Zero A.D.

Inviting 5th graders to enjoy math through augmented reality with an historical adventure game

Team Members and Roles

Ashlee Reynolds - User Testing
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PROBLEM AND SOLUTION OVERVIEW

Imagine a child's perspective on learning math: you sit in class for a few consecutive hours in school, you go home to do sheets and booklets of similar math questions, and you do it again the next day. The repetitive and static nature of this type of learning system does not motivate children to be interested in math, but makes learning math a rather programmed chore. Furthermore, the system does not always provides children math materials based on their needs and understandings. As a result, we want to design an application that can make the experiences of learning math positive and encouraging to elementary school children. We want to focus on the dynamic and adaptive aspects of learning through making the children interact with more than just math questions when learning, but also historic figures and the environment.

CONTEXTUAL INQUIRY PARTICIPANTS

We regard elementary school children as our primary customer, and the parents and caretakers of the children as clients. Since Ashlee is tutoring for several families living in Palo Alto, the families are asked to be interviewed about their perspectives on learning math in elementary school. The interviews of both the children and the parents are presented together.

It is worth noting that the families interviewed are relatively high-income and well educated families, with the parents in various professions and the kids often being top of their classes.

1. Family of MK, EK and SK
   MK is a fifth grade boy and EK is a first grade girl. SK is their mother. SK has an Asian background, but both children grow up in USA. She is a psychologist and has strong opinions on how children learn in disciplined environments. EK is in the age of a first grade, but she's studying second grade materials.

2. Family of AV and GV
   AV is a first grade girl, while GV and her husband are both professors at Stanford.
3. Family of TR, GR and DR
   This is a family of white americans. TR is a fifth grade boy while GR is a girl in second grade.

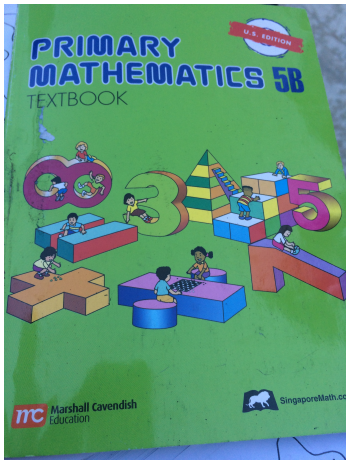


Figure 1. Textbook used.

CONTEXTUAL INQUIRY RESULTS

The children in general have positive experiences with learning math and doing math problems, even though the confidence they get from having a private tutor and being top of the class would help in that respect. The parents told us that for their children, going to school does not seem to be a challenge, while doing homework seems to be a challenge they are willing to take on, implying that the children see homework as what they are responsible of. However, we do observe that the children enjoy the process more if they can do homework along with some other activities they like, such as drawing and group activities. Every children like drawing, and drawing on a whiteboard or paper while doing math problems seems to be the most enjoyable for them.

In addition, most of the children treasure break time and play time when doing homeworks. Although the children of SK often do not want to take a break, but instead want to continue doing homework, other children enjoys having break time. There are gender differences in what activities they would pursue during break time - the boys like to play sports, including baseball and basketball, together, while the girls like to play word games with their supervisors. The boys are really into the competitive aspects of sports, as TR often asked Ashlee to check on the Giants' games while doing homeworks so that he can make a report of their games and share it with his friends.

Figure 2. Children enjoy drawing on the board when solving problems.

Besides break time, children also have food, such as cookies and snacks, and sticker prizes for rewards. Rewards seem to be an important part of doing homework for them, since they do pay significant efforts in solving the problems. The children usually have to go through several iterations of solving one question before they can find the correct answer. In the mean time, they would have to erase what they draw and write on the boards and papers to start again, and erasing is often viewed as a toll.

Though they in general like being rewarded, different children do have different takes on rewards. The mothers tell us that the girls are more likely to want to do well in homeworks. Moreover, they observe that there is also a factor of being pleasers and non-pleasers. Pleasers do want to do well in homeworks to receive the recognition from teachers and their supervisors. So although most children like having physical rewards like snacks and breaks, mental rewards like recognition and acclaim also play a role in the rewards.

