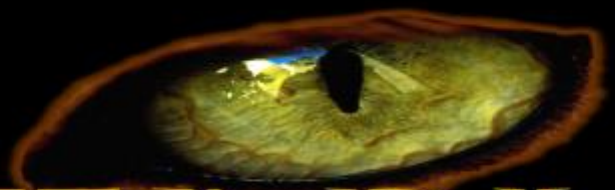

STABLE EYES

Keeping your videos steady in an unsteady world.

EE 15N: The Art and Science of Engineering Design

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Abstract

For the vast number of people who use smartphones as their primary filming device, many are frequently unable to produce high-quality, immediately-shareable videos of their most important moments; such as recitals, sporting events, and concerts. Stable Eyes took the design steps necessary to address this problem, pursuing a variety of wide-ranging ideas and ultimately developing a physical mount design that is affordable, universal, and portable. The final design, a chest-stabilized physical mount, provides strong, handheld stabilization for the average smartphone filmmaker. After a number prototype refinement stages, Stable Eyes produced a tangible product that allows for immediate stabilization and production of shareable video.

Executive Summary

For the 68% of adults who own a smartphone of some kind, their device has become their primary mode of communication, photography, and increasingly, videography (citation?). However, the majority of events people are filming today - such as concerts and sporting events - last too long for comfortable filming, leading to compromised video quality. Additionally, 86% of these mobile filmmakers report that they are often unsatisfied with their handheld footage due to excessive shakiness and tilt.

Stable Eyes approached this problem using proven design methods to craft a solution. After careful brainstorming and consideration of existing solutions and potential designs (including both hardware and software approaches), the team chose to develop a physical, chest-stabilized mount that would allow for any smartphone filmmaker to capture quality video that was ready for immediate sharing. This was decided after careful review of such comparative design tools as objective trees, priority benchmark charts, best of class charts, and a morphological chart. The

ultimate design was then held to a range of objectives and constraints including (but not limited to) minimal cost, universal application, and effective function.

After the final design was decided upon, the team worked to prototype a physical mount that would allow for primary testing and immediate feedback. Work with a foam core model allowed for final adjustments and notes before the construction of a working prototype composed of ready-made materials. Upon completion of the final prototype, numerous tests were completed and the device proved to meet basic expectations. The fine details of our (rough) model were further explored through the use of computer aided design (CAD) drawings, allowing us to visualize a complete and uniform product free from the constraints of pre-existing functions associated with ready-made materials.

Upon further development, Stable Eyes hopes to create a product well-suited for the active lifestyle of the typical smartphone filmmaker by incorporating increased phone support and maximized stabilization capabilities.

Introduction and Overview

Background of the Problem

In the twenty-first century, smartphones have become an essential part of first-world citizens' lives. According to research done in 2015 by the Pew Research Center, a nonpartisan fact tank that conducts public opinion polling, demographic research, media content analysis, and other empirical social science research, 68% of adults own smartphones of some kind - significantly up from the 35% reported in 2011. Similarly, an even higher 73% of teens between the ages of 13-17 own a smartphone as last reported in 2015. Based on this comprehensive survey, the numbers are only projected to continue rising. Consequently, camera sales have exponentially decreased since 2009 according to a camera marketing expert Heino Hilbig from Mayflower Concepts. This is due to the fact that people have transitioned from recording with an actual camera to recording with the camera in their smartphone. As smartphone companies optimize their products to include cameras that become better and better in terms of specifications and speediness, users have embraced the instantaneous nature of recording media. The ability to capture high quality video has allowed users to not only share images, but share

73% of Teens Have Access to a Smartphone; 15% Have Only a Basic Phone

% of all teens who have or have access to the following types of cell phones

	Smartphone	Basic phone only	No cell phone
All teens	73%	15%	12%
Sex			
a Boys	71	16	13
b Girls	74	14	12
Race / ethnicity			
c White, non-Hispanic	71	17[d]	12
d Black, non-Hispanic	85[ce]	7	8
e Hispanic	71	15	14
Age			
f 13-14	68	14	18[f]
g 15-17	76[f]	16	8
Sex by age			
h Boys 13-14	64	16	19[ik]
i Boys 15-17	75[h]	16	8
j Girls 13-14	72	11	17[ik]
k Girls 15-17	76[h]	16	8
Household income			
l <$30K	61	22[no]	17[o]
m $30K-$49,999	67	16	18[o]
n $50K-$74,999	76[l]	12	12
o $75K+	78[lm]	13	9
Parent educational attainment			
p Less than high school	60	21	19[s]
q High school	72	15	13
r Some college	76[p]	12	12
s College+	75[p]	16	9
Urbanity			
t Urban	73	16	11
u Suburban	74	14	12
v Rural	68	16	15

Figure 1.Pew Research Center's Teen Relationship Survey. March 16, 2015

videos as well. An abundance of social media companies are moving away from images and towards centralizing their software around videos. For example, Facebook and its subsidiary companies, Instagram and Facebook Messenger, have all added features where the user can instantly upload a video and view it. Whenever a user opens a Facebook app, those uploaded videos are the first thing users can see. Furthermore, many companies are also adding real time video sharing abilities where users can share personal live streams such as YouTube, Facebook, and Instagram.

