

# **MATH Outside the Box**

*Children's Math challenges grounded in real world applications*

## **Team**

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David Young - Design

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## Problem

For many elementary school children, learning math is about sitting in classrooms and doing sheets of questions, and consequently math becomes their least favorite subject.

## Solution

Through interactive and dynamic challenges in the real world, Math Outside the Box introduces children to the fun and practical aspects of math. With our application, children engage math as an interesting and useful tool when exploring their surroundings and themselves.



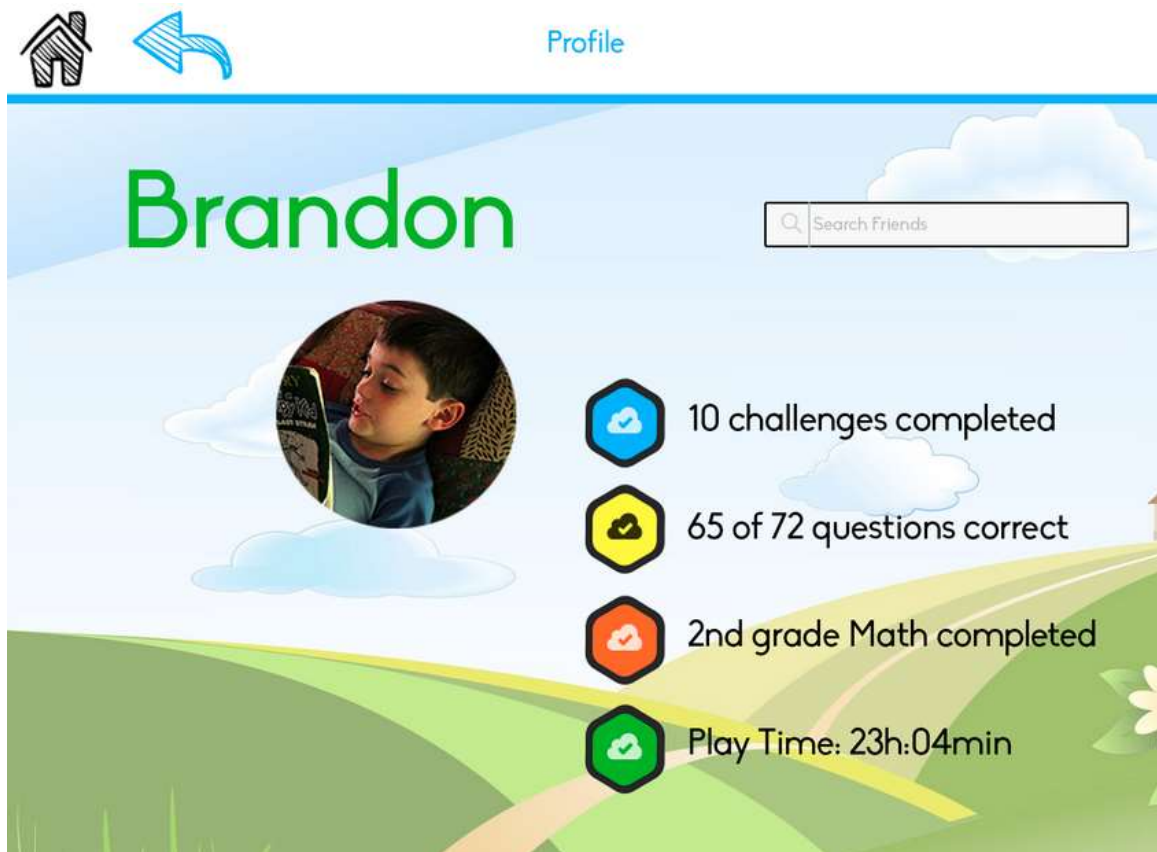
The landing page of the app which allows the user to choose between three tasks, do challenges, view profile and view progress. The challenge task brings the user to one of the practical Math challenges we have designed and implemented.

## TASKS

On the landing page of the app, the user is given an option to choose one of the following three tasks:

- **Profile – simple task.**

This task is simple as it involves the child viewing their profile which is one page showing the number of challenges completed, number of hours played, solution accuracy, and what level of Math they have worked on. The child may also search for friends and view friends' profiles. We chose to include this task because during testing, the children got very excited about seeing how they and other children were doing on the challenges.



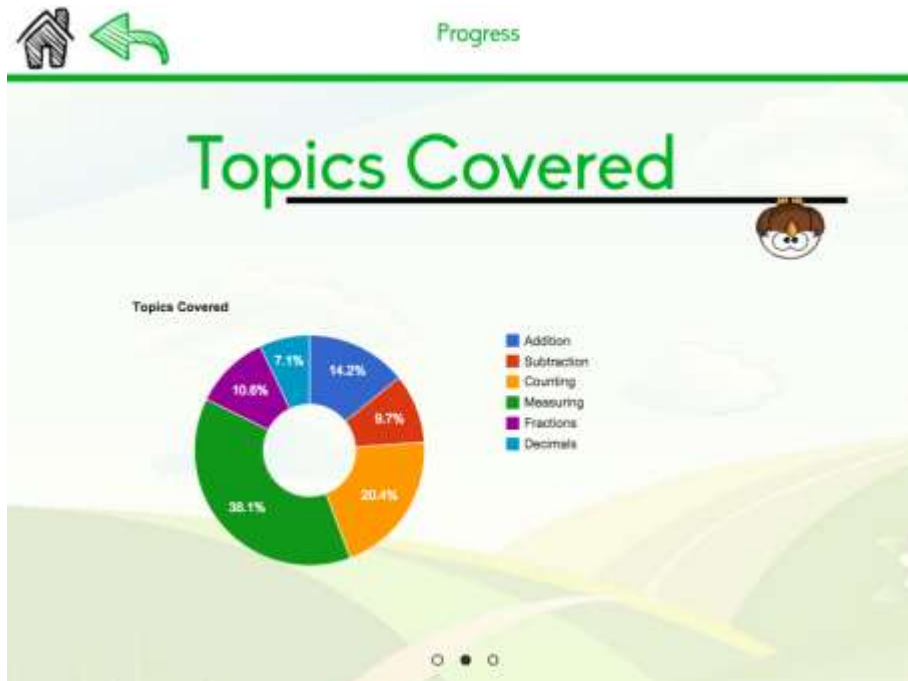
The profile of one student, Brandon.

- **Progress – medium task.**

This task is medium as it involves the parent viewing and interpreting (and very likely acting upon) charts showing how their child is doing. We chose to include this task because during parent testing, multiple parents mentioned that their preferred applications for their kids were those that gave parent feedback.



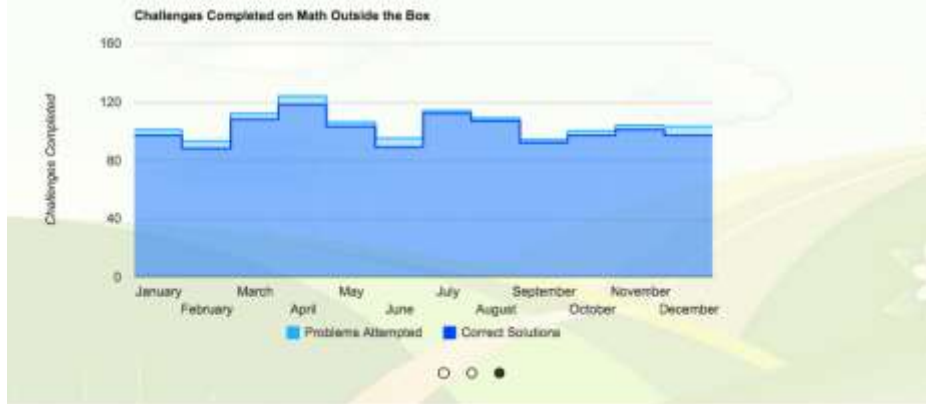
The first of three pages in the progress Task, this page shows how many hours the app was used each week



The second of three pages in the progress Task, this page shows the topics covered while using the app



