Math Whiz – Final Report

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1 Focus Setting Process

1.1 Overview

Due to conflicting schedules of participants, we decided to conduct two separate focus setting sessions on the 15th and 22nd September 2006. After gathering input by all stakeholders we picked the most emphasized foci for our project. We are going to focus on the integration of Tablet Math Whiz into the curriculum at Glendale School and on the aspect of keeping kids motivated to use Tablet Math Whiz.

The first focus setting session was conducted at Glendale Elementary School at Flinton, PA. Three 4th grade mathematics teachers and the school's superintendent participated. One of the teachers has had experience using the tablet before, whereas the other two teachers never used the system in class. We introduced this group to the Contextual Design process and gathered then questions and concerns related with the Tablet Math Whiz system in an affinity diagram. Stakeholders then exchanged their results and formed groups of concerns in the affinity diagram.

The second focus setting was conducted at CMU with our project advisor Prof. Ananda Gunawardena. Instead of letting him write down his questions and concerns, we asked him to talk about his personal project focus while we recorded sticky notes. We than asked him to place the notes into the existing affinity diagram, relating his concerns with the existing one from teachers and the superintendent.

Finally we set the focus without the actual stakeholders by pruning sticky notes and grouping higher category groups of notes. Thereof we selected two groups as our main foci for our project.

Figure 1-1: Affinity Diagram

1.2 Focus Session Participants

Name	Position	Role during session	Session participation
Dr. Daniel Bruno	Superintendent of Glendale Elementary School	Stakeholder	1
Dawn Cabino	4th grade teacher of Glendale Elementary School	Stakeholder	1
Pam Moyer	4th grade teacher of Glendale Elementary School	Stakeholder	1
Jen Lechner	4th grade teacher of Glendale Elementary School	Stakeholder	1
Daniel Petty	Math Whiz Developer, CMU CS Masters Student	Stakeholder	1
Prof. Ananda Gunawardena	Head of project, Advisor	Stakeholder	1
Jason Cornwell	HCI Masters Student at CMU	1. Moderator 2. Protocol	1 & 2
Ekta V. Shah	HCI Masters Student at CMU	1. Diagramming 2. Protocol	1 & 2
Robin Kim	HCI Masters Student at CMU	1. Time Keeper 2. Diagramming	1 & 2
Louisa Poythress	HCI Masters Student at CMU	1. Protocol 2. Time Keeper	1 & 2
Jonas Hinn	HCI Masters Student at CMU	1. Protocol 2. Moderator	1 & 2

1.3 Grouping of questions and concerns

2nd level groups	1st level groups
Integration with curriculum	Scheduling time for use
	Handwriting issues
	Integration with curriculum
	Training
	Technical Issues
Keeping kids motivated	Individualization
	Feedback to students
	Keeping kids motivated
Support for Administrating the system	Adding functionality
	Teacher interface
	Feedback concerns to teachers
Measurement and Monitoring	Improving learning
	Pre-Tests
	Standardized Testing

1.4 Choosing project focus

From the second level sticky note groups, we have chosen two as main project focus:

- A: Integration with curriculum

  Focus A has evolved from the largest collection of sticky notes in our affinity diagram. This focus is about how to integrate Tablet Math Whiz successfully into the curriculum of 4th grade class at Glendale Elementary School. Is there enough time for using Tablet Math Whiz in classes? Should Tablet Math be used in small or large groups? How to conduct Tablet Math Whiz training?

- B: Keeping kids motivated

  All stakeholders came up with questions on how to keep kids motivated for Tablet Math Whiz while learning basic math skills. Is a reward system required for kids? How to deal with individual pace of learning? How to give the kids better feedback if the system has issues handwriting detection?

2 Contextual Inquiry

2.1 Introduction

We went a second time to Glendale Elementary School for the purpose of data gathering using Contextual Inquiry [4] technique. We interviewed 4th grade students who learn basic math skills using Math Whiz Tablet PC and also interviewed teachers of these students.

While preparing for the interviews, we started to worry whether the standard procedure for contextual inquiry was appropriate for children in 4th grade. After researching the topic, we found the work of Allison Druin who attempts to design technology for children with children at the University of Maryland, College Park. Chapter 2.2 gives an overview of cooperative inquiry [2] method and our experience interviewing children.

