Final Project
Design Journal

Group # 2

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Purdue University
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Introduction

As virtual reality (VR) becomes more prevalent, the problems associated with the use of VR becomes more known. Additionally, VR headsets are expensive, uncomfortable, and importable. Many stakeholders are involved with the innovation of VR, such as game developers, students, and gamers. In order to enhance VR, the portability and comfort must be increased. Through the use of interviews with stakeholders and the exploration of existing solutions.

Problem Statement

(10/7/2016) Virtual reality hardware is uncomfortable, not easily portable, and too bulky to carry around for VR users.

(10/19/2016) Seventeen to twenty-four year old males who play two to six hours of video games per week need an inexpensive and portable VR headset made of more comfortable materials, because current VR headsets are expensive, uncomfortable, and impractical on a college budget.

(10/31/2016) Virtual reality hardware is not easily carried by the user.

List of Stakeholders

Who is involved?
- Gamers
- Professors/educators
- Therapists/researchers
- Patient (users)
- VR developers
- Elementary Students
- Parents
- Senior citizens
- College students
- Military trainees

Field Work Plans
- Connor:
    - Adults (Interview - In person/ call)
        - Have you ever used VR?
        - Did you enjoy your experience?
        - Which headsets have you used?
        - Were the headsets comfortable?
        - Anything specific that made the headset uncomfortable?

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- ○ Naval Academy student (Interview - text/call)
  - ■ Are you aware of the use of VR in military training?
  - ■ Have you used VR as a part of your training?
  - ■ Do you know anyone who has used VR as a part of their training?
  - ■ Do you believe the use of VR in training enhanced the experience
  - ■ Was the VR headset used comfortable?
  - ■ Did the level of comfort affect the quality of training
- ● Cody:
  - ○ Dr. Whittinghill- Email and set up a meeting time (or just an email conversation).
    - ■ What is your experience with VR?
    - ■ What kind of problems did you encounter?
    - ■ Have you ever used mobile VR systems for smart phones and other devices?
    - ■ Did you ever encounter problems with these systems being Oculus Rift VR headset. It explains the design features in addition to the technological features as well as reasons this headset works and does not work.

Benchmarking Existing Solutions

·   This article discusses many ways VR is uncomfortable and causes many physical discomforts such as motion sickness and dizziness. It goes to explain the design flaws with the headsets such as the tight elastic bands, the uncomfortable eye and nose padding, and the weight of the headsets. It also discusses the programming aspect of VR that causes problems such as the lack of proper graphics and the lag in motion sensing which can cause motion sickness and disorientation.

o   Currency: This article is very current because it was published on September 1, 2016, so just over a month ago, and technology doesn't change that quickly.

o   Relevancy: This is relevant because the some of the physical discomfort associated with VR is due to the headset design, which can be changed to make VR a more pleasant experience.

o   Authority: Lavison is the Chief Digital Strategist at his own consulting firm and has been writing about technology for over five years.

o   Accuracy: This article might not be entirely accurate because people have the tendancy to exaggerate their unpleasant experiences, so his experience with VR might not have been as negative as he states in the article.

o   Purpose: The purpose of this article was to explain the discomforts of VR and what specifically causes problems.

Statt, Nick. (June 28, 2014). Google's cardboard VR headset is no joke -- it's great for the Oculus Rift. *CNet.* Retrieved from https://www.cnet.com/news/googles-cardboard-vr-headset-is-no-joke-its-great-for-the-oculus-rift/

·   This article discusses the practical uses of Google Cardboard, even though it sounds ridiculous. It explains how portable and cheap VR is a great way to expose people to VR without spending a lot of money. In addition, it is light and cheap, so it can be easily assembled and transported from place to place, without the fears of it being broken or damaged.

o   Currency: This is an older article that was published in 2014, and VR technologies have changed quite a bit since then.

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o   Relevancy: This article is relevant because it explains the purpose of portable and cost-effective VR headsets and how they could be made.

o   Authority: Statt wrote for many other news sources about technology such as ReadWrite, Popular Science, and Newsweek.

o   Accuracy: This article is accurate because he was simply laying out the pros and cons of portable VR systems such as Google Cardboard.

o   Purpose: The purpose was to explain Google's motivation for creating a cardboard VR headset and how it will affect VR in the future.

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Connor Hoban

Keywords: Virtual Reality, Physical, Comfort, Enhance

Solutions:

1. Springs: A patent was filed for the design of a head mounted display (HMD) that is very similar to Virtual Reality headsets. The patent detailed the use of springs on a band that wraps around the head in an attempt to distribute the weight of the headset more evenly around the head, rather than most of the weight resting on the nose.
    a. Source Evaluation
        i. Currency: The patent is fairly current as it was filed in 2013, however there may have been more advancements since.
        ii. Relevancy: The information is highly relevant as the design in the patent is attempting to solve the same problem my group is trying to solve.
        iii. Authority: The authors of the patent is a group of inventors, however the article does not detail any affiliations. Unfortunately, the article doesn't provide any credentials either.
        iv. Accuracy: The article is without bias as it simply details the design of a device.
        v. Purpose: The intended purpose of the patent is to ensure the inventors of the device are given credit for the design and prevent people from stealing their design.

    Patents; patent application titled "headset with comfort fit temple arms" published online. (2015). Journal of Engineering, , 2871. Retrieved from http://search.proquest.com/docview/1642741643?accountid=13360

2. Comfort Rating System: One of the leading companies in the Virtual Reality industry, Oculus Rift, is beginning to implement a rating system to evaluate the comfort level of particular Virtual Reality software. The rating system has three ratings: comfortable, moderate, or intense.
    a. Source Evaluation:
        i. Currency: The article is very recent as it was written in 2016.
        ii. Relevancy: The information is relevant as it provides a way for consumers to abstain from uncomfortable VR experiences, albeit in a unique way.
        iii. Authority: The article was written by the organization IEEE, a prominent organization made up of engineers and scientists dedicated to the advancement of technology.

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        iv.   Accuracy: Although the article is about a specific company's method for preventing discomfort, it was written by a qualified, independent third party and did not seem to be biased.

        v.   Purpose: The intended purpose of the article is to share the news of the design.

IEEE (2016). *Nausea Ratings for Virtual Reality*. IEEE Transmitter. Retrieved from
https://transmitter.ieee.org/nausea-ratings-virtual-reality/

3. Counter-weight: Sony designed a counter-weight system for their headset in an attempt to increase comfort. In Sony's Playstation Virtual Reality headset, the weight of the optics is offset by a counterweight in the back of the band. This allows the headset to be supported by the back of the user's head, rather than their nose.
   a. Source Evaluation:
      i. Currency: The article is very current as it was written in 2016.
      ii. Relevancy: The article is very relevant as it details an attempt to solve the same problem my group is trying to solve.
      iii. Authority: The author is Ben Kuchera, a member of Polygon, a tech review organization.
      iv. Accuracy: There does seem to be bias in the article as the article is essentially designed to sway the reader towards Playstation VR, however, the article does contain unbiased facts about the Playstation VR headset and how it prevents discomfort.
      v. Purpose: The article is intended to persuade the user that Playstation VR is comfortable.

Kuchera, B. (2016). *The Playstation VR is the Most Comfortable Headset Ever Made*. Polygon. Retrieved from
http://www.polygon.com/2016/10/5/13167546/playstation-vr-pre-review

Audra Gierscher
Key words: Virtual reality, headset, bulky, motion sickness

Solutions:

Dingman, H. (2016). Oculus Rift VR headset: The magical, yet unfinished birth of virtual reality. *Pcworld*, *34*(5), 58.

·   The solution to the comfort problem many people experience while using VR was to make the headset out of different materials. Older versions of VR headsets typically used an elastic band to hold the headset on the player's head. <u>However, the Oculus Rift headset uses flexible plastic and stiff fabric to allow the headset to be worn more comfortably and taken on and off easily. These changes prevent the headsets from squeezing the face, thus increasing comfort. However, because it is not made from elastic, the headset will occasionally slip down and have to be readjusted like glasses.</u>

o   Currency: This article was published in May of 2016 so it is very current. Although VR technology changes rapidly, the Oculus Rift headset is still cutting edge.

o   Relevancy: This article is relevant because it talks about the comfort aspects of the Oculus Rift headset and the specific features that make it more comfortable and easy to use.

o   Authority: Dingman is a well-known author for PCWorld, a leading technology reporting company. He has also worked in the field, creating background music for games.

o   Accuracy: This article is accurate because Dingman works for such a large company that they would ensure his opinion is fair and unbiased because his findings will lead consumers to buy or reject this product.

o   Purpose: The purpose of this article is to explain the benefits and drawbacks of the new

Tim Huber
Key words: VR, Virtual Reality, Comfort, Discomfort, Enhance, Portable

Solutions:

(description and reference to the publication or website)

1. A head to hands tracking technique that requires no setup. This also enables a much wider range of virtual environment-style navigation and interaction. This makes the interaction much more authentic.
    a. Currency: This article was written in 2000, it may still be useful as an example of ideas that were used.
    b. Relevancy: This article is relevant as it sets out to solve the problem of portability with VR.
    c. Authority: The authors are E. Foxlin from InterSence Inc., and writer M. Harrington.
    d. Accuracy: The article contains no bias.
    e. Purpose: This article describes a new technique to be implemented into VR.
    f. Citation: E. Foxlin and M. Harrington, "WearTrack: a self-referenced head and hand tracker for wearable computers and portable VR," *Wearable Computers, The Fourth International Symposium on*, Atlanta, GA, USA, 2000, pp. 155-162. doi: 10.1109/ISWC.2000.888482. URL: http://ieeexplore.ieee.org.ezproxy.lib.purdue.edu/stamp/stamp.jsp?tp=&arnumber=888482&isnumber=19202