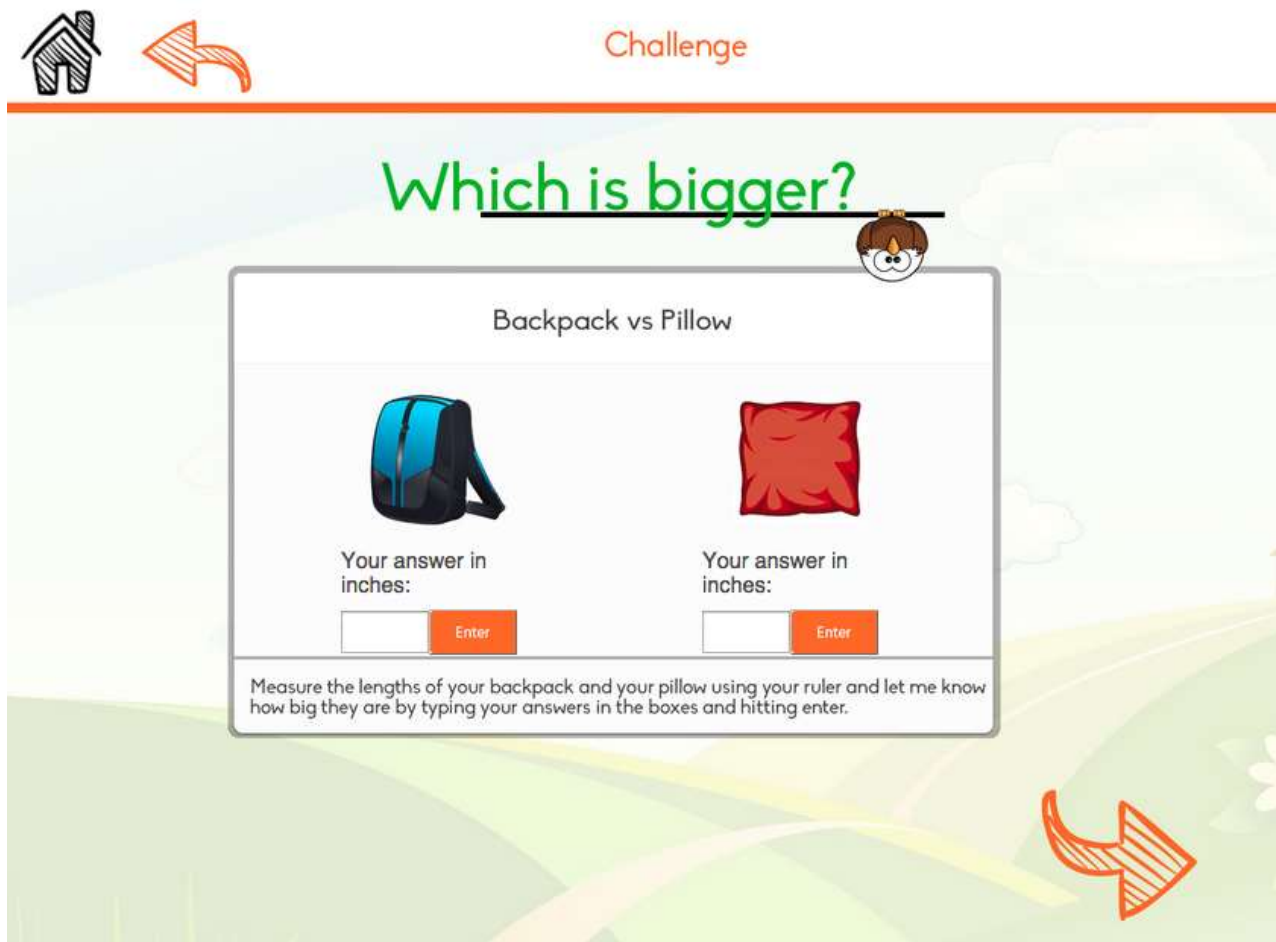
# Solution Accuracy



The third of three pages in the progress Task, this page shows the accuracy of the child's solutions each week.

- **Math challenge – complex task**

This task is complex as it requires children to do a practical challenge, then to mathematically apply the results of that practical challenge. In the single challenge that has been implemented, the practical aspect is the measurement of various objects around the house, and the mathematical aspect is using these measurements to decide which object is bigger. This task is really central to the application, and we designed it to be simple, straightforward, and active, based on feedback we received during testing.



The first of three pages in the implemented challenge



## Challenge

# Which is bigger?



### Pencil vs TV



Your answer in  
inches:

Enter



Your answer in  
inches:

Enter

Measure the lengths of your pencil and your TV using your ruler and let me know how big they are by typing your answers in the boxes and hitting enter.

The second of three pages in the implemented challenge



## Challenge

# Which is bigger?



### iPhone vs iPad



Your answer in inches:

Your answer in inches:

Measure the lengths of your iPad and your iPhone using your ruler and let me know how big they are by typing your answers in the boxes and hitting enter.



The third of three pages in the implemented challenge



## MAJOR USABILITY PROBLEMS ADDRESSED

### 1. Problem

*[H2-4 Consistency and standards] [Severity: 3]*

*During the challenge tutorial, there are two buttons that say 'I want to know my speed', back-to-back. Having both of these buttons can confuse the user, as they may not understand why they have to do the same thing twice. Maybe the change the name of the first button and make it say something that can lead into the next screen.*

*[H2-4 consistency and standards][Severity 3]*

*The 'I'm not sure' button for the speed challenge covers simple division sometimes and long division at other times. That can be confusing. Maybe, after showing users how to find the speed with simple division, have a button allowing them to see a tutorial on doing long division.*

*[H2-2 Match between system and the real world][Severity 4 ]*

*The lesson doesn't really follow the format of how a child would solve a similar problem in the real world. For example, the problem (  $x/y$  ) is set up for them and all they have to do is the division. The help button gives all of the steps without explaining each step as a child may need in the real world. It makes more sense for the lesson to make them setup the problem, and if they need help to give them step-by-step help.*

### 1. Solution

These problems were specific to the speed challenge, which we have decided not to implement. After user testing, research on similar apps, and building the med-fi, we recognized that within our time constraints, we needed to design simpler challenges. The speed challenge presented too many complications especially in explaining the challenge during testing. Therefore, like most other Math apps, we decided to target younger kids (grades 1-2) with challenges focused on measurement. No visual available for this change since the speed challenge was deleted, rather than updated.

### 2. Problem

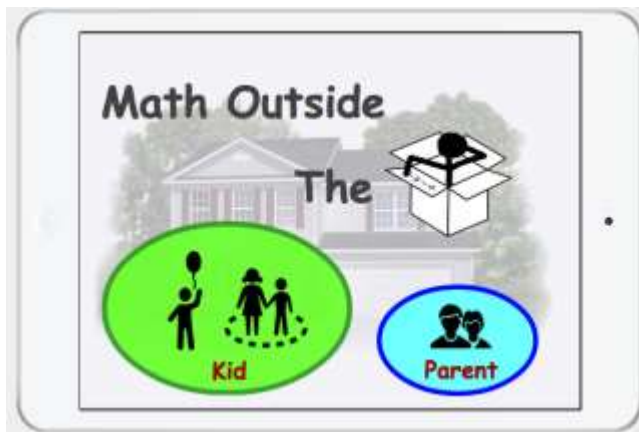
*[H2-1 Visibility of system status][Severity 3 ]*

*Once you click the child or parent button, you can't tell who you are logged in as at the home page. With multiple children and adults using the app on the same device, users may get their profiles mixed up. Insert the name of the user in front of the "Logout" button (i.e. Logout Brandon). Additionally, you are logged in when entering the app but are never asked to log in (perhaps this is just hard-coded because of the prototype). Put a login even if the user and password are already filled out or use iOS digital print to sign in.*

### 2. Solution

We no longer have separate logins for parent and child. There was no reason really, as the parent/child sections didn't contain any information that should not be shared with parent/child. As shown in screenshots below, as opposed to the landing page of the med-fi prototype (left), the landing page of the hi-fi prototype does not include a separate login for

parent vs. child. Instead, they both use the same account, and have access to the same things.



Landing page of Med-fi



Landing page of Hi-fi

### 3. Problem

*[H2-7. Flexibility and efficiency of use][Severity 3 ]*

*The plus and minus signs on lessons are not very intuitive or efficient. Children may not recognize this convention and this may slow down their interaction when trying to switch from one lesson to another. On top of that, whenever I want to start a new challenge on the Challenge list, I need to do 2 clicks. I click to expand the challenge and then click to start. Perhaps switch to a traditional table view style list of lessons or an option to start directly from the list view.*

*[H2-4 Consistency and standards][Severity 3]*

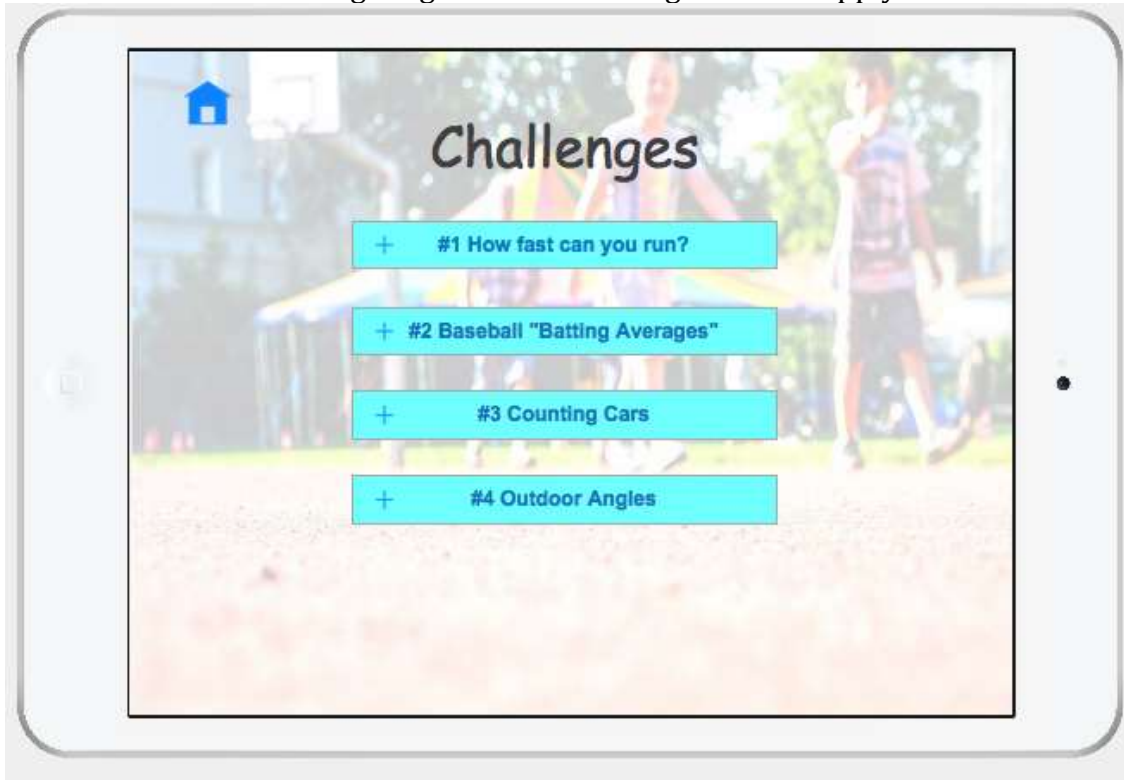
*When you click "Challenge of the Week" from the child home page, multiple lessons appear. It is assumed that the first lesson is the challenge of the week; however, children may not realize this is the lesson they are supposed to do and instead incorrectly click another lesson*

*[H2-7: Efficiency of Use] [Severity 3]*

*The button "Do another challenge" takes me to the home and not challenge list. Take the user to the list of challenges.*

### 3. Solution

While the challenge list had been present in the med-fi prototype, only one challenge had been implemented, therefore Challenges #2, #3 and #4 (as shown below) were not clickable. Since we also only implemented one challenge in the hi-fi prototype, and we did not want to have a bunch of unclickable links, we decided not to implement a challenge list in this prototype. Therefore, unfortunately, the heuristics having to do with a challenge list and navigating between challenges did not apply.