With this multitude of video sharing platforms, there has never been a better time to share videos. Today, video uploading occurs at outstanding rates. For every minute streamed on YouTube, 4 hours of video are uploaded. However, there seems to be one problem that plagues many videos. Videos are typically shaky and unaligned; therefore, they can be distracting or unpleasing to watch. Reasons for this include: user's arms fatiguing from holding the phone, users not realizing that the phone is unaligned, and natural shakiness due to moving the phone camera around.

In order to learn a little more about this phenomenon, we as a team decided to poll Stanford students about their experience with recording videos. The questions and results from 169 students include:

58% of poll responders said their arms get tired when filming with their smartphone at sport events, recitals, concerts, etc.

86% of poll responders are often unsatisfied with their handheld footage due to shakiness.

This data allowed us to conclude that not only are viewers unsatisfied videos, but so are the people recording them. Users are aware that their own recorded videos suffer from these issues that lower the quality of their content.

Problem Statement

While attending recitals, sporting events or concerts, most people record the moment on their phone to share with friends on Facebook, Snapchat, Instagram or Messenger. However, it is often difficult to manually hold a phone stable while filming for the duration of these events, resulting in video that is jittery, tilted or shifted. This prevents users from uploading rapidly or live streaming video that is of satisfactory quality, ultimately compromising the video sharing experience. How can we enable users to quickly generate high-quality, shareable videos at an affordable cost?

Analysis of Existing Solutions

Smartphone Gimbal

Although the Smartphone Gimbal is indeed very stable, it comes with various drawbacks. The first, and most prevalent, reason why many people do not purchase smartphone gimbals is because they are very expensive. The price of these range from $150 up to $400. Furthermore, most smartphone gimbals require batteries, so users must recharge or replace batteries in the gimbal when they run out of power. This adds another inconvenience most people do not want to worry about to a device designed to simplify their experience.

Smartphone Wearable Stabilizer

There are currently various wearable stabilizers for smartphones ranging from head mounts (as seen above), to body strap-on stabilizers. These solutions eliminate the need to hold the phone with our hands. This means the user will not get exhausted from holding the phone. However, wearables are cumbersome to put on, to take off, and to use. Users must take extra time to attach the wearable correctly.

Furthermore, most wearables are not aesthetically pleasing. Because of these uncomfortable drawbacks, this solution does not solve our problem.

Post Editing Software

The third and final solution includes software which users would use after recording. If used properly, tools such Adobe Premier Pro can effectively edit and stabilize a video. However, software usually involves some prior skill which takes time to develop. Moreover, using a post editing software involves transferring a video from the phone to possible another device or app which takes time. Therefore, this solution does not allow for instantaneous sharing. A final drawback with software such as Adobe Premier Pro or Sony Vegas is that they are also very expensive. In summation, software solutions require prior knowledge before using, do not allow for rapid sharing of a video, and can be very costly, rendering them all somewhat ineffective.

Design Process

Brainstorming Process

During our initial brainstorming process, the group decided that we wanted to tackle a problem that focused on stabilizing an object. We looked at many issues like stabilizing a coffee cup while biking, counteracting the motion of turbulence that a person feels on an airplane, and minimizing the impact that a child feels during a car crash. Through an extensive elimination process, the group decided to focus on stabilizing the motion of a phone in situations that have a lot of movement. We sketched many possible ideas for the product we envisioned; however, we later realized that we were brainstorming with a solution centered around having a handheld device already in mind, causing us to have designs that were all the same with only slight differences. Once we realized our dilemma, we resolved it by (1) narrowing down our problem statement so that it focused on higher-quality video production by counteracting jittery and shaky motion and (2) brainstorming diverse ideas outside of some handheld products such as software development.

