Home Opioid Patient-Controlled Analgesia (PCA) Box

Team 11	Recovery Improvement Interactive Technologies (RIIT)
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Sponsor	Seattle Children's Hospital & The University of Washington
	Dr. Lance Patak, Dr. Stuart Solomon, Dr. Jacob Gross

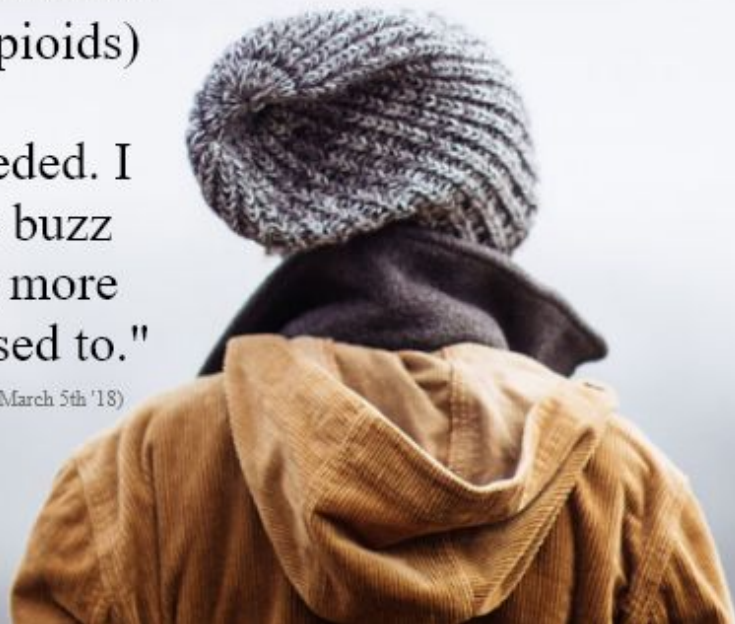Milestone 3 **Evaluate** (May 7)

Project Overview

Opioids provide necessary pain relief to postoperative patients. However, opioids can be addictive, dangerous, and are often subject to misuse. Our project, an in-home oral Patient-Controlled Analgesia (PCA) box, will address these issues by providing patients with the guidance they need to manage their pain effectively during their postoperative recovery.

Our team will be researching, designing, prototyping, evaluating, and iterating a Patient-Controlled Analgesia (PCA) device and companion app that monitors and manages opioid prescriptions while connecting patients to doctors throughout the postoperative recovery phase.

"I got in a car accident and was in the hospital for three or four months. At first, I took (opioids) for the pain as prescribed, as needed. I started to like the buzz so I began taking more than I was supposed to."

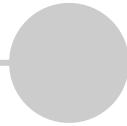- Cassaundra Blasingame (Time Magazine March 5th '18)
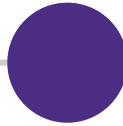
Design Process

Milestone 1
Design

Milestone 2
Prototype

Milestone 3
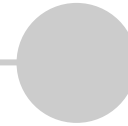**Evaluation**

Milestone 4
Iteration

Pill Box
Companion App

Physical Computing
Interactive Demo

Usability Testing
Data Analysis

Pill Box 2.0
Updated Companion App

Milestone 3
Evaluation

Project Manager: Finn Thompson

Milestone 3 Overview

The evaluation phase is an essential part of the process to focus our designs on potential users. In this phase, we used Milestone 2's prototype deliverables in a usability research study to identify where our designs succeed or fail to meet our goals. By creating a data pool from a diverse sample of users, we isolated what pieces of our prototypes to retain, change, or remove during the upcoming Iteration Phase.

- Research Questions
- Methods
  - Test Kit
  - Recruitment
  - Study Sessions
- Analysis
- Findings & Design Recommendations
  - Device
  - Companion App
- Moving Forward
  - Process Overview
  - The Final Phase

Necessary   Over-prescribed   Addictive   Dangerous

Research Questions

Device

1. Do users encounter errors, either as a result of hardware or software design, that impact their ability to successfully acquire medication from the device?
2. Do users understand the dose information on the heads up display?
3. Do users desire any features (additional prescription info, settings, etc.) that we do not have implemented?
4. Are users satisfied with their ability to acquire medication from the device?
5. Do users understand the wording of the pain questions?

Companion App

1. Do users understand the concept of the historical data chart display and prescription progress gradient?
2. Do users understand the information hierarchy in the app?
3. Do users desire any features (additional prescription info., settings, etc.) that we do not have implemented?