The interviews and observations of children using Math Tablet did not reveal surprisingly new insights. However, we learned from teacher interviews about difficulties when integrating Math Whiz tablet into the syllabus which is dictated by SAXON [5] math teaching system.

2.2 Cooperative Inquiry

Cooperative Inquiry is Allison Druin's approach to create new technologies for children, with children. This methodology is comprised of Contextual Inquiry as introduced by Holtzblatt et al., Participatory Design and Technology Immersion technique. Contextual Inquiry is very demanding for children, because their attention is distracted fast from work when adults observe and interrupt. Also, partnership is difficult to establish between an adult interviewer and a child. Cooperative Inquiry tries to resolve these issues which is summarized in the following guidelines.

2.2.1 Cooperative Inquiry Guidelines

- Both adults and children observe, take notes and interact with observed user (see Figure 2-1).
- The child becomes not only informant, but also researcher, helping to reveal the user's mental model.
- An interactor works with the observed child to avoid the child feeling „on stage".
- The interactor does not take notes for the child not being distracted.

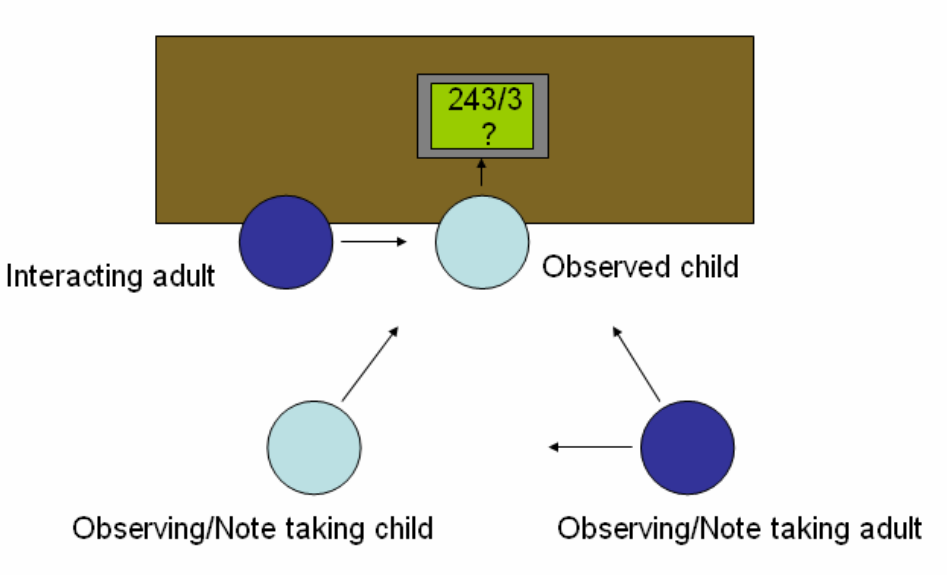


Figure 2-1: Cooperative inquiry setting

2.2.2 Cooperative Inquiry – Our experience

We were unable to establish a long term partnership as proposed by A. Druin due to time limitations of our project. Also, we did not have time to recruit a kid for the purpose of interviewing, so we omitted this technique on site.

Nevertheless, we tried to adapt our interviewing process in order to create optimal conditions for data gathering. We had the interacting interviewer role which did not take notes but focused on establishing a fruitful partnership by asking directed questions. We tried to take pressure from the interviewed kids by conducting the interviews in their natural work environment: the class room. Also, we interviewed three children on the same table at the same time, making them feel more comfortable among their fellow students.

The interviewing with the students was not the last activity at Glendale Elementary School. We managed to meet the children again for a Participatory Design session at the end of our project. Read more about our experience below.

3 Work modeling

3.1 Introduction

We followed the Contextual Design process to evaluate and integrate data gathered from Contextual Interviews at Glendale Elementary School. We created the different models from each interview and conducted interpretation sessions to collect insights into work practice of the children when using the Math Whiz tablet.

The following chapters show the various models in their final consolidated version. The breakdowns are indicated with a red lightning bolt and carry timestamps or line numbers from videos, audio recordings or scripts.

Two inquiries on kids working with math practice sheets did not provide useful data because the practice sheets were created specifically for the purpose of the interviews.

