Pocket Board

A user-centric skateboard that offers unprecedented convenience and portability without sacrificing performance.

Dan Yu
Priyanka Muhunthan
Angel Rubio
Motasim Zawawi

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I. Executive Summary

Each day, students who choose to skateboard to class are faced with the inconvenience and insecurity of having to leave their boards outside of the classroom—thus risking theft or potentially imposing a fire hazard. Although biking remains students' preferred method of transportation around a college campus, the rising prevalence of boarding to get around means that a growing population are afflicted by the aforementioned concerns. One writer and reporter, Dan Reimold, goes so far as to say that boarding on a college campus "has officially morphed from cult sport to mainstream ride." (Reimold). Essentially, the need for a more efficient and convenient method of getting around a college campus warrants the development and research into ways in which to revolutionize the modern skateboard. This is the task that our engineering team sought to target and solve through our inventive *Pocket Board*.

Our team took various approaches to solving this engineering task. We began with rapid prototyping using cardboard in order to see which designs were viable as models. After filtering each prototype on the basis of a variety of metrics and constraints, we settled on the "extendable" skateboard. This design revolves around the idea that skateboarders distribute their weight evenly across the front and back halves of a board; this allows for the removal of the midsection of a board—cutting down on both size and weight. Our team designed and created a model for a skateboard that reached a compression levels of 65% of its original size. We envision this design eventually growing into a lighter, stronger, more convenient board that can be compressed in size and stowed away into a bookbag or carried with a single hand.

II. Introduction

A. Background

Bicycles have become a common sight on university grounds. This widespread use of bikes has been motivated by the need to utilize environmentally friendly transportation methods on college campuses. According to an article from the Transport Policy Journal, "the bicycle offers riders speed and flexibility over short distances [as well as] produces no pollution, uses no energy, is silent, can be accommodated with relatively little space, and is fast and cheap" (Balsas 38). Many campuses have been or are being redesigned to become more bike-friendly. In fact, there is a list of the top bike-friendly US universities that includes more than 30 colleges. This has led to many startups, such as Zagster, to employ bike-sharing systems on different campuses.

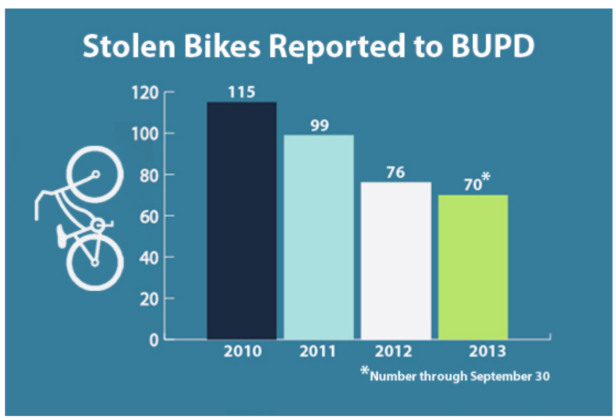


Figure 1: Pictograph of number of bike thefts reported to the Boston University Police Department from 2010 - 2013 (Barlow).

Bikes have become the popular mode of transportation around US campuses. However, there are problems associated with a dependence on bicycles. Bike parking requires a lot of infrastructure and cost. From the students' perspective, the hectic parking process is still an issue. Ann McClur, author of *Go With the Flow: Campus Traffic and Parking Solutions* from University Business claims that when asked about bike parking on a college campus, "most constituents… probably have a horror story to tell." The students have to search for an available parking spot and then use a complicated locking process that involves chains and ropes in order to prevent theft. Yet despite the decrease in the number of bike thefts reported over the years—as shown in figure 1—bike theft remains the number one crime on college campuses (Chirbas). Even though many colleges are raising awareness about bike theft, locked bikes can still be stolen if they aren't properly locked. Chirbas, in one of his Stanford Daily articles, reveals that a majority of the bikes that are reported stolen in any given college campus "were either not locked or not properly secured to a bike rack" (Chirbas).

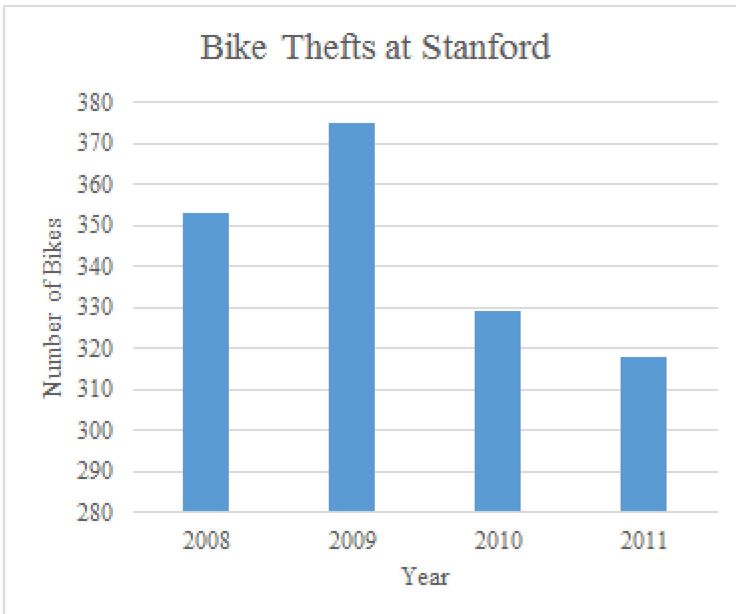


Figure 2: A graph of the number of bike thefts reported to the Stanford University Police Department over a span of four years (Chirbas).