In terms of educational software, the children have variable responses, none of which really match an educational game geared toward learning and practicing math. One of them tell us that they are not allowed to use Google Search when doing their homework, while two others talk about mobile applications that give them digital books to read and make highlights on, and even ask questions about the readings. One child talks about a math video game that the 'cool kids' in his class plays, but soon comments that the game is really just a video game.

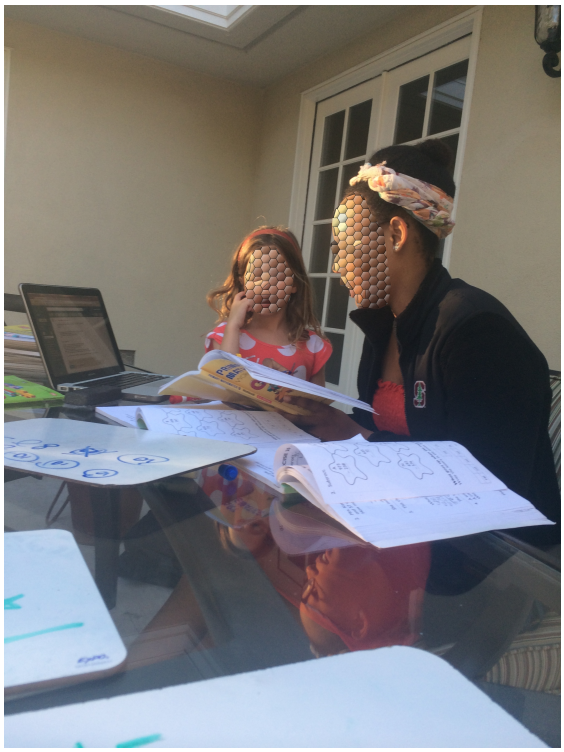


Figure 2. Working with a tutor on correcting the answers.

SK, the mother of MK and EK, recommends an iPad application named DreamBox. DreamBox is also a software about math game that children love to play. She particularly likes the application because it provides a lot of parental feedbacks while she does not have to be involved when the children are playing.

The mothers also make more suggestions on other aspects of their children learning math and educational games. When asked whether they think a successful math education should make their children a math whiz, top of the class, above average, or just average, all three mothers express that they would like their children to become top of the class. SK said that math whiz implies certain amount of talents and special abilities that may not be plausible for every kids, and she would not push her children to that goal.

The more important part of the mothers' responses is that they all value the adaptive learning system, in which the difficulty of the teaching and practices is adjusted based on the level of the children. When the questions the children face become too easy or too difficult for them, they lose interest on doing the question. However, if the difficulty of the questions raise when the children get more questions correct, their motivation will still be up.

TASK ANALYSIS QUESTIONS & ANSWERS

1. Who is going to use the system?
   Compared with the other children we interviewed, the 5th graders understand the concept of learning math and doing homework the most. We decided to take advantage of this and focus on designing the application for 5th graders. In addition, we want to provide the parents a way to review the progress of the children with a parent mode.

2. What tasks do they now perform?
   The tasks the children currently perform to learn math are pretty standardized. These include: (1) going to school to be taught math concepts, (2) doing homework in the form of sheets or booklets, sometimes with a tutor or a parent, (3) the problems they solved are corrected by parents, teachers or tutors, and (4) playing educational math games occasionally.

3. What tasks are desired?
   As opposed to doing a list of math questions in the booklets, children enjoy problem solving more when there are physical objects exhibiting how the problems are in reality.
   In addition, the children really enjoy rewards to their efforts. Often during tutor hours, the children enjoy break time and play time after doing several questions, since the feedbacks to them being right or wrong can definitely be more than crosses and checkmarks.
   For the parents, we learn that parents would like to have minimal involvement into the children's learning, but however want to be informed with the progress their children are advancing.

4. How are the tasks learned?
   The concept of going to school is considered given for elementary school children, as they have yet to realize that there are other options than school. As a result, when they are taken to school and in classrooms, the teachers are responsible to teaching the children about learning.
   On the other hand, the children do not know about doing homework before they enter fourth or fifth grade. The older siblings and the parents play an important role in introducing doing homework to the children as what the 'big kids' do. This often makes the children excited about doing homeworks, and some of them even make their own homeworks before they are assigned any type of homework by teachers.