2. Simply making small modifications such as making the model 22% lighter and adding an easily found directional pad. This article shows that VR is still new. It is far from perfect and is on the first step of its journey.
    a. Currency: The article was written in 2015 so it is fairly current
    b. Relevancy: This article is relevant as it shows what developers have done to fix the existing problems.
    c. Authority: This article was written by Drew Onaloff of TechCrunch.
    d. Accuracy: There is a small amount of bias as Drew states he is more in favor of the mobile VR rather than the PC VR.
    e. Purpose: This article is supposed to present a new model of VR being released and hint at the future of VR.
    f. Citation: Drew Olanoff (2015), Oculus Founder: Cables To Be Major Obstacle In VR Industry For A Long Time. TechCrunch. https://techcrunch.com/2015/11/01/oculus-founder-cables-to-be-major-obstacle-in-vr-industry-for-a-long-time/
3. Adjustable lenses allowing the user to fit the headset to their needs. This would ensure that each player can use the device while being comfortable. This would also help make VR appealing to more people.

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a. Currency: Very current, 2016.
b. Relevancy: This Article is relevant as it shows an innovative method applied to make VR an overall more enjoyable experience.
c. Authority: PR Newswire Association LLC
d. Accuracy: No bias noted.
e. Purpose: This article's purpose is to present an idea with which VR can be made more enjoyable.
f. Citation: Nunulo VR launches on kickstarter, bringing better and more comfortable virtual reality experience to users regardless of visual acuity. (2016, Jul 19). PR Newswire Retrieved from http://search.proquest.com.ezproxy.lib.purdue.edu/docview/1805244871?account id=13360

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Dylan Goebel (10/13/2016)
Key Words: Google Cardboard Virtual Reality Portability Portable Pocket Sized Hardware

Solutions:
   (description and reference to the publication or website)

1. A Pocket sized version or recreation of google cardboard. Basically the same exact thing as google cardboard but made of different material and a little smaller.
   a. Currency: Article published at the beginning of 2016
   b. Relevancy: Relates exactly to our topic of making virtual reality easier to carry around
   c. Authority: The website has a few adds but the author is legit.
   d. Accuracy: Accurate to the product.
   e. Purpose: To bring awareness to this "enhanced" version of google cardboard
   f. Citation:

THARLER, S. (2016, February 5). THIS POCKET-SIZED VR HEADSET IS LOOKING TO CRUSH GOOGLE CARDBOARD. Retrieved from http://www.maxim.com/gear/goblin-pocket-virtual-reality-headset-2016-02

2. A virtual reality foldable glasses. It basically clips to your phone so you can enjoy virtual reality apps and can fold up nicely to fit in your pocket.
   a. Currency: This article was published at the end of 2015
   b. Relevancy: Relates exactly to our topic of making virtual reality easier to carry around
   c. Authority: Seems like a legit website. Not a forum and has a bunch of different articles on it.
   d. Accuracy: The article author is the editor and publisher of Hypergrid Business. She has been a journalist for more than 20 years.
   e. Purpose: To bring awareness to a new portable virtual reality hardware
   f. Citation:

KOROLOV, M. (2015, December 31). Homido Mini is a super small VR headset. Retrieved from http://www.hypergridbusiness.com/2015/12/homido-mini-is-a-super-small-vr-headset/

3. A virtual reality IPhone case. It hold the lenses on the back that flip up and allow the user to use virtual reality on their phone at any time.
   a. Currency: Brand New. Not even on the market yet.
   b. Relevancy: Relates exactly to our topic of making virtual reality easier to carry around

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       c. Authority: Created by the company "Figment"

       d. Accuracy: Fully accurate, taken off of the manufacturer's website

       e. Purpose: This Product is being produced to Make Virtual reality convenient and more portable

       f. Citation:

Figment VR Virtual Reality in your Pocket. (n.d.). Retrieved from
http://www.figmentvr.com/

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Cody LaDuke
Key Words: Google- attempts to create more comfortable VR headsets/portable VR hardware

Solutions:

1. The PlayStation VR headset seems to be one of the more comfortable headsets on the market. The headset has a padded and adjustable headband that is easily manipulated and very user friendly. The goggles are surrounded by a thin rubber as opposed to a thick padding to add comfort. This makes the device rest on the user's face, as opposed to clamping down and pinching it.
    a. Currency: The article was just published on October 13th, 2016 in the *Telegraph*, so it is very recent.
    b. Relevancy: It presents a great solution to our problem that has already been implemented once.
    c. Authority: The article came from a British online news source known as *The Telegraph*, which means it does not have the validation of a real peer-reviewed page, but it is a well-trusted new organization.
    d. Accuracy: Seems to be based mostly on user experience, so while it may be accurate for some people, the experience may be different for each individual user.
    e. Purpose: The reason for PlayStation making these kinds of designs for the headset was to add comfort to the list of things to be considered when creating a VR headset.
    f. Source Citation:
        Hoggins, T. (13 October 2016). PlayStation VR review: The headset to make virtual reality mainstream. *The Telegraph*. Retrieved from http://www.telegraph.co.uk/technology/2016/10/05/playstation-vr-review-the-headset-to-make-virtual-reality-mainst/
2. Google began developing a "VR headset" known as Cardboard that is much easier and less expensive to make than a regular headset that users may be more familiar with. The headset is much more lightweight and portable than other VR headsets.
    a. Currency: The article was written a year ago in November of 2015, so some of the information may be slightly dated.
    b. Relevancy: The article presents a way to make VR more streamlined and comfortable.
    c. Authority: The article was written in the Massachusetts Institute of Technology (MIT) Technology Review journal, so it is a well-informed organization on this topic, but it may not be as peer-reviewed as other journals.
    d. Accuracy: The information presented is accurate.
    e. Purpose: Google would like to make a more affordable, more comfortable VR headset that has a universal usage for smart phones.
    f. Source Citation:
        Simonite, T. (3 November 2015). Google aims to make VR hardware irrelevant

before it even gets going. *MIT Technology Review*. Retrieved from
https://www.technologyreview.com/s/542991/google-aims-to-make-
vr-hardware-irrelevant-before-it-even-gets-going/

3. In a less-than-par solution, MSI decided to attempt to create a backpack that is made of a gaming laptop that users could take their VR rigs with on the go. This does mitigate the multiple wires needed for the normal VR headset, but it also adds the weight of a backpack, so in the way of portability, it may not be the best solution.
    a. Currency: The article was published in May of 2016, so it is fairly current.
    b. Relevancy: It attempts to mitigate the comfort problem with VR, but not so much the portability.
    c. Authority: The article came from PC World, which may have accurate information, but is not peer-reviewed.
    d. Accuracy: The information presented is accurate.
    e. Purpose: MSI wanted to make gamers have the ability to take not just their VR experiences on the go, but also general video gaming experiences.
    f. Source Citation:
        Hachman, M. (31 May 2016). The Backpack PC is a portable VR rig that leads MSI's gaming and VR lineup at Computex. *PC World*. Retrieved from http://www.pcworld.com/article/3075740/laptop-computers/the-backpack-pc-is-a-portable-vr-rig-that-leads-msis-vr-and-gaming-lineup-at-computex.html

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Rhea Manocha
Keywords: virtual reality, comfort, discomfort, bulky, portable, graphics, headaches

Solutions:
1. HTC and Valve created a headset, the HTC Vive. The article discusses the problems of the Vive include that it is difficult to set up, disorienting, expensive, and bulky (weight - 1.2 pounds). Additionally, in order to use the Vive, users need a significant amount of peripherals, such as a PC with an excellent graphics card and many cables. The software is still in its infancy - most of the games are what the author calls "experiences," or simulations of a simple concept. However, the author adds that though simple, the new environment VR provides is transformative to even the simplest ideas.
    a. Currency - This article was written earlier this year, so it is up to date on modern VR technology.
    b. Relevancy - Most of the content focuses on the positives and negatives of a specific VR headset, and relates to our problem because the Vive has multiple issues we identified.
    c. Authority - The author is a writer for The Washington Post, and the article was reposted on The Chicago Tribune, which are both credible news sources.
    d. Accuracy - When compared to other similar articles, other authors tend to say similar things.
    e. Purpose - The purpose of the article is to evaluate current new technology.
    Tsukayama, H. (2016, April 7). *Virtual reality headset is bulky, complicated, expensive ...and awesome*. Retrieved from http://www.chicagotribune.com/bluesky /technology/ct-htc-vive-virtual-reality-headset-review-20160407-story.html
2. Though most VR technology is consumer-focused, this article discusses new technology that is business-facing. Modal VR adapted modern VR technology to better fit businesses (for example, the headset is wireless). It contains examples regarding applications such as law enforcement and emergency response training.
    a. Currency: It is extremely current, as this article was published yesterday.
    b. Relevancy: This technology is very modern and solves one of the problems we are looking at, the elimination of peripheral products.
    c. Authority: Business Wire is a website owned by Berkshire Hathaway, a credible conglomerate company.
    d. Accuracy: The information presented is accurate.
    e. Purpose: Modal VR's purpose is to create hardware so businesses can create adaptable solutions for problems they have.
    Caro, K. (2016, October 12). *Founder of Atari, Nolan Bushnell, Launches Industrial-Grade Virtual Reality Platform Built For Business - Modal VR™*. Retrieved from http://www.businesswire.com/news/home/20161012005453/en/Founder-Atari-Nolan-Bushnell-Launches-Industrial-Grade-Virtual
3. A study on non-immersive VR discussed how VR tech can be used in the medical field. The researchers focused in particular on rehabilitating people who had strokes. They

found that non-immersive virtual reality was actually not as effective as recreational activity in developing motor skills.

    a. Currency: The study was conducted this year and was completed in September, so is current.

    b. Relevancy: The article discusses how VR is applied, and brings up the point of non-immersive VR, whereas we had been focusing on immersive VR. It also points out the problem of how currently, VR tech may not be as effective in treatment as lower-cost options.

    c. Authority: The article was published in The Lancet Neurology, a peer-reviewed medical journal.

    d. Accuracy: The information presented is accurate.

    e. Purpose: The researchers were finding how non-immersive VR can be used to treat patients who have had strokes.