Screenshot of the challenge list from med-fi prototype. This feature was not implemented in the high-fi prototype.

### 4. Problem

*[H2-8 Aesthetic and minimalist design][Severity 4]*

*Within the actual lessons, multiple background images and a variety of color schemes distract from the overall purpose of the app. Specifically, changes in the color of the instruction "bubbles" may confuse users. Instead use color for accent and purpose instead of making everything really colorful.*

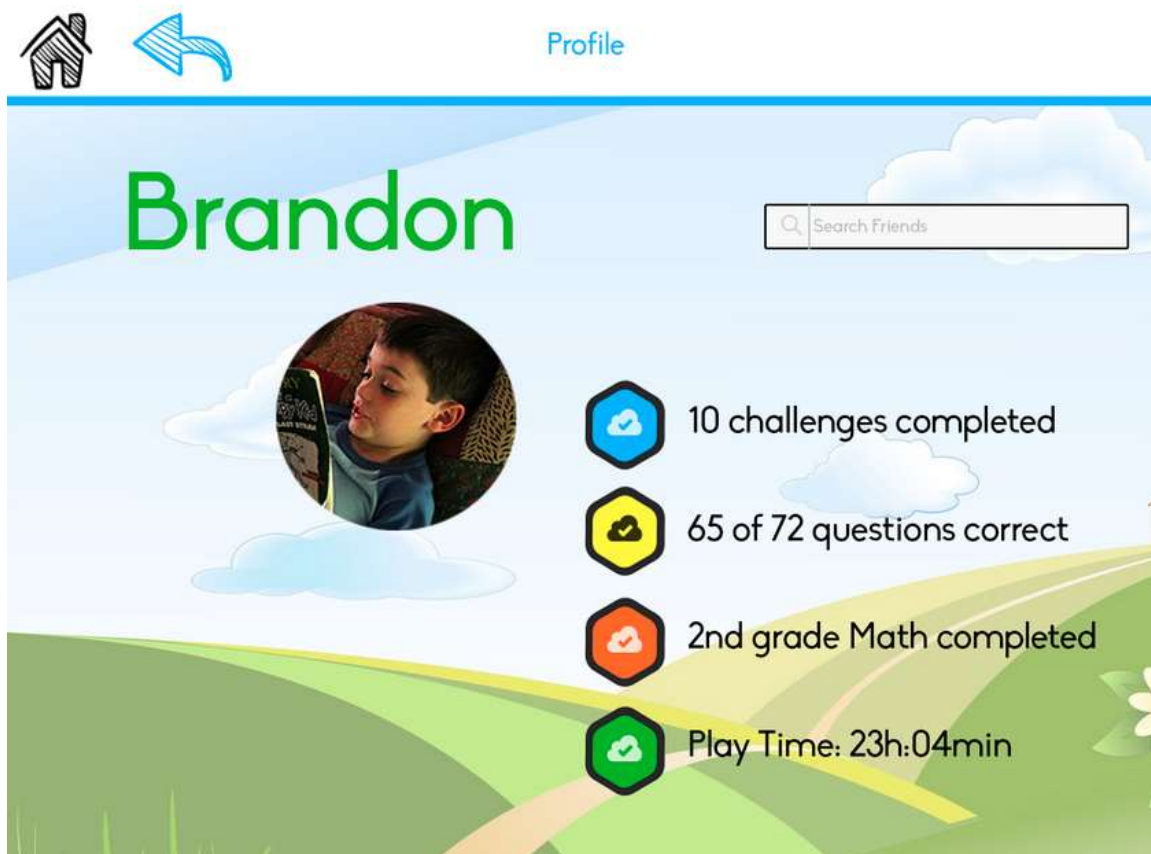
### 4. Solution

When we implemented the med-fi, we did not really have a colour scheme in mind. We have come up with a colour scheme, shown below, and used that for the high-fi. However, note that colour is still a main feature and not just used for 'accent'. We

decided to keep the app colourful as that was a pattern we saw with other apps for kids on the market, and also because during testing, the kids tried to colour/draw on the page.



Our colour scheme



See the colour scheme implemented in the landing page

## 5. Problem

*[H2-2. Match between system and the real world][Severity 4 ]*

*Although the app effectively speaks the users' language, the quantity of text does not coincide with the real-world attention span of young children. It feels that the large amount of text pulls the focus away from math and more towards reading and comprehension. Limit the amount of text per instruction to only a couple sentences, and definitely not whole paragraphs. Throughout the lesson, instructions often give a bunch of steps at once, forcing the user to remember information from multiple paragraphs all on one page. Children may forget or get distracted easily, resulting in them not finishing the lesson. Split up tasks into more mini steps that force more interaction between steps so users don't have to recall information. Ask the kid to input the time is too much information. And instead of taking the kid out of the flow to show the stopwatch, the stopwatch could be already accessible in that page.*

## 5. Solution

To have less text, we made challenges simpler, and made sure to only have a small amount of text on each page. Now only one instruction is given at a time and instructions are, on average, one-sentence long. In reference to the stopwatch, we got rid of the toolkit, since that seemed very confusing to kids during testing, and the simpler challenges we decided on did not require it. See below for comparison between the text-heavy challenge page of mid-fi (first image) and the text-light challenge page of the high-fi(second image).



A page explaining part of the original challenge from the med-fi prototype



The third of three pages in the implemented challenge of the hi-fi prototype

## 6. Problem

*[H2-3 User control and freedom][Severity 4 ]*

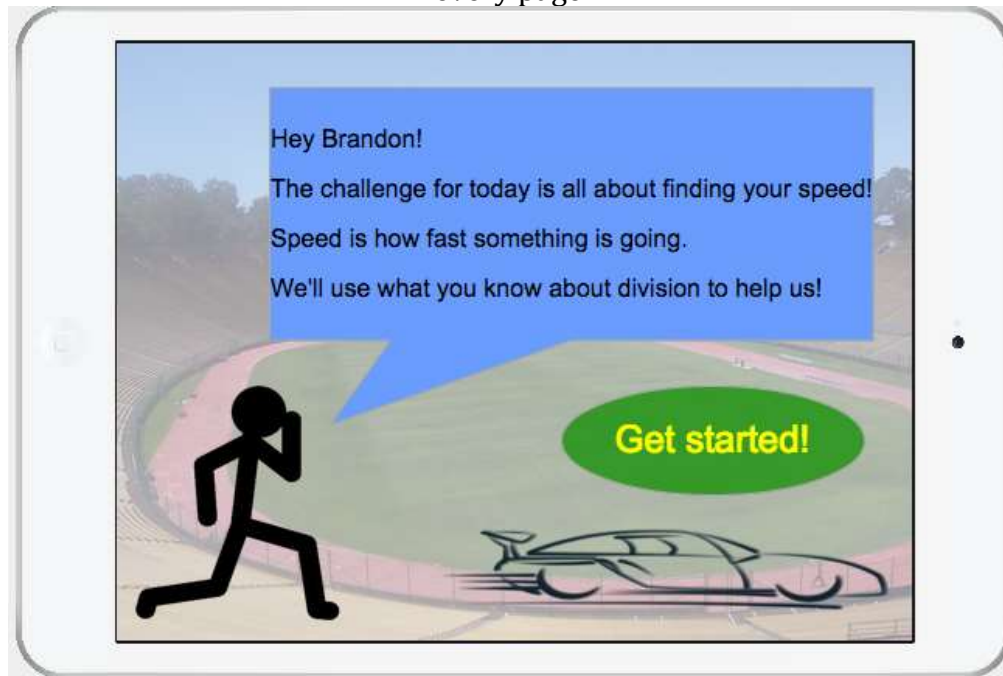
*Throughout the app, backwards navigation is frequently missing and sometimes hard to find. Specifically, there is no back button between steps in the tutorial and no back button on parent home page. A large consistent convention for a back button would decrease the chance of users making a mistake and getting lost. For instance, if the user enters the system as a parent and "Check out this week challenge", I can go back to my main page leading to user frustration. On top of that, there is no backwards navigation once a user is at the child home page or the parent homepage. The logout button from child home page should go back to where they can log in as parent or as a child.*