Methods

Question

How can we design our study to enable us to best address our research questions?

Purpose

Define the approach we will take to answer our research questions throughout our usability evaluation sessions.

Result

A test kit containing all necessary content to conduct effective usability research consistent across all participant sessions.

Test Kit Components

Screening Survey

We used a screening survey to quantify and identify potential participants. We created our survey in Google Forms and distributed it via hyperlink.

Purpose and Research Questions

These components served as a cornerstone for our test kit, setting the focal point, purpose, and goals of the test kit.

Test Script

We created a test script to ensure that each study session was run consistently for each participant with a focus on answering our project's research questions. It mapped every instruction, task, and important feature of the study. The moderator read the script to the participant and supplied the participant with a copy to follow along. The script was not used for answering user questions, or the questions we felt needed to be asked during the study.

Consent Form

This form allowed us to make an agreement with participants concerning how we would collect and use data in each study.

Pre-Test Questionnaire

This questionnaire contained questions that provided us with additional background identifiers used to organize participant data into defining categories.

Post-Test Questionnaire

In this questionnaire, we defined and asked questions according to notable actions and comments made by the participant throughout the study.

Task Sheets

These sheets enabled users to clearly see and reference the task being done. Each sheet contained post-task questions to provide additional detail concerning the users experience with each task before additional information altered their opinions.

A link to our test kit and all of its contents can be found here: RIIT Test Kit link

Recruitment

Goal

We desired a diverse set of 6-8 participants with varied experience using medication dispensers.

Approach
- Craigslist
  - Created an ad which received no responses.
- Social media
  - Posted invitations to our study on Facebook, received no responses.
- Guerilla style recruiting
  - Michael and Finn asked individuals on campus in Allen and Odegaard libraries if they were willing to participate, resulting in four participants.
- Personal networking
  - Through text and personal invitation, Ian was able to recruit two participants.

Participant Demographics
- 4 students
- 2 non-students
- 2 inexperienced with prescription medication
- 1 Medical student
- 1 Pre-Med student
- 1 Human Centered Design and Engineering student
- 1 Computer Science Engineering
- 2 Married with children
- All Male

Study Sessions

For our usability studies we reserved private rooms in the Allen Research Commons and in Odegaard Undergraduate Library where we could host the study in a distraction-free space. We had two notetakers: Ali Morgan and Finn Thompson; a videographer: Michael Beach; and a moderator: Ian Russell. In the study room we set the device up between the two notetakers, across from the moderator and in front of the videographer. The participant was then placed in front of the device, with the videographer behind and moderator across from them.

After introductions, if the participant had yet to fill out the screening survey we asked them to do so. Following the survey we presented them with the test script and the moderator guided them through a think-out-loud warm up exercise, the consent form, the pre-test questionnaire, each task, and the post-task questions. At this point, all team members asked post-test questions as determined by the participant's actions and comments throughout the study. Then, Finn Thompson gave the participant a guided tour of our companion application followed by additional questions. After each study, the participant was thanked by each member of the research group and given a $5 Amazon gift card as a gratuity for their participation.

Moderator

Device

Script/Tasks

Note taker

User

Videographer

Note taker
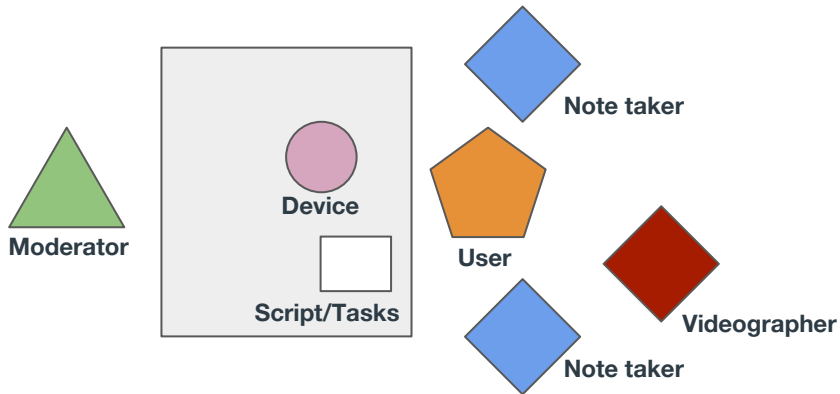
Layout of usability test.

Analysis

Question

How can we effectively analyze the data and notes we collected in our studies?

