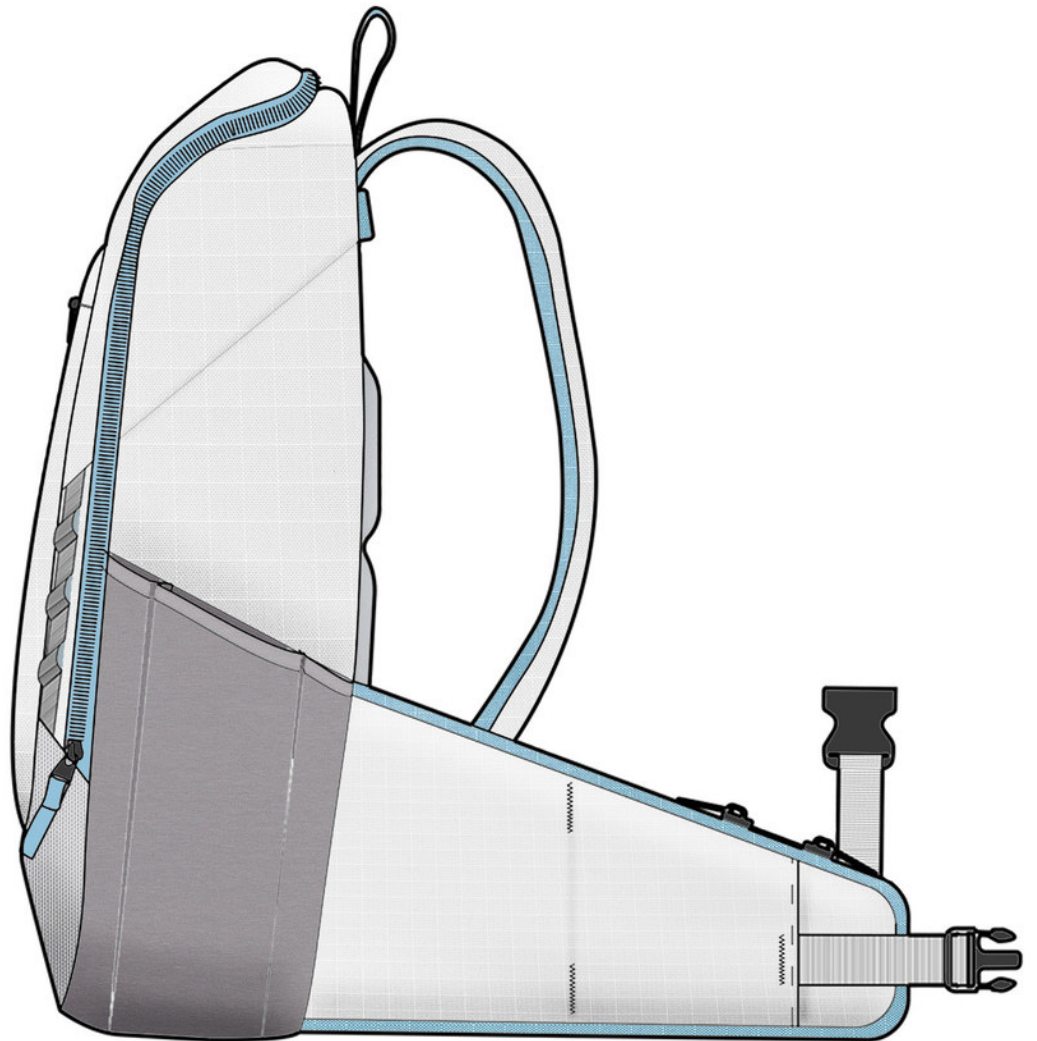
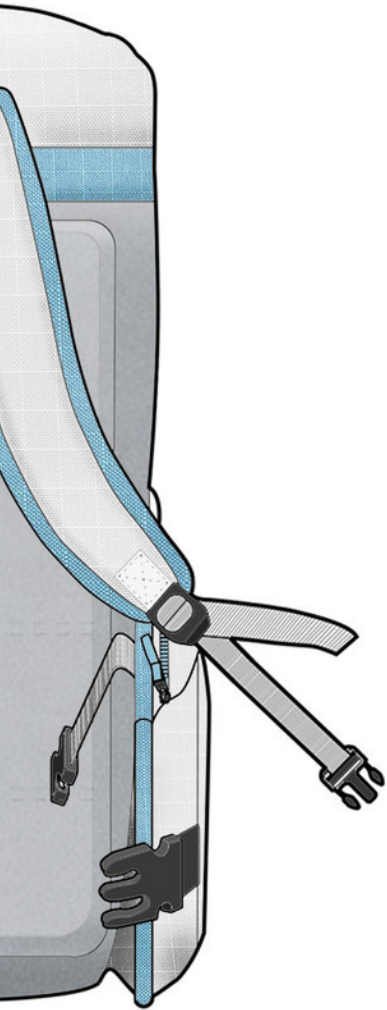