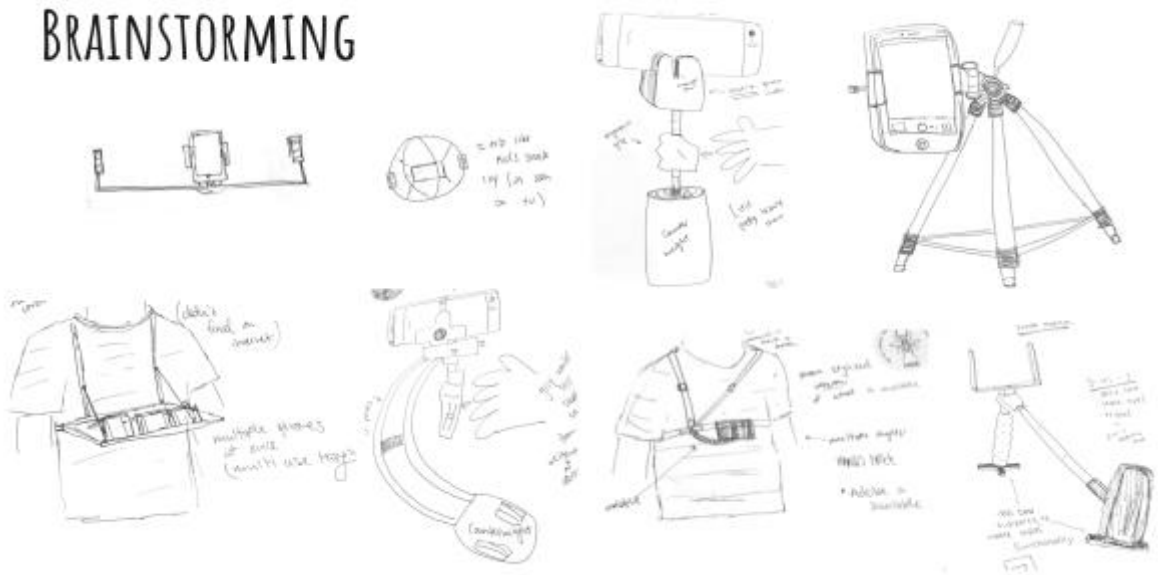


Figure 2. Sketches from our first brainstorming session

Objectives and Constraints

After the brainstorming process, our group created objectives and constraints based on what we believed a consumer would desire from a phone stabilizer, such as convenience and low cost. We created an objective tree and listed our constraints to help us prioritize our objectives and evaluate our designs based on our standards.

Objective Tree

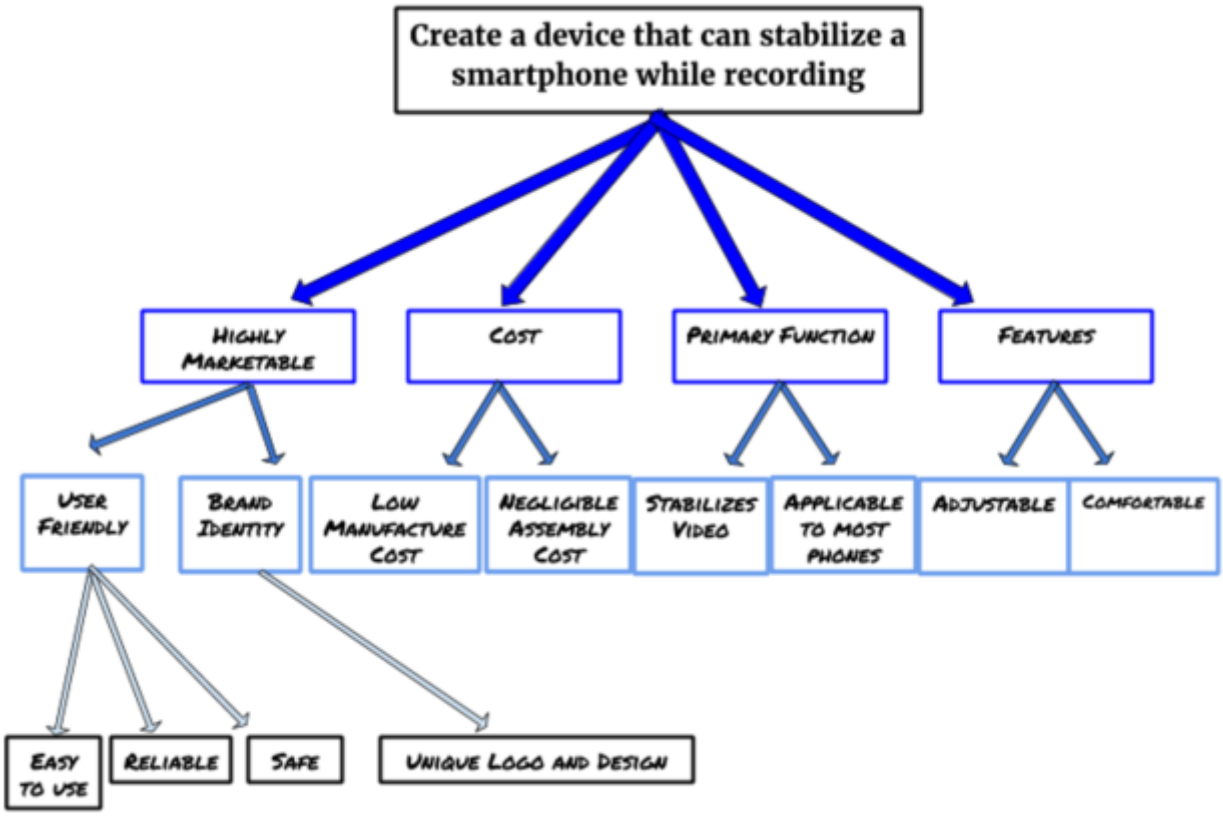
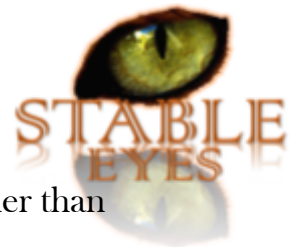


Figure 3. Objective Tree [Paulina]

Based on the objective tree, our group decided that the objectives would be a high level of marketability, cost, features, and primary functions. Our group emphasized the importance of the consumer for our product, which is why we made cost a second-tier objective, both for manufacturing and marketing. Additionally, we



wanted to make sure our consumers found our device to be an assistance rather than a burden, which is why we prioritized a user-friendly device that was applicable to most smartphones. We emphasized the importance of having a strong brand identity with special features to increase our product's marketability. Through our objective tree, our group narrowed and specified the objectives we wanted our product to achieve.