Saposnik, G., Cohen, L. G., Mamdani, M., Pooyania, S., Ploughman, M., Cheung, D., . . . Bayley, M. (2016). *Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): A randomised, multicentre, single-blind, controlled trial*. The Lancet Neurology, 15(10), 1019-1027. doi:10.1016/s1474-4422(16)30121-1

Background/Summary

This section was created to discuss the background research that was done via interviews and observations of people, connect to the group's benchmarking solutions, and to refine our POV statement and possible solutions. The team worked individually to find different information with their own interviews, observations, and solutions. After that, the team came together to pool our information together to begin making decisions on where the team would go next. The result of this section was to give the team a jumping off point, by putting all of the information together to decide on how the project would begin.

Interviews and Observations

Connor Hoban

I interviewed two people: a student of the Naval Academy who has used Virtual Reality for training, and the Technical Lead at the Envision Center, Purdue's Virtual Reality Research Lab.

Naval Academy Student - Aidan Reilly:
- Have you used Virtual Reality within the context of your training for the military?
  - Yes.
- What applications did you use VR for?
  - I was put into a simulation where I was presented with a combat situation. In the situation there were various "enemies" as well as civilians. I was tasked with marking the enemies without marking any civilians.
- Did you experience any problems using the VR, i.e. discomfort, nausea, etc.?
  - The whole experience made me feel nauseous. The quick movements in the simulation made me kinda motion sick, and the uneven weight of the headset put a lot of strain on the front of my face.
- Do you know anyone else who has complained of similar discomfort?
  - Yeah, most of the other students I have talked to about it, dislike the simulation for those reasons.

Technical Lead at the Envision Center - George Takahashi:
- What kind've research is done here at the Envision Center?
  - Most of our research is oriented towards potential applications of VR.
- What kind've VR headsets do you work with?
  - Name a type of headset and we have it here at the Envision Center. We work with all kinds of headsets.
- What are some problems you know of with the ergonomics of VR headsets?
  - Depending on the type of headset, there are different problems associated with the ergonomics of that headset. Non-portable headsets like the HTC Vive are heavy and compress against the face. Portable headsets like Google Cardboard require the user to physically hold the equipment and, due to the fact they are

made out of a rigid material, cardboard, versus the foam on the HTC Vive, they don't perfectly fit every head size.

Name: Connor Hoban

	WHAT (What are they doing?)	HOW (How are they doing it?)	WHY (Why are they doing it this way? Take a guess!)
1	I wore a VR headset	It was a bit uncomfortable	It was uncomfortable because of the weight

Possible problems observed: The headsets are too heavy. Most of the weight is focused in the front of the headset putting a lot of pressure in one place, right on the nose and forehead.
Process for data collection: For my observations, I went to the Envision Center at Purdue to try out and observe Virtual Reality for myself.
Quantitative data related to problem: 100% of the people who tried on a VR headset with me admitted to the headset being heavy.

Tim Huber

1. Subject 1: 19-year-old male in college, gamer, uses VR regularly
   a. Question 1: Is VR comfortable or uncomfortable? Explain.
      i. Answer 1: Every once in awhile I will get a bit nauseous if I play too long. But besides that it's pretty comfortable.
   b. Question 2: If you could change one thing about the headset to make it more comfortable what would it be?
      i. Answer 1: I would definitely do something about getting nauseous, I don't want to have to take breaks in the middle of a game because I'm not feeling well. And it's not just me either, some of my friends have the same problem.
2. Subject 2: 16-year-old male, gamer, uses VR regularly.
   a. Question 1: How would you describe the comfort of VR?
      i. Answer 1: I think that it depends heavily on the type of games you play; some games have you move around a lot more than others. But I'm usually pretty comfortable while playing.
   b. Question 2: What are some changes you would suggest to improve comfort?
      i. Answer 2: Do something about the nausea. I'm not the best with motion sickness to begin with but from what I hear it's a common problem.
3. Subject 3: 76-year-old female, farmer's wife, first time using VR.
   a. Question 1: Did you find the headset comfortable or uncomfortable? Explain.
      i. Answer 1: Uncomfortable, I didn't like that thing strapped to my head. It hurt my eyes too.

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b. Question 2: How would you fix VR?
    i. Answer 2: I would make it so it wasn't so close to my face and wasn't hurting my eyes.

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Rhea Manocha
- Interview #1
  - Interviewed George Takahashi (Technical Lead, Envision Center)
  - Works with different types of virtual reality in the Envision Center - Oculus VR, Microsoft Hololens, "The Cave" (enclosed room of screens), Google Cardboard, HTC Vive, Samsung Gear VR
  - Has been doing research in VR area for many years
  - Interview style - tour of Envision Center, less formal than asking set questions, questions created as we went along through different areas
  - Demoed HTC Vive application - allowing chemists to visualize and manipulate molecules
    - HTC Vive one of best new types
  - Interviewee explained how solving problem of portability and comfort is very broad - focus on improving a specific aspect of ergonomics
  - Specific example - Purdue commissioned special cardboard VR with tabs that adjust lenses for people with different eyes (especially helpful for children - generally tend to have eyes set closer than adults)
  - Think about materials used in VR - comfort, hygiene, weight, portability etc.
    - Glass vs. plastic (Hololens?)
    - Materials that collect dust/dirt/sweat easily
- Interview #2
  - 18 year old male living on campus, plays video games around 1 hour or less per week
  - Have you ever used VR?
    - Yes, only once, at a friend's apartment
    - Used HTC Vive
  - Do you have a preference for VR headsets? Is this due to comfort, cost, graphics, etc.?
    - Enjoyed technology
    - Headset was comfortable, not too heavy
    - Graphics - pretty good graphics, not a noticeable difference from regular video games
  - Do you have or are you interested in purchasing a VR headset?
    - Don't have one, would probably buy one
    - Might not buy a headset due to cost
  - How do you think VR should improve?
    - Need better/more games
- Interview #3
  - 18 year old international male student living on campus, played video games 12 hours per week prior to college, plays less than 1 hour per week now
  - Have you ever used VR?
    - Yes, Oculus VR, played a game, browsed Internet

- ○ Do you have a preference for VR headsets? Is this due to comfort, cost, graphics, etc.?
    - ■ Resolution was not good
    - ■ Character could not move throughout space, only turn
    - ■ Sound effects enhanced experience, made it feel more real
- ○ Do you have or are you interested in purchasing a VR headset?
    - ■ Yes, purchasing Playstation VR
    - ■ Has a controller (feels more natural to use), more game options
    - ■ Other are too expensive for what they are, such as Hololens
- ○ How do you think VR should improve?
    - ■ Needs better resolution
    - ■ Cheaper headsets - can't move, improve by moving throughout space

Audra Gierscher

Interview 1:

- ● Subject: Nine year old male who is in the third grade. He plays video games for about 2 hours a week
    1. Would it be cool to go on field trips without leaving school?
        a. "Yeah! It would be easier because I wouldnt have to take a long bus ride and miss lunch time or recess!"
    2. Which is more comfortable to wear: Swim goggles or a bike helmet?
        a. "A bike helmet because it's not pinching my eyes and nose. And you don't get wet and the goggles won't fog up."
    3. Do you play video games? If so what kind?
        a. "Yes. I play Pokemon, football games, and *GuitarHero* because they're fun and hard and I like trying to learn new things."

Interview 2:

- ● Subject: Eighteen year old college female. Freshman at Ball State University, nursing major. Plays about 3 hours of video games per day.
    1. Have you ever used virtual reality? If so what system?
        a. "No, it is too expensive for me and my friends to afford, so I do not have any experience with any particular system."
    2. What are some drawbacks to VR that you have experienced or heard of?
        a. "From people I know who have used VR, they have said dizziness is a big problem, although they didn't know what caused it."
    3. How much would you be willing to pay for a VR headset?
        a. "Since I am a college student, I would not be able to spend very much. The most I would spend would be $75, but less would be better due to the college budget."
    4. What kinds of video games do you play and why?
        a. "I love playing first person, role-playing, and storybook style games because it allows me to become more engaged in the story and escape from the real world. I can be anyone I want in a video

game and can change the fate of the game if I want, it helps give me some control, even if I've had a really bad day where nothing has gone right."