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Final Product

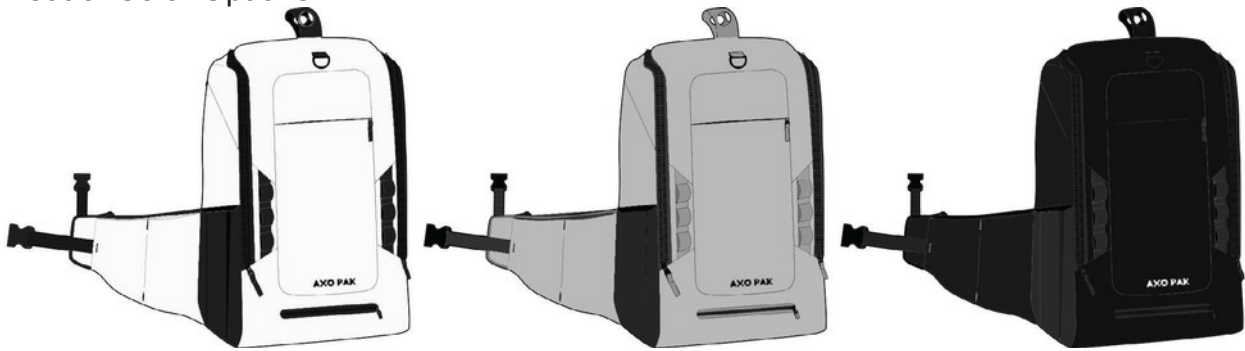






Additional Color Options

Neutral Color Options



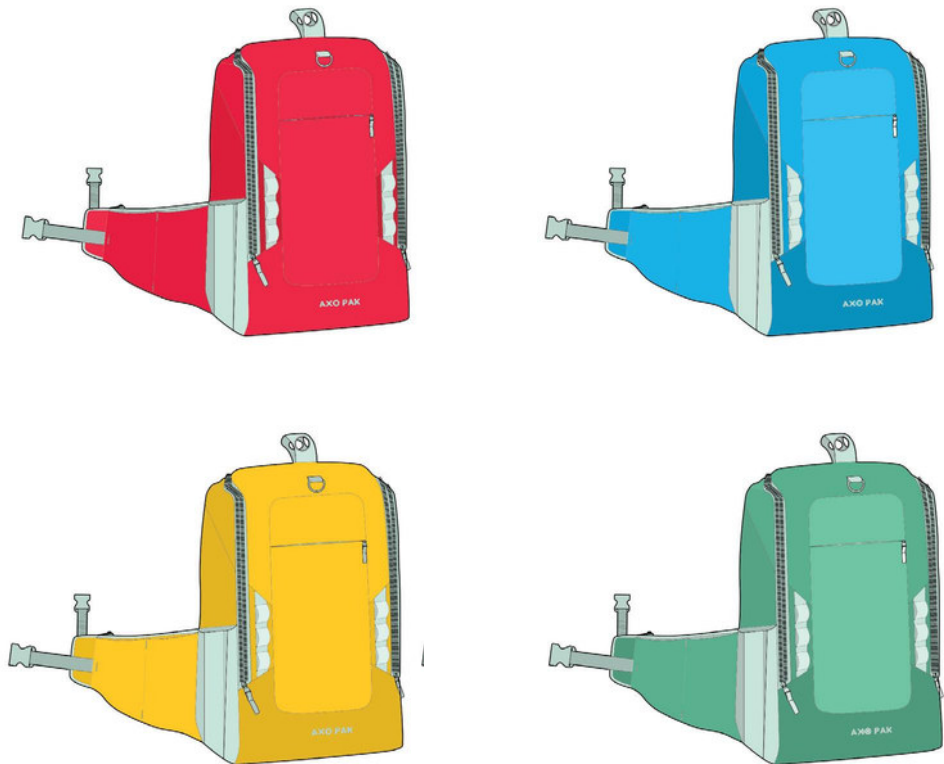
Multi-Color Options



Multi-Color Options Cont'd

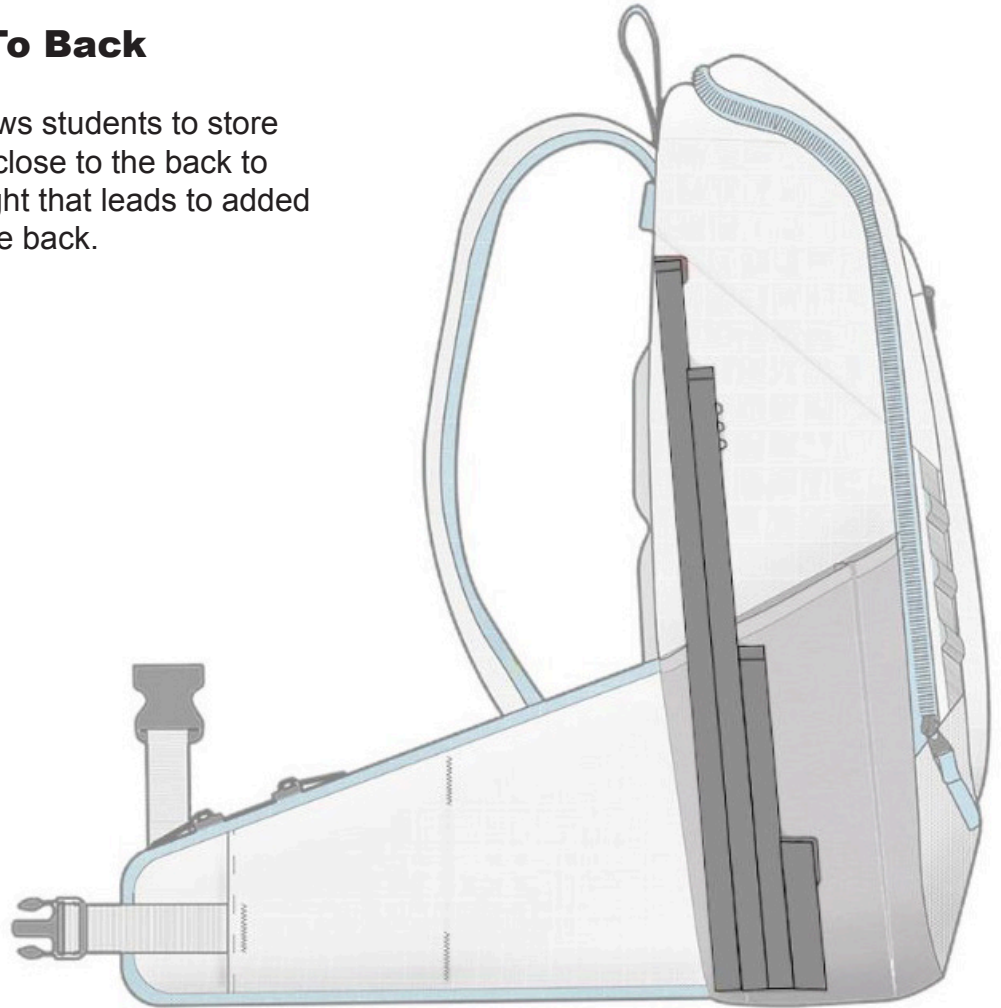


Monotone Color Options

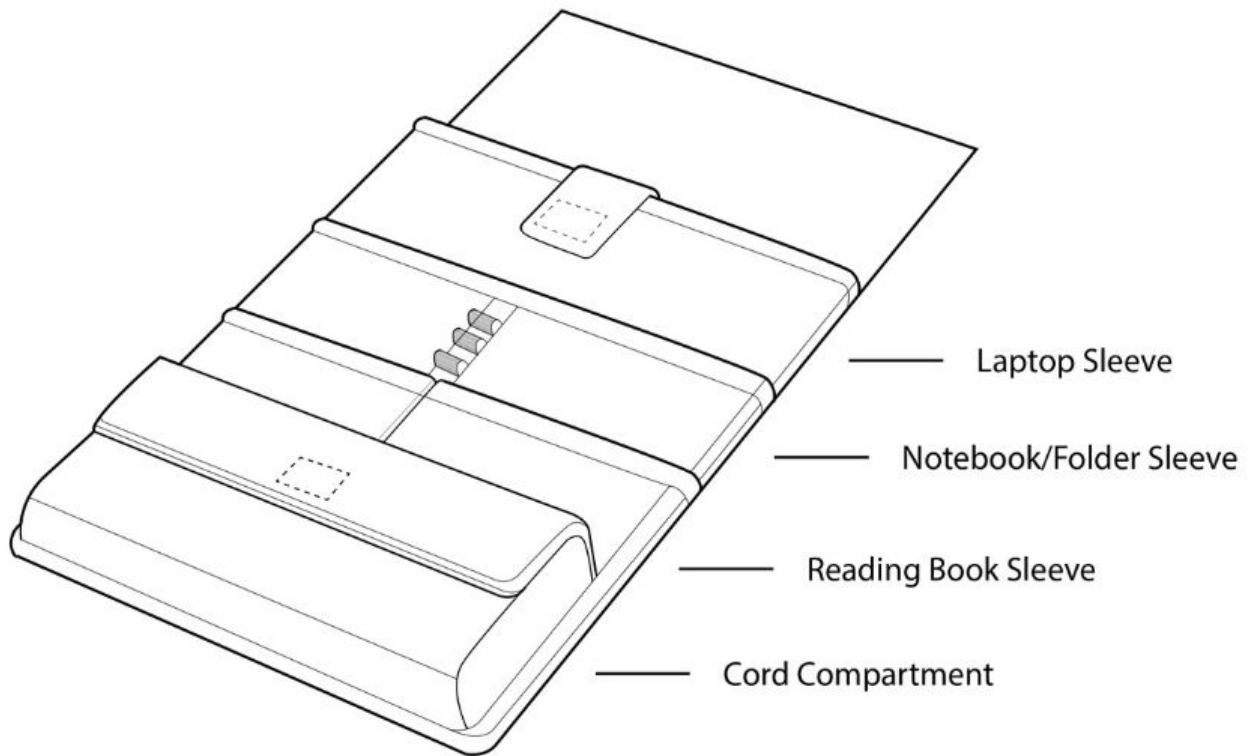


Bigger Items To Back

Inside organizer allows students to store their heaviest items close to the back to reduce hanging weight that leads to added stress or injury on the back.



Each pocket is designed specifically to hold an essential item that a student would typically put in the main compartment of their backpack such as laptops, notebooks, folders, reading books, and various electronic cords. The heavier the item, the closer it's placed to the student's back.



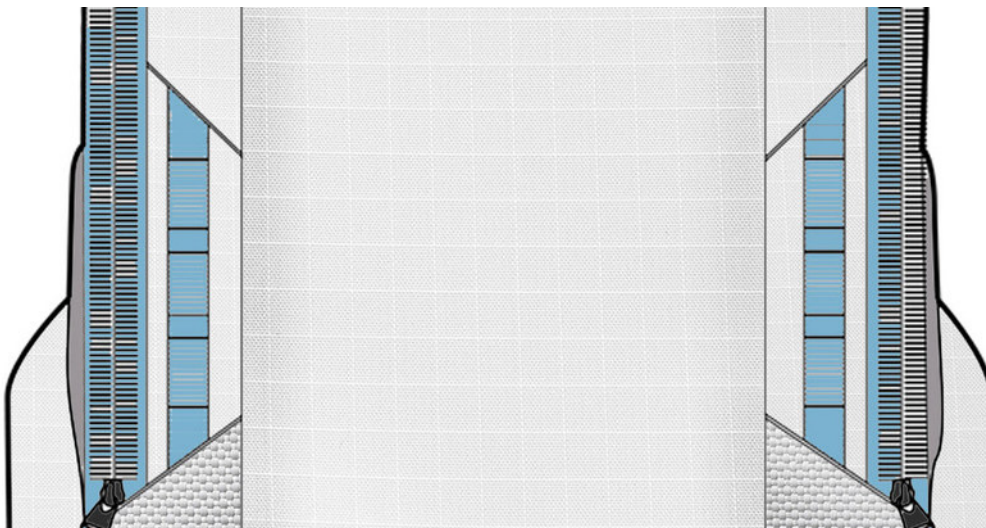
Additional Feature #1: Clamshell-Opening Front

Instead of using a traditional top opening system like you see in traditional backpacks, I incorporated a clamshell opening system for the student to have ample access to their supplies.



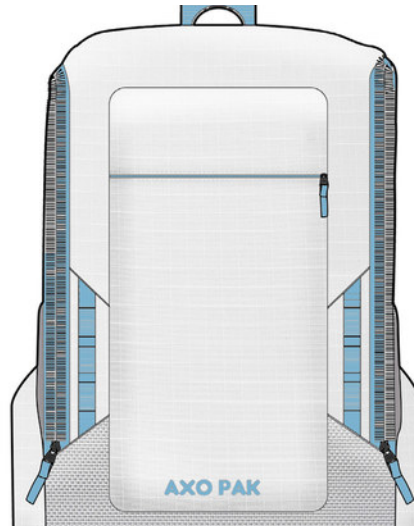
Additional Feature #3: Accessory Loops

Nylon webbing loops were added to the front of the backpack for students to attach various accessories and clip-on items such as hand sanitizer, keychains, and other clip-on accessories.



Additional Feature #2: Front Pocket

Absent from the previous prototypes, a front pocket was added to the Axo-Pak to store various items that the student may need.