3.2 Cultural model

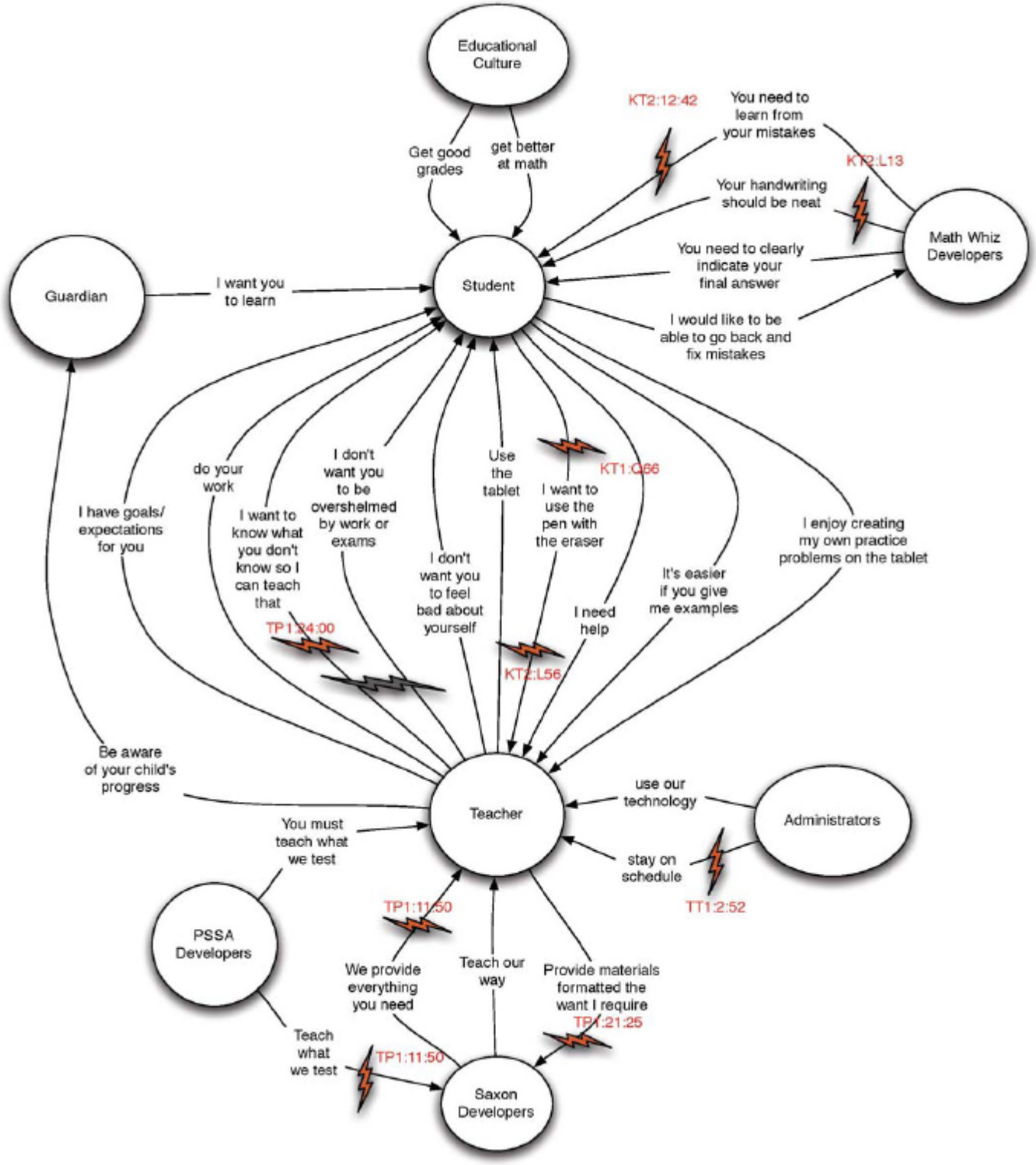


Figure 3-1: Consolidated Cultural Model

3.3 Sequence Model

Intents	Strategies	Steps
Do Math Tablet Exercises		
Log in	Enter Login Information	Enter Name
		Enter Birthday
		Click Submit
	Confirm Exercise	Click "do exercise" button
Answer Problem	Work out problem solution	Works through problem, entering scratch work.
		Copy final answer into answer box
		Hit submit button
		Start Next Problem
		[If previous problem is incorrect, error is shown here.]
Exit System	Review Results	Look at Summary Info
	Log Out	Click Back Button
		Click Logout Button