Interview 3:

❖ Subject: Nineteen year old college female. Freshman at Ball State University, education major. Plays about 2 hours of video games per day.

➢ Have you ever used virtual reality? If so what system?
■ "Yes I have. I tried it with some friends who had a VR system. I used a Samsung headset, although I am not sure what model."

➢ What are some drawbacks to VR that you have experienced or heard of?
■ "It is really awkward to play in public because others can't see what you are seeing, so you look crazy."

➢ How much would you be willing to pay for a VR headset?
■ "I would be willing to $600 to $1000 for a VR headset because I loved the total immersion in the game world. It allowed me to be almost one with the game and experience video games in an entirely new way."

➢ What kinds of video games do you play and why?
■ "I play horror, action, and shooter games. I love being scared. It makes me feel alive and I love the feeling of adrenaline."

Cody LaDuke

What is your experience with VR?
- Dr. Whittinghill: Researcher, user, enthusiast, graduate school
- Cody Phrampus (roommate): Research Projects, design projects for class: first person Pac-Man, virtualized whiteboards
- Korben: VR Viewmaster

What kind of problems did you encounter?
- · Dr. Whittinghill: Motion sickness: wrote a paper that showed research that could have decreased symptoms by 13%.
  ○ Cannot see a nose, put a virtual nose in the software, which helped. No one could perceive it unless they tried, like a normal nose.
- Cody: Motion sickness
- Korben: It was kind of bulky and weird to wear.

Have you ever used mobile VR systems for smart phones and other devices?
- Dr. Whittinghill: Latency: gyroscope is not quite as responsive. Resolution problem, too close proximity.
- Cody: Played around, not much, one of the initial things looked into for AR whiteboard.
- Korben: Yes, the Viewmaster was a smart phone VR headset.

Did you ever encounter problems with these systems being uncomfortable?
- Dr. Whittinghill: Not a very comfortable thing generally. If it is comfortable it lets light in easily.

- Cody: Oculus was uncomfortable.
- Korben: It was very awkward

How do you think these things could be fixed?

- Dr. Whittinghill: Some talk about active cooling, which blows air across eyes, drying them out. Air permeable, not light permeable material?
- Cody: Scaling down would be helpful, less wires.

Dylan Goebel

College Student Interview: A female, CIT major, non-user of Virtual Reality, living in the honor's college.

What do you know about Virtual Reality?

A: It exists; I have seen commercials about it.

What is keeping you from buying and carrying around a VR device?

A: It is huge! And looks fragile.

Does it look comfortable?

A: No, it looks bulky and heavy, unproportioned.

What aspects do you like about it?

A: That you can view cool virtual reality stuff with your phone.

What do you want to see in it?

A: I want it to be smaller, something along the line of glasses maybe. Bluetooth to your phone?

Purdue Virtual Reality room observation.

How comfortable is current VR?

A: They are actually more comfortable than I thought, but the hand held phone VR is a little more uncomfortable

What kind of portable VR is there?

A: Google cardboard and literally hundreds of other variants because GC is open sourced.

What kinds of things go into making a headset comfortable?

A: Many! From the fabrics and the materials to foam vs leather. So much goes into comfort.

College Student Interview: A male, CS major, user of Virtual Reality, living in Wiley hall.

What do you know about Virtual Reality?

A: A little bit, not much. Just the google cardboard, not any of the VR's that connect to computers

What is keeping you from buying and carrying around a VR device?

A: I have a google cardboard, but I don't carry it around because it is too big. It doesn't easily fit in my pocket.

Is it comfortable for you to use?

A: I haven't had a problem with the comfort at all.
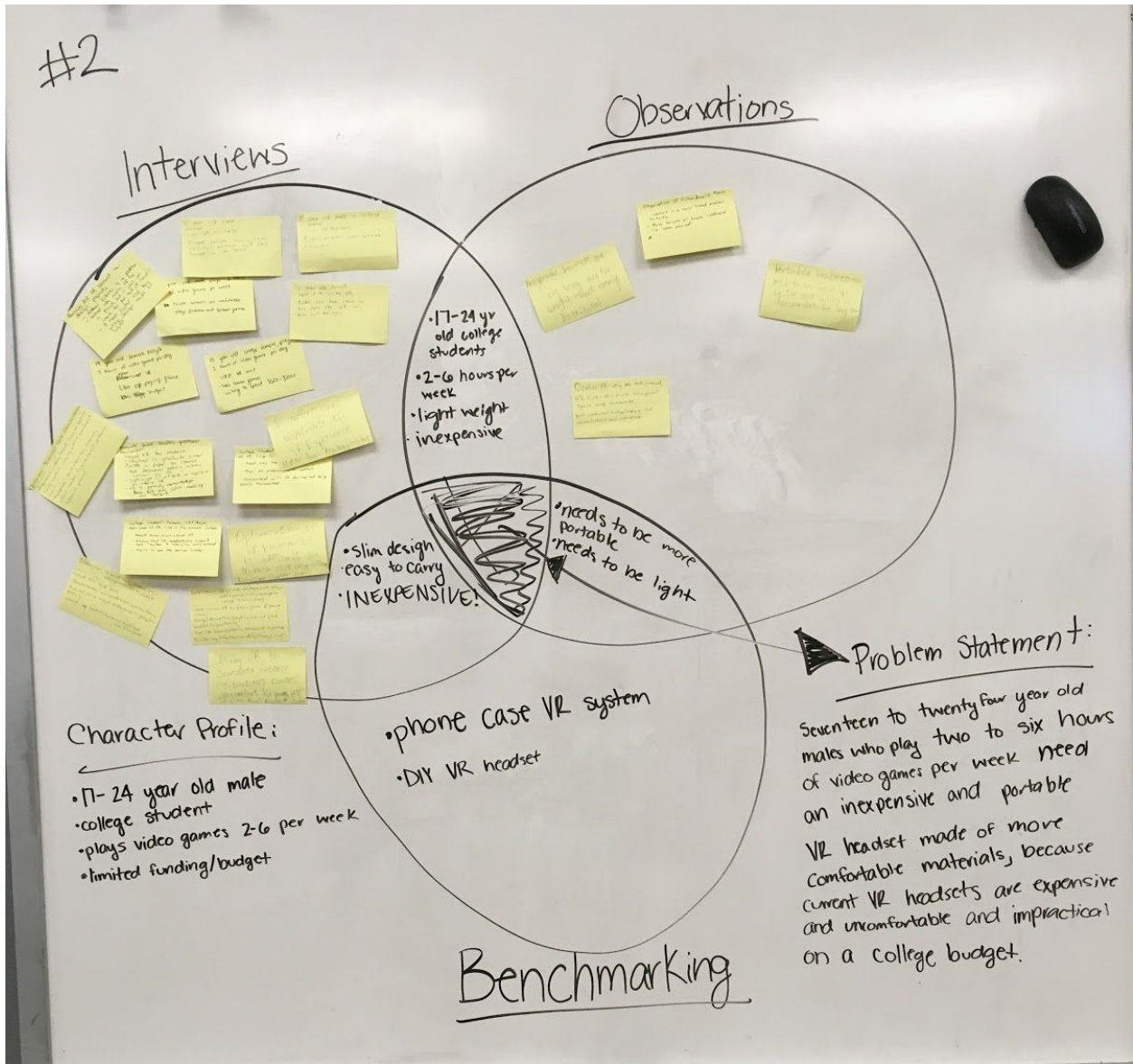
What aspects do you like about it?

A: I like that I can see virtual reality with my phone and not have to spend a ton of money on it.

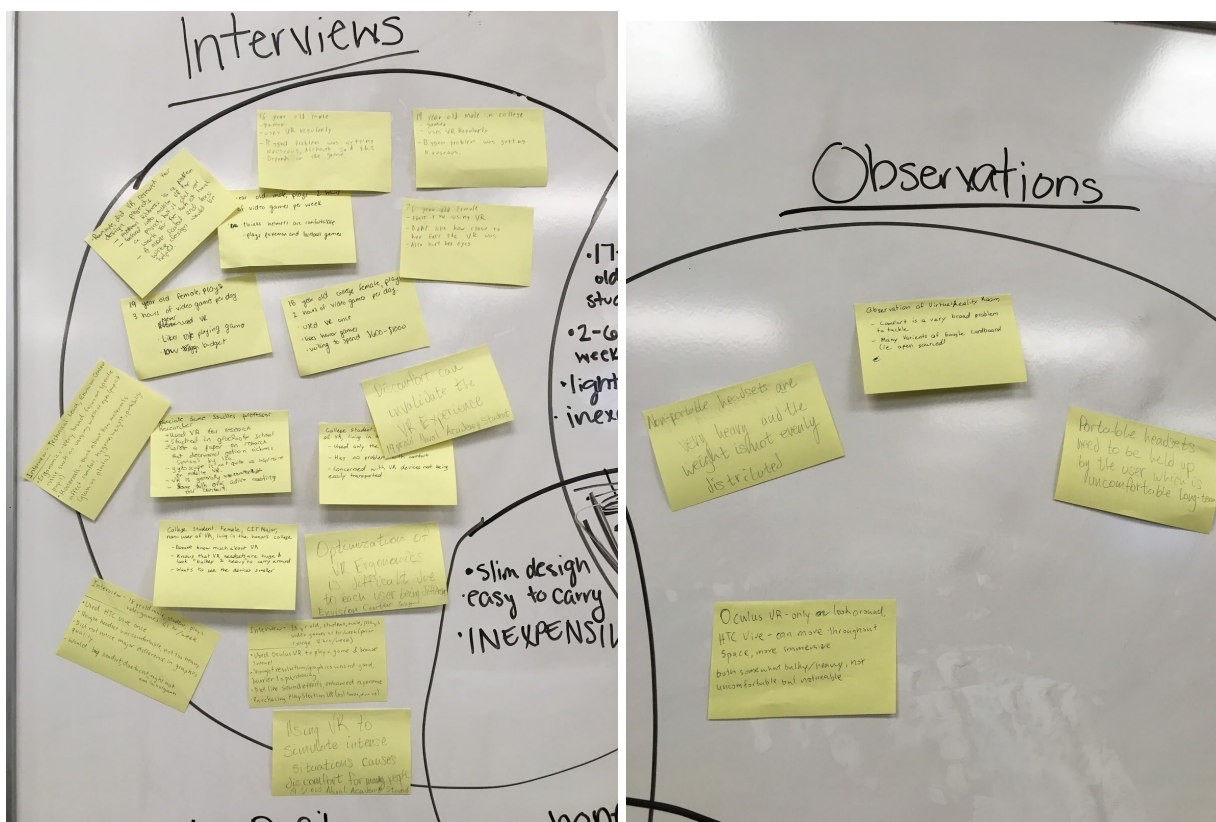What do you want to see in it?