The parking and theft issues have led a number of students to either walk or skateboard as a means to get around a campus. The appeal of skateboards stems from how it offers a smooth and efficient way of commuting around campus without the hassle of finding a parking space. In fact, skateboarding is the second most popular method of transportation on some college campuses, one of which includes Stanford University. They come in a wide range of shapes and styles, from huge, heavy longboards to small, lightweight penny boards.

B. Problem Statement

With tight and demanding schedules, college students are always searching for easier and more convenient ways to get around. On today's campuses, the most popular mode of transportation is biking. Unfortunately, there are numerous downsides to riding around campus on a bike: the hassle of a bike chain, the burden of potential police tickets, and the persistent fear that one's bike will be stolen—after all, studies have found that "college students have a 53% chance of having his or her bike stolen" (National Bike Registry). Skateboards and in particular, longboards, have already been adopted by some students, as they offer an escape from these detriments. Operable without the need for a bike chain, longboards are much less unwieldy compared to bikes. Additionally, riders of skateboards qualify as pedestrians, meaning that they are granted a higher level of comfort while cruising on campus roads (California DMV). Because it is impractical to bring large, clumsy skateboards to their seats, students must often set their boards outside of or in the back of a classroom during lectures—a pronounced downside owing to the structure and design of a skateboard itself. Left around the classroom, these skateboards pose a fire and safety hazard in the classroom and are subject to theft by others. Our project seeks to remedy these issues in an intuitive and cost-effective manner.

III. Problem Assessment

A. User Perspective

The marketability of a skateboard that can be reduced in size depends on the rideability, the durability, and—in large part—the style of the board. From the perspective of a skateboarder, the convenience offered by a skateboard's concealability comes second to achieving a smooth riding experience. This level of rideability can be measured by the distance traveled by a skateboarder and the time it takes to travel that certain distance. There is currently an abounding number of boards—skateboards, longboards, and penny-boards—that offer a smooth riding experience. But these boards have the troubling issue of lacking portability, where for example, a college student cannot bring his or her board with them into class. The portability factor that ties into our project's design must make it both convenient and intuitive for a user to compress his or her board and stow it away as they see fit.

B. Builder Perspective

The builder's goal is to create a skateboard that offers an unprecedented level of portability without sacrificing the level of rideability of conventional boards. And by taking into consideration the target demographic of these skateboards (namely, younger individuals) we can customize the boards to fit their needs. Typical skateboards tend to favor abstract or avant-garde style designs on the board faces, which is a trend that our boards should follow. Therefore, as the builders, we need to select a design that has the option of customizing the board's face to fit one's "style." But the board's shape must also be taken into consideration. As shown in figure 3, there are a variety of possible board frames that lend to different people's tastes. The design we choose must select both a style and shape that appeals to our target demographic.

Figure 3: A variety of different board styles and shapes exist for customers to individualize and personalize their boards to their tastes (Yongkang).

But the most important point from an engineering standpoint is achieving an adequate level of compression. The goal of this project is to allow ordinary skateboards to be stowed away in one's bookbag. There are various ways in which a skateboard's size can be reduced—but the one that scores highest on the design metrics (safety, size, cost, durability, portability, and rideability) will be the final design for the first rideable prototype. The builder must then learn from testing the prototype with many users and redesigning the prototype based on user responses. We are not only looking for the "best" solution to a creating a more portable skateboard, but a solution that is simple and intuitive as well.

IV. Problem Constraints

One of the most important constraints to consider with our *Pocket Board* is user safety. Skateboarding can be a dangerous activity; this has lead many hospitals, organizations, and board manufacturers to encourage riders to wear a helmet and protective gear when riding a skateboard. Indeed, the Nationwide Children's Hospital has found that "an estimated 111,000 kids younger than 18 are treated in U.S. hospital emergency departments for skateboard-related injuries each year" (Nationwide Children's Hospital). When diverging from the normal design of a skateboard, we inherently change the way it interacts with its environment. The amount of stress, strain, and deformation the board can withstand changes whenever we add hinges, connectors, or extendable parts; we must account for this when designing our board to be as safe as possible. Though the maximum weight a board can support varies from brand to brand—also depending on style and shape—most boards can carry up to a 220-pound person without breaking (SNAP). Our skateboard must be able to support a maximum of 220 pounds as well.

Our *Pocket Board* aims for ease-of-use, convenience, and portability when stored. There are many different sizes of skateboards available for different types of riders. But according to skateboard expert, Steve Cave, most decks are about 28-32 inches long and about 7-8.5 inches wide. In order to achieve any level of noticeable reduction in size, our skateboard must be at least 25 inches when in its compressed form. Another consideration is the "set-up" or assembly time that comes with interacting with the *Pocket Board*. It will take time to stow away when not being used for a ride, and it will also take some time to unfold before being ready for use. This time (to fold or unfold) must be less than 3 minutes as we strive to offer the highest level of convenience and ease-of-use to the rider.