Next, our group created constraints to determine the standards our product must meet. The first constraint for our design was that it must be transportable because our product needed to be able to record videos in diverse settings, like a soccer game or a concert. Our product also had to be lightweight (if it was a physical device) and easy to use because we wanted the customer to focus on recording the video instead. Finally, we needed the device to enable rapid uploading and livestreaming so that the consumer could record quality videos in real-time.

Description of Design Possibilities

Once we set our objectives and constraints, we eliminated some bizarre ideas from our brainstorming sessions that did not meet most of our objectives and constraints, such as the photography app that allowed people to request professional photographers in the area to record their videos. From the ideas that we eliminated, we focused on six designs and analyzed the qualities of each.

Post Video Editing App

Our first design idea was to have a post-video editing application that used frames from the video to rapidly produce a high-quality video once the video finished recording. The application was user-friendly because it allowed the user to record without any additional equipment. However, the downside to using the post-video editing app was that it did not allow the user to live-cast stable videos because the app stabilized the video after the recording.

Video Guide Application

A software-based design that we considered was the Video Guide App, an app that runs while people are recording to guide them on how to keep their camera leveled. The app was designed to utilize sensors within the phone so that whenever people tilted their phone, they would get a notification from the app telling them which direction to move. The app was beneficial because the user could record stable videos in real-time without the need for a physical device. However, the app would not be able to overlay other applications like Facebook Live and Snapchat, meaning that people could not record videos on any other app at the same time, inhibiting real-time sharing. Another downside to this design was that it may be a distraction to users because the user would have to focus more on stabilizing the phone instead of recording a video with the angles he or she wanted, reducing the user-friendliness of the product.

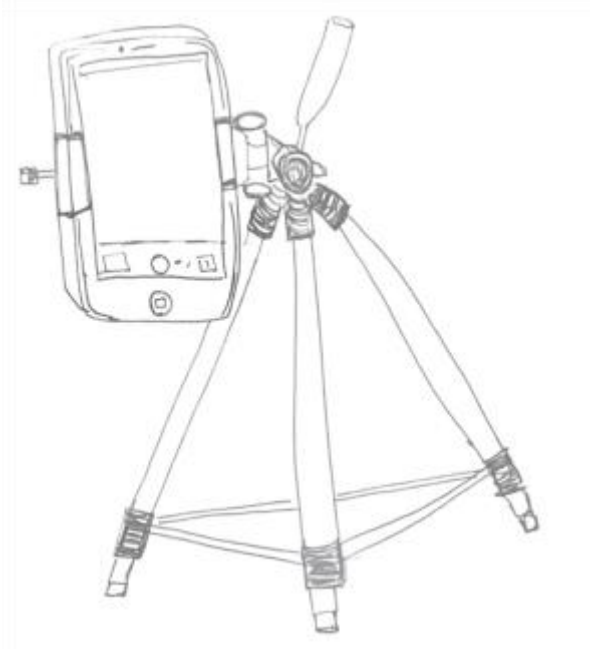


Figure 4.Sketch for the alternative design of the tripod with extendable legs

The Tripod

Another design that we considered was having a tripod for smartphones. We envisioned that the tripod would model traditional tripods but be tailored to a phone instead of a camera. Additionally, we wanted the legs of the tripod to be extendable so that the tripod could have range in height. Although the product is transportable, some of the drawbacks for choosing this design is that it may be a hassle for the user to have to set up the tripod, and they would have to find a flat surface to put the tripod on.

Wearable Phone Holder

A hands-free design alternative that we considered was a wearable phone holder. Our vision for the design was that the phone would attach to a person through two straps across the chest and stomach. Attached to the straps would be a caterpillar-like structure (pictured above) that counteracted the motion that a person's body makes. The disadvantages of selecting this design was that it felt inconvenient, uncomfortable, and not aesthetically pleasing for the user to use because they would have to wear straps and a weird structure around their body.