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A: I want to have a device that is way more comfortable to carry around. Something smaller that can fit in my pocket

#2

Interviews

Observations

- 17-24 yr old college students
- 2-6 hours per week
- light weight
- inexpensive

- Slim design
- easy to carry
- INEXPENSIVE!

- needs to be more portable
- needs to be light

Character Profile:

- 17-24 year old male
- college student
- plays video games 2-6 per week
- limited funding/budget

- phone case VR system
- DIY VR headset

Benchmarking

Problem Statement:

Seventeen to twenty four year old males who play two to six hours of video games per week need an inexpensive and portable VR headset made of more comfortable materials, because current VR headsets are expensive and uncomfortable and impractical on a college budget.

## POV Statements - Refined Solutions

- Rhea Manocha - Bodysuit/Clothing VR
  - POV: Young adults aged 13-25 who use virtual reality to play games or conduct research need an ergonomic design that accounts for differences in head size, including the width from pupil to pupil, because according to the technical director at the Envision Center, virtual reality headsets can cause eye strain because looking through lenses that are not optimized for a user's eye width or discomfort for people with larger or smaller heads because the band around the head does not fit well with the head size.
- Audra Gierscher- Headphones VR
  - POV: Males in the age range of seventeen to twenty-four years of age who play two to six hours of video games per week average need a comfortable, portable, and inexpensive VR headset because current VR headsets are too expensive for most college students to afford and are uncomfortable to wear and unusable outside of laptop or computer setup.
- Connor Hoban- Ski Goggles VR
  - POV: Consumers of Virtual Reality products need Virtual Reality equipment to be more ergonomic and comfortable because discomfort while using Virtual Reality equipment can cause "motion sickness and headaches" (Interview of Naval Academy student who has used VR equipment in their training).
- Dylan Goebel- Phone Case VR

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- ○ POV: People from the age of 16-22 that are on the go, use virtual reality on their phones, and do not have a bag or simply do not wish to carry a separate VR device need a phone case that has a VR headset built into it that will fold into a nice, easy to carry, phone case when not used because This will save space, the user will not have to carry around a separate device so the user can use VR, and it is extremely efficient
- Tim Huber- Glasses VR
  - ○ POV: Sixteen to twenty-four-year-olds who use VR need a portable yet comfortable method of using and carrying VR such as VR glasses, because current VR headsets are bulky and not very portable.
- Cody LaDuke- Charging Hat VR
  - ○ POV: College students need a virtual reality experience that is portable and self-sustaining through a built-in charging system because they are constantly moving and to paraphrase what Dr. Whittinghill said in my interview with him, VR systems are not very comfortable and viable for movement, generally.
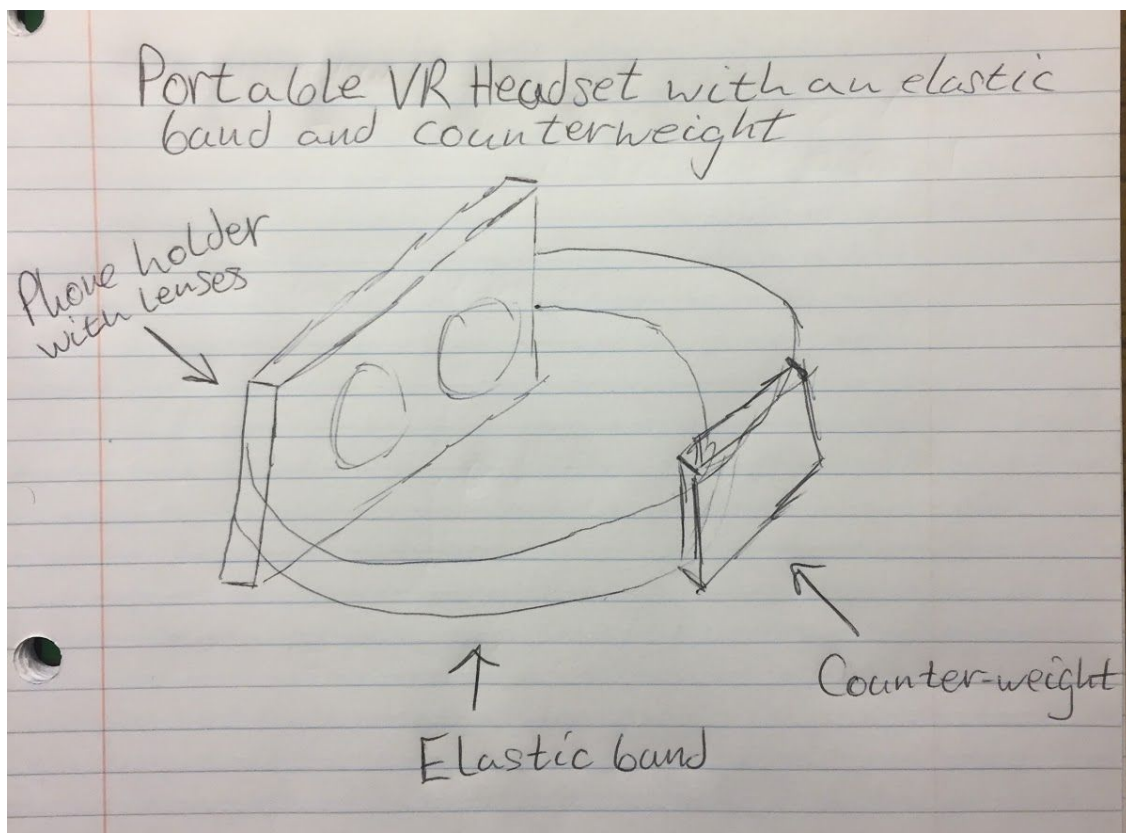
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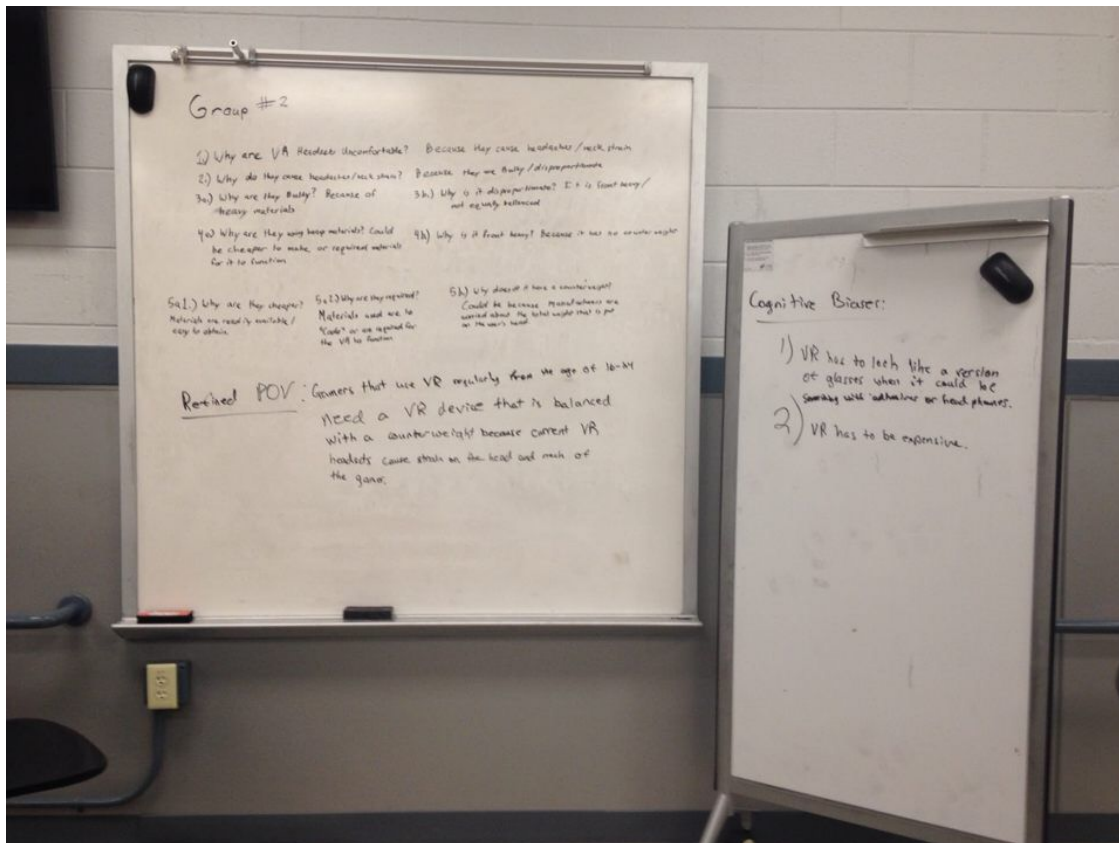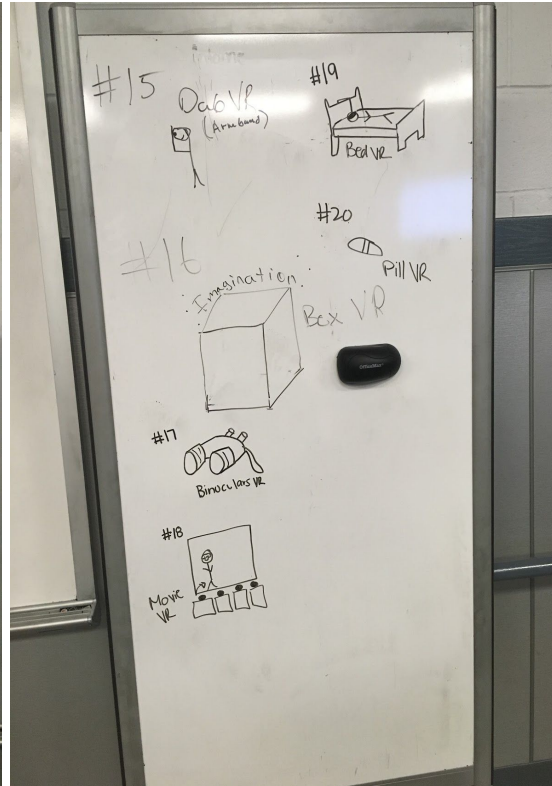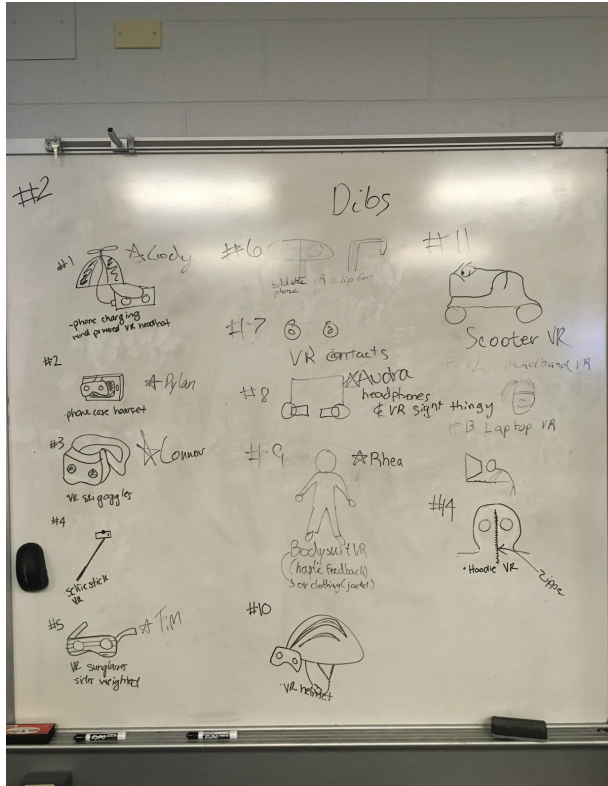
Refined Innovative Solutions