V. Problem Objectives

One of our constraints involved safety, as we require our board to support a maximum of 220 pounds. But there are safety objectives we would like to achieve with our board as well. It should safeguard a user from pinching or otherwise hurting themselves while using the mechanism we implement in reducing the skateboard's size. In addition, the skateboard must be easy to operate. A design that is "intuitive," or easy to use, must allow the modified skateboard to function very similar to a normal skateboard. Riders should be able to easily turn and have little problem maneuvering around. The quality of the ride should also be comparable. Customers should have little to no trouble transitioning to our board; the mechanism in which our board reduces its size should also be intuitive. In short, the overall goal for our Pocket Board is to provide a ride and feel that is as close to a normal skateboard as possible, while still offering a mechanism that lets the user reduce its size.

There are many objectives that follow from this overarching goal. One objective is that our product be marketable, from which a whole host of sub-objectives result. First and foremost, the skateboard should be stylish; our target customers, college students, can be picky when it comes to design. Studies have shown that younger individuals tend to prefer skateboards that are sleek and simple yet sophisticated. In considering price, we want to consider the living status of college students, who tend to be strapped for cash. Therefore, our skateboard should be relatively inexpensive. According to the T2 Web Network—a service that provides pricing on various products—a skateboard can range from anywhere between $20 and $400. This difference in price can be mostly attributed to quality; for example, professional skateboards can range anywhere from $100 to $250. The more common skateboards, and the ones college students are most likely to use, cost between $50 and $100. Therefore, we would like our skateboard to cost no more than $100 to manufacture. Another attractive feature of our skateboard should be its portability. Users, particularly college students, should not find it clunky, unwieldy, or troublesome to carry and store while the board is in its reduced-size form. In being easy to carry, it goes without saying that our skateboard should be relatively lightweight. Most skateboards are under 9 pounds, with a deck weighing about 4-5 pounds and the wheels and trucks weighing in at about 2-3 pounds. Our skateboard design should aim to also be less than 9 pounds. We also want the skateboard's reduced-size form to be as small as possible; it should be concealable. In being marketable, a Pocket Board should be durable. While there is no stated lifetime on a normal skateboard, we expect our skateboard to last at least a year. This means that the mechanism in which the skateboard folds, the deck, the trucks, and the wheels should not break or be easily damaged beyond use before this time. It is especially important that the folding system of the skateboard can be used hundreds of times without fail.

VI. Design Metrics

In selecting the best design, it is necessary to come up with scales that we can use to evaluate how each design fares against one another. We developed several design metrics to help us rate how well a particular design fulfills our objectives.

One easily measurable objective is cost. Measured in US dollars, the costs of various boards can estimated by aggregating the costs of its components. Points will be assigned based on price: 0 (unaffordable) to 10 (affordable). More specifically, we will subtract the cost of making a design divided by 50 from ten to get the total points.

Three objectives for our design were for it to be lightweight, portable, and concealable. The first is the easiest to measure. We would use units of weight (pounds) to determine how heavy or light a skateboard design is. In measuring the second objective, we would use the Use-Value Analysis that awards points on a scale of 0 (completely inconvenient) to 10 (perfectly portable). In addition to using our own rankings for portability, we should also take into account the opinion of the skateboard's users. This will be done by having them fill out a survey ranking its "portability," similar to above on a scale of 0 to 10. Another objective relating to size is for the skateboard to be a small as possible in its reduced form. To measure its "concealability," we can measure the height, width, and length of the skateboard in its reduced size form, using units of inches. Since some designs might be shorter but thicker than others, we should also use volume to measure the reduced size of the skateboard. We will assign points linearly, going from largest volume (0) to smallest volume (10). (Dym & Little 57).

Another objective that is hard to “measure” is the stylishness of the skateboard. Here, we would again use the Use-Value Analysis to assess this objective. The ranking would be from 0 (completely unstylish) to 10 (very stylish). As above, in addition to our own rankings, we should conduct a survey of users and potential customers that ask them to rate the stylishness of the skateboard using the same scale. (Dym, Little, & Orwin 57).

The “intuitiveness” of a design is something that will also largely depend on the user. We could measure this objective by noting the time it takes for a user to fold or unfold the skateboard. Points would be assigned based on how quickly a design can be folded or unfolded with 0 for the longest time and 10 for the shortest time.

We also want our skateboard to be durable. To quantify this, we will subject the skateboard to various strength, stress, and strain tests. These tests will include bending the board at the ends, apply large amounts of force to the deck, and riding the board under different conditions, such as rough road, smooth road, etc. to test the wheels and trucks. Points will be assigned based on how well the skateboard performs in each of tests, 0 being very poorly and 10 being excellent. (Dym & Little 57).

In measuring the safety of the board, we will count the number of possible injuries that could result when trying to fold or unfold the board. This can include pinching, poking, or being cut by sharp edges. Points would be assigned based on safety: 0 (multiple possibilities for injury) to 10 (no injuries).