5. Where are the tasks performed?
   In general, doing homework and practicing problems are performed at home, on a desk either outdoor or indoor. There are essentially no fixed locations for the children to do math problems, but wherever is convenient for the parents and tutors to be able to keep an eye on the children.

6. What's the relationship between customers and data?
   In fifth grade, where children are starting to learn more about algebra, it is less convenient to find readily available examples in home settings to exhibit the ideas of these math problems. As a result, although parents can determine whether the children have done a math problem right or wrong, it is more difficult to re-teach the process and thinking behind the concepts in a concrete way for the parents.
7. What other tools does the customer have?
   Traditionally, math is taught in classrooms, where teachers can use drawings and physical objects to guide the students through concepts. However, most practices are still written sheets of multiple choice and fill-in questions.
   In regions where computerized classrooms are more available, Khan Academy is sometimes used for teaching, on top of other digital math teaching tools. Educational games on tablets, on the other hand, are also a common source of practices. In particular, S.K. points out an iPad application named DreamBox that provides various math games and feedbacks for parents.

8. How does the user communicate with each other about the task?
   Children do not usually collaborate on doing math problems. One of the children did talk about joining an after-school Math Club, in which they use history examples to teach math. Apparently the reason they do not talk about math problems with other children is that they were taught in school that these activities would result in copying each other's answers. In addition, when they play math games, the parents can be involved in the process of guiding them to use the softwares.

9. How often are the tasks performed?
   Children have to go to schools daily during weekdays, although the frequency of homeworks is a little less than that. Children are usually not forced to do homework on any given day, as long as they can finish the work and turn in homework in time. Since these families hire Ashlee as a tutor, the children can often finish homework during tutoring hours. However, S.K.'s children did express that their mother made them do homework over the weekends.

10. What are the time constraints on the tasks?
For fifth graders, the homework can take a variety of working time to finish. The times they use to finish homework vary from 10 minutes to 1.5 hours, although when doing homework, the children are not attentive to the problems all the time.

11. What happens when things go wrong?
Children can ask their babysitters, their mothers and the teachers. Some of them also would try harder on their own, but usually results in getting tired and giving up. When the others point out errors in their solutions, the children usually responds by erasing and redoing the problems again.

REVISED TASKS with Complexity, Importance and Relative Frequency

1. Users learn math concepts (complex, moderate importance, least often)
During this task, the users are trying to understand a concept they do not understand. In addition to learning math concepts in school, our users should be able to learn and review new concepts in our application. Practice makes perfect, however our CI participants show that trial-and-error approach is very common when they try to solve problems and can be frustrating at times. As a result, we think that a math educational game should provide not only practice problems of learned concepts, but also illustrations and demonstrations of a concept when necessary.

2. Users do math problems (moderate, high importance, often)

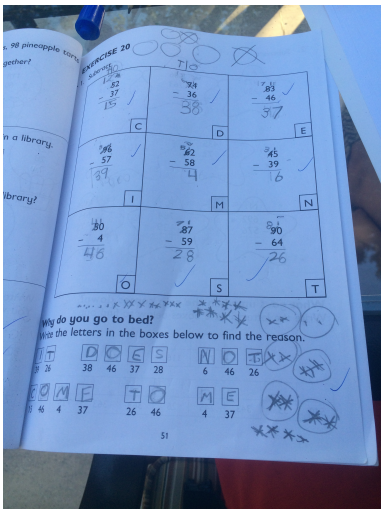


Figure 4. A page of the booklet with homeworks.

In this task, the user is trying to solidify their understanding of math by practicing problems, and to potentially get rewards. Compared to doing a list of problems present in a booklet, we want to make the users able to explore the application while problems appear more naturally from the scenario, in order to make the problems more spontaneous. We also want to make the difficulty of the questions be adjusted as the children do more questions, rather than having a fixed set of questions to ask. With the ability to ask questions that apply to the scenario the children is in, our application makes practices nature and dynamic.