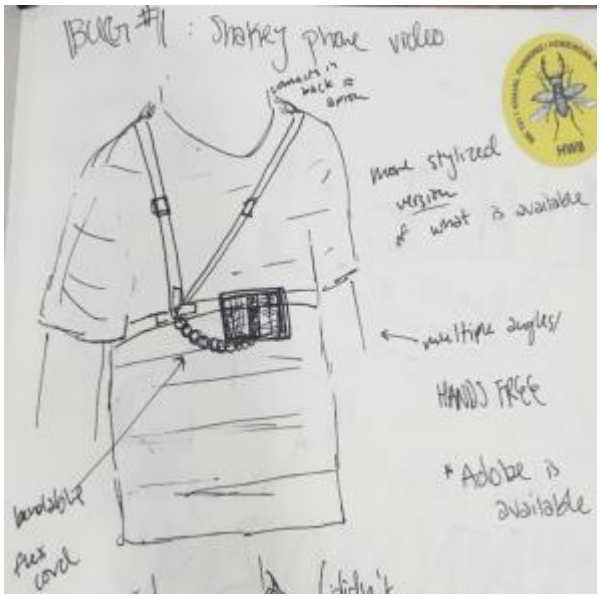
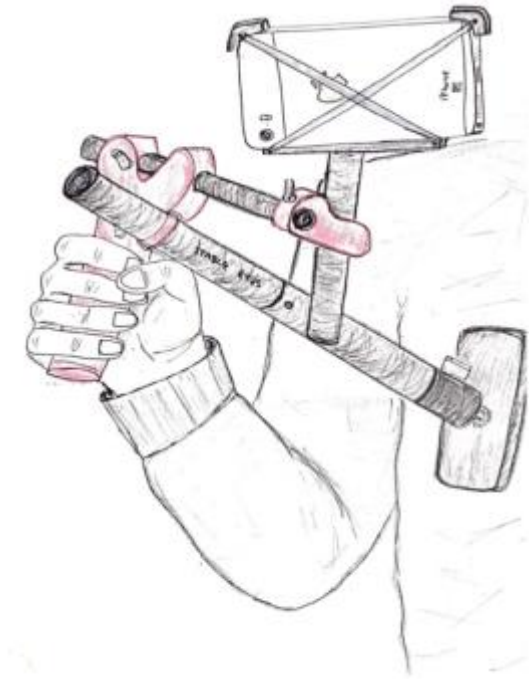


Figure 5.Sketch for the alternative design of the wearable phone holder



Physical External Mounting Device Stabilizer

The physical external mounting device stabilizer was envisioned so that the user could hold the phone with a handle while the device rested on their chest to stabilize the phone. The physical external mount was easy to use, transportable, and convenient. However, we did not find the device to be as aesthetically pleasing for the user.

A new phone with an innovative signal processing system

The last design we considered was making a completely new phone with an integrated signal processing system. The phone would provide high-quality real-time video though a faster digital image processing system. The downside to picking this design was that it would be extremely expensive to produce and we also wanted a product applicable to most smartphones.

Evaluation of Design Alternatives and Final Design

To select a final design choice, we evaluated our designs through a priority benchmark chart, a best of class chart, a morphological chart, and an intense group discussion that evaluated each design's feasibility based on our skills and time constraints.

Priority Benchmark Chart

Design Constraints (C) and Objectives (O)	**Priority (✓)**	**Solution 1:** Portable Phone Tripod	**Solution 2:** Physical External Mounting Device Stabilizer	**Solution 3:** Multi-functional (wearable) Extender	**Solution 4:** Video Guide App	**Solution 5:** Post Video Editing	**Solution 6:** Phone Redesign with +Signal Processing
C: Transportable	✓✓✓	(1)=✓✓✓	(1)=✓✓✓	(1)=✓✓✓	(1)=✓✓✓	(1)=✓✓✓	(1)=✓✓✓
C: Enables rapid upload or live stream of quality video	✓✓✓	(1)=✓✓✓	(1)=✓✓✓	(1)=✓✓✓	(1)=✓✓✓	(0)	(1)=✓✓✓
C: Easy to use	✓✓✓	(1)=✓✓✓*	(1)=✓✓✓	(0)	**(0)**	(0)	(1=)✓✓✓
O: Aesthetic	✓	(0)	(1)=✓	(0)	(1)=✓	**(0)**	(1)=✓
O: Cost-efficient	✓✓	(0)	(0)	(0)	(1)=✓✓	(1)=✓✓	(0)
O: Durable	✓	(0)	✓	(0)	(1)=✓	(1)=✓	(1)=✓
O: Compatible with all phone types (Universality)	✓✓✓	(1)=✓✓✓*	(1)=✓✓✓	(1)=✓✓✓*	(1)=✓✓	(1)=✓✓✓	(1)=✓

Figure 6.Priority benchmark chart for our final six design choices

Best of Class Chart

Constraints and Objectives	**Solution 1:** Portable Phone Tripod	**Solution 2:** Physical External Mounting Device Stabilizer	**Solution 3:** Multi-functional (wearable) Extender	**Solution 4:** Video Guide App	**Solution 5:** Post Video Editing	**Solution 6:** Phone Redesign with +Signal Processing
C: Transportable	3	2	4	1	1	1
C: Easy to use	4	2	3	5	6	1
O: Aesthetic	2	1	3	-	-	-
O: Cost-efficient	3	2	5	1	4	6
O: Durable	2	1	3	-	-	-
O: Compatible with all phone types (Universality)	1	1	1	3	2	-

Figure 7.Best of Class chart for our final six design choices

Analysis of Priority Benchmark Chart and Best of Class Chart

Based on the priority benchmark chart and the best of class chart, we found that neither a physical product or a software-based product proved best for further development. . The priority benchmark chart favored the software-based product, with the Video Guide app receiving all but three check marks available. On the other hand, the best of class chart favored physical products because the objectives and constraints were more applicable to physical products. Overall, we found that neither of the charts helped us a reach a final design choice. Instead, we used the charts to eliminate the Video Guide app and the post-video editing app because they did not meet all of our constraints.