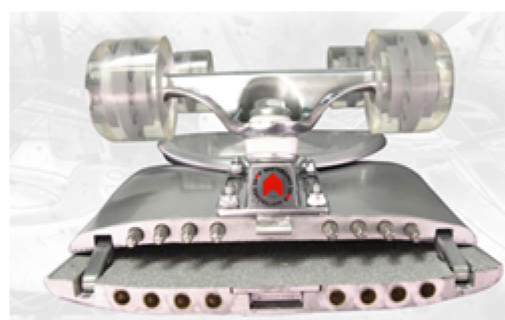
The last, but most important objective to measure is “rideability.” For example, the board should be easy to turn. It should be smooth to ride on. In short, it should be as close to a normal skateboard as possible in terms of ride quality. The best way to measure this objective is through beta testing and user satisfaction surveys. Points will be assigned based on how well a design turns and rides. Here, we would again use the Use-Value Analysis to award points from 0 (not at all) to 10 (perfect). (Dym & Little 57).

VII. Existing Solutions

As one would expect, there are already viable solutions that exist in creating a folding skateboard. One company, SNAP Skateboard, seems to be the most popular. It has two folding skateboards. The first one is called the SNAP skateboard, one of their first designs. In fact, they often label it as “the world’s first folding skateboard” (Weiss). This board has a deck made out of “aircraft grade 6061-T6 aluminum” and is split up into three parts (Weiss). The board also contains hinges that are the main folding mechanism. The two ends of the board have round, steel pins in the sides of them that fit into holes on the sides of the middle section, locking to provide a stable platform to ride on. Originally a length of 36 inches, the board can be folded down to 14 inches. This small shape makes it ideal in fitting into lockers, backpacks, and suitcases. Its has wheels that are 56mm. The skateboard costs $119. (Weiss). This design is pretty rudimentary, but hinges with locking pins are a good start for an idea. The aluminum also makes it lightweight, which is a material we should consider in making our skateboard. This price is a little high, but still reasonable given the material and quality of the board. It looks very similar to a normal skateboard when extended fully, which is something we hope to emulate in our design. The design seems pretty intuitive and easy to use to as well.

Clockwise from top left:

(1) Top view of skateboard
(2) Side view of skateboard
(3) Folded
(4) Underside

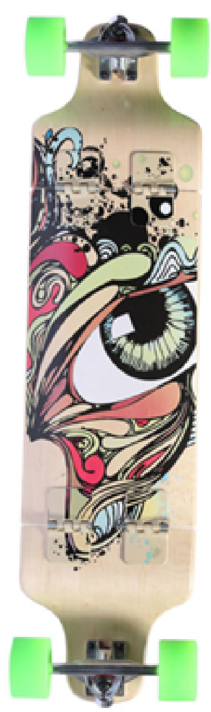


https://snapskateboard.com/gallery

The company has another folding skateboard, called the SNAP Longboard. It is a 38 inch longboard that can be collapsed down to only 19 inches when folded ("About the Board"). The deck consists of 8 layers of Canadian maple wood and is divided into 3 shorter sections. The two ends of the board can fold down using simple hinge mechanisms. These hinge mechanisms are located about a third of the way in from each end of the board. According to the SNAP website, the downward force exerted by a rider are "absorbed by the incredibly durable hinges, which results in a controlled flex – like a vehicle's suspension system" ("About the Board"). These hinges, the website maintains, give "a super smooth ride quality that's unmatched by any conventional longboard" ("About the Board"). It uses 52mm wheels made of urethane. The board itself is a little heavy. The deck alone weighs 6 pounds. Altogether, the longboard weighs about 10 pounds. It can support a maximum of 220 pounds. ("About the Board"). At such a high price of $179 it seems to be selling pretty well, as the website currently says they are out of stock. ("About the Board"). This design, however, is also pretty rudimentary. We think that we can find many other ways to neatly fold a skateboard so that it will be smaller than this design. In particular, the folding over the wheels make the skateboard very wide, even though the length is reduced by a good amount. The main improvements to make with this design is a lower price and a better way to fold the board.

Clockwise from left:

(1) Underside of skateboard
(2) Side of skateboard
(3) Folded
https://snapskateboard.com/gallery



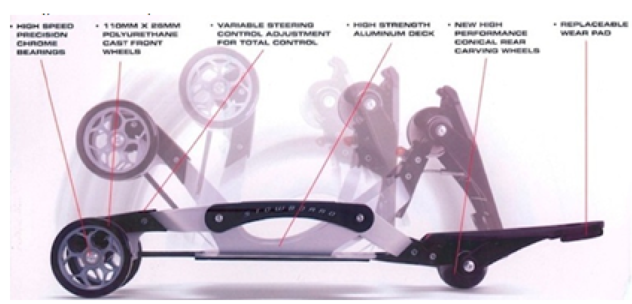
Another popular design is called the Stowboard. This design incorporates a highly complex folding system. Upon folding, “the Stowboard folds to the size of a 4” stack of notebook paper” (“About”). Unfolded, it is about 30 inches long, shrinking to about 11 inches when folded. This small size makes it perfect for storage in a backpack. The body is made of aluminum and plastic, making it lightweight. It weighs about 6 pounds (“About”). The wheels are made of polyurethane. The Stowboard is a much more different from a normal skateboard than the other designs. It does not look the same, and the feel of it is different too. Indeed, riding on it has been described as “surfing on waves or snowboarding on fresh powdered snow” (“Stowboard Portable”). On the website, there is a whole page just dedicated to teaching people how to ride the Stowboard. Rather than four wheels, the skateboard has 3 wheels, two in the front and one in the back. Though the actual design is not fully explained on the website, one can get the gist of how it works by the video provided: The deck of the board has a “beam” attached to it. This beam then connect the two sides of the board that have the wheels. These two sides can rotate about the beam, folding in when needed. Essentially, the board is like a robot arm, with multiple points of rotation about which to fold. All in all, it costs $99.95. (“About”). This design is notable for its low price given such good quality. However, the Stowboard is not very stylish. It looks a little bulky and is not very sleek. In addition, it does not resemble a normal skateboard, which is something we want in our design. The unique folding feature, however, is quite innovative; it is not a simple design that one could come up with easily. The feature also seems pretty intuitive to use.