3. Users receive feedbacks on the performances (simple, moderate importance, most often)
   The feedbacks are categorized into two type: (1) the children receive the solution of the question they just attempt, and (2) the parent can view the progress the children have made. The first part is important since the children do need to know if they do the questions correctly or not, and the feedback will include information about the relevant concepts if they want to review it. The second part is important for the response we had from SK that parental feedbacks are important deciding factors of whether an application is helpful for the family.

THREE BEST APPLICATION IDEAS

1. History + Math
   From the description of the child in the after-school Math club, many children are interested in discussing math questions in historical context. We want to make an adventure game that is based on this theme, in which the users can be a character in a historical scenario. While the users explore the events in the era, they will encounter math questions about the world around them. This is a theme-centered idea, and there have been similar games before, but not as focused on education.

2. Math Portal
   Many mobile adventure games currently have purchasing portals, through which the users can pay to receive boosts, for instance extra coins or items. We think it is possible to design a type of portal that grants these rewards based on math questions answered. This way the users can access the questions at any time and get rewards from answering them. However, we do think that this idea does not promote the children's motivation to learn math, but rather use math problems as a way to play more video games.

3. Augmented Reality
   Since we want our users to experience the use of math in daily life, we think augmented reality would be an appropriate technology to address the issue. We envision the user to use photosphere functions to scan the environment, and an algorithm would identify the objects present around. Afterwards, the users can select whichever objects they are interested in, and the application would propose some actions and math questions about the object and its surroundings. The users can then experiment with the object and answer the questions to receive feedbacks.

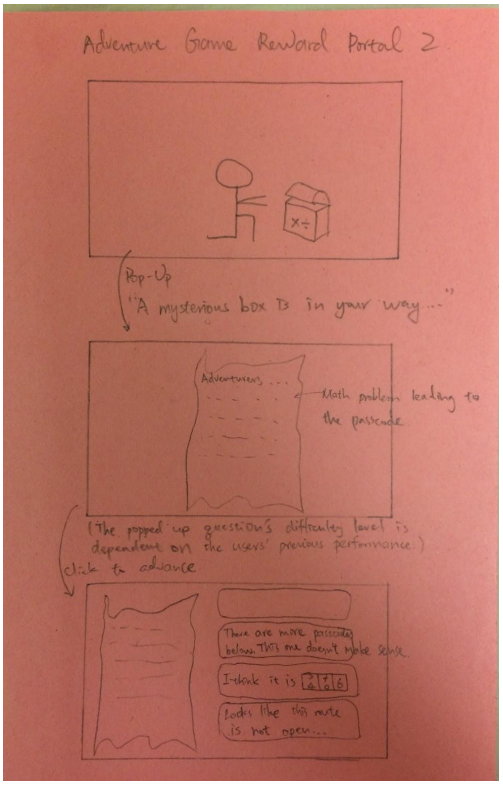
Table 1. The table evaluating different ideas (ratings are out of 10).

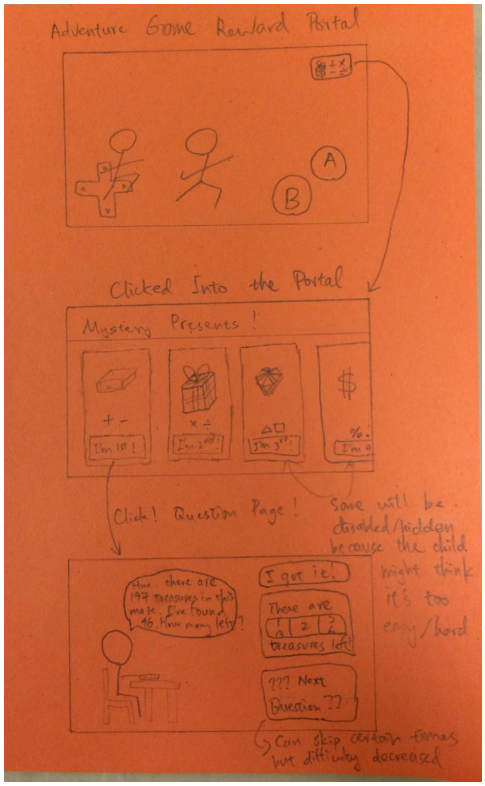
	Feasibility	Importance	Interest
History + Math	8	7	8
Math Portal	9	5	4
Augmented Reality	3	7	9