## 6. Solution

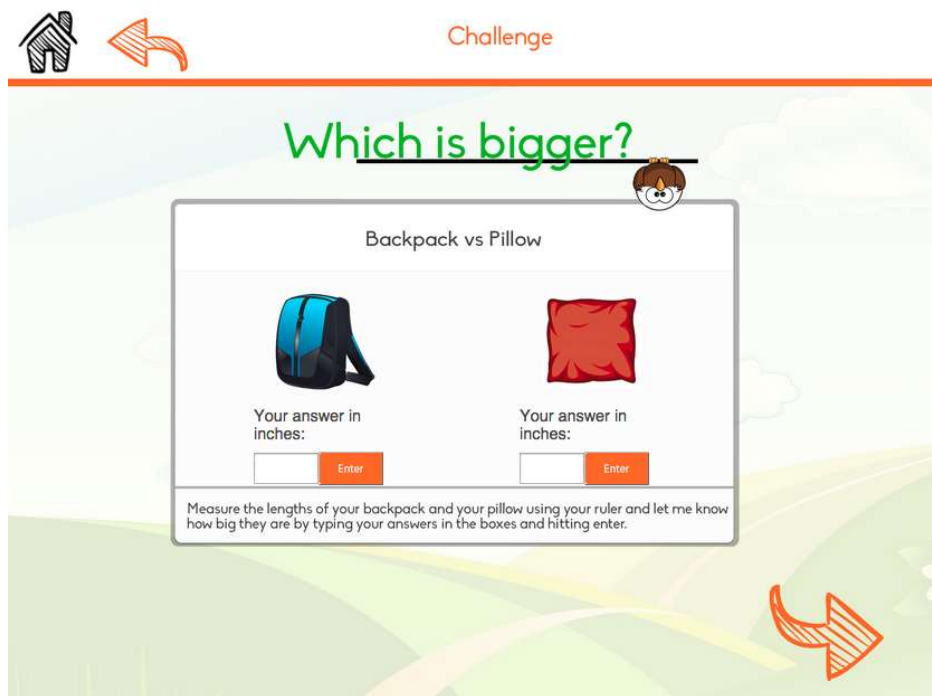
The logout button no longer exists as both parents and children now use the same account. In terms of logging in and out of the actual app, that has not been implemented yet.



However, we did take this suggestion very seriously and implemented both back buttons and home buttons on all pages of the high-fi, as we agree that freedom to navigate within the app is very important. See below for comparison between the mid-fi (first image) that has no back buttons and the high-fi(second image) which has a back and home button on every page.



A page explaining part of the original challenge from the med-fi prototype



The first of three pages in the implemented challenge of the hi-fi prototype

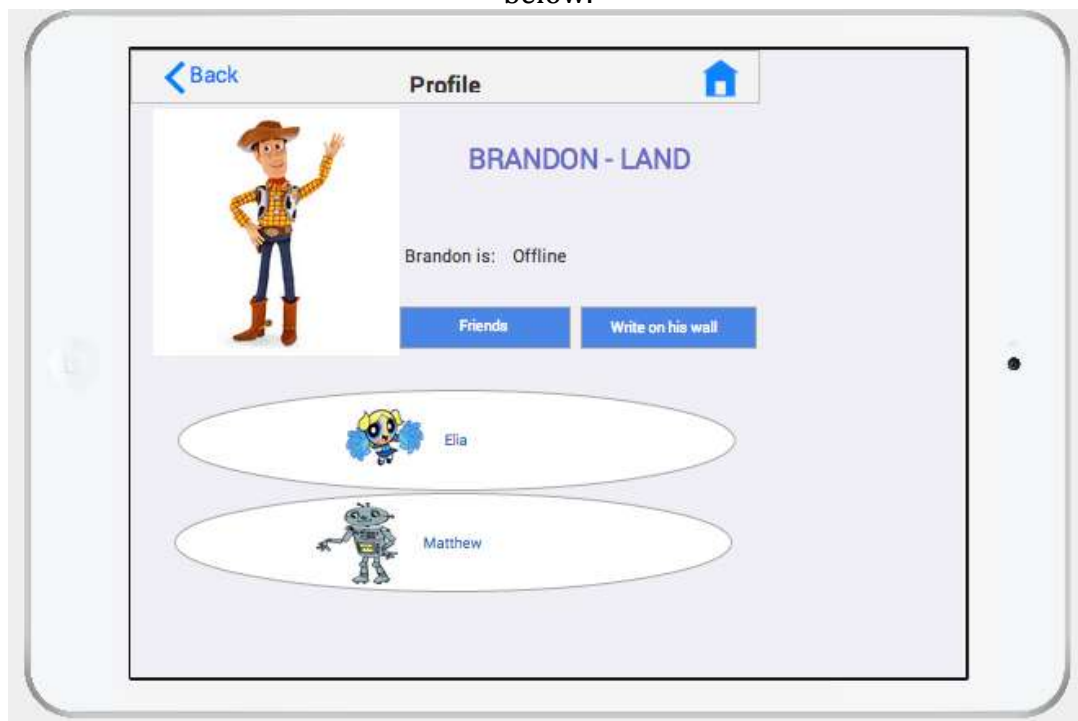
## 7. Problem

*[H2-4 Consistency and standards][Severity 3 ]*

*On the user's profile page, "friends" looks like a button, but it is very unclear what it does. User's may think that this is an action to "Friend" that individual instead of a way to see that individual's friends. Perhaps add more text to the button to clear up any confusion (i.e. "See Brandon's Friends"). And there are inconsistencies on the profiles. For instance, on the profile of Brandon, when I click on Elia it takes me to Elia's profile while when I click in Matthew it takes me to the chat screen.*

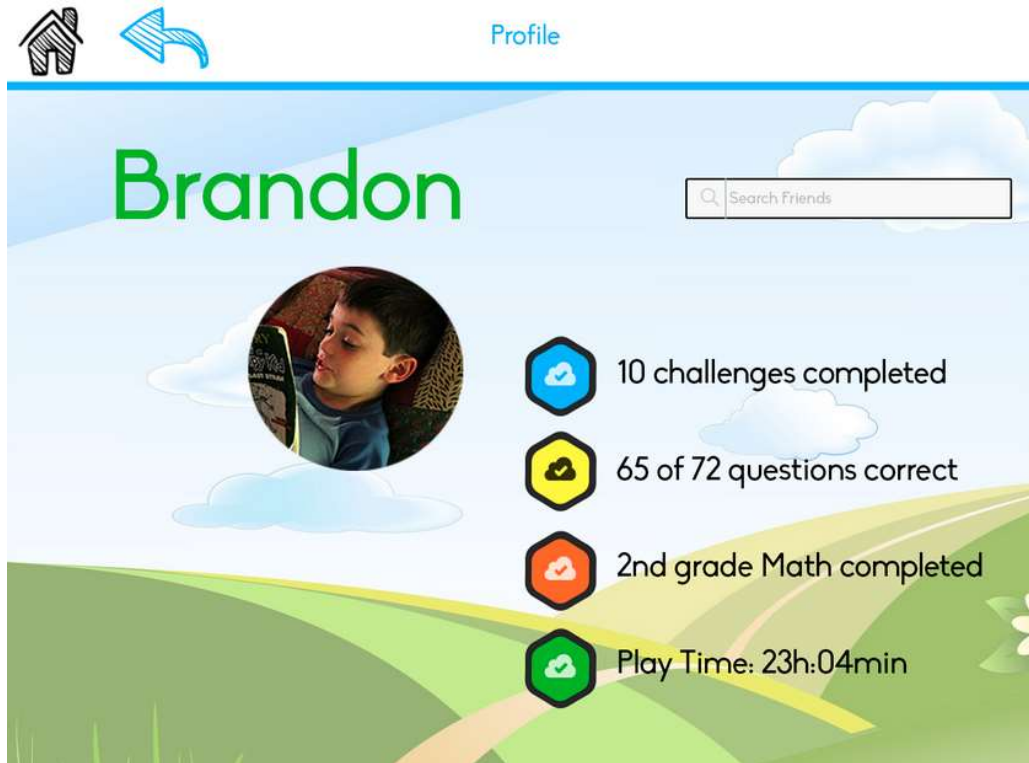
## 7. Solution

The social aspect has been dramatically reduced from the med-fi to the high-fi. In the med-fi, the social aspect included posting on your friend's walls, adding friends, and comparing yourself to your friends. Now the social aspect is simply a profile page of the user as well as an option to search for 'friends', that is, to see the profiles of other users of the app. Note the changes in the profile page from med-fi (first image) to hi-fi (second image) as shown below.



The profile of one student, Brandon, in the med-fi prototype.





The profile of one student, Brandon, in the hi-fi prototype.