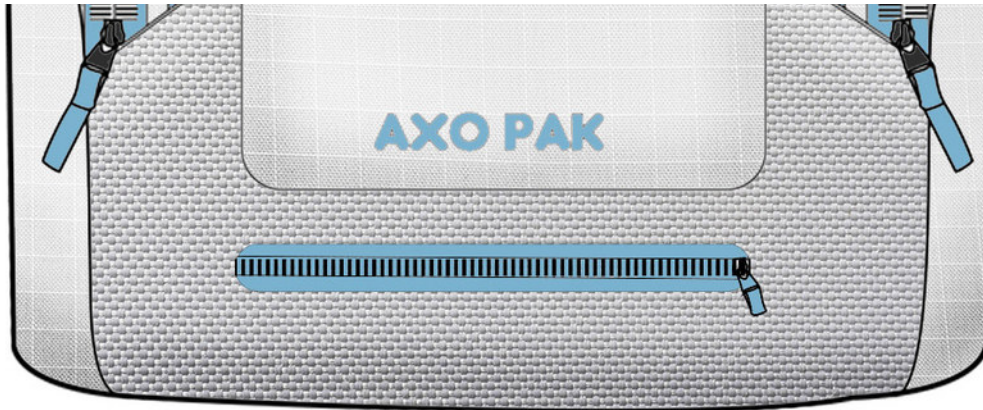
Additional Feature #4: Reflective Material

Reflective material was intentionally placed around the backpack for safety and visibility whenever the student is walking in poor lighting conditions, especially near the street.



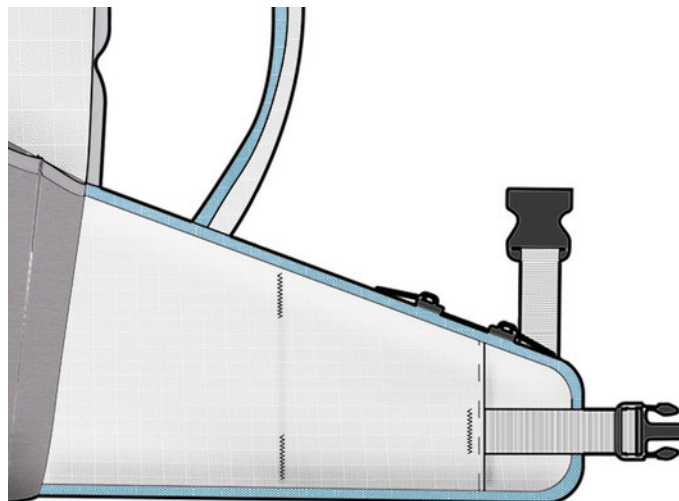
Additional Feature #5: Collapsible Sports Pouch

A removable sports pouch, made from easily cleanable material was added to the front of the backpack to hold sports clothing or equipment that may be dirty from wear and play.



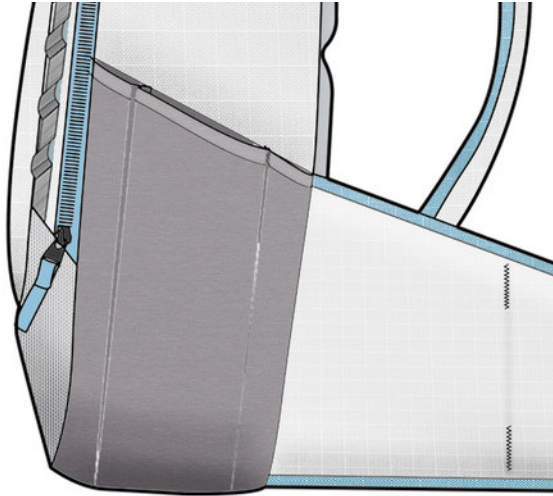
Additional Feature #7: Side Compartments

The side compartments were another feature that saw a revision. The zipper was moved to the top of the compartment to allow for easier access and storage.



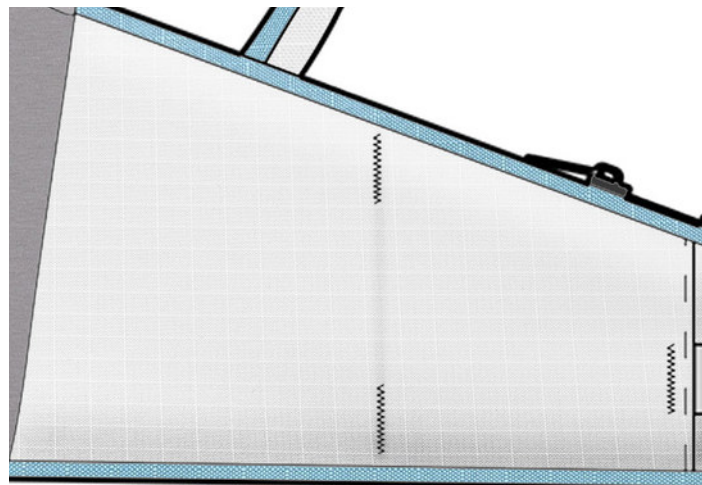
Additional Feature #6: Side Pocket

Although the side pocket may not be a new feature, its design was revised by adding a few hidden slits that open up to hold even larger bottles or equipment.



Additional Feature #8: Quick Access Card Holder

With the outsides of the side compartments freed up, card holder pockets were added via an additional layer of material and two bar tacks, giving the student quick and easy access to their ID, transportation pass, or other cards they may require.



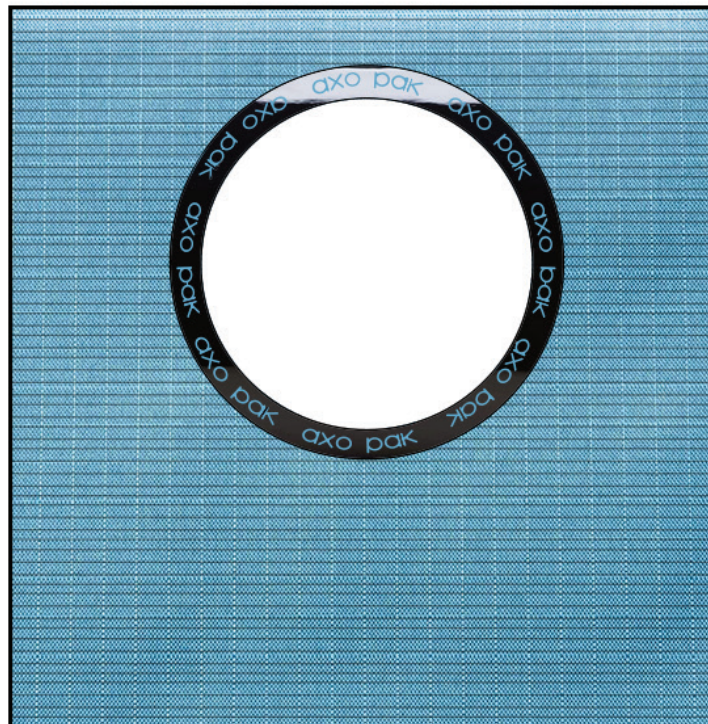
Additional Feature #9: Ergonomic Padded Back

Although each of the previous prototypes included foam padding, targeted closed-cell foam was placed on the back of the backpack to not only give the student more cushion on their back, but also added flexibility via grooves in the foam.

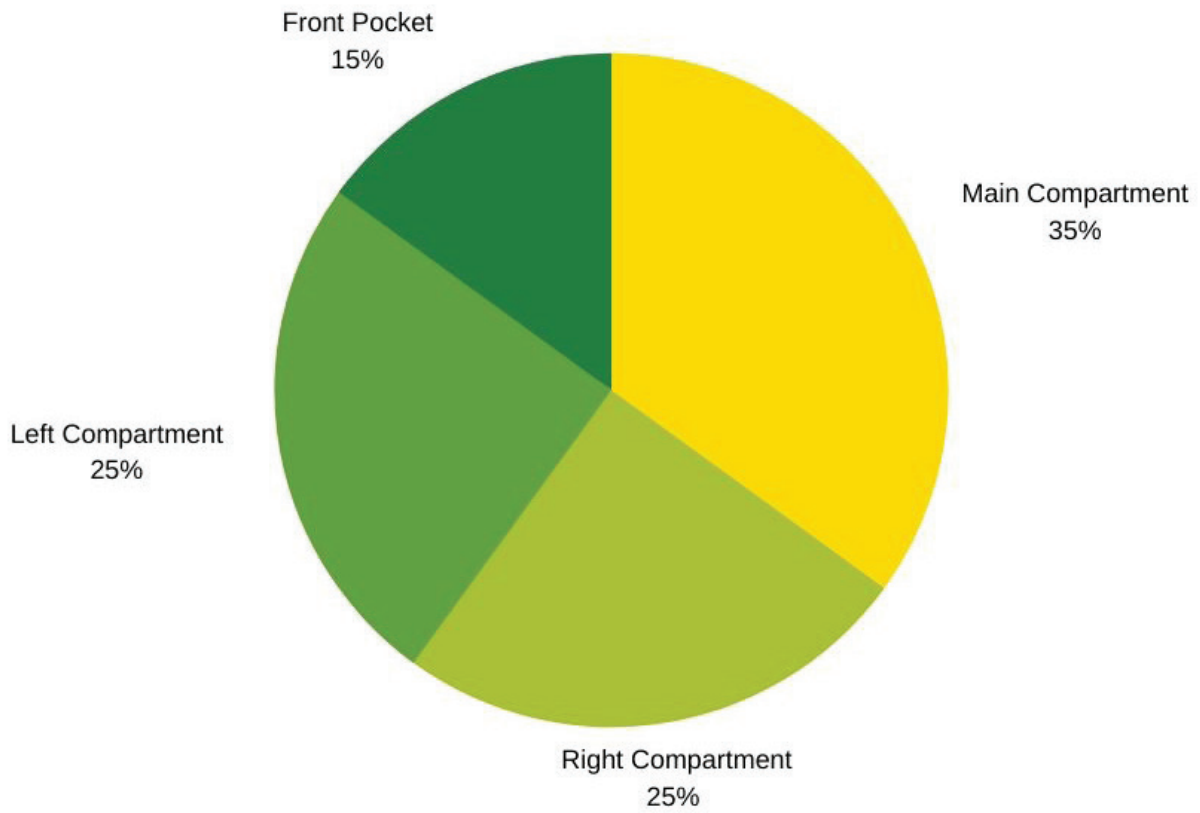


Additional Feature #10: Pull Tab Style Handle

Following the design inspiration of various basketball sneakers, a pull tab-like handle was designed for the student to both hold onto and hang their backpack with.