SUMMARY

At last, we decided that the history and math idea does not conflict with the augmented reality idea. In other words, it would be interesting to merge the two ideas and be able to recreate historical scenarios and add the interactive component that augmented reality can provide. This is the best way to address the problem that learning system needs to be dynamic and adaptive, as both ideas feature the idea of change and adapting to the environment. The feasibility of completing the whole augmented reality system may be low, but we plan to start from completing several virtual reality scenarios, i.e. creating an environment allowing the users to explore a small part of it, to give the users a sense of the ultimate goal when doing user testing.

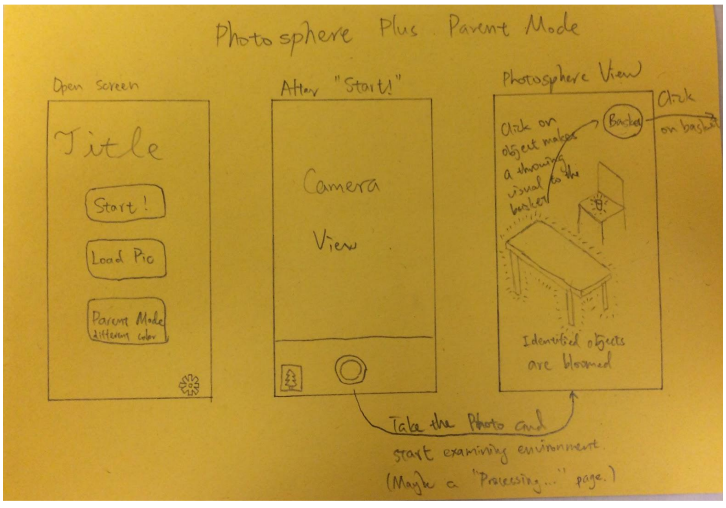
SKETCHES OF IMPORTANT SCREENS

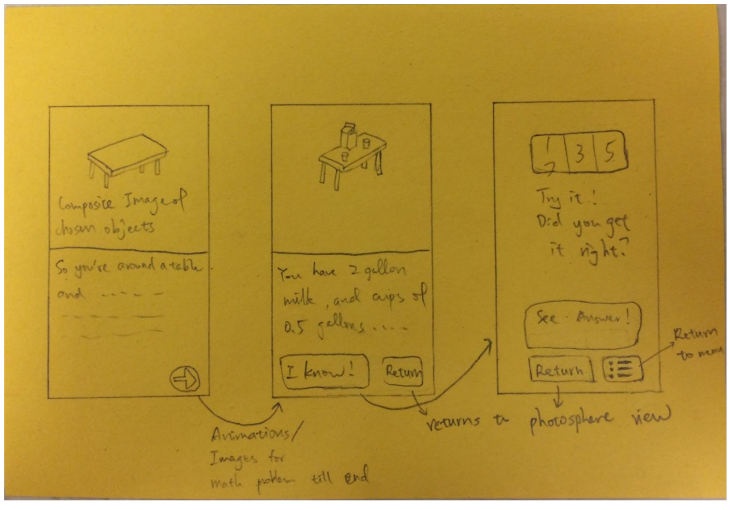




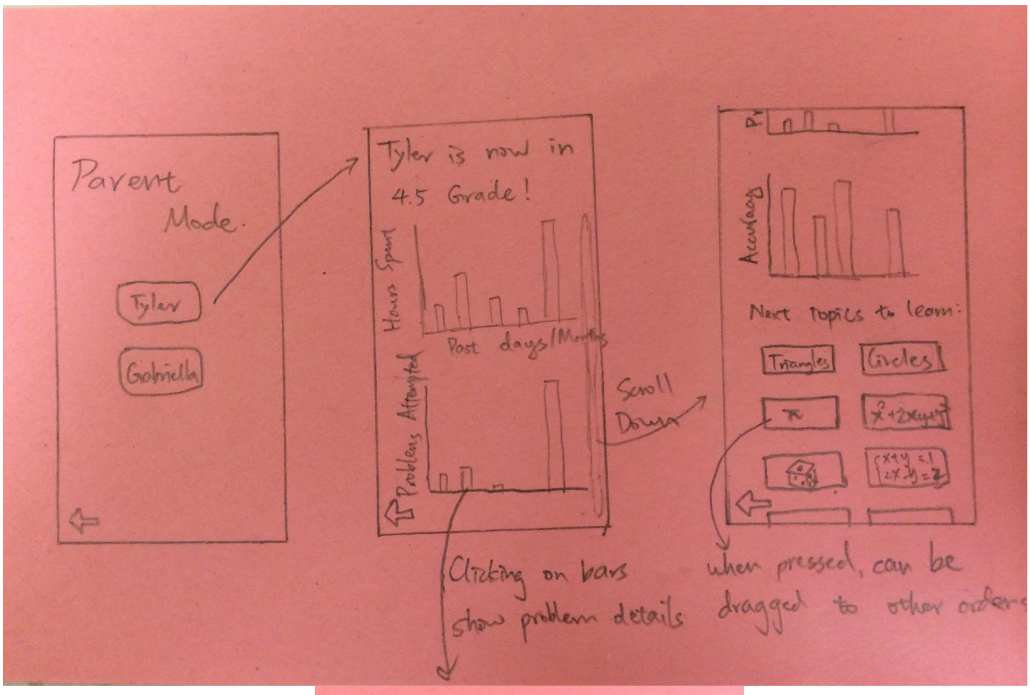
Two different design of the math portal idea (Brad H).

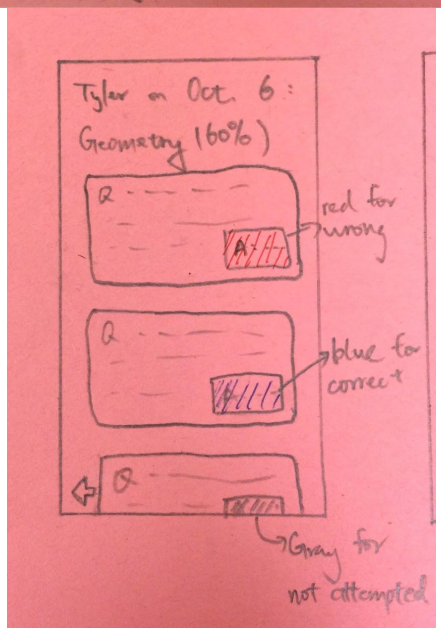
An example of an augmented reality interface (Brad H).

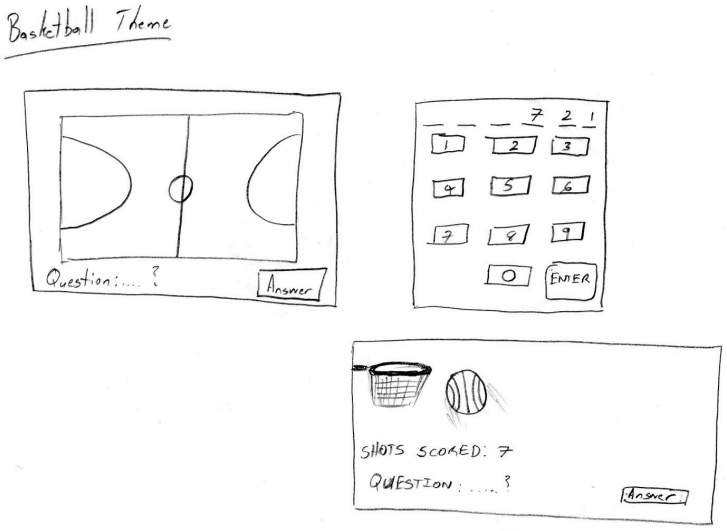




An example of the parent feedback mode (Brad H).