Left to right:

(1) Unfolding procedure

(2) Side view + design details

http://foldingskateboard.com/About.html



VIII. Design Evaluations

A. Classic Folded Skateboard

In deciding how to approach the problem of effectively building a portable skateboard, our conceptual idea was to add a hinge to the middle of the board—thus allowing it fold down the horizontal center. But with the board folded in half, we found that the wheels and trucks overlapped with one another; this resulted in unused and unwieldy space between the board's wheels and its hinge. While this design decreases the amount of space occupied along one axis, it more than doubles the amount of space that had previously been occupied in another direction. The biggest constraint that this design failed to meet was that it did not fit into a regular sized backpack. As this is our primary metric for portability in our *Pocket Board*, we chose not to continue developing on this design. If it had not failed this constraint, the board might have been a success due to the optimal positioning of its center of mass. Additionally, the board would have provided a smooth ride and experienced compared to other designs; perhaps this is why the design already is present in the market place. Though unsuccessful, this design proved our initial doubts with a classic folded skateboard and led to the offset double folded skateboard.

Figure 4: The classic fold skateboard uses the most obvious method of folding a skateboard down its horizontal center to reduce size.

B. Offset Double Fold Skateboard

After the obvious space problem that was present in our first design, we decided that we needed to utilize the empty space that existed. Our solution to this, was to move the hinge from the center of the of the board, and to have the fold be skewed towards one side of the board. Due to this arrangement, the board, including the wheels, were able to be folded together in a way that drastically decreased the size in one dimension and kept the about the same size in the other two dimensions. While this design did also decrease the amount of space taken in one dimension, and kept the others to be relatively equal, we decided not to continue with this design. Fearing that the board, would not be safe enough to side due to altering the center of the mass, we saw this risk to be too high to pursuit as it could certainly lead to a person being injured or worse. Also, by changing the center of the mass, we were making the board more weak in one side, and thus the board was in risk of being destroyed in a large enough force was applied to in. Additionally, we found that the design would not be as aesthetically pleasing since the design would end up not being symmetrical.

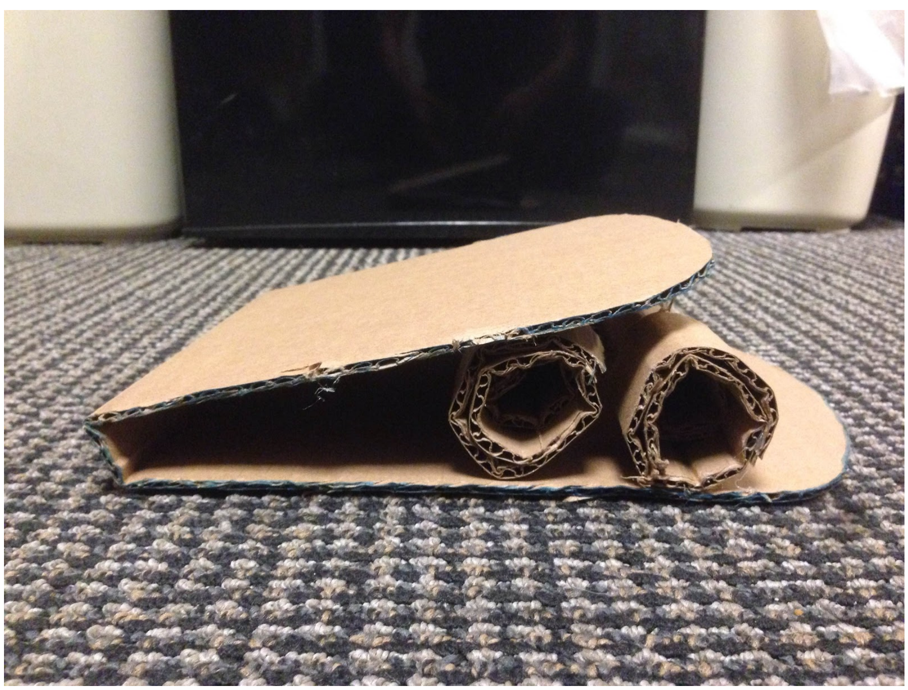


Figure 5: The offset double fold remedies the issue associated with the classic fold by removing the existing overlapping trucks and wheels.

C. Triple Fold Skateboard

In looking for a way to satisfy our objectives while maintaining an innovative mindset, we came up with the triple fold skateboard. This design took a normal existing skateboard and added three folding points. Taking an approach that nearly mimics the style of an accordion, the triple fold skateboard positions the wheels away from the center of the wheel with the three segmented parts of the board collapsing against one another. We concluded that not only was this design not intuitive and easy to use, it presented the problem that the three hinges would certainly result in a rough riding experience. This would immediately cause a rider to distaste the board, with no feasible way of improving the user's experience. With three hinges, the inherent danger of the user hurting themselves while folding or unfolding the board also increases.