Weight Breakdown



Total Weight: ~20lbs

Main Compartment (7lbs)

- 3 Subject Notebook (2lbs)
- 3 Folders (12oz)
- Reading Book (2lbs)
- Binder (11oz)
- Tablet/Laptop (1lbs)

Front Pocket (3lbs)

- Sneaker (3lbs)
or
Clothes (2lbs)

Side Compartment (5lbs)

- Pencil case (1.5oz)
- 6pack of Pencils/Pens (6.5oz)
- 10pack of Markers (5oz)
- Keys (3oz)
- ID Card (1oz)
- Calculator (5oz)
- Pencil Sharpener (1oz)
- Toys/Handheld Game (1.5lbs)
- Water Bottle (6oz)
- Random Things (5-10oz)

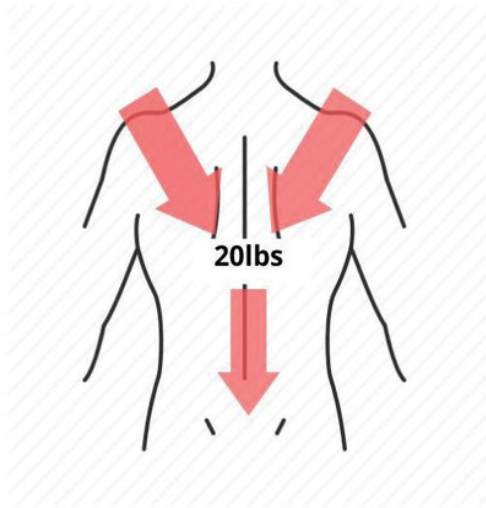
Side Compartment (5lbs)

- Pencil case (1.5oz)
- 6pack of Pencils/Pens (6.5oz)
- 10pack of Markers (5oz)
- Keys (3oz)
- ID Card (1oz)
- Calculator (5oz)
- Pencil Sharpener (1oz)
- Toys/Handheld Game (1.5lbs)
- Water Bottle (6oz)
- Random Things (5-10oz)



Weight Breakdown

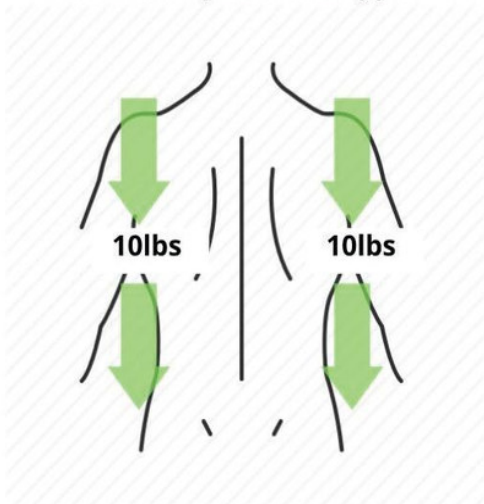
Conventional Backpack



With all of the weight centered in one place, this puts **all of the stress on the spine.**



Axial Backpack Prototype

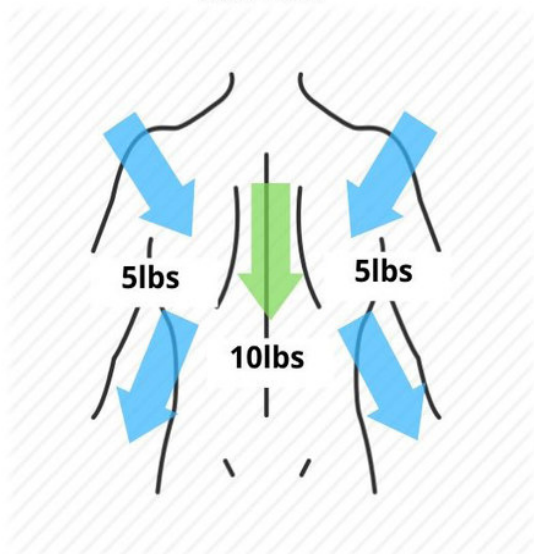


With all of the weight placed on the shoulders & hips, this puts no stress on the spine and **balances the weight on the load-bearing areas of the body.**



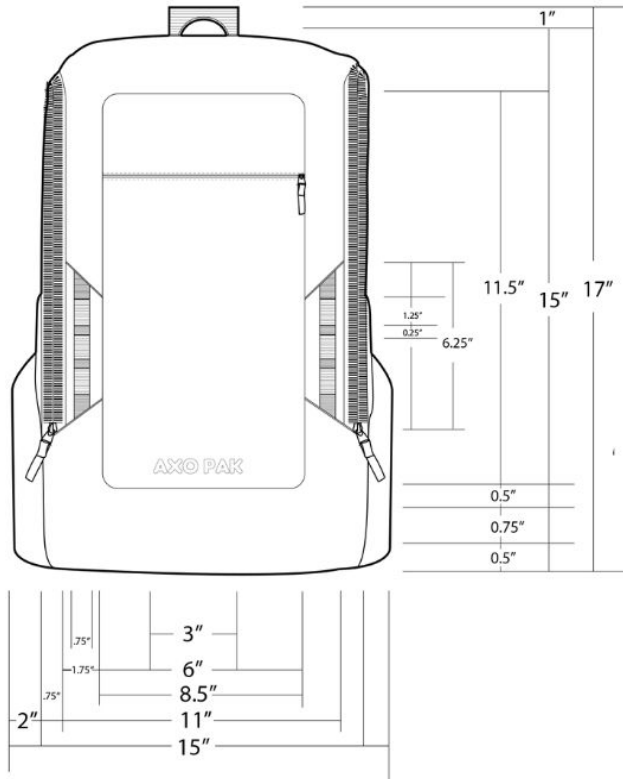
Axial Backpack Prototype

Axo-Pak

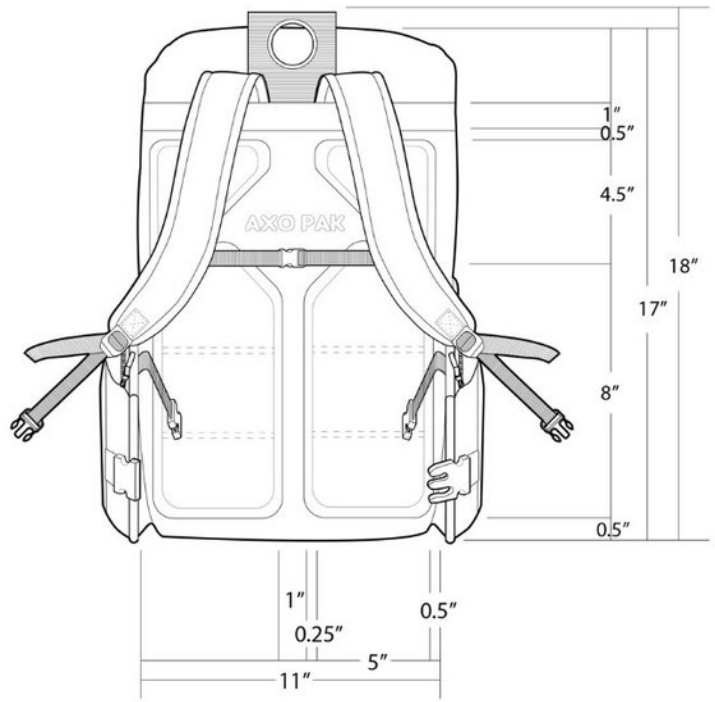


With all of the weight being balanced and displaced across multiple parts of the body, **less stress is put on the spine** and **all other areas have very minimal weight**.