Purpose

Translate the data into key findings.

Result

An organized set of data and definitions from which we can draw effective findings.

Data Analysis

Post-task forms (1=positive, 5=negative)	P1	P2	P3	P4	P5	P6	Average
Task 1 difficulty	1	1	1	1	2	1	1.17
Task 1 satisfaction	2	1	2	1	2	1	1.5
Task 1 helpfulness	1	1	4	2	1	2	1.83
Task 2 difficulty	1	1	1	1	1	1	1
Task 2 satisfaction	1	1	2	2	2	1	1.5
Task 2 helpfulness	1	1	1	4	1	1	1.5
Task 3 difficulty	1	1	1	1	1	1	1
Task 3 satisfaction	1	1	1	1	2	1	1.17
Task 3 helpfulness	1	1	2	1	1	1	1.17

Event	Spon.	P1	P2	P3	P4	P5	P6	Count X
Trouble on removing pills from device	X	X	X	X	X	X	X	7
Wasn't sure what the device did or was meant to do		X	X					2
Thought pain responses might impact pill availability	X						X	2
Noted or confused by being asked pain question multiple times	X	X			X			3
Thinks pain question could be worded differently	X				X		X	3
Wanted a different way to respond to pain questions	X	X			X	X	X	5
Misinterpreted dosage display information		X		X		X		3
Misinterpreted dosage display interactivity			X			X		2
Screen not detecting taps successfully sometimes			X	X	X	X		4
Wanted more information on/about app graph		X		X	X			3
Commented on device's slow dispensing time			X			X		2

Screenshot of data spreadsheet.

To begin analyzing the data, we created a spreadsheet and entered in each participant's data from the screening survey, pre-test questionnaire, post-task forms, and post-test questionnaire. We also created a section with notable events, defined as an issue or comment common to multiple participants. These events, paired with the participants who encountered or noted them, allowed us to quickly identify root problems to define our findings.

The data pictured here represents a subsection of our spreadsheet, showing the post-task responses and notable common events, along with the number of participants for which each event is applicable.

Severity Scale

To classify our findings, we defined a three-point severity scale as follows. These ratings allow us to quickly identify which issues are the most important to address in our upcoming Iteration phase.

Low Severity
A low severity issue can be an annoyance to a user but does not impact their ability to use the system. Issues with this classification should be fixed after addressing medium and high severity issues.

Medium Severity
A medium severity issue moderately annoys some users and may impact their ability to easily use or understand the system.

High Severity
A high severity issue significant annoys users and impacts their ability to use or understand the system. Issues with this classification will prevent the system from consideration for mass adoption.

Findings & Design Recommendations

Question

What key findings did our study produce?

Purpose

Identify ways our device, interface, and companion app can be improved.

Result

A list of design recommendations to guide our Iteration Phase.

Findings Overview

Device

1. Aspects difficult to understand for 1st time users (High Severity)
2. Difficult to collect pills from vup (High Severity)
3. Pain question asked too frequently (High Severity)
4. Device tilts when pressed hard (Medium Severity)
5. Unsatisfactory pain response options (Medium Severity)
6. Slow pill dispensing time (Low Severity)
7. Unclear pain question (Low Severity)

Companion App

1. Context wanted for weaning graph (Medium Severity)
2. Visual clarity wanted for app hierarchy (Medium Severity)

Device

Finding 1: Aspects Difficult to Understand for 1st Time Users
(High Severity)

Finding

We introduced our device to our participants simply as a smart prescription management device. As a result, several of our participants were unsure of how the device functioned as they used it for the first time.

- P1 and P2 commented that they were not sure what the device did or was meant to do.
- Our sponsor and P6 thought their responses to the pain questions (bottom right) might affect the number of pills they can access, as it is asked before the user picks the number of pills they want.
- P1, P3, and P5 misinterpreted the dots on the dosage display (top right) to represent suggested dose (rather than available dose).
- P2 and P5 believed the dosage buttons would not be interactive when the time until next dose was displayed (25 minutes vs "Ready" in top right image).