Connor Hoban: Portable VR headset with an elastic band and counterweight.
- Description: My proposed solution is to have attach an elastic band to a portable VR gear allowing the gear to attach to the user's head rather than have to be held in the user's hand. Additionally, I propose the addition of a counterweight on the back of the elastic band in order to balance the weight of the gear and remove strain from the user's nose and forehead.
- Why is this Innovative?: This solution is innovative because, while there are already portable VR headsets with elastic bands, I have been unable to find a portable VR headset with both an elastic band and a counterweight.
- Sketch:

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Tim Huber: VR glasses
-Description: Instead of a headset with a strap large frame, I suggest a pair of glasses, they would have a thin build much like the google cardboard, allowing portability. It would also have the usual comforts an ordinary pair of glasses would have.
-Why is it innovative: This solution would be innovative because it combines the use of VR with wearing glasses which most people wear, if not prescriptioned then sunglasses.
-Sketch:
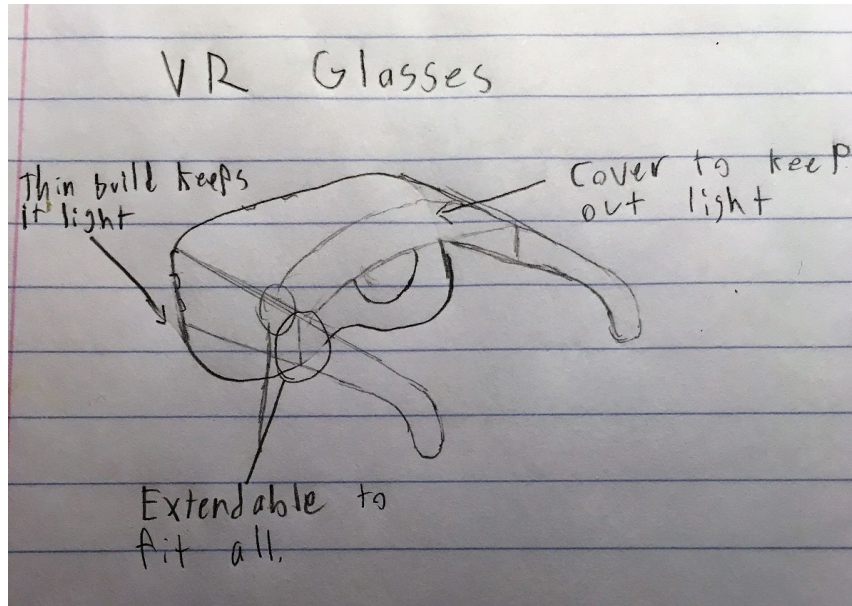
Cody LaDuke: Charging Hat VR

Description: The individual solution I am working with is a Virtual Reality headset with a built in phone charger for the smart phone that the device is running on.

Innovative: After some minor digging on the Internet, it appears that while this concept may be being thought of as a possible idea, it has not even come close to any sort of market. This idea is different because it has a self-sustaining property, similar to the portable Apple charging adaptors that are fairly popular, the hat itself will have a charging adaptor that will have to be charged separately, but can provide an extra boost in power for the phone being used while out, about, and playing with VR.

Sketch:
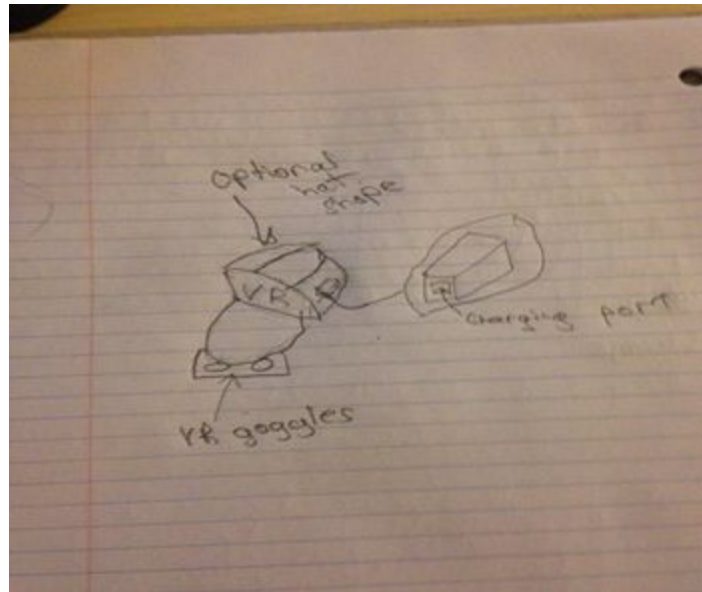
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Dylan Goebel: Phone Case/Strap Headset

Why have a VR headset built into a phone case?

Because it is convenient to carry around

Why is it convenient?

Because the user doesn't need to carry a seperate VR device, it is already attatched to the phone.

Why would the user need this?

Because the user may not want to carry around a sepirate VR device

Why wouldn't the user want to carry around a seperate VR device

A: Because they are lazy & do not wish to hold onto/be accountable for it

B: Because the user doesn't have a bag or purse to carry it with.

A: Why don't they want to hold it?