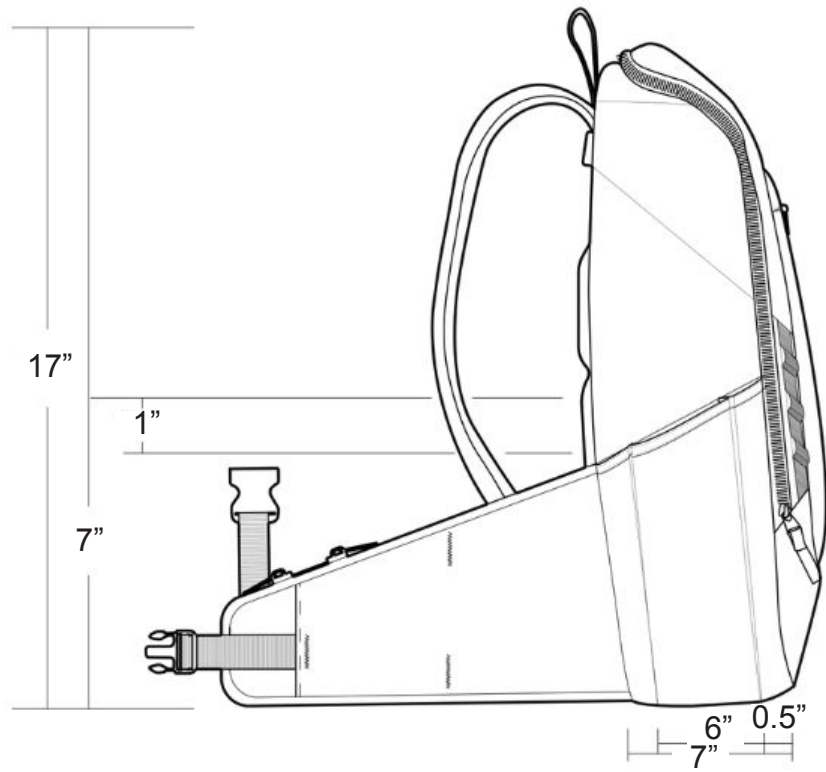




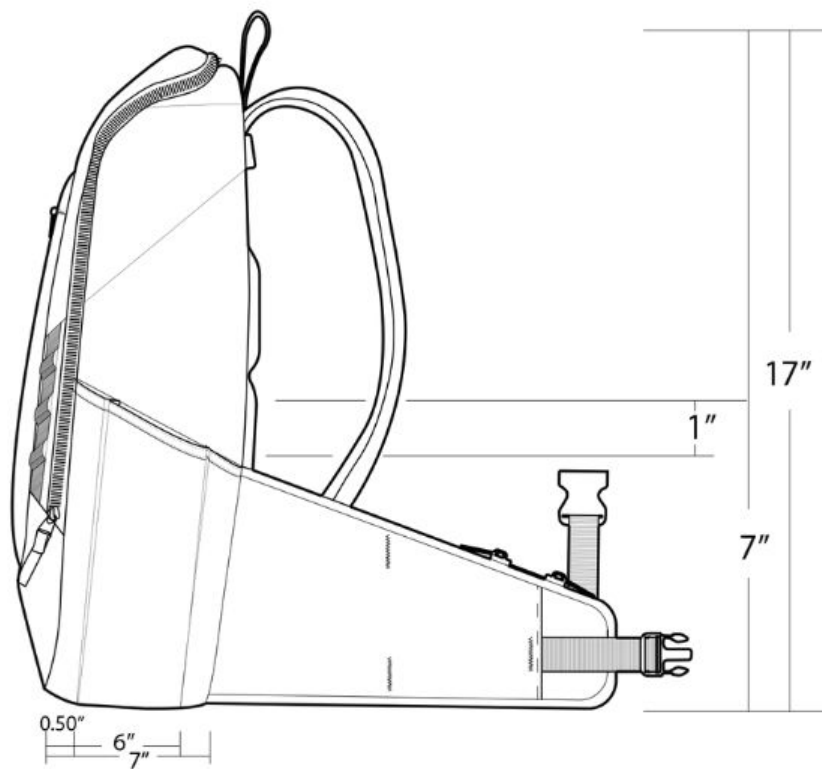
FRONT

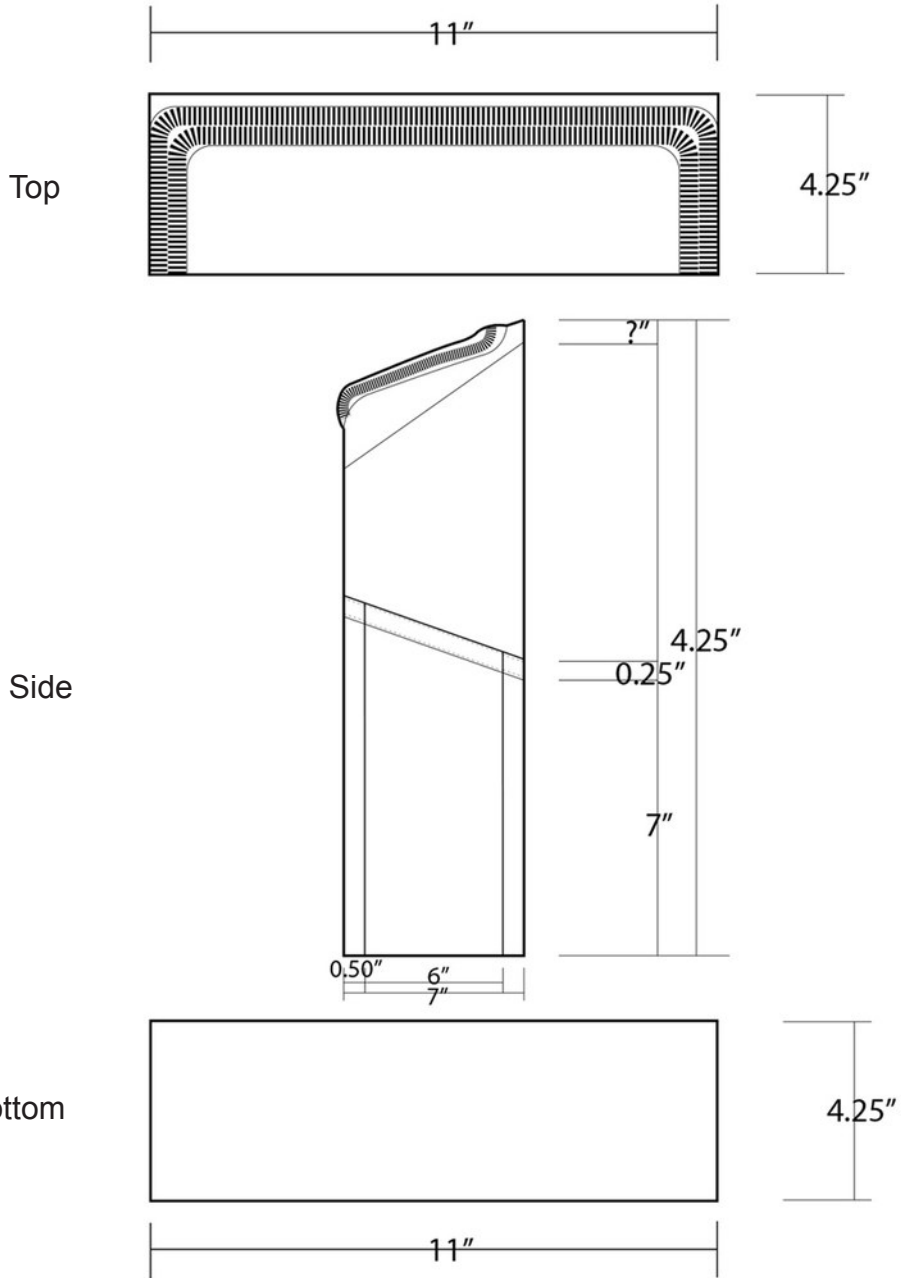


BACK

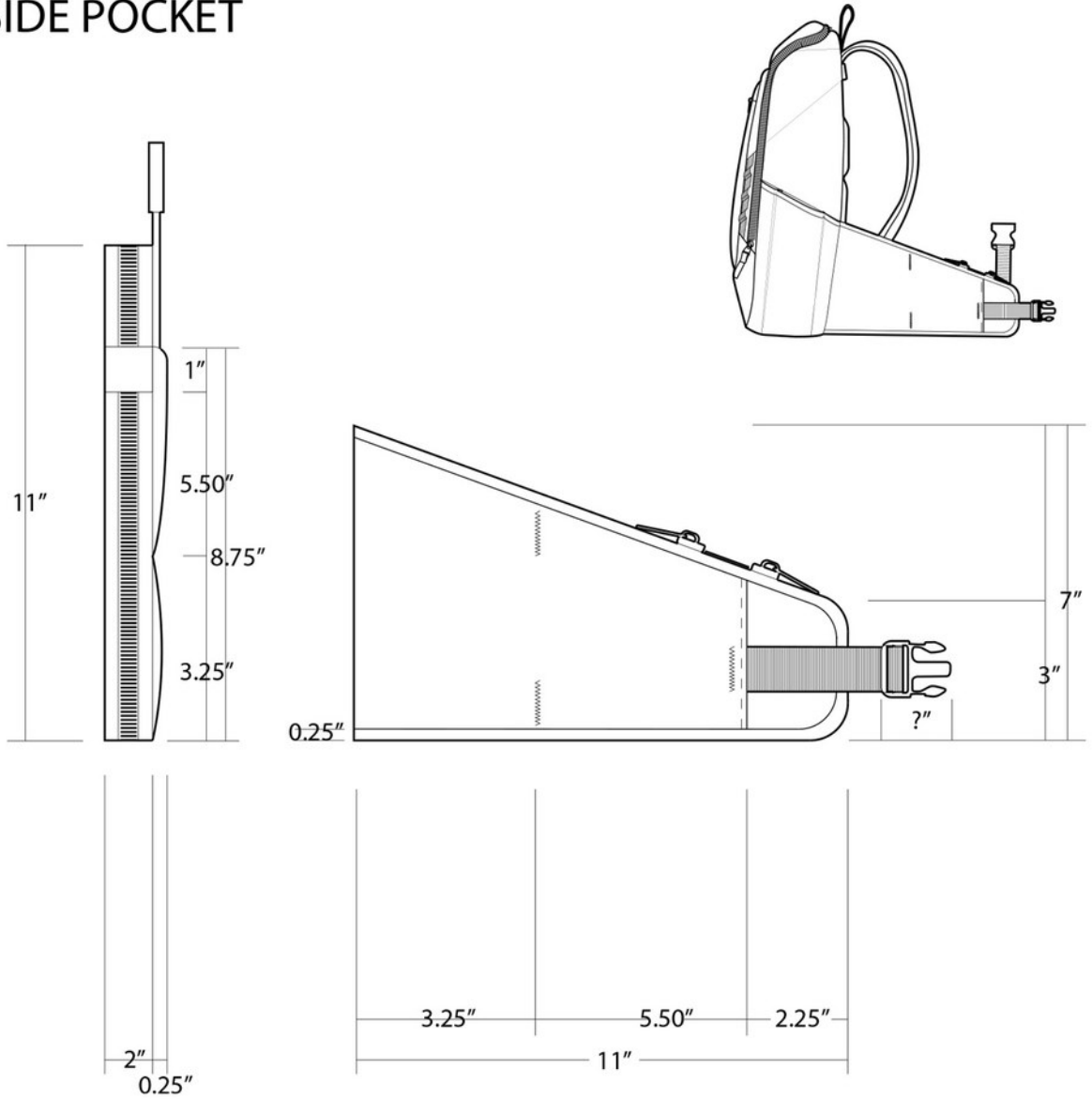


Sides





SIDE POCKET

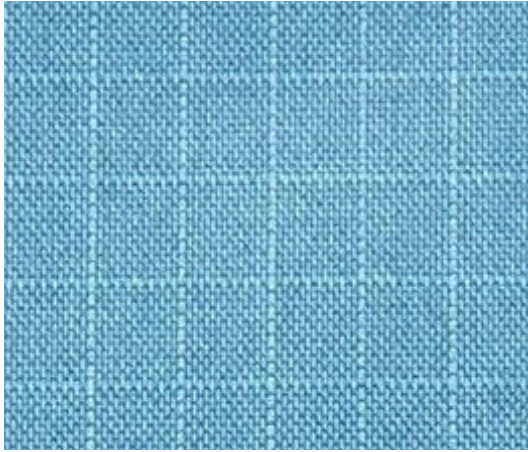


9

Materials



Materials



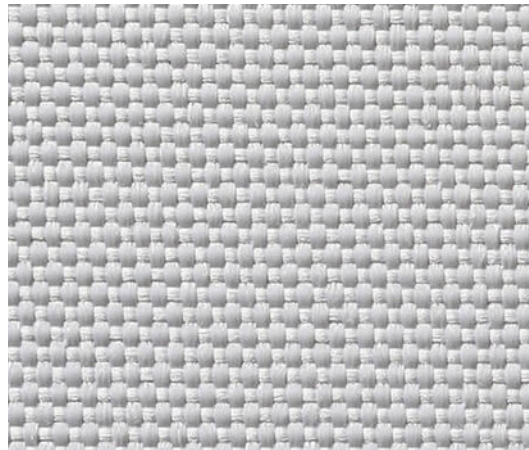
Rip-Stop Polyester

A thin and flexible yet strong material for the main & side compartments.



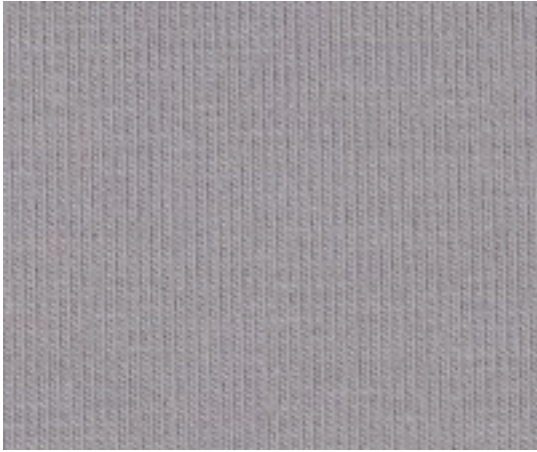
Polyester

A lightweight, durable, and strong material for the bottom and other areas that need reinforcing.



Nylon Webbing

A light thin sturdy webbing used to connect the buckles, straps, front loops, and handle.



Poly-Lycra

An elastic, lightweight, and strong material for the water bottle/small equipment pocket.



Polypropylene

PP plastic will be used for the hardware of the backpack (i.e. zippers, sliders, buckles, etc.).



Closed-Cell Foam

Air tight closed cells used for the back padding providing a rigid and stable support for the back.

10

**Costing
& Retail**



Costing

Materials Cost (\$16.50)

Ripstop Polyester - \$3.84
800D Polyester - \$3.67
Poly-lycra - \$1.72
Nylon Webbing – \$0.91
3mm Closed Cell Foam - \$0.28
Thread - \$0.26
Release Buckle - \$1.92 for (4)
Adjuster Slider - \$0.70 for (2)
D-Ring - \$0.16 for (2)
#6 Zipper Teeth/Tape - \$0.84
#10 Zipper Teeth/Tape - \$1.12
#3 Zipper Teeth/Tape - \$0.62
110D Polyester Lining - \$0.46

Labor Cost

$\$16.50 \times 30\% = \4.95

Factory Cost (FC): \$21.45

The FC is made up of the Material Cost & Labor Cost added together

Materials Cost = \$16.50

Labor Cost = \$4.95

Landed Cost (LC): \$36.83

The LC is made up from the FC, the shipping cost and the tariff fee added together

Tariff: $\$21.45 \times 42.6\% = \9.13

Overseas Shipping: \$1.75

Warehouse Storage & Shipping: \$4.50

Wholesale Cost: \$50.00

MSRP: \$99.99



Target

Due to the higher price point of the Axo-Pak, Target would be a great store to sell in since it caters to a middle to high class market, contrary to a store like Walmart that focuses on low budget items.



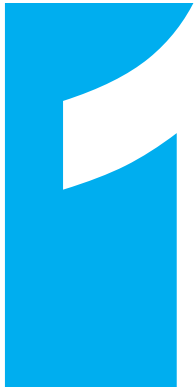
Staples

Staples is another store that sells backpacks and caters to a market that is willing to pay higher prices for premium products, making it an ideal store for the Axo-Pak.



Dick's Sporting Goods

Because the Axo-Pak has features that appeal to students with extracurricular activities such as sports, Dick's would also be a great store to sell in.