Design Recommendation

Make a printed Quick Start Guide to help clarify the device's affordances and use. This guide would be supplied to post-operative patients when they receive the device from a pharmacy or hospital. A nurse or pharmacist would also explain the use of the device to patients before they leave the hospital.
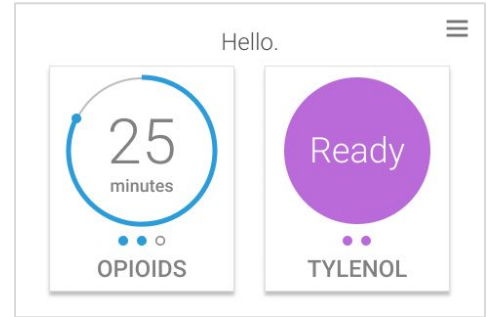
The home screen dosage display.
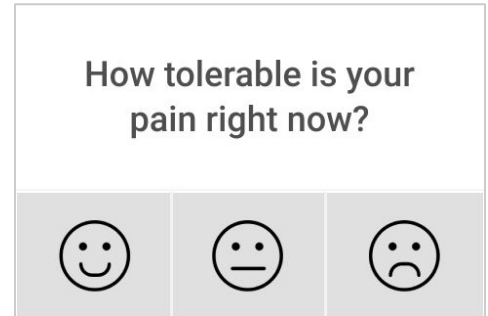
The pain question asked every time a patient requests medication.

Finding 2: Difficult to Collect Pills from Cup (High Severity)

Finding

Retrieving pills from the device requires the participant to reach into an opening located at the base of the device.

- Every participant (P1 - P6) and our Sponsor had difficulty retrieving the pills from the device.
- Our participants retrieved pills from the device in every task, so we repeatedly observed this difficulty, making it one of our most severe findings.

Design Recommendation

Redesign the pill receptacle to be larger and smoother for easier pill retrieval.

Device pill receptacle.

Finding 3: Pain Question Asked Too Frequently (High Severity)

Finding

Our sponsor, P1, and P4 were annoyed or confused by being asked the pain question (right image) multiple times in quick succession. The device asks the question before each pill request, so if a user needs opioids, then Tylenol, then replacement opioids (which is the scenario in our study's tasks), the user then has to answer that question three times in quick succession. Our participants were unsure of whether their response should be changing between occurrences and wondered why they were being repeatedly asked the same question.

Design Recommendation

Adjust software to only display current pain question at most once per 15 minutes. While this recommendation will result in less data being collected, we believe this change is valuable for fostering quality user experiences.

How tolerable is your pain right now?
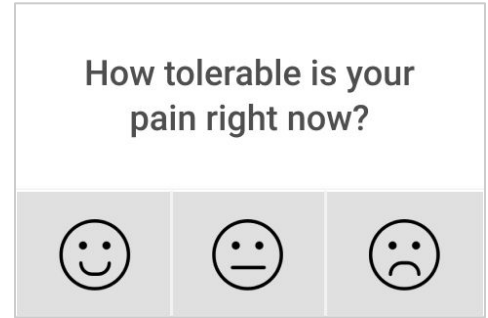
The pain question asked every time a patient requests medication.

Finding 4: Device Tilts When Pressed Hard (Medium Severity)

Finding

Due to the touch screen's placement near the top of the device, the device can easily tilt back under the force of a strong press. We encountered this issue in our own testing, and in our studies one participant (P6) pressed the device with enough force to cause it to tilt. The device tilted nearly every time he pressed it, and under more force, the device could possibly tip over backwards, damaging the components and disrupting the user experience.

Design Recommendation

Add weight to the device. The electronics cavity in the base of the device has space that can be filled by heavy materials to reduce the risk of tilting and tipping. We will research what the best approach to adding weight is (i.e. ball bearings, bits of metal, sand, etc.) and add it to the next version of our device in the Iteration phase.

Device tipping when pressed.

# Finding 5: Unsatisfactory Pain Response Options
(Medium Severity)

Finding

The "How tolerable is your pain right now?" question is intended to understand the patient's level of pain at the moment. We learned early in the project from our sponsors that using a number system ("How bad is your pain, on a scale from 1 to 10?") is ineffective when comparing pain levels due to subjective perspectives on pain. Consequentially, we opted to use emotive faces for our scale and we limited users to three options, both due to screen size constraints and to keep the interaction simple.

Our sponsor and four participants (P1, P4, P5, P6) were unsatisfied with the happy, neutral, and unhappy face options to answer the pain question. They desired more granularity to choose from. Our sponsor commented on how a post-operative user likely would not be using the happy button often. P4 specifically noted that he would prefer text options over faces.