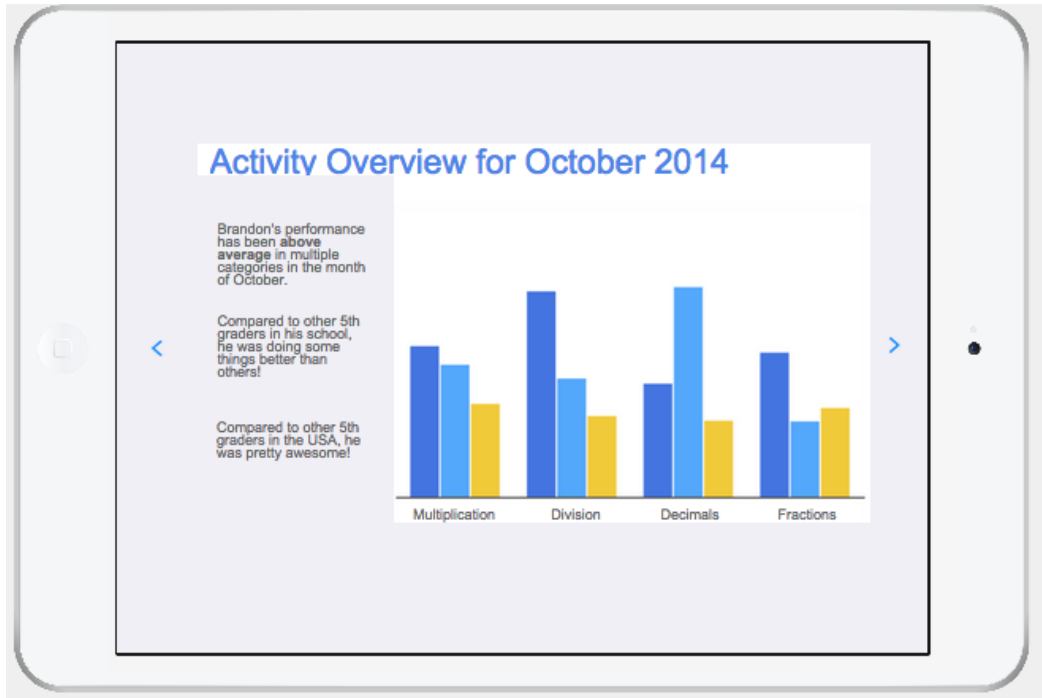
## 8. Problem

*[H2-10. Help and documentation][Severity 5]*

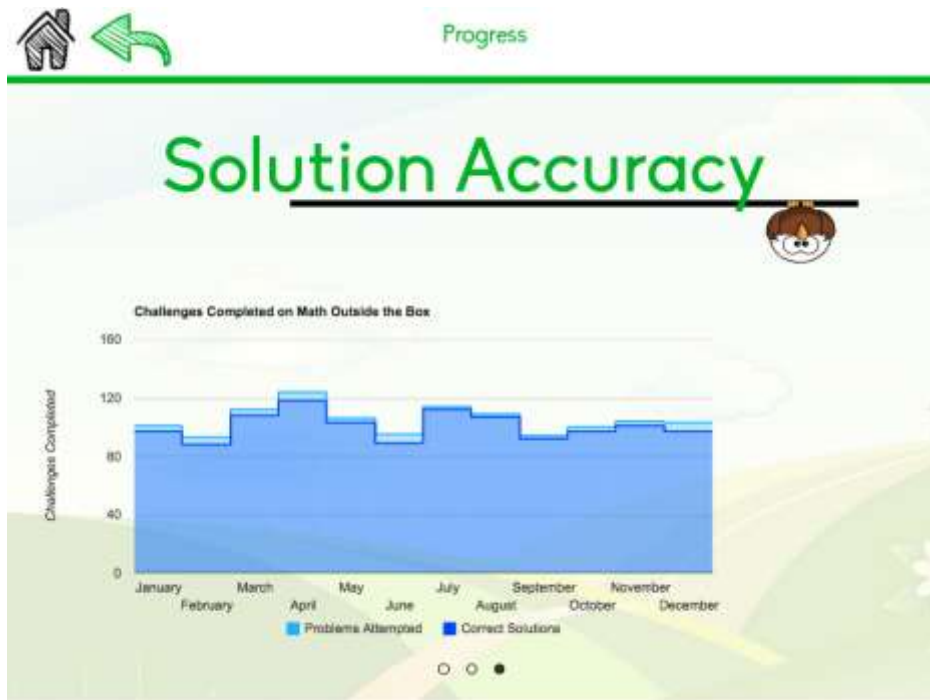
*Within the parent view, what is going on in the graphs is unclear. Parents may not know what lines represent their child, class averages, or national averages. The information here is also not easy to search or quickly digest. It is unclear how performance is measured (there are no numbers). Provide simple, labeled graphs in an easily navigable fashion.*

## 8. Solution

As suggested, we have provided 'simple, labeled graphs in an easily navigable fashion'. In fact, the graphs had not been fully implemented in the med-fi, so we totally agreed with this suggestion. Note the changes in the graphs from med-fi (first image) to hi-fi (second image) as shown below. In addition, the graphs of the hi-fi are interactive.



Graph from the med-fi prototype showing activity overview of a child.



Graph from the hi-fi prototype showing activity overview and in particular, solution accuracy, of a child.

## 9. Problem

*[H2-8: Minimalist Design] [Severity 3]*

*The challenge top score shows the speed of each kid. But that is not what the app is about. The app is not trying to make kids run faster or practice more exercise. The app is trying to teach math. Put a better metric on the scoreboard like accuracy measuring speed.*

## 9. Solution

We decided to get rid of the challenge top score/leaderboard. This was something we had been debating since testing, when some kids did not like the fact that other kids were 'better' than they were. In the end, we decided morale was key, and so we decided to get rid of the leaderboard. No visual is available for this change since the leaderboard was deleted, rather than updated, but see below for an image of the old leaderboard.



Leaderboard from med-fi prototype

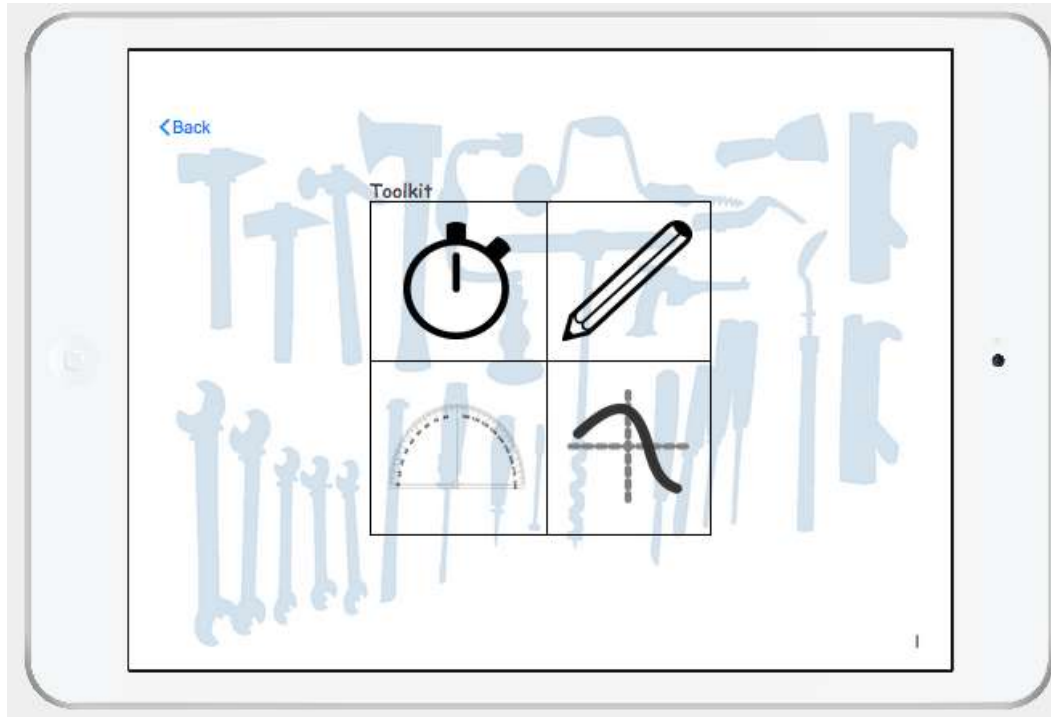
## 10. Problem

*H2-8 Aesthetic and minimalist design] [Severity 4]*

*In the toolbox, the design may be too minimalist. Each icon is slightly unclear as to its function – what does the pencil do? What does the graph do? Add text labels to the icons.*

## 10. Solution

As mentioned before, we got rid of the toolkit, since that seemed very confusing to kids during testing, and the simpler challenges we decided on did not require it. No visual is available for this change since the toolkit was deleted, rather than updated, but see below for an image of the old toolkit. The problem with the graph was also addressed in problem 8 above.



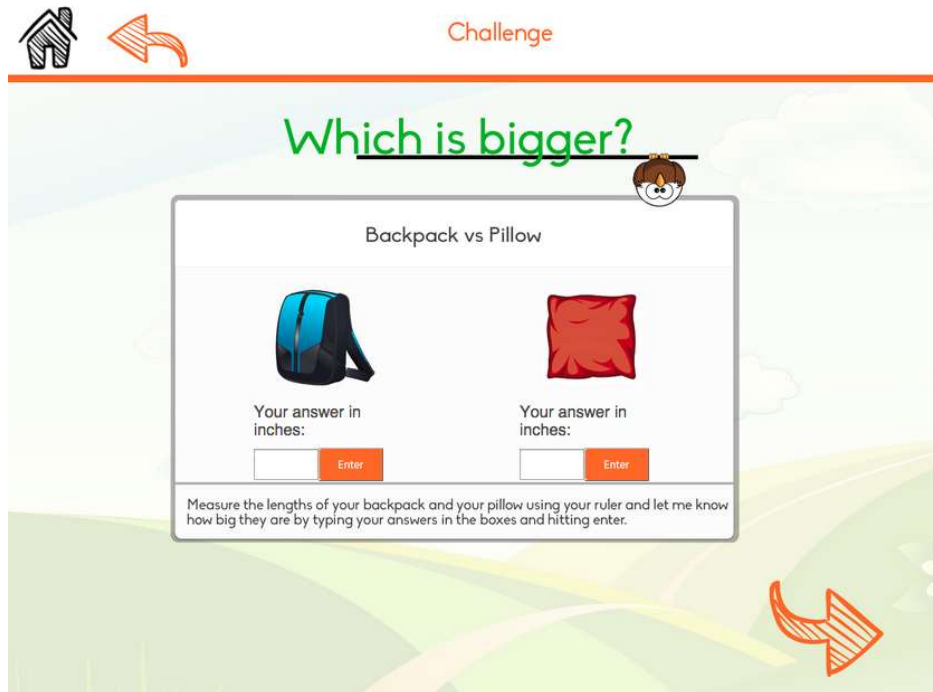
A picture of the toolkit as it was in the med-fi. The toolkit was not included in the hi-fi prototype.

### **Other Changes**

One other key change we made was to change the background image used in the challenges section of the mid-fi to a paler, less distracting image. We also used this image on most other pages of the app, rather than just the challenges. Note the changes in the background image from med-fi (first image) to hi-fi (second image) as shown below.