**Market
Research**



Target Users



Parents

Middle school students

Middle class (& up)

Actively concerned about child's health & well-being

What are parents concerned about?

There are a lot of things that parents are concerned about when it comes to their children. According to a survey conducted by Mott Poll, researchers found that stress (of their child) was one of the top ten health concerns for parents. The 2017 report is based on a nationally representative household survey of 2,051 adults, which included 1,505 parents of children ages 0-18.

What do parents look for when buying a backpack for their child?

- Durability
- Pockets
- Adjustable Straps/Shoulders
- Padding
- Size-Appropriate for Age
- Bag Weight
- Style
- Tough, abrasion-resistant, or waterproof materials



Students

In middle school

Active in extracurricular activities

What are students concerned about in middle school?

- Expressing individuality
- Keeping Up with School Assignments and Project Deadlines
- Confronting bullies
- Finding friends

What do students look for when choosing a backpack for school?

- Colors
- Brand Names
- Style
- Images
- Customization

Consumer Persona: The Student



Name: Alex Miller

Age: 12

Grade Level: 7th Grade

School: Trinity Middle School

Short Bio:

Alex Miller is a bright and vibrant student. She's starting her 7th grade year and is going back-to-school shopping with her parents. She's eager to get a new backpack, mainly because the strap from her last one she had broke. Probably due to all the times she wore the backpack on one shoulder. Her last backpack was also a \$20 JanSport backpack that her parents got her for elementary school. It did what it needed to then, but now that she has more school work and is on the basketball team, she constantly feels the added weight of all the items she's required to carry. This time around, Alex wants a backpack that is more comfortable and has more pockets to allow her to organize her things better. Alex also looks forward to getting a backpack with a little more flair that really shows off her uniqueness. As new captain of the basketball team, she wants to make an impression both on and off the court.

Values:

- Comfort
- Style
- Organization

3 Words To Describe Them:

Unique
Smart
Talented

"I want a backpack that looks nice, holds all my stuff, and feels comfortable no matter what's in it."