Morphological Chart

Functions	Options			
Stabilization	Portable Phone Tripod	Handheld stabilizing chest device	Wearable Attachment to hold phone while recording	Real-time processing (app or cloud-based software)
Materials (If Physical)	Foam/ styrofoam	Plastic	Natural materials (wood, organics)	Silicone
Aesthetics	Sleek-look			N/A
Ease of Use	If app or cloud-based software, can process video without a lot user input	Folds into place	Expands without struggle	Snaps in place
Attachment to phone (If Physical)	Tight-fit around phone (like case)	Clench grip	A pouch	

Figure 8. Morphological Chart for our final four design choices

Analysis of Morphological Chart and Final Design Choice

The morphological chart helped our group look at the functions necessary for our product and ways to complete each function. Through the morphological chart, our group discussed which design we could actually produce within our time constraints. From looking at all of the charts and the design choices, we decided that the handheld stabilizing chest device was the best design choice because it best met all of constraints and objectives. Furthermore, we believed that the handheld stabilizing chest device would be something within our skillset that we could design, prototype, and refine within three weeks.

Final Design

Prototyping Process

We began prototyping by deciding to do a simple model out of cheap materials to find possible points of failure before making anything too realistic. Cory told us that if our first prototype turned out pretty, then we were doing it wrong. Maddie took ME 101 this quarter and learned how to do rapid prototyping with foam core and simple materials as a starting point that we could use as a frame of reference for making a more attractive actual example later.

By creating this model, we learned how we could possibly simplify the design to make it more streamlined and cheap. We knew that shortcuts to making the model would also be shortcuts in manufacturing that would ultimately help optimize for a product that is more accessible for anyone to buy. One of the main changes made during the foam core stage can be seen in comparison to the original sketch we made for the final design, where the holding mount for the phone is offset to the right of the handle/grip pole as seen below.

We decided that this was unnecessary because the phone can just as easily be placed in line with the handle through a joint to adjust the orientation of the phone. We also decided that having three different points of adjustment was making the model unnecessarily complicated, and possibly annoying to constantly adjust. The way we drew the mount for the phone was also changed because we figured that a solid adjustable clamp would be much more reliable than the strange stretch and hold system we drew where elastic straps would stretch over each corner of the phone to hold it in place. We thought this would be overly complex and prone to breaking.

Through the foam core model, after setting it up linearly, we realized that it also allowed users to orient the Stable Eyes to take videos horizontally or vertically depending on what they needed, augmenting the video capabilities further. The foam core model was built to be static for durability, which means that it is non-adjustable and only fits phones the size of Maddie's 5E iPhone. The length of the model is also fixed to be comfortable for Maddie's arm, approximately 10 inches.

The foam core prototype also showed us that grip is very necessary to hold the device comfortably for more than a few minutes, which is why we added electrical tape. Also, the chest support we made was 3.5 by 6 in and about 1.5 inches deep, and we found that it was somewhat large for most people, and that in order to optimize the balance between having enough surface area to remain flat and stable, and being small enough to rest inside the natural contour of our shoulders, we needed to shrink the size by about 75% in the final. This worked out well with the size of the brush that we had already purchased even before making that decision.

Figure 9. Front view of our mock prototype


Figure 10. Side view of our mock prototype

The most important part of creating the foam core model was testing to see if our concept would even work and be worth pursuing further without redesign. When we were testing the video quality, we realized the way the notch the phone rests in was designed allows it to occasionally fall out. However, overall we found

that the video was much higher quality than the videos we took by hand. We used the jitteriness and the focus as indicators for comparison.