Figure 6: The triple fold skateboard reveals the flaws associated with having too many points of folding in any of our designs.

D. Skateboard with Detachable Wheels

When looking closely at any conventional skateboard, one can notice that the wheels protrude outwards from the board by a significant distance. This is one of the primary reasons skateboards take up so much space. In this prototype, we allowed the board to have detachable wheels, which not only decreased the space taken by the board but also allowed each board to be folded in new and creative ways. Unlike the previous designs, in which the actual board decreased in size, as shown in figure 7, this design does not actually decrease size but instead turns the board into two components that should be able to be easily stored.

Other ways of attaching the wheels in order to make them detachable. While there may be a wide range of devices and tool to achieve this purpose, we agreed that making the trucks being attached via magnets to be the most effective. Magnets provide the advantage of being strong and stylish than other offerings. However, if we used a strong magnet, the user would not be able to remove the trucks when they wanted to. Our unique solution to this was to this was to utilize electromagnets that the user would have the ability to turn on and off whenever they wanted to. Due to this, we decided that this design would be impracticable since the electromagnets would add a large cost to the board. Additionally, by having an electronic device that needs to continuously charged, the boards ease to use drastically decreases as the board unable to used if the batteries are not charged. Most importantly, the security of the user decreases as there is a greater risk of injury should the electronics ever fail.

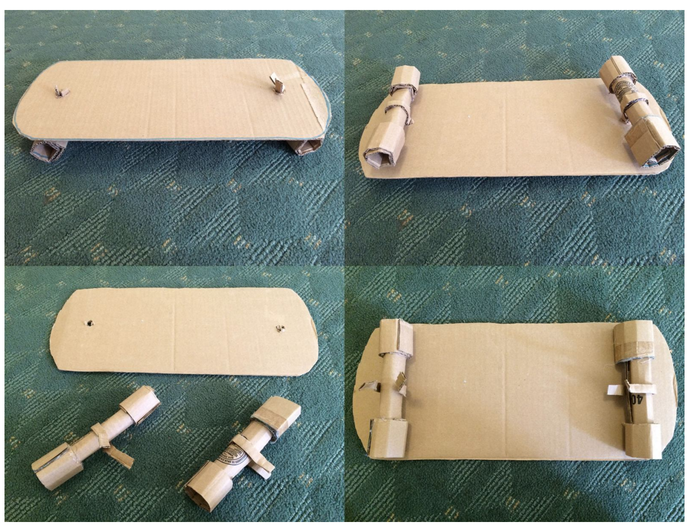


Figure 7: The skateboard with detachable wheels. This rough prototype features how a board with detachable wheels could potentially work.

E. Extendable Skateboard

One of the designs we created focused around making the board extendable and retractable as a way to achieve various levels of compression. As you can see from figure 8, this prototype was by far the most complex. It involved splitting the skateboards into two sections and then linking them via retractable rods, which would then be used to slide the boards together and compress the board. The concept for this design came from observance of skateboarders, where the entire midsection of a board is untouched by the average rider. This allows us to remove this unnecessary space and instead connect to two separated sections with a retractable rod. The cardboard prototype for this design focuses on proving that an extendable midsection allows for a skateboard to reach a highly compressed state.

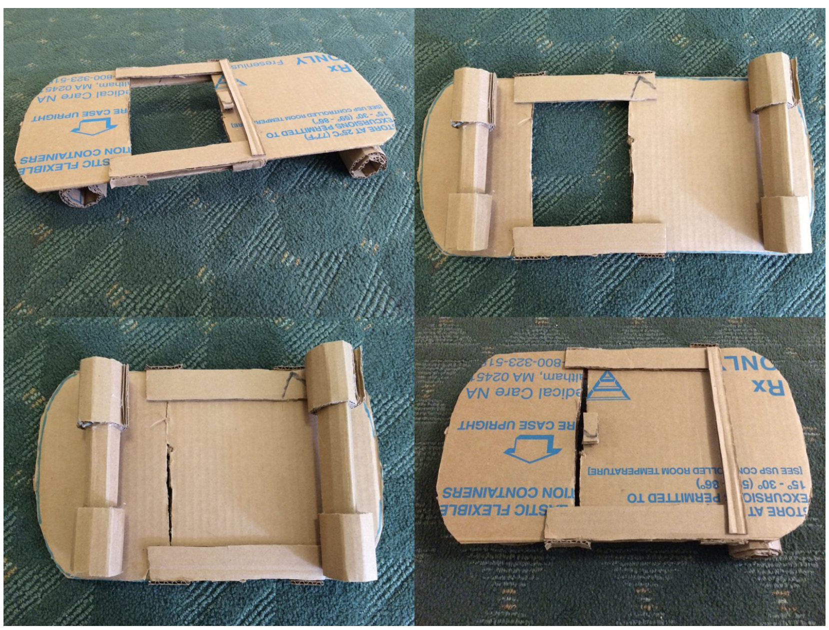


Figure 8: The extendable skateboard prototype. This prototype makes use of essentially “rails” that are attached to one side of the board and help to extend the other half of the board.