- Alex Miller

Consumer Persona: The Parents



Names: Jason & Donna Miller

Ages: Early 40's

Occupations: Computer Technician (Jason) & Middle School Teacher (Donna)

Household Income: \$90,000 (Middle Class)

Short Bio:

Jason & Donna are both proud parents of a smart and athletic daughter. Donna is a teacher at Alex's school and notices the amount of weight students carry on a daily basis, which makes her concerned for her daughter's health. They realize they made the mistake of being cheap with her backpack, so this time around they want to ensure their daughter's physical safety, especially now that she's playing sports. Although, they aren't the richest family, they'd rather pay more for a backpack that will last a lifetime than be cheap and have to buy the same backpack over and over.

Values:

- Safety
- Longevity
- Versatility

3 Words To Describe Them:

Proud
Safe
Adaptable

“Our daughter deserves a backpack that's safe, long-lasting, and excels just as much as she does.”

- Jason & Donna Miller

Competition



Deuter Step Out 12 Backpack

\$50.00

Pros:

- Very ergonomic
- Attractive colors and style for kids
- Many interior pockets
- Lifetime warranty

Cons:

- Small (only 11 liters)
- Intended for students in K-5th
- Somewhat expensive price



L.L.Bean Junior Backpack

\$29.95

Pros:

- Attractive colors and style for kids
- Affordable price
- Reflective materials

Cons:

- Not very ergonomic
- Few pockets
- No padding on back



JanSport Superbreak Backpack
\$14.95

Pros:

- Comes in many color options
- Lightweight
- Very affordable

Cons:

- Not very ergonomic
- Cheap materials
- No padding on back



The North Face Recon
\$98.95

Pros:

- Very ergonomic
- Highly durable
- Many interior pockets
- Lifetime warranty

Cons:

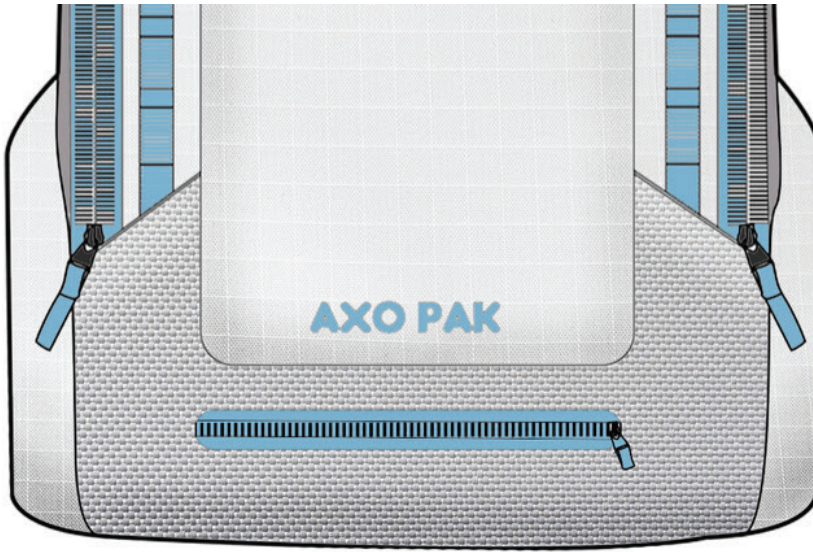
- Limited dark color options
- Expensive price
- Recommended for high schoolers

12

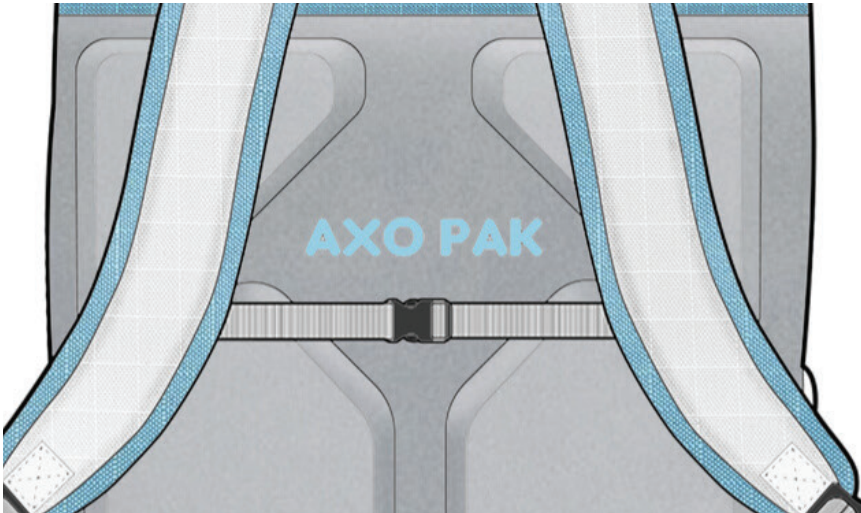
**Details &
Hardware**



Details

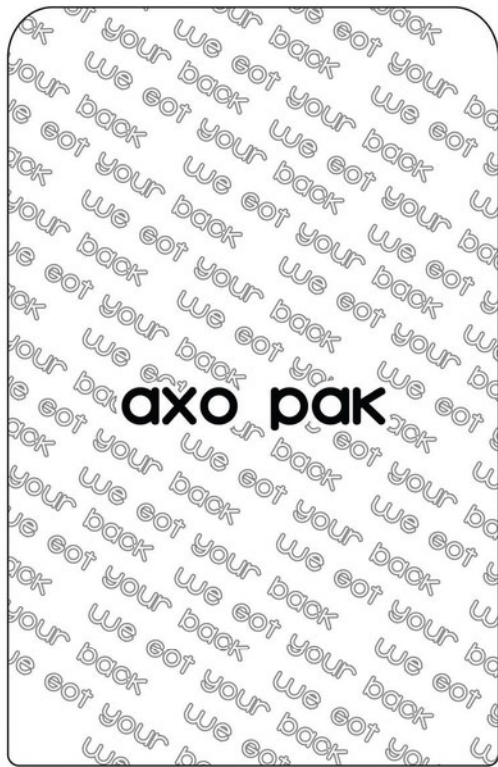


Embroidered Logo

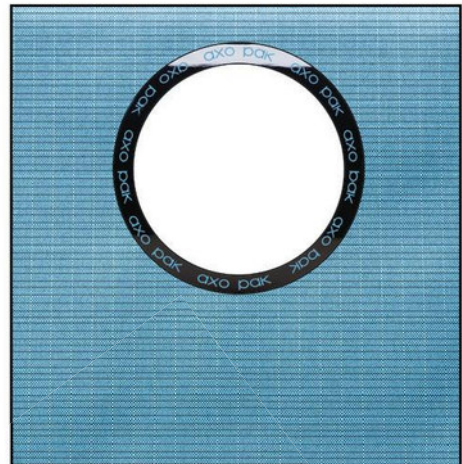


Sponge Silk Screen Logo

Hardware Elements



Dye-Sublimated Branded Lining Material



Sponge Silk Screen
Pull Tab Logo



Sponge Silk Screen
Zipper Logo

1

3

Appendix



Industry Overview*

Market Size: \$173m

Number of Businesses: 96

Industry Employment: 1,199

The global backpack market was estimated to be worth around 17.2 billion U.S. dollars in 2018 and was forecast to reach a value of 22.5 billion U.S. dollars by 2023. Backpacks are also commonly referred to as rucksacks or knapsacks. Backpacks fall within the bags and luggage industry. Baggage or luggage consists of bags, cases, and containers which hold a person's articles while they travel. Bags and luggage are typically broken down into three main classifications: travel, casual, and business.

Growing student enrollment ratio coupled with government efforts to encourage education for all children is anticipated to further propel the growth. Rising focus on providing basic education to children is attributed to the rising number of schools and colleges and students across the globe. As per the National Center for Education Statistics in 2018, about 56.6 million students attended elementary and secondary schools. Growing student enrollment is projected to boost the demand for school supplies including school bags, which in turn is anticipated to drive the market growth.

Rising demand for sturdy and spacious school bags with trendy designs is anticipated to bode well for the market growth. Demand for good quality materials capable of carrying excess load without transferring it to the back or shoulders of the students carrying them is expected to bode well for the product innovation as well as demand.

Evolving teaching methodologies and rapid digitization have resulted in increased use of tablets, laptops, and other electronic gadgets. These gadgets increase the weight of the bags, which is anticipated to drive the demand for lightweight bags and fuel innovation in terms of raw materials and manufacturing technologies. Rising use of eco-friendly materials such as recycled plastics is projected to positively influence the growth of the market.

Fabric Insights

Polyesters accounts for the largest market share and is expected to be the fastest growing segment over the forecasted period. The growth is attributed to higher strength of the material compared to other fabrics. The waterproof nature of this fabric makes it durable for manufacturing sturdy school bags.

Nylon is the second largest and fastest growing segment in the school bags market. The fabric has high elasticity and can be used for manufacturing bags designed to carry different load requirements. Availability of trendy designs and patterns is anticipated to further fuel the segment growth.

Distribution Channel Insights

Online distribution channel is estimated to register the fastest CAGR over the forecasted period owing to growing penetration of e-commerce industry coupled with rising influence of social media on consumer purchasing decisions. Availability of offers and discounts, quick product delivery and easy returns, free shipping, and ease of comparison are some of the factors driving the segment growth.

Offline distribution channel held the largest market share approximately 80% in 2018 and is expected to maintain its dominance over the forecasted period. Rise in the number of offline stores such as hypermarkets, supermarkets, omni channels, house and office goods and specialty stores is anticipated to propel the expansion. Excluding some of the major players the market is mostly driven by unorganized players. These small players target small retailing shops for selling their products leading to the growth of the segment.