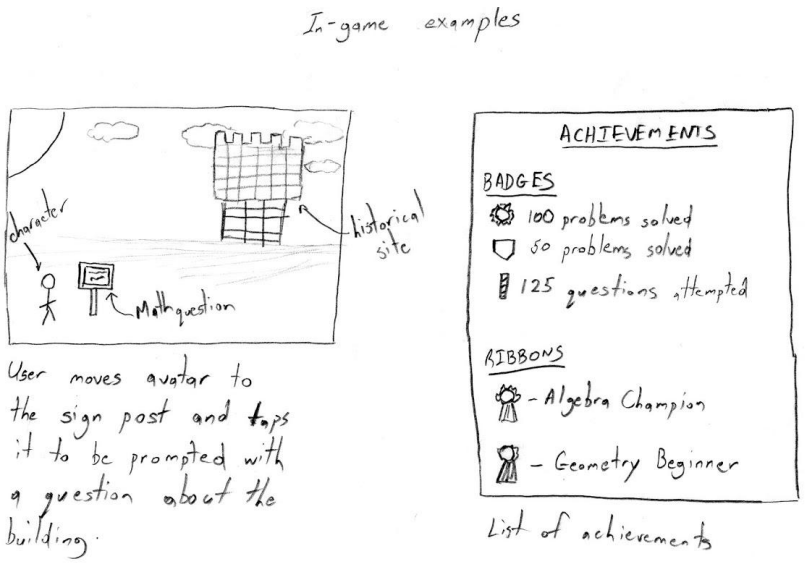




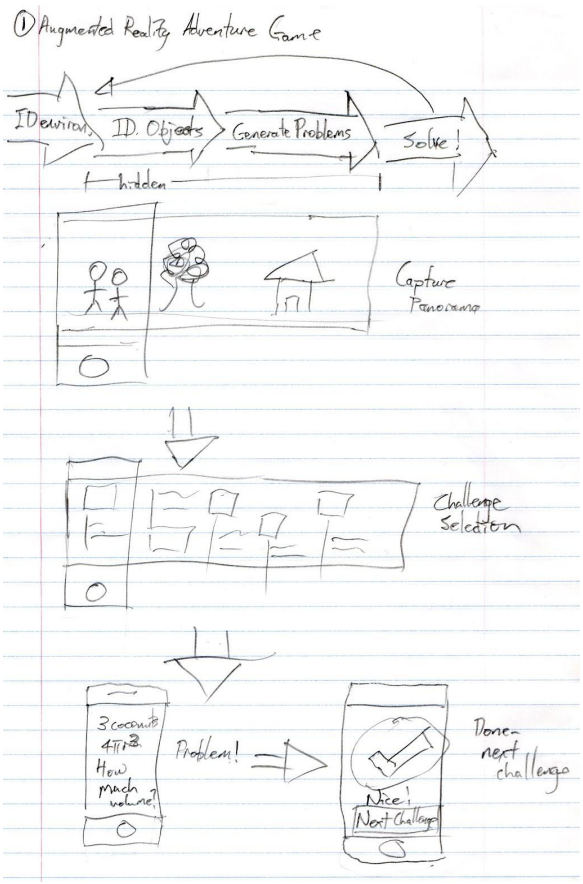


An example of a sports themed question (David Y).