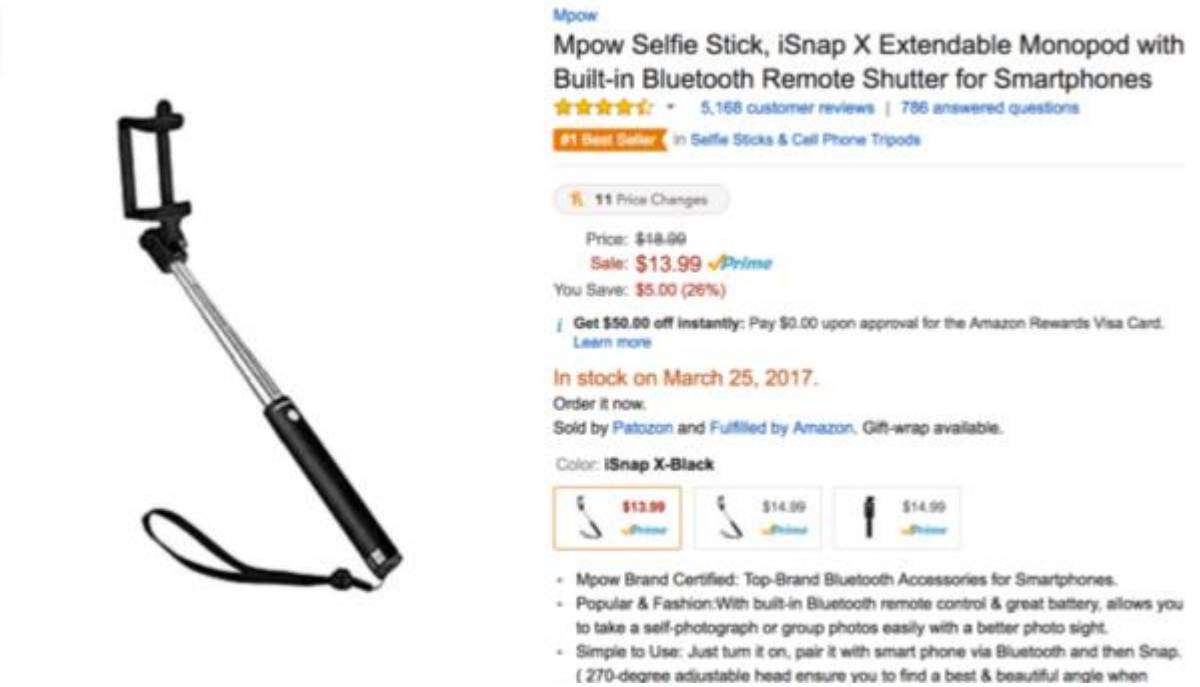


Figure 11. Image of our Selfie Stick from our Final Prototype

When we moved on to our final prototype, we ordered a selfie stick from amazon that was on sale for $7 at the time listed below. This device already had some of the features we were looking for – extendibility and an adjustable phone mount – so we thought we could modify it to meet the objectives of our own project. It was also by far the best rated version available, scoring a 4.5 stars out of 5,168 reviews, which we knew would give us a good reliable base product to work with.

Next, we ideated on what other materials we could use as an additional handle coming out of the base. We thought about weight grips, rolled tubes of plastic, or even small slim water bottles. We ended up selecting a hair brush handle because we thought the black plastic would match well with the black plastic selfie stick and feel ergonomic. We broke the handle off of the brush by using a ping pong paddle as a wedge and having Sam apply pressure through his bike (see below). For the chest

pad, we thought about using an arm cushion or some sort of pre-made pad that would be comfortable and approximately the right size, and we ended up buying kids knee pads. We thought they would be plush enough on one side to sit against one's body, but solid enough on the back to have the selfie stick attached to it.

Once we started assembling the prototype, we realized that the knee pad was large, awkward, and generally difficult to work with. To conserve materials and utilize what we already had, we attached the fabric from the knee pads to cover the jagged edges on the head of the brush we had broken, and we attached the end of the selfie stick to it with super glue and some creative duct taping. After adding gussets to improve stability, we had out final prototype (pictured below before the gussets were applied). This model was able to produce videos of similarly high quality after testing as well. See results section for more details.

Figure 12. Images of the final prototype

Detailed Description

Components

After extensively prototyping, we could fine-tune the details of our final design. We were certain that this design would successfully perform our main objective- to stabilize videos- in addition to fulfilling our other objectives, like ease-of-use and universality for all smartphones. Each component of our product had a specific purpose, outlined in the following four parts:

1. The pad part of our design, located at the end of the main beam, creates a second point of contact to create the balance and stability required of our product. It rests on the user's chest without the need for cords or other intrusive attaching techniques. For this pad, our team used a material that is both sturdy and comfortable. It can also be slightly molded to adjust to any body type, and fits comfortably on the dominant side of the user's chest. For example, if the user is right handed, the pad would sit on the right side of their chest. If the user is left handed, it would be on the left side. Since our product relies on slight pressure and friction to stay upright, the texture of the pad is soft, but not completely smooth.
2. The main beam allows the user to hold their smartphone straight, at the angle that they prefer. It is sturdy and made out of hard plastic. In our

current design, this beam is extendable which means that the user can also use our product as a normal “selfie-stick,” to ensure that they get the exact shot they want. However, for future designs, we need to adjust the amount of extension so that the user does not need to worry about it slipping and extending while recording.

3. The grip of the product, directly underneath the phone mount, is the second point of contact that creates stability. It is extremely comfortable to hold because it ergonomically fits in the user’s palm, just like a brush handle. It has small rungs that create some friction, making it easier to grip. From our previous prototyping, we learned about the importance of the placement of this grip. It needed to be balanced, and provide the maximum amount of support in order for us to achieve our objectives.
4. The phone mount is a clip like structure that can securely hold any type of smartphone, thus making our product universal. It is extremely easy to use and does not require a manual to figure out how to attach the phone, which was one of our objectives. The user simply lifts the top part of the clip, inserts their phone, and then lets the top part clamp down on it.