Design Recommendation

Create a new response option for the pain question by adding an additional emotive face to the scale. The new face should be added between the neutral face and the unhappy face to create an semi-sad option. We believe the extra face should fill in space on the negative side as positive pain responses are presumably less common for users following a post-operative pain prescription.
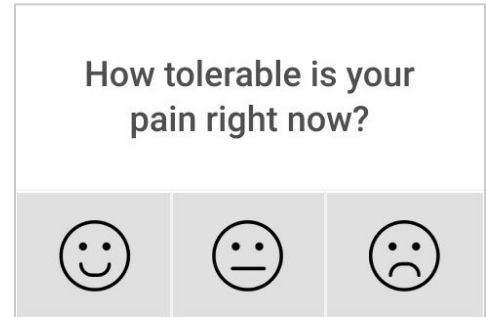
The pain question asked every time a patient requests medication.

Finding 6: Slow Pill Dispensing Time (Low Severity)

Finding

Two participants (P3 and P5) commented on how long it took the device to dispense pills once requested. Specifically, the device takes about three seconds per pill, meaning that users would need to wait nine seconds for their pills if choosing the maximum of three pills. This wait time could be unacceptable for a user seeking pain relief as soon as possible.

Design Recommendation

Decrease the time it takes for the device to dispense pills. After the conclusion of our last participant session, we modified one variable in the code and reduced the time per pill down to half a second, meaning that the device now takes 1.5 seconds to dispense three pills. We still need to stress test this quicker speed to guarantee that the device will dispense without fail, but this issue is a simple fix.
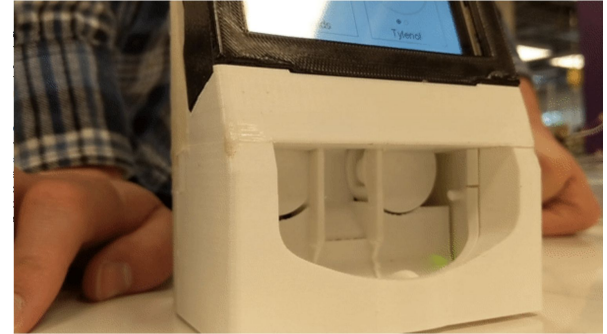
Device slowly dispensing pills.

# Finding 7: Unclear Pain Question (Low Severity)

Finding

Our sponsor, P4, and P6 all voiced their opinion that the pain question could be worded differently. In the version of our prototype we evaluated, we had the question phrased as "How tolerable is your pain right now?" in order to gather users' pain data. Specifically, these participants mentioned that the word tolerable was something that they more closely associated with mood than physical wellness, and our sponsor and P6 (all from a medical background) noted that tolerability is subjective.

Design Recommendation

Given enough time, we would recommend conducting additional research to evaluate the effectiveness of similar questions:

- "How bad is your pain right now?"
- "How is your pain right now?"
- Etcetera

As we do not have the time to conduct such research, our recommendation for the Iteration phase is to change the question to "How bad is your pain right now?" which seemed to be the best option for now based on discussion with our sponsors.

How tolerable is your pain right now?
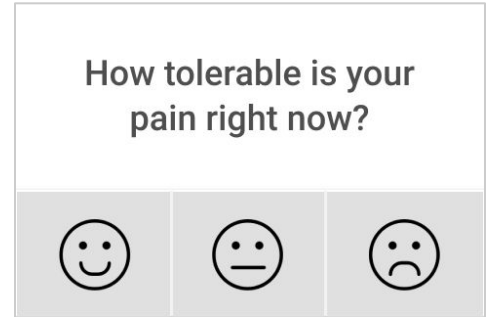
The pain question asked every time a patient requests medication.

Companion App

# Finding 8: Context Wanted for Weaning Graph
(Medium Severity)

Finding

This graph represents a user's progress towards weaning off of their opioid medication, where individual data points represent dose actions as reported by the device. The color scale represents the user's current progress trend relative to expectations according to their prescription. For example, a user in the green successfully weans off of opioids in the first few days, while a user in the red is not weaning off their prescription as quickly as they should be, which may merit a call from the doctor.

When we walked participants through the app, we asked their opinion about this graph and if they understood it or what could be added or change to improve it. Three participants (P1, P3, P4) wanted more context for the information displayed in the graph, such as an appropriate y-axis label, explanations for the colors, and context for the graph as a whole.