F. Interlocked Skateboard

When looking for a new idea for a portable skateboard, we had inspiration from an unlikely source- legos. Lego blocks, are not much when they are seperate, but when connected and linked together, they can turn to almost any model imaginable. Our idea was then to have two separate entities that would form a complete skateboard when interlocked. While we all agreed that the idea of having a skateboard that we would snap together was cool, theres was a large list of reasons that we did not continue to develop the board. By having the interlocking design centered at the middle of the board, there was a large risk of danger to the user. If the user were to incorrectly balance himself on the board or the if the locking would inherently fail, the board could break apart into two pieces while being used, putting the user in danger. In line with our mission of increasing portability, this design would not have decreased to volume that the board took up, simply where the volume was located. It was decided that this backpack would not easily fit inside a backpack, thus while it did meet our constraint of fitting inside a backpack, it did it in a manner that was adequate.

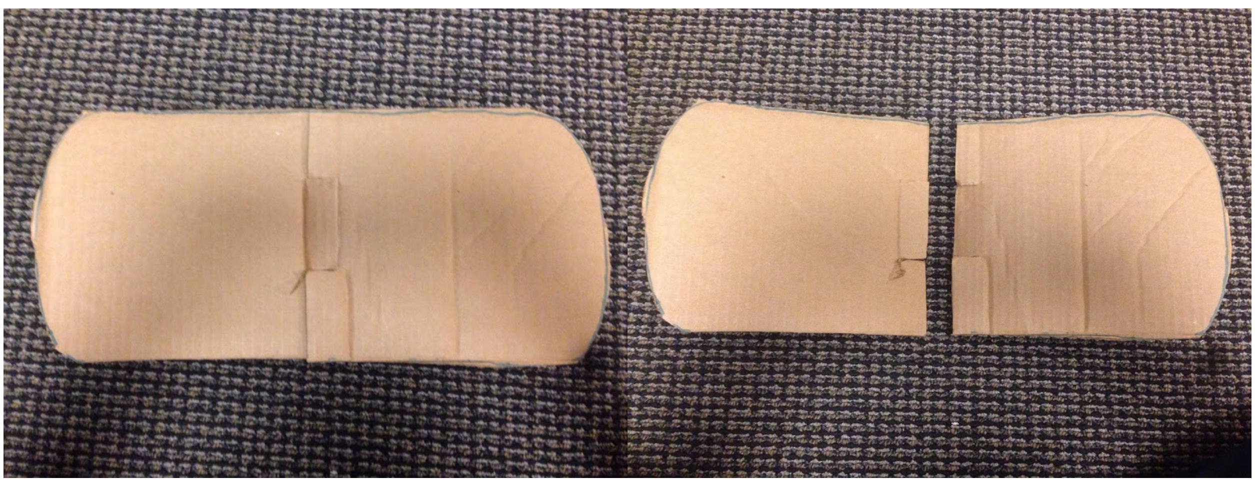


Figure 9: The interlocked skateboard uses a lego-like pattern to pair the two halves of the skateboard. When separated, the two halves can be independently and optimally stored.

IX. Finalized Design Selection

The finalized design selection for *Pocket Board* will incorporate an extendability that uses separated skateboard parts for the front and back of the board. The idea stems from observing skateboarders and realizing that weight distribution of the riders primarily rests on the front and back quarters of the board. As shown in figure 10, the skateboarder's feet are placed strategically at the very front and back of the board (Tadej). This means that nearly half of a skateboard—the midsection of a board—is unused by its rider. In order to take advantage of this fact, we opted for a design with two separate parts for the front and back of a skateboard that is structurally connected at the removed center area to allow for extendability.

Figure 10: A skateboarder distributes his or her weight primarily over the front and back portions of the board, leaving a large segment of unused space in the middle of the board (Tadej).

We crafted our initial prototype using retractable rods—that in actuality, are shower curtain hangers—connected to the undersides of the two front and back skateboard segments. As shown in figure 11, the two parts are connected by a rod that can be extended and retracted to the skateboard's full length and to the skateboard's compressed size. This effectively reduces the size of the skateboard to 65% it's original size (18.25" / 28.25"). The rod is fastened to both segments of the skateboard through screws, bolts, and rounded clips that maintain the structural integrity of the board in maintaining rideability. Since the retractable rod relies on itself spinning on an axis in order to lock and unlock itself, one side of the board locks the rods in place while the other side allows the rods to swivel along its length-wise axis.