A page explaining part of the original challenge from the med-fi prototype



The first of three pages in the implemented challenge of the hi-fi prototype

## DESIGN EVOLUTION

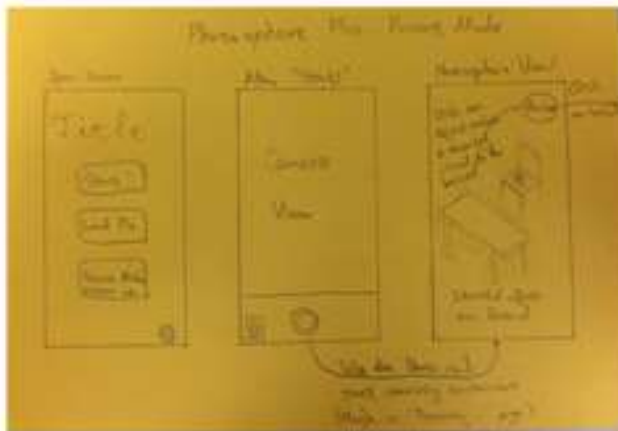
### Original Sketches

Originally we had a range of conflicting ideas for how we could make Math challenges practical and fun. Some of these ideas are represented in sketches below:

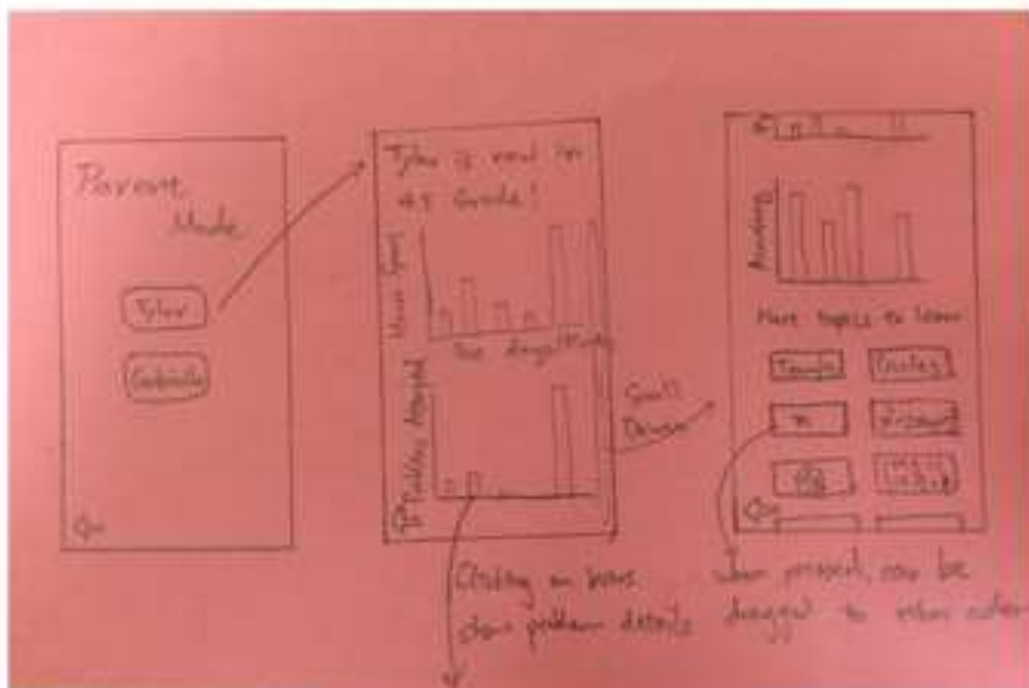


Two different design of the math portal idea (Brad H).

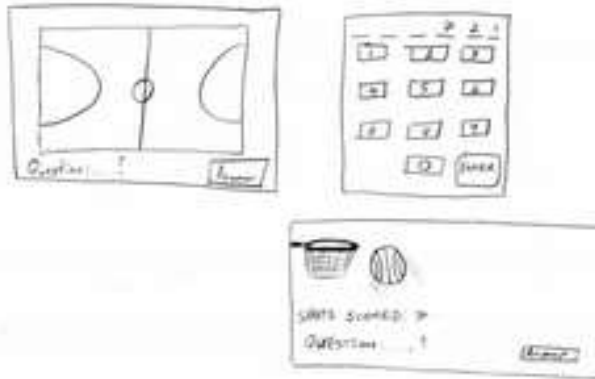
An example of an augmented reality interface (Brad H).



An example of the parent feedback mode (Brad H).



Basketball Theme

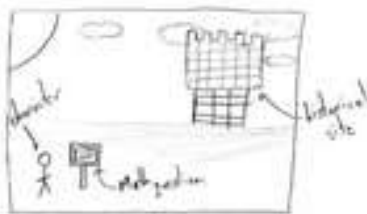


An example of a sports themed question (David Y).

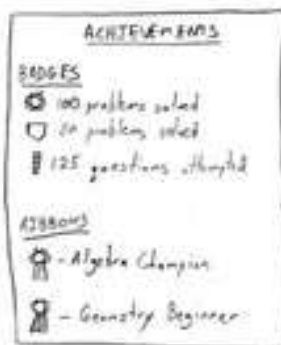


Possible logo (David Y).

I-game examples



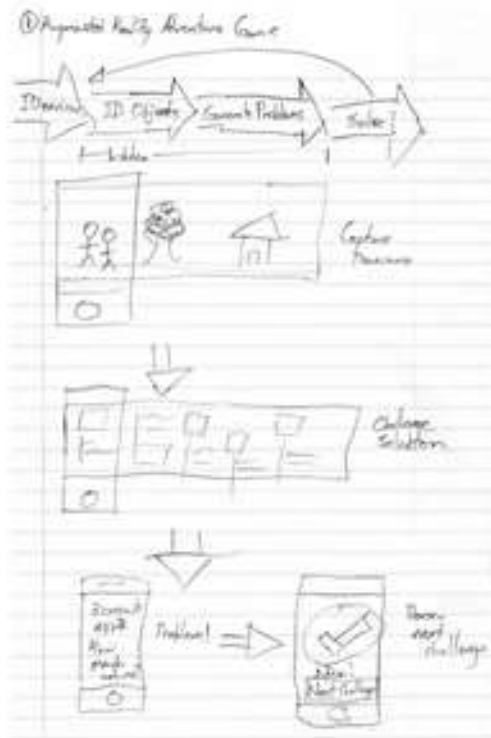
User moves avatar to the sign post and taps it to be prompted with a question about the building.



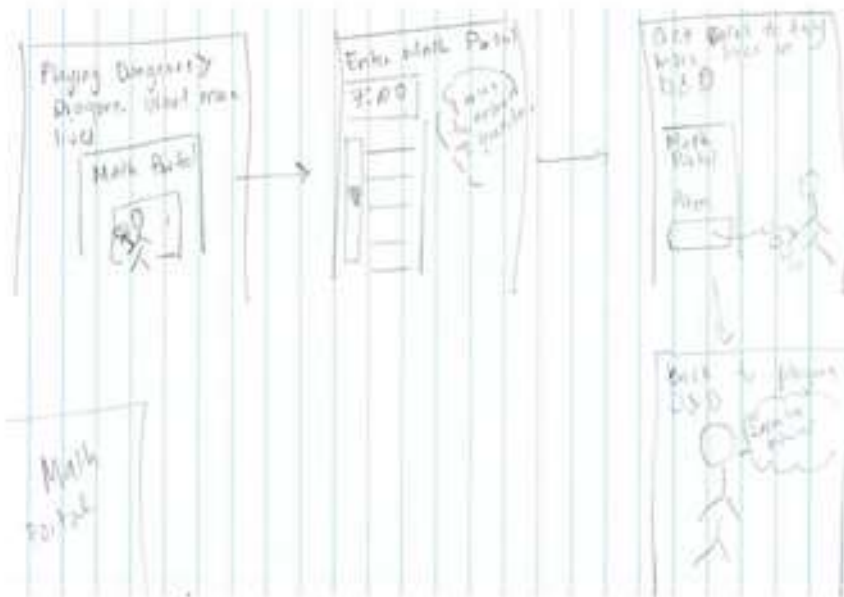
List of achievements

An example of historical themed interface and the badge system as rewards (David Y).



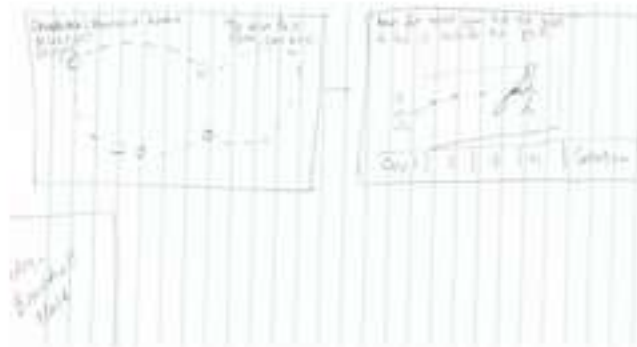


An example of the augmented reality system (Charles Y).

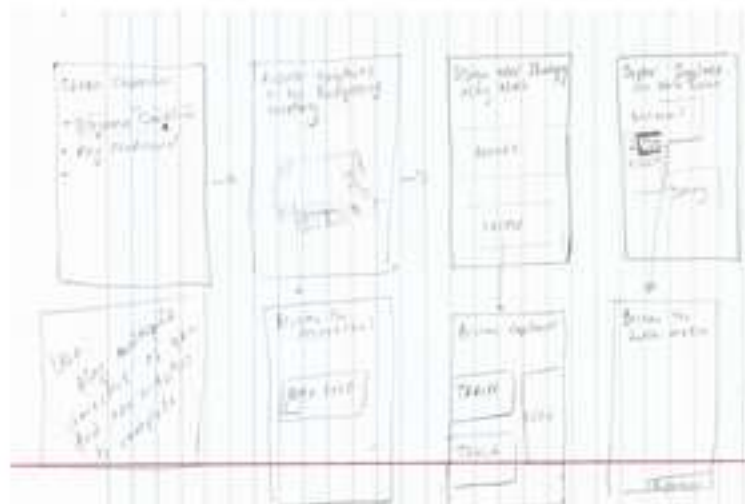


Another example of the math portal design (Ashlee R).