Because it is a lot of work to keep the device from being stolen or the user from losing it

B: Why don't they have a bag

Because the user does not wis to carry a bag

Refined Product

Counterweight — **straps**

Back
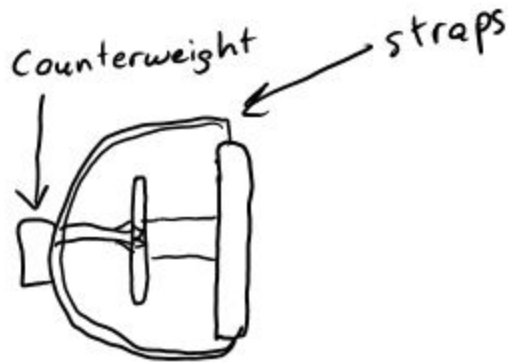
Side

Counterweight
& straps are
a single piece
that can detatch
from the case

This product is not out on the market. I have not seen anything like this. I took two ideas and put them into one to create this innovative solution. This is in fact a solution to our problem because it addresses the issue of VR being portable, comfortable and convenient.

Rhea Manocha - Bodysuit VR

Original Concept: Virtual reality bodysuit
Adapted: Sensors embedded in adhesives

To enhance VR by making it more portable, a solution is to create haptic sensors that are embedded in adhesives. This would allow for more functionality while not requiring heavy, cumbersome peripheral equipment or cables. The haptic sensors could be used to provide feedback to the user through vibrations (such as a reward when completing a level). Additionally, additional adhesive sensors could monitor vitals such as heart rate, which could be used to enhance research data or change what is happening in a game to make it more immersive.

In this example from a [TED talk](), doctors monitored patients through a wearable "temporary tattoo" adhesive - essentially a patch that helped them keep track of vitals. They put circuits on adhesives rather than hooking people up to large machines through traditional technology, which allowed for more mobility. This could also be used in virtual reality to monitor vitals and in turn change the situation the user is experiencing.

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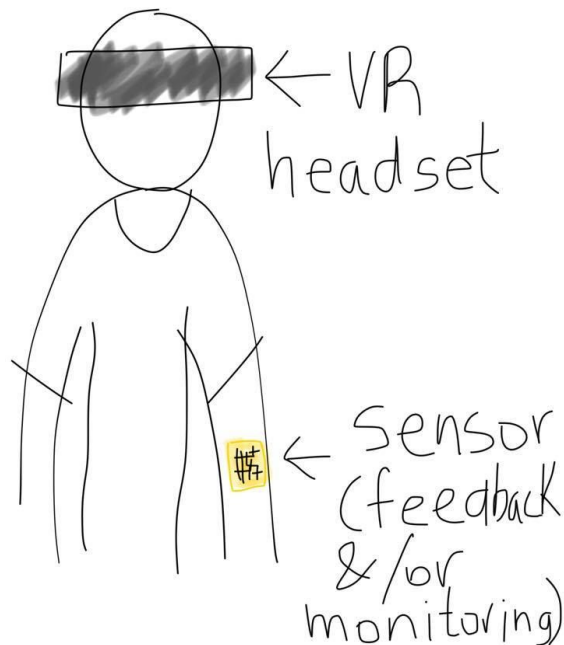
Audra Gierscher

The headphones VR would be more innovative if the lenses could be adjustable so they fit more people. The adjustable lenses would be more comfortable because it would help the VR set fit more people and improve comfort because the incorrect lens distance can cause motion sickness.

Different from existing solutions because it focuses on having multiple functions and building off existing and relatively cheap technology. This solution is also different because it is not an entire headset that covers the whole face.

padding to improve comfort (small weight inside to act as a counter balance)

padded earpiece with high sound quality to make more comfortable

light weight plastic curve around back of head to improve balance

lenses are adjustable to fit everyone face size (improves experience) retracts into area behind speaker on headphones.

holds phone for video portion.

Innovative because.....
- its bluetooth
- lenses retract into headphones for portability
- can be used just as headphones
- 1st headphone VR set

The headphone VR aligns with the problem statement because headphones are not too expensive, are comfortable, and portable.

Methods

The purpose of this section was to find the problem that the group wanted to work on by interviewing people, listing out problems in the field, and observing the Purdue virtual reality room. After analyzing the findings, the group decided to tackle the problem of portability and comfort of virtual reality devices. Through the thorough observation of peers and exploration of existing solutions, the solutions for improving the comfort and portability problems of VR to enhance the experience of VR for users became much clearer.

Root Cause Analysis
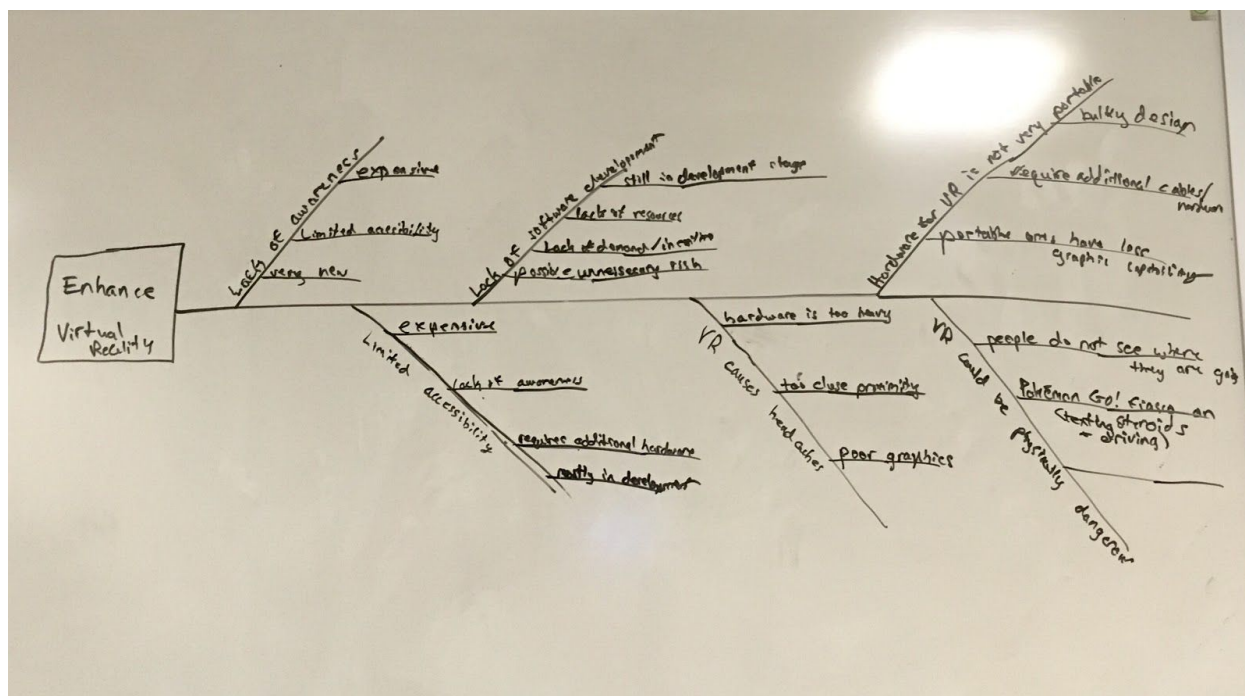
- Connor
    - Uncomfortable?
    - How do you think these things could be fixed?
    - Questions: see interviews below
- Audra: Gamers, children
    - Gamers: Interview-call, email, face-to-face
        - Have you ever used VR?
        - Have you experienced any problems with discomfort?
        - What systems have you used?
        - What kind of games so you play?
        - Have you considered portable VR headsets (like cardboard)?
    - Children: interview- face-to-face, FaceTime
        - Would it be cool to go on field trips every week without leaving school?

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- - - Do you play videogames?
    - - What would make school more interesting?
    - - Do you like school?
- Dylan:
  - Purdue Virtual Reality room observation
    - - How comfortable is current VR?
    - - What kind of portable VR is there?
    - - What kinds of things go into making a headset comfortable?
  - College student (interview)
    - - Have you used VR?
    - - Is it too expensive?
    - - Comfortable or not comfortable?
    - - What do you like about it?
    - - What do you want to see in it?
- Tim:
  - Gamers (interview- email/text/call/face-to -face)
    - - Have you used VR?
    - - Describe your experiences
  - Patients (Interview- email/text/call)
    - - Have you used VR?
    - - Did this help you? If so how?
- Rhea:
  - VR developers (interview - email/call)
    - - What are some problems you have encountered while developing VR products?
    - - What areas do you think the VR industry needs to improve in order to gain popularity?
  - College students (interview/observation - in person)
    - - Have you ever used VR? Why/why not?
    - - Do you have a preference for VR headsets? Is this due to comfort, cost, graphics, etc.?
    - - Do you have a VR headset? If yes, do you carry it around?
  - Therapists/researchers (interview - email/call)
    - - What are some problems you face when treating patients or conducting research?
    - - What developments in VR are necessary or would you like to see in order to make your use of VR in treating patient/research more effective?

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Decision Matrix

Versquadce

Group 2

1=bad
5=great!

Solutions	Criteria				Constraint	Total
	Comfort	Portability	Accessability	Cost.	Existing Technology?	
Counter-weight System	4	1	2	4	Yes	11
plastic+fabric headband	4	3	4	4	Yes	15
Phone case VR headset	3	5	5	4	Yes	17
Modal VR	3	4	2	1	Yes	10
DIY VR	3	4	5	5	Yes	17
Rating System	NA	5	5	3	Yes	13

Potential Pitfalls:

- Counter-weight system- does not really take away weight from the headset.
- Plastic and fabric headband- headband could be uncomfortable and not really fix the problem.
- Phone case VR headset- is not available to purchase yet, so the results of the product are not available to analyze.
- Modal VR- has very specific uses that may not apply to the more general usage for which we are designing.
- DIY VR (Google Cardboard)- does require a bit of work on the part of the consumer to assemble the rig and may not be the greatest and most durable design.
- Rating System- would be hard to get every consumer to give a rating for every experience.