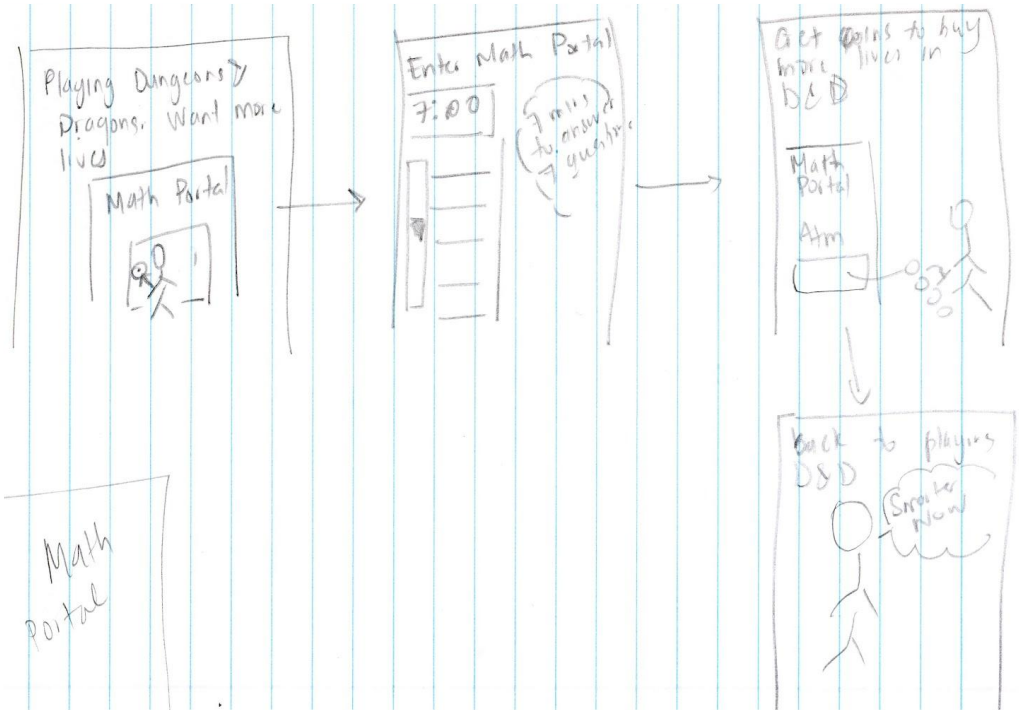
Possible logo (David Y).



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

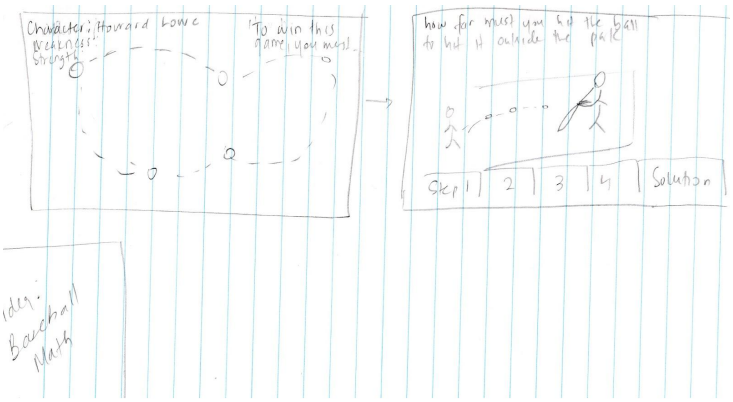


An example of the augmented reality system (Charles Y).

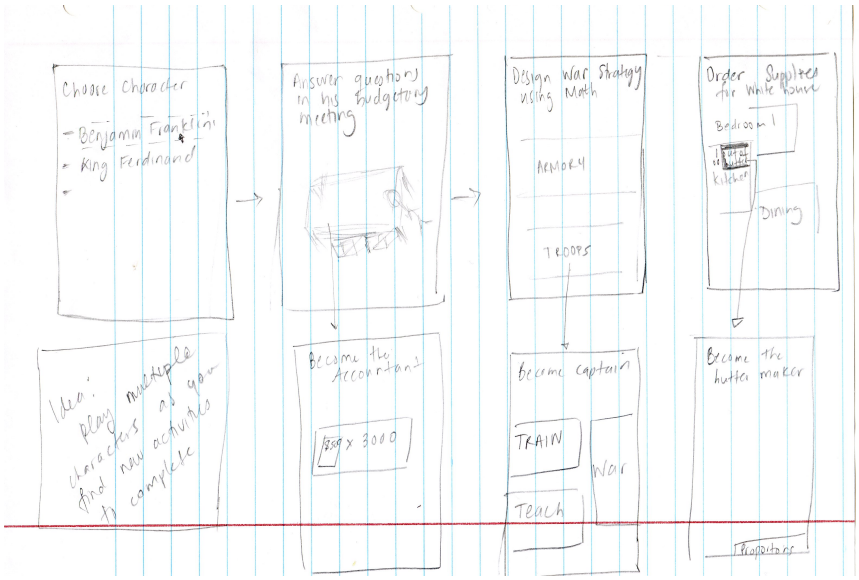


Another example of the math portal design (Ashlee R).

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).