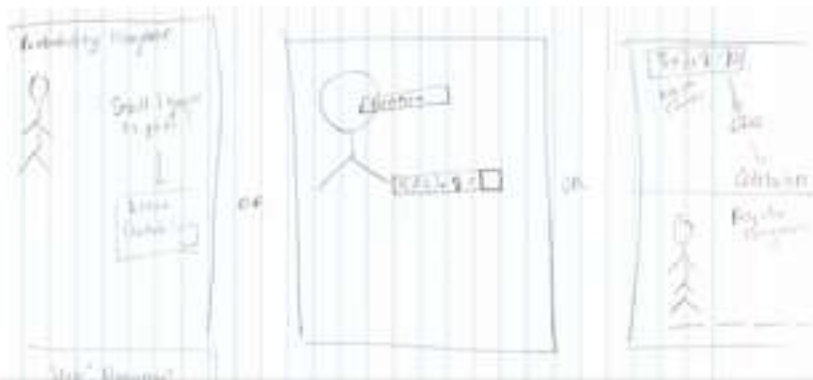
An example of a basketball related question (Ashlee R).



Historical game in which the user selects different characters as themselves (Ashlee R).



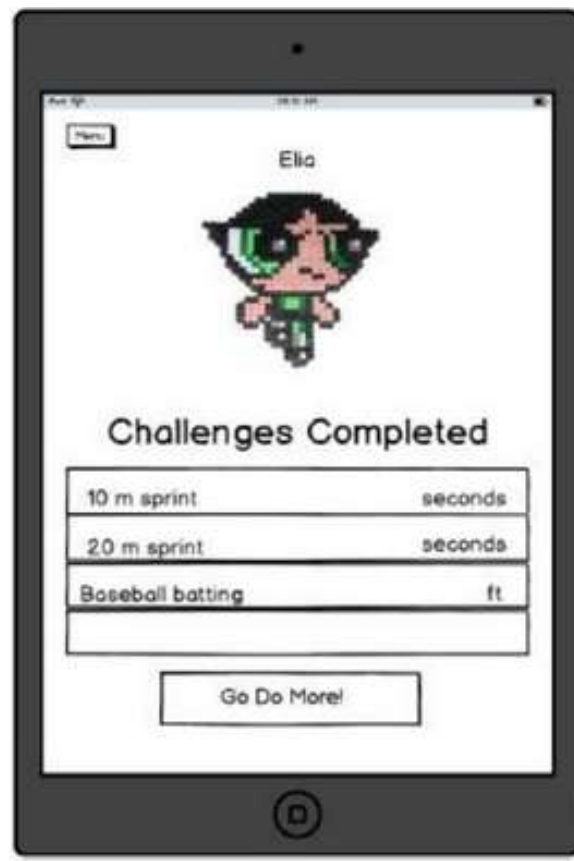
A hangman game using math questions (Ashlee R).



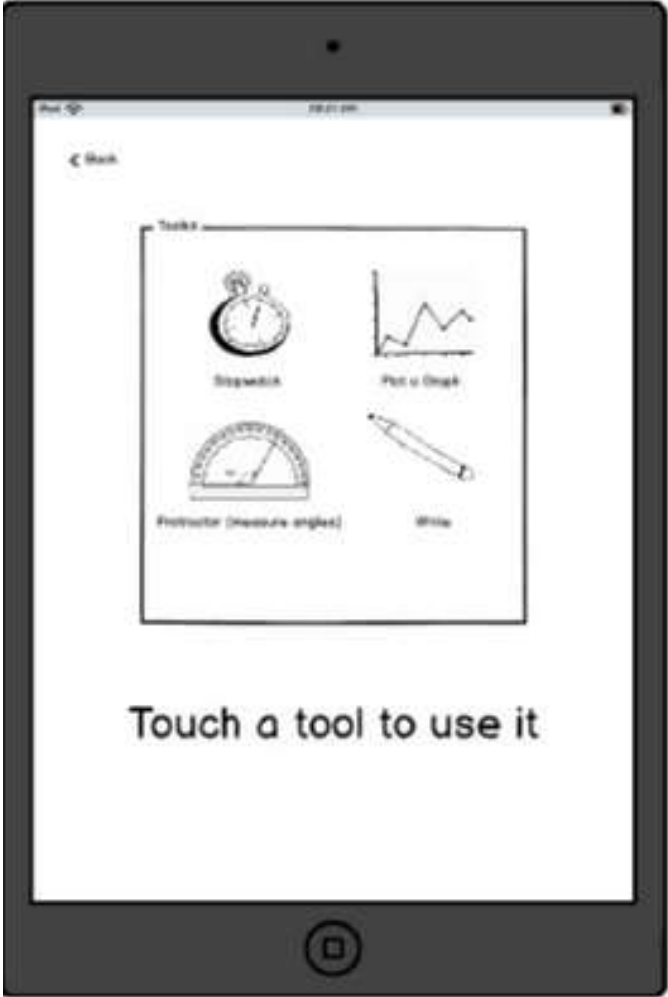
In reference to sketches above, the math portal idea required interaction with another app, and so was not possible. The augmented reality idea was too complicated to implement in the time we had. We decided against the historical interface (and thus the name Zero.A.D) because we couldn't find a good reason for making this Math game historical, and overcomplicating it. In terms of sports-related games, we also decided against that for our initial implication since we want our app to be about practical Math, not physical Math, and we want everyone to be able to get involved. We decided against the hangman game for much the same reasons we decided against the historical interface. So of the initial designs, we kept one thing – the parent feedback – because parents insisted on it during user testing.

We were left with the challenge of finding a practical, not-extremely-physical challenge that was simple enough to be completed by kids on their own. We decided to do a speed challenge (which in the end, turned out to also be too physical and competitive), and in fact we implemented this in the low-fi. Images of some screens from the low-fi prototype can be seen below.

### Low-fi Prototype



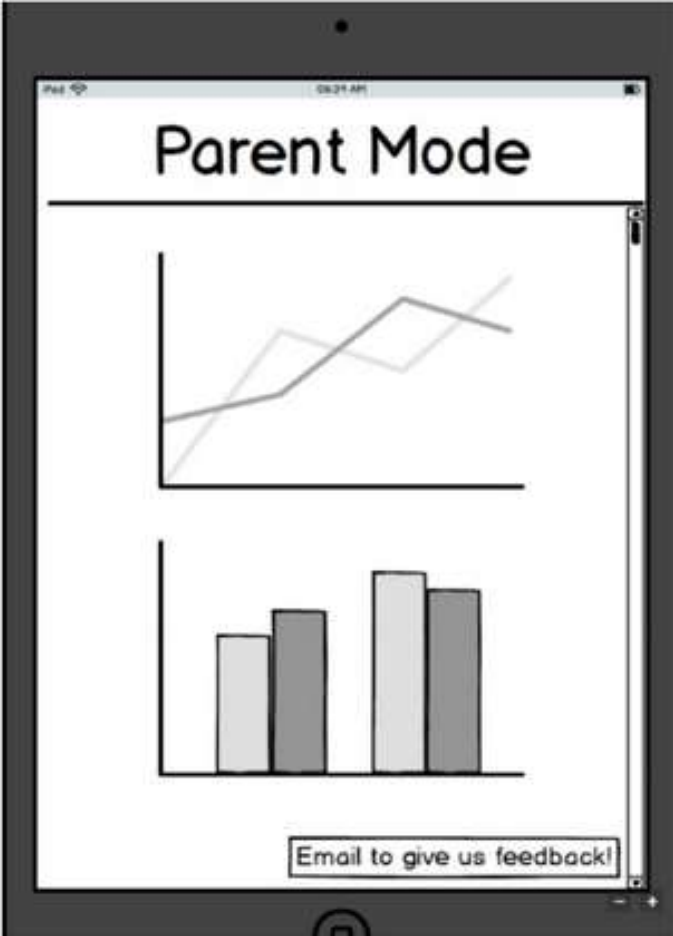
Profile Page from Low-fi Prototype



Toolkit from Low-fi Prototype



All screen from low-fi



Parent Mode from Low-fi Prototype



Leaderboard from Low-fi



First step of Challenge from low-fi

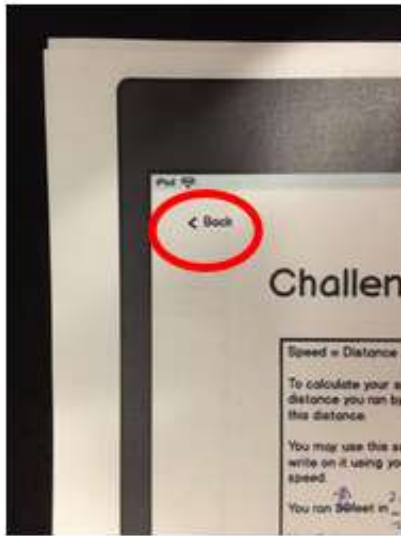
### **Low-fi to Med-fi prototype**

We made four major revisions to our from low-fi to med-fi interface (Note that this section was taken from the previous med-fi write up):