Finalize Prototype

After getting all of the required information and creating a rough prototype, moving on to finalizing the prototype and adjusting any errors in it was the next step. Being able to find and equip the prototype with more practical and efficient materials was instrumental to the improvements made to the prototype. These changes allowed for more thorough testing and analysis of the solution. The end result of the prototype was effective and was able to achieve the goal of comfort and portability. The prototype was then shown to peers, users, and stakeholders to receive feedback.

- Changes made to prototype

- - - Changed sides to telescoping antennas to make it retractable
      - Rationale: The intent for the antennas go back to our original idea of the VR part of the headphones retracting into the headphones when you aren't using it.
    - Fixed structural integrity of rigging by gluing popsicle sticks rather than using tape, cut so it can be split in half using velcro
      - Rationale: The antennas are way more sturdy than the popsicle sticks, velcro, and paperclips.
    - Secured band
      - Rationale: The band kept coming off the headphones while the prototype was being used.

- Innovation:
  - Extending braces was enhanced so that it was actually able to extend and sturdily hold the phone. The braces were adjusted to be able to fold back up into the headset for times when the VR is not in use. We also enhanced the overall build to make it sturdier and more convenient.
- Stakeholders:
  - Casual Gamers- This product would give casual gamers a way to play certain VR games while on the go and with a way to block out background noise. As long as the headphones being used are good quality, sound could be blocked out and the experience can be as immersive as possible. The rig may not be useful for a lot of on-the-go playing due to the fact that the phone is put in front of the user's face, but the retractable phone stand will help with easy carrying for users.
  - VR developers- This headset will give certain developers another reason to consider adding more immersive VR experiences for portable devices. (iOS, Android, etc.) This will cause mobile VR app developers to consider new ways of making mobile VR experiences more immersive and innovative. The product will help developers appeal to a larger segment of the population than what was being appealed to before.
  - College students- College students using this product will be able to carry VR much more easily and wear it more comfortably while maintaining a college level budget. Having headphones that work as a VR headset as well as a normal pair of headphones will saving money while being able to enjoy two extremely popular past times.
- Systems concept map:
  - Our solution fits into the boundaries of the Grand Challenge we decided

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on because it can be applied to research in other areas, fits a larger demographic, and has less strain on the head and neck.

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Mentor Meeting Agenda 1

Meeting on October 31 with Dr. Hartman

- Narrow focus on *problem statement* (not POV)
- The "and" part of problem - leads to null hypotheses
- Discussed problem statement and POV
- Problem: Virtual reality hardware is uncomfortable, not easily portable, and too bulky to carry around for VR users.
- Go with portability - others harder to measure because more subjective
- Set up the problem statement well to help solution

Note: Meeting was brief due to time constraints

Mentor Meeting Agenda 2

Obstacles and Issues (8 minutes):
- Making the rig sturdy, while also being light and portable.
- Finding times that work with everyone.
- Finding suitable materials.
- Pricing of the headset
- Cost to produce and cost of materials

Future Plans (8 minutes):
- Getting actual lenses for use on the headset.
- Improving the headband, because it is not elastic.
- Improving the counterweights, because they are kind of clunky.

Faculty Reactions (8 minutes):
- Look at directional speakers in Microsoft Hololens
- Taking advantage of human physiology and why body parts are shaped the way they are.
  ○ Ears are made to funnel sound.
- Not much is needed to produce sound
- Immersive experience versus portable experience will affect the cost.
- Use a mock-up that is close enough to the size and weight that we want.
- Will this be comfortable for an extended period of time?
  ○ Would you want to wear this at work for 8 hours a day?
- Size is a huge challenge
- More weight in the back, without additional weights.
- Elasticity wears out over time (Microsoft Hololens).
- Research and talk about materials, may not be able to get our hands on them.
  ○ Would be made out of different kinds of materials….
- Research human eye focal length (near-sighted versus far-sighted versus pure 20/20 vision).
  ○ Make adjustable antennas function accordingly.

Review Action Items (6 minutes):
- Counterweights could be within the headband, but the headset comes with an additional clip-on counterweight to distribute weight for different phone sizes.
- Use a more elastic substance for the headband.
- Finding better materials for the rig, to make it more portable.

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Gantt Chart

Tasks	Meeting 24	Meeting 25	Meeting 26	Meeting 27	Meeting 28	Responsibility
Update table of contents/headings						All
Submit design journal and Gantt chart						All
Submit mentor meeting minutes						Cody
Infographic (and quiz)						All - individual
Final Design Journal						All - individual
Design and Innovation Definition						All
Final Presentation						Rhea, Dylan, Connor
- Rough draft outline						Rhea, Dylan, Connor
- Final draft outline						Rhea, Dylan, Connor
- Slides						Rhea, Dylan, Connor
Ordering materials for prototype						Audra
Handle prototype						Tim
English Kickstarter script						Audra, Cody, Tim

Results

With everything completed in the prototyping phase, the team presented the working prototype to the class in order to receive constructive criticisms. The prototype yielded its own results when tested.

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Feedback

This section is dedicated to the results that were received from the in-class presentation of the working prototype prior to edits and revisions. The team presented to the class, as mentioned above, the first prototype of the headset to receive peer feedback. The result was a good array of suggestions for how the project could proceed.

- Will this work for all phones?
    - Yes. It will be optimized to be able to fit all smartphones and function with them.
- How will the counterweight work with different phones?
    - Extending band will allow for an adjustment in weight. Staple or glue the band into the headset.
- Was weight tested during testing?
    - Yes, although it was limited due to resources.
    - What other testing was done?
    - Tested comfort, phone fitting, Adjustability.
- Need to work on actual rigging of headset especially phone holder.

Discussion

The initial prototyping and testing produced some very useful data. The counter-weight seems like a viable way to balance the weight of the headset, and the extra strap adds support that makes the headset more ergonomic. The next step would be to make a working prototype of the envisioned final product to confirm the initial testing. The improvement of ergonomics and comfort on a VR device enhances VR by fitting a larger demographic as well as causing less strain on the head and neck of the users.

Concept Map
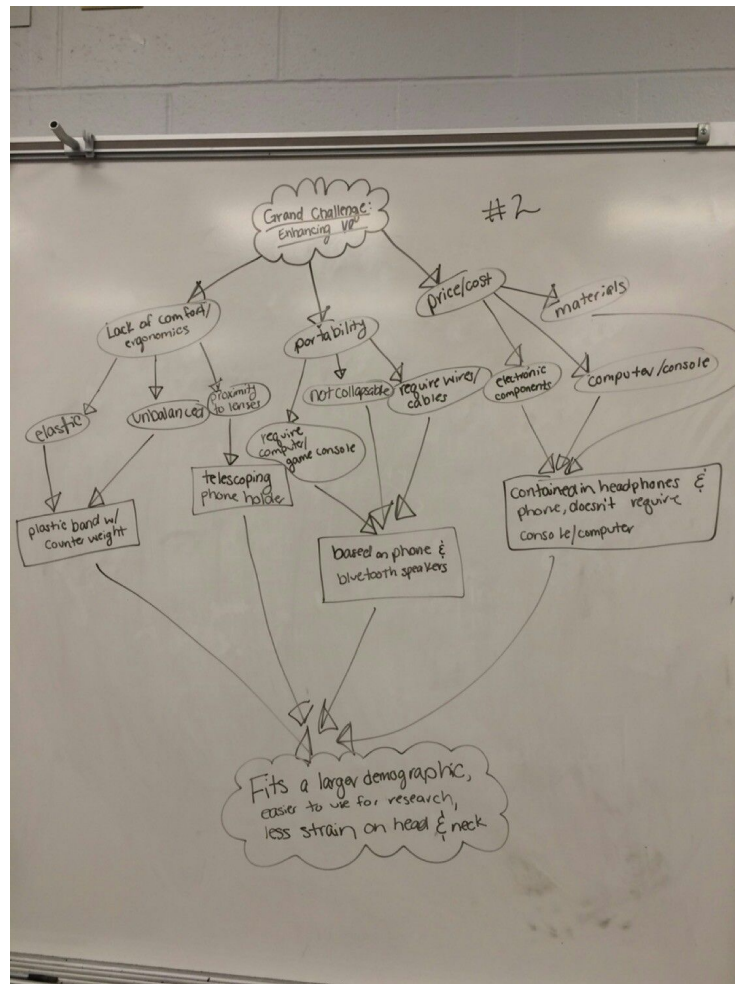
Conclusion

Initial prototyping went very well. Testing of the prototype seemed to indicate the addition of the counterweight and the extra strap successfully improved the ergonomics and comfort of the headset. The headset's comfort was greatly increased by removing strain from the front of the user's head and balancing the weight. Improving the ergonomics of VR makes the technology more accessible as well as making the whole experience more pleasant.

Recommendations

For future TECH 120 students, we recommend thoroughly researching all solutions, not just the ones that have worked, but also the ones that have failed. In addition, we recommend using the "brain drain" ideation method, because after all the crazy ideas are out, valuable solutions are formed.