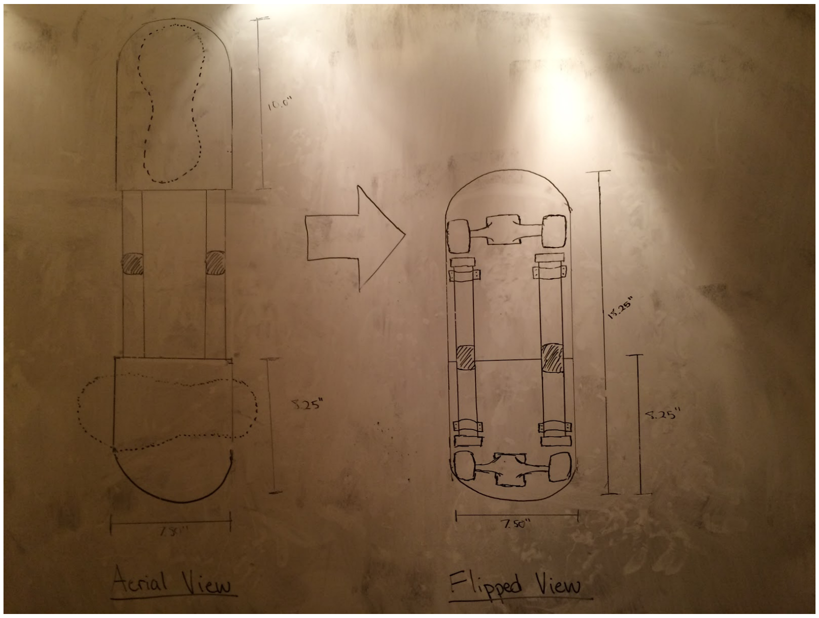


Figure 11: Design model for the proposed final design selection. The design relies on the hypothesized idea that skateboard midsections only need a stable structure in place of the removed midsection to prevent the board from collapsing in on itself.

X. Design Cost Analysis

G. Cost of Production

Materials Used	*Cost of Material*
Skateboard (31.02” x 7.99”)	$25.19
Two Retractable Rods	$17.56
Nuts, Bolts, and Screws	$4.50
Machinery and Equipment Usage	$2.50
(+, =) Total Cost:	$49.75

H. Estimated Profit Margin

Estimated Sale Price per PocketBoard	$80.00

Total Cost of Product	$49.75
(-, =) Estimated Profit Margin	$30.25

XI. Prototyping Schedule Layout

Time Span	*Engineering Objective / Task*
Weeks 1 - 3	Design Brainstorming and Market Analysis
Weeks 4 - 10	Rapid Prototyping
Weeks 11 - 14	First Round of Testing
Weeks 15 - 19	Prototype Optimization (Deck Material, Shape, Wheel Size, Truck Size, Etc.)
Weeks 20 - 23	Second Round of Testing
Weeks 24 - 25	First Beta Release
Weeks 28 - 30	Evaluation of Customer Satisfaction and Market Viability
Weeks 30 - 34	Product Re-Design
Week 35	Second (Commercial) Design Release

XII. Prototype Evaluation

Following the design model for the proposed final design, our team successfully created our first “rideable” prototype of the *Pocket Board.* The design is complex yet intuitive. Our first task was to cut a skateboard at the correct points so that it can fit most people’s feet—with the front foot pointing forward and back foot pointing out towards the sides. While testing the board, we found that the front and back feet of the user could fit just enough on the board. As can be seen in figure 12, this arrangement of the feet is the typical stance a skateboard has while using a regular skateboard. The only exception is the midsection has been removed and replaced with a low-weight stainless steel retractable rod.

Figure 12: A demonstration of how one would skate on the prototyped board. With front and back feet using only the necessary parts of the board.

Each prototype comes with both its successes and its failures. The success of this first prototype stems from its rideability. But this is also the area where it suffers severely in performance. It can support a rider of up to 140-pounds, a measure which we tested by sequentially adding weight onto the board in its extended state until sufficient strain caused the board to either deform or "crack." This falls short of the ability for a majority of modern skateboards to withstand weights of up to 220-pounds, as mentioned in our design constraints. Being only capable of holding a maximum weight of 140-pounds decreases our potential market demographic significantly and therefore presents an issue that must be addressed in future prototypes. But aside from rideability, the board succeeded in many respects.

In terms of simplicity, this prototype reigns supreme. When presented with the board, strangers could intuitively understand the extendable mechanism. A majority of these individuals immediately set the board on the ground and proceeded to pull the two separate segments apart from one another. Another metric we set out to achieve was safety. We wanted to ensure that the user couldn't pinch themselves while opening and closing the board but found that this wasn't even an issue. While attaching the retractable rods to the underbellies of the board, we used packaging tape to cover the exposed wood of each side that moves into contact with one another when in its compressed form. This prevents pinching because the tape adds a buffer area for slower compression when the user is sliding the two sides together.

Figure 13: Our team's first "rideable" *Pocket Board*, featuring both expandability and concealability by fitting into a conventional backpack.

Further failures with this design, however, must be addressed. First and foremost, the design uses stainless steel rods, which presents an unanticipated oversight. Towards the front of the board, there are two rods that protrude far past the board as shown in figure 13. This is not intentional. The reason we couldn't remove these unnecessary parts of the retractable rods in that we couldn't cut the material (stainless steel). Stainless steel is holds a mixture of chromium and nickel, which help stabilize the substance (Houzz). Because of this physical property, the common oxy-acetylene torch cannot produce a clean cut and instead melts the surrounding material away. Though plasma torches can be used, we didn't have access to one.

Moving on, there is improvement and further development to be done as we iterate on future renderings of the *Pocket Board*. Along we way, we ran into failures both in our cardboard prototypes and even in our first "rideable" prototype. But it was through these failures that we learned the most as engineers. We learned that it's never cut and done where engineers simply set out to accomplish a project and succeed—instead, they spend time designing their product and further perfecting their design. Our *Pocket Board* represents a novel solution to reducing the size of a skateboard that has never been seen before. And although it is currently a mere rough prototype, we believe that with continued iteration and great engineering design practices, the *Pocket Board* can revolutionize the way we see transportation.

XIII. References

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