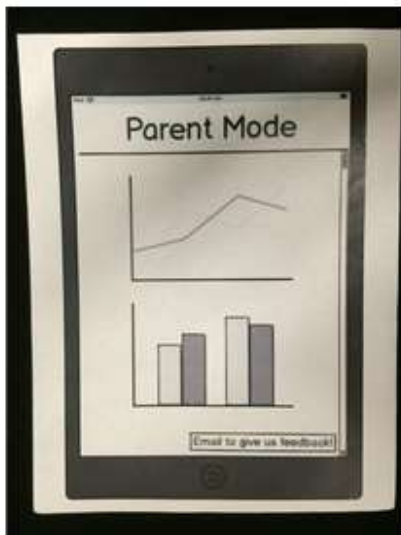
- Buttons – During testing, the kids did not use the back button and had problems figuring out how to go back. So, we made the button bigger and more obvious. The



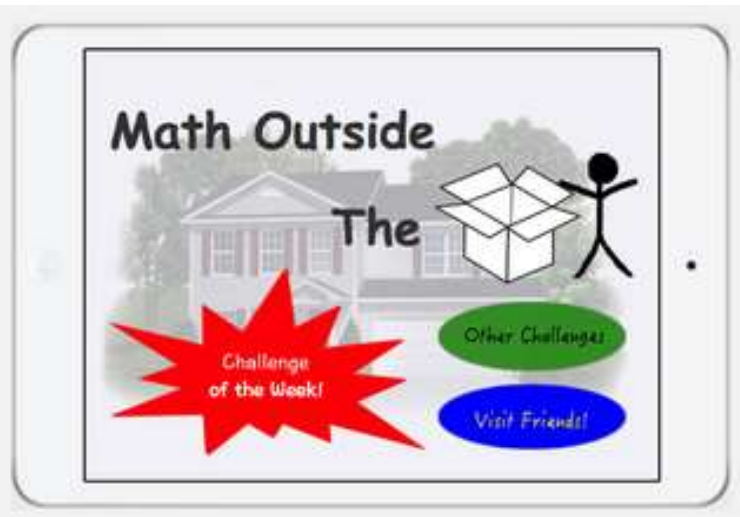
revised version is on the left below.



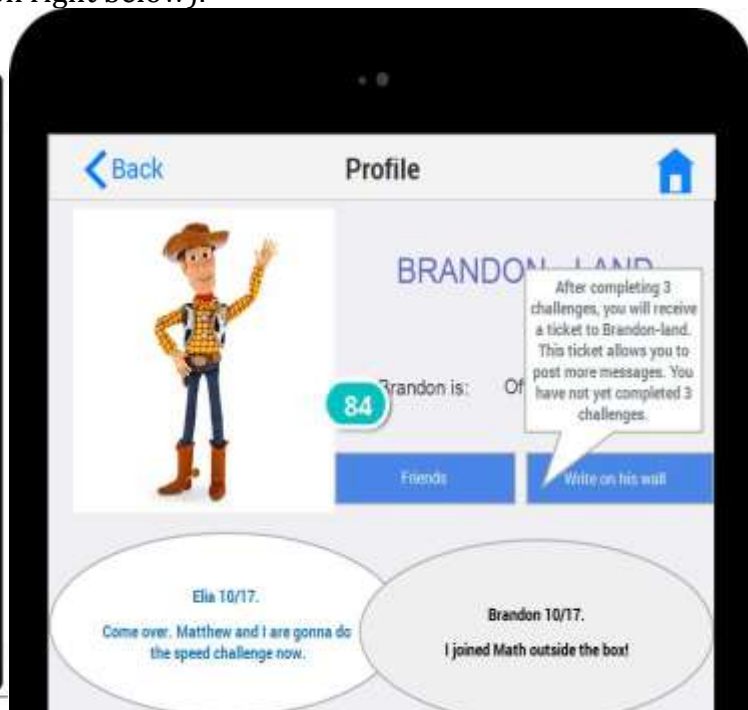
- Parent Control – The Parent Portal before had a few graphs that were not very informative (See picture below on the left). However, the main realization from testing was that most parents have multiple children that would use an app like this. We made improvements so that each parent can access feedback on multiple children and this feedback is much more informative (See picture below on the right).



- Menu – Previously, the menu was a list of options that appeared on the side of the pages (as shown on the left below). The kids during testing mentioned that it was boring, and 'didn't do anything'. We also noticed that it was a bit hard for the kids to find the menu. So we made the menu bigger, brighter and with more shapes and interesting figures (as shown on the right below).



Social Aspect – Previously, the social aspect was a small part of the application and not considered a task of its own. During testing, we noticed that the kids were very excited about the social aspect, and one child repeatedly asked for ‘a ticket to Matthewland’. We recognized that the social aspect could become an interesting task of its own and these ‘tickets’ to the social part of the application could be used to motivate children. Therefore where there were previously only profile pages (seen on left below), the social aspect of the application now includes the ability to post on friends’ walls and add friends. However kids can only do so after completing a certain number of challenges, and receiving the ‘ticket’ to the land of their friends (seen on right below).



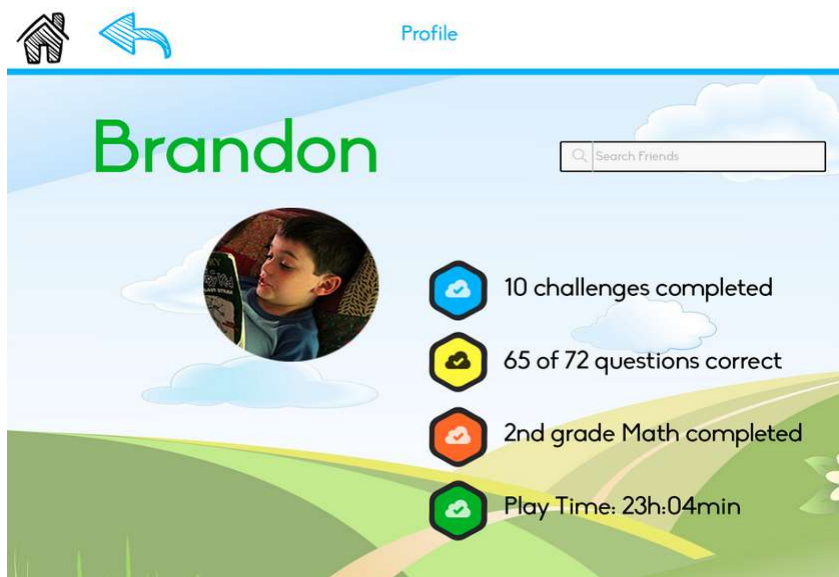
[insert pictures]

## Hi-fi Prototype

The changes made from mid-fi to hi-fi have already been explained in detail above, and most changes were as a result of the heuristic evaluation. Here are a few of those pages for comparison with the previous prototypes.



Landing Page of hi-fi



Profile Page of hi-fi



# Solution Accuracy




One of three parent feedback pages of hi-fi, labeled 'progress'




# Which is bigger?



Backpack vs Pillow



Your answer in inches:



Your answer in inches:

Measure the lengths of your backpack and your pillow using your ruler and let me know how big they are by typing your answers in the boxes and hitting enter.



One page from the challenge, of hi-fi prototype

## PROTOTYPE IMPLEMENTATION

### Development Process

First, we created the images in *Photoshop*. Then we used *Paint* to process the PNG's (from *Photoshop*) so as to measure the bitmap values. We wrote code in *Jade*, *CoffeeScript*, and *Less*, then used an IDE called *IntelliJ* and a package manager called *Harp* to compile the code written in *Jade*, *Coffee Script*, and *Less* into *HTML5*, *JavaScript*, and *CSS* respectively.

*Jade*, *Coffee Script*, and *Less* are succinct, modular languages that allowed us to do more in less time. However, in the end, we had to scrap all the *CoffeeScript* code and write directly in *JavaScript* because *CoffeeScript* didn't compile well to *JavaScript* when integrating with a third party API. We also had to build one page in *HTML5* because *Jade* was not compiling correctly to *HTML5* in some instances. It seems these compilation issues arose because the IDE was using an outdated version of *CoffeeScript*.

In terms of the compilation from *Jade* to *HTML5*, we had abstracted a lot of header code into a template, and what worked fine on a harp server (our development server), did not work well on the Stanford AFS server so that when pushed to Stanford AFS server, none of the header files were there. To solve that, we had to write some of the header files in *HTML5*.

In terms of external libraries, we used Google Charts, which provided a lot of framework code that gave us a range of great, interactive charts to choose from and saved us from doing too much coding. Unfortunately, Google Charts was down for a while, and we didn't realize; we thought the problem was with our code, and this led to hours of pointless debugging attempts.

### Wizard of Oz Techniques

The device logs no data, and so there is no feedback to any answers entered. Instead, the app behaves as if every answer entered is correct.

Also, although there is an option to search for friends, that feature returns no friends in response to a search. This is because 'Brandon' has no friends, that is, we haven't implemented a database of friends.

### Hard Coded Data

The challenge template is hard coded, that is, we are not drawing from a database. The achievement, scores and all the information in the single available profile, Brandon's, are also hard coded. All the data in the charts found on the progress screen is hard coded in *JavaScript* as well.

### What is Missing?

Progress:

Circular sliding and Contrast-colored arrows have not yet been implemented.

Profile:

There is no secondary depth description about the profile available. There is also no access to friends, and no access to game history.

### Challenges:

There is currently only one challenge available, though we have designed more that we would like to implement. Also, there is only limited error checking in the current challenge, and the feedback loop has not been implemented so the user is not told if their answer is correct or not. A 'help' option for the challenge has also been designed but not implemented. We would also like to implement more instructions, an introduction, and a conclusion for the challenge.