Design Recommendation

Update the weaning graph to have context and labels for the y-axis and colors.
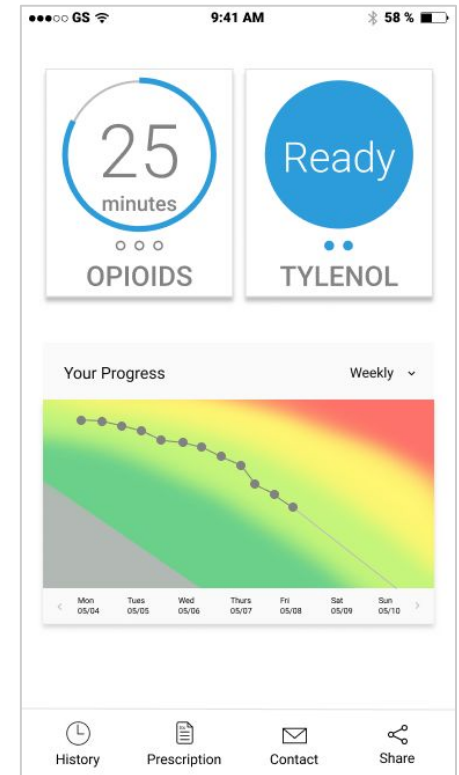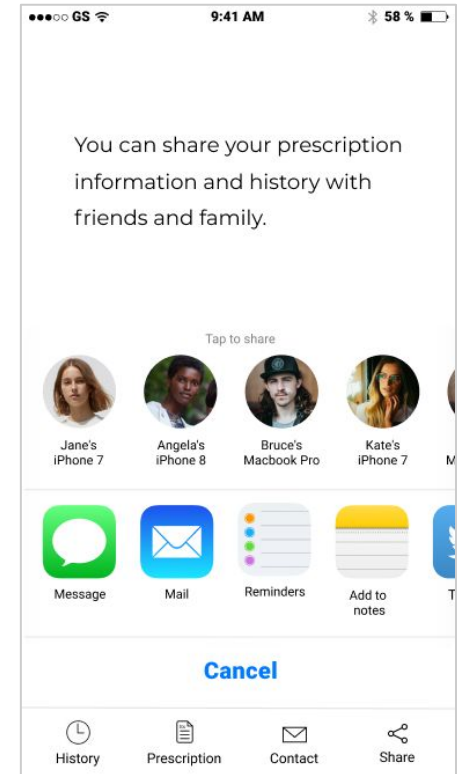

History Screen of Companion App.

Finding 9: Visual Clarity Wanted for App Hierarchy
(Medium Severity)

Finding

The wireframes for the Companion App were designed with minimal aesthetics to keep the focus on the content during usability testing. During the companion app walkthrough, one participant (P5) commented on the design as a whole and mentioned that the app did not use enough color or shading to create hierarchy. He specifically commented on how the cancel button blended in with the rest of the Share screen (as pictured at right).

Design Recommendation

Update the aesthetic of the Companion App to provide more a defined visual hierarchy.

Share Screen of Companion App.

Design Recommendations Recap

Device

1. Adjust software to only display current pain question at most once per 15 minutes.
2. Redesign pill cup to be larger and smoother for easier retrieval.
3. Make a printed Quick Start Guide to help clarify the device's affordances and use for first-time users.
4. Add weight to the device to prevent tilting and tipping.
5. Add an additional emotive face to the pain question response options.
6. Decrease the time it takes for the device to dispense pills.
7. Change the pain question to ask how bad pain is, rather than how tolerable it is.

Companion App

1. Add y-axis label and context to the weaning progress graph.
2. Update the app aesthetic to better convey hierarchy.

Moving Forward

Process Overview

In Phase 1, we turned conceptual ideas into concrete artifacts so systems can be built and tested.

In Phase 2, we created a 3D and 2D Prototype for the PCA device, the device interface, and the companion app using 3D printing, physical computing, and digital interactive wireframes.

In Phase 3, we evaluated and analyzed our PCA device and companion app through usability evaluations with participants.

In Phase 4, we will Iterate on our design by utilizing what we have learned from all previous steps in this process.
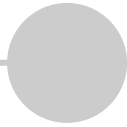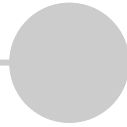
The Final Phase

Milestone 1
Design
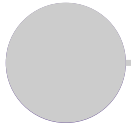
Pill Box
Companion App

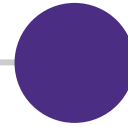**Milestone 2**
Prototype

Physical Computing
Interactive Demo

Milestone 3
Evaluation

Usability Testing
Data Analysis

Milestone 4
Iteration

Pill Box 2.0
Updated Companion App