CAD Drawings

Our team decided to make CAD drawings of our product in order to see how each component fit together. This was the best way for us to visualize how our product looked as a clean, singular piece. One of our original objectives was to have unique aesthetics for our product, so the CAD drawings helped us to test whether or not this would be met if our product went into production. Additionally, it allowed us to experiment on our product even more without the cost of wasting any materials.

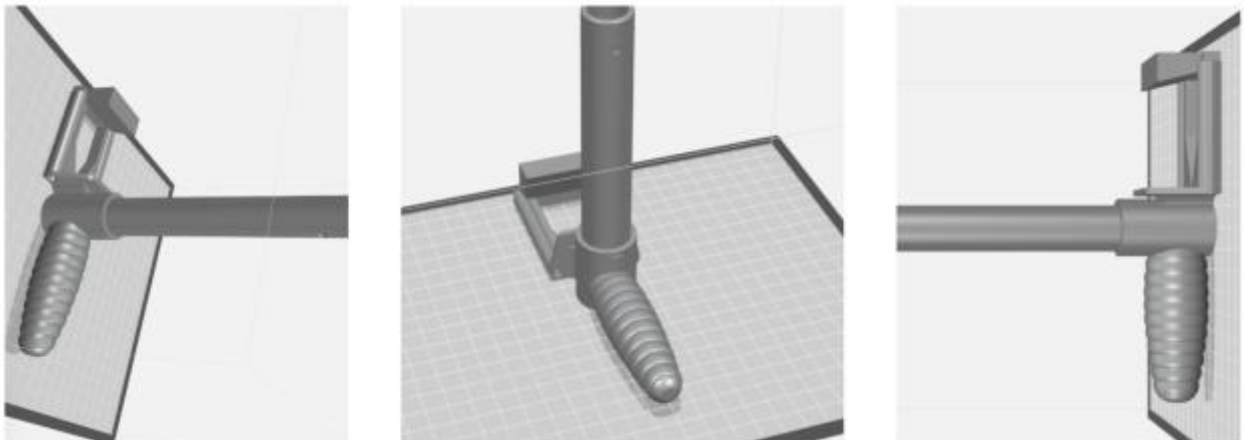


Figure 13. Images of CAD drawings

Results of Final Design

A large quantity of the testing we did was informal throughout the prototyping process. After our presentation, we had Maddie practice using the Stable Eyes to pretend to video the next presentation, simulating how it would feel to actually video an event for 30 minutes. After this lengthy duration, she says her arm still felt fine, and she experienced no fatigue. A short 2-3-minute video clip taken towards the end indicated that the video quality remained constant as well. "The overall video experience is actually improved" she said emphatically. “The Stable Eyes device allows you to press the start and stop button on the stick without touching the actual

phone at all, preventing it from getting shifted or bumped at the start and stop of the video. Because the device prevents your arm from getting tired by distributing the phone weight and offsetting it against the shoulder, the phone doesn't even block your view as you take the video. You can just relax and forget you are performing a task as opposed to simply enjoying the viewing experience. As I extended the stick, the stability was somewhat reduced, showing how important it would be to include ball spring détente device in the actual product to prevent contraction. Also, the slot to insert the phone into didn't prevent any other functions or capabilities. In general, it was actually pretty fun and easy to use. I think it would be a very accessible tool for most ages" she elaborated. See the videos included as examples of the final product results.

Materials and Cost

Parts:	Cost:
Pad:	$1.50
Handle:	$1
Support Stick (extendable)	$7
Total Manufacturing Cost:	$9.5
Profit Margin/Product	$5
Product Cost Estimate:	$14.50*

*Figure 14. Table of Costs *These Cost estimates were based on the raw material purchase prices for one prototype, and does not account for potential of mass-production.*

Pad: Will be used to stabilize the support stick with phone on the chest.

Handle: A handle on the farthest end of the phone stabilizer stick for user to hold on to as they record. Comfortable and ergonomic in design.

Support Stick: Will serve as the main part of our stabilizer. Will have an extendable pole and will securely hold the phone.

Conclusion

We initially sought to develop a product that would enable quality smartphone film production by minimizing shake and tilt. After careful development and consideration of a wide range of ideas - including both physical and technological designs - we chose to further develop a handheld, chest-stabilized mount that would provide physical stabilization with minimal effort. Our design proved effective and efficient, with final testing resulting in stabilized, ready-to-share video. The final product met our ideal functions of stabilization, portability, universal attachment, and lightweight materials, all while being completed within our limited time window. Upon further development, we would hope to enhance the functions of our design, with a special emphasis on portability and range of use. Some ideas include a collapsible handle (or a folding design) to increase portability, and increased mount

strength to enable use during high-risk or "extreme" activities such as outdoor recreational activities (biking, skiing, climbing, etc.) or roller coaster rides. Ultimately, we reached our short-term goals and created a product that satisfied our objectives and constraints. We relied heavily upon proven design methods, such as the priority checkmark and morphology charts, that allowed us to efficiently move from a broad problem statement to a functioning prototype. We encountered challenges and setbacks, but after reverting to the original design processes, we were able to ultimately move forward and utilize our mistakes to craft a functioning product.

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