School Bags Market Share Insights

Major market players include Nike; Puma; Delsey; Targus Inc.; VIP Industries; Belmil; and Herschel Supply Company. The companies focus on product innovation in terms of durability and materials. For instance, Nike recently launched its extra padded school bags to reduce the extra weight on arms of the children.

Research Links

Medical Research

- <https://kidshealth.org/en/teens/backpack.html>
- <https://kidshealth.org/en/teens/pt.html>
- <https://kobleder.at/en/health-and-protection/>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6267109/>
- <https://well.blogs.nytimes.com/2009/07/21/weighing-school-backpacks/>
- <https://www.healthychildren.org/english/safety-prevention/at-play/Pages/Backpack-Safety.aspx?nfstat us=401&nftoken=00000000-0000-0000-0000-000000000000&nfstatusdescription=ERROR%3a+No+local+token>
- <https://www.sciencedirect.com/science/article/pii/S0264127519302163>
- <http://article.sciencepublishinggroup.com/html/10.11648.j.sr.20160403.13.html>
- <https://consumer.healthday.com/encyclopedia/children-s-health-10/kids-ailments-health-news-434/backpacks-and-kids-645623.html>

Product Research

- https://www.washingtonpost.com/local/education/schools-and-lockers-no-longer-the-right-combination/2018/01/24/9aa4222a-fa09-11e7-ad8c-ecbb62019393_story.html
- http://www.lightningpacks.com/lightningpacks.com/Ergonomic_Backpack_%7C_Lightning_Packs,_LLC.html
- <https://herschel.com/shop/backpacks/mammoth-backpack-medium?v=10269-02524-OS>
- <https://ergo-plus.com/back-belts-to-prevent-low-back-injuries/>
- https://www.vertepac.com/store/vertepac_xtr-18/
- <https://www.backtpack.com/backtpack-in-action/heavy-school-backpack-problem-solved/>
- <https://www.backtpack.com/product-info/why-it-works/>
- <https://www.backtpack.com/our-story/what-is-an-ergonomic-backpack/>
- <https://pangolinswithpacks.com/the-definitive-guide-that-you-never-wanted-anatomy-of-a-backpack-50eea89bbe56>
- http://mathandreadinghelp.org/articles/Why_Are_Some_Schools_Banning_Backpacks.html
- <https://pangolinswithpacks.com/the-definitive-guide-that-you-never-wanted-anatomy-of-a-backpack-50eea89bbe56>
- <https://pangolinswithpacks.com/the-definitive-guide-that-you-never-wanted-shoulder-straps-26ec3860bbc6>
- <https://www.ergobag.com/ergonomics/>
- https://www.huffpost.com/entry/backpack-school-bags_n_3860144
- <https://www.ebags.com/product/deuter/step-out-12-backpack/303450?productid=10777369>
- <https://www.businessinsider.com/best-backpack-students#the-best-for-high-school-4>
- <https://www.grandviewresearch.com/industry-analysis/school-bags-market>

Costing/Pricing

- <https://www.statista.com/statistics/744071/manufacturing-labor-costs-per-hour-china-vietnam-mexico/>
- <https://www.2regularguys.com/calculating-your-true-costs-of-sublimation/>
- <https://www.alibaba.com/showroom/wholesale-hiking-backpacks.html>
- <https://fashion-incubator.com/what-does-it-cost-to-prototype-a-bag-or-clothing-line/>

Materials & Technology

- <https://www.behance.net/gallery/68070393/Functional-knit-structures-for-footwear>
- https://www.core77.com/posts/87856/This-Ornate-3D-Printed-Chair-Made-Using-Generative-Design-Can-Fold-Down-Flat?utm_source=core77&utm_medium=from_title
- <https://www.dezeen.com/2014/06/08/nike-3d-printed-sports-bag-fifa-world-cup-2014/>
- https://www.core77.com/posts/71173/How-To-Find-the-Best-3D-Printing-Material-for-Your-Designs?utm_source=core77&utm_medium=from_title
- https://www.core77.com/posts/71172/How-to-Select-the-Right-3D-Printing-Process?utm_source=core77&utm_medium=from_title
- <https://www.intechopen.com/books/textiles-for-advanced-applications/multifunctional-foldable-knitted-structures-fundamentals-advances-and-applications>
- <https://www.simplify3d.com/support/materials-guide/#all>
- https://www.researchgate.net/publication/265970019_The_Effect_of_Fabric_Weave_on_Tensile_Strength_of_Woven_Kenaf_Reinforced_Unsaturated_Polyester_Composite
- <https://www.behance.net/gallery/68070393/Functional-knit-structures-for-footwear>
- <https://www.complex.com/sneakers/2013/07/know-your-tech-nikeskin>
- <https://pangolinswithpacks.com/the-definitive-guide-that-you-never-wanted-backpack-fabrics-566aa1567af9>
- <https://www.nike.com/t/mercurial-vapor-13-elite-fg-firm-ground-soccer-cleat-14MsF2>
- <https://news.nike.com/news/nike-joyride-cushioning>
- <https://news.nike.com/news/nike-acg-defining-sport-utility-for-the-city>
- <https://news.nike.com/news/nike-acg-react-terra-gobe>
- <https://news.nike.com/news/lebron-17-official-images-and-release-date>
- <https://news.nike.com/news/zoom-unvrs-flyease>
- <https://www.complex.com/sneakers/2013/07/know-your-tech-nike-flywire>
- <https://news.nike.com/news/nike-flyknit-sports-bra>
- <http://www.fluorocarbon.co.uk/news-and-events/post/18/what-is-ultra-high-molecular-weight-polyethylene-uhmwpe>

Consumer Research

- <https://www.businessinsider.com/cool-backpacks-for-kids>
- <https://www.inc.com/peter-roesler/nrf-survey-suggests-near-record-back-to-school-spending-in-2018.html>
- <https://www.loyalparents.com/helpful-tips-for-parents/top-10-features-in-choosing-a-school-bag/>
- <https://redtri.com/cool-kids-backpacks/slide/1>
- <https://www.parents.com/kids/education/elementary-school/choosing-the-best-backpacks-for-kids/>
- <https://www.parents.com/toddlers-preschoolers/everything-kids/back-to-school-worries-a-new-survey-reveals-parents-top/>
- <https://www.understood.org/en/family/taking-care-of-yourself/dealing-with-emotions/how-to-manage-5-common-worries-about-kids-with-learning-and-thinking-differences>
- <https://www.psychologytoday.com/us/blog/the-athletes-way/201708/top-10-concerns-parents-have-their-own-kids-and-others>
- <http://money.com/money/4425114/parents-rising-costs-after-school-activities/>
- <https://www.readingrockets.org/article/understanding-concerns-parents-students-disabilities-challenges-and-roles-school-counselors>
- <https://pdfs.semanticscholar.org/df33/a7fd11bd87f5f8251481a67c2168100f45da.pdf>
- <https://www.degruyter.com/downloadpdf/j/aut.2015.15.issue-3/aut-2015-0004/aut-2015-0004.xml>
- <https://www.sciencedirect.com/science/article/pii/026635389500114X>

Moving Forward

Originally, my plan was to reach out to a backpack manufacturer overseas to help me manufacture multiple backpacks, however, due to the events of COVID-19 I was unable to contact both foreign and local manufacturers. I then decided to create a single final prototype on my own, but then our school's campus closed. This not only meant that I had to move off campus, but also that I had no access to the school's design resources. In light of the situation, my professors encouraged me to direct my attention to the final presentation and capstone book.

After the presentation and capstone book is complete, my goal is to continue working on my final prototype in order to have a physical model for both myself and the university. Once the factories overseas open back up, I plan on reaching out to a manufacturer to create a handful of personalized samples in various color options that I can give out to the students at the Salvation Army Kroc Center Homework Zone Program that helped me with this project.

Lastly, I plan on reaching out to various investors or creating a KickStarter page to fund mass production of this backpack. After that I'll reach out to various companies about the possibility of putting this backpack into their stores.

Thank You

(Read this like the ending credits to a movie)

First of all, I want to give thanks and credit to my Lord and Savior Jesus Christ. Without him none of this would've been possible.

To my family and friends:

I'd like to thank you all for your support throughout this long college process. You all have made it worth it.

To the university and faculty:

Thank you for giving me the knowledge and resources to achieve this great milestone.

I want to give a special thank you to:

Mike Leonard

Thank you for clearing your hectic schedule to meet with me more times than I can remember. Your time and creative input was invaluable.

Todd Kramer

Thank you for your mentorship and role as my professor through all these years. You've taught me so much about the field of soft goods (and beyond) and for that I'll always be grateful.

Mark Havens

Thank you for your honesty, encouragement, and faithfulness. Even though we could always see how tired you were, you always came to class with positive words and great feedback.

To my classmates:

it wasn't easy fitting in. I was an early, yet late, transfer and I was one of only a handful of people of color in our entire program, but somehow I still managed to call the studio my home. Thank you for your acceptance.

To the Homework Zone Kids and Parents:

Thank you all for being willing to work with me on my project! You all have a special place in my heart and I promise I will find a way to repay you all for helping me!

And to everyone else that wasn't mentioned...thank you.



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