Figure 3-2: Consolidated Sequence Model

3.4 Flow Model

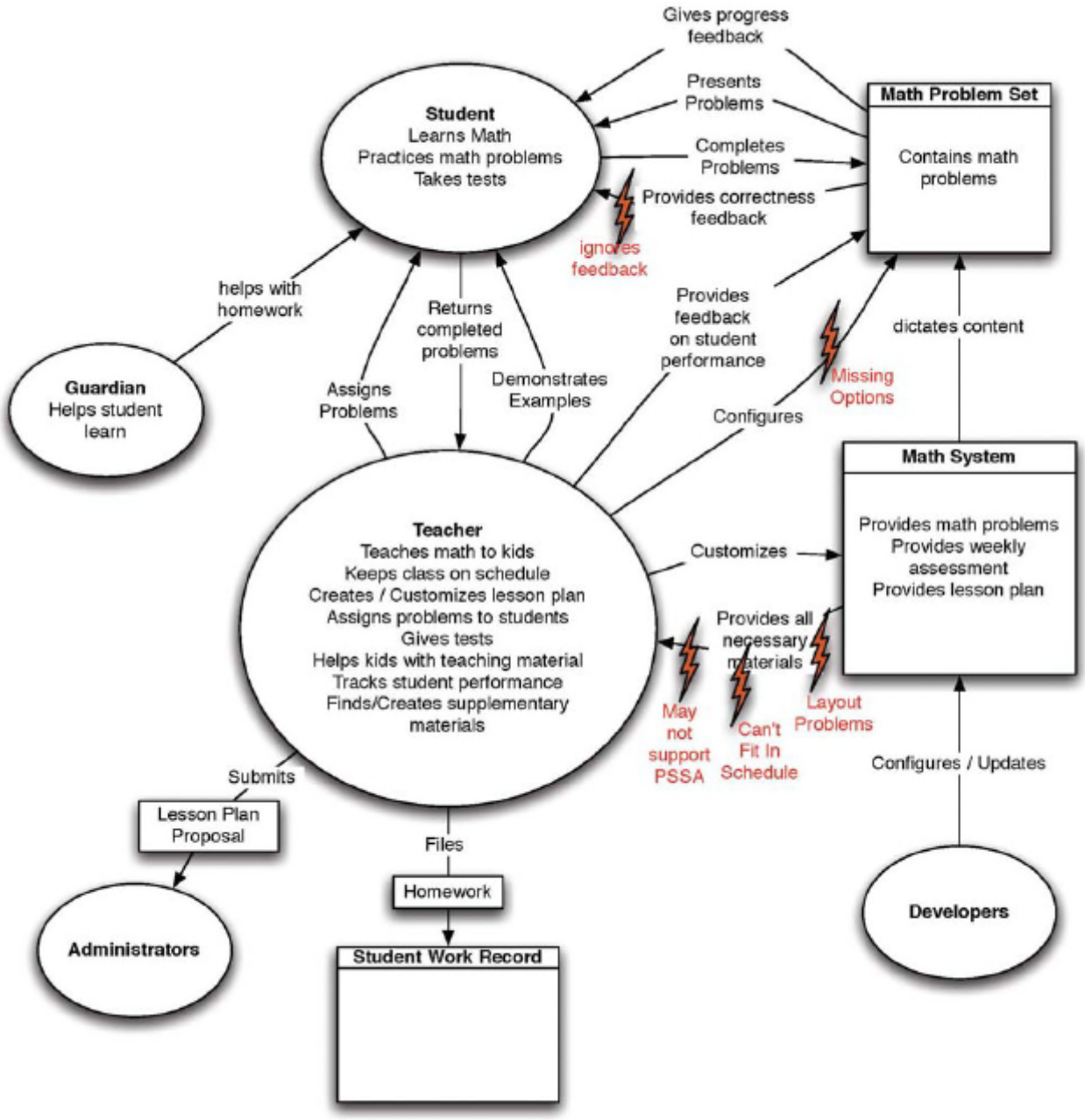


Figure 3-3: Consolidated Flow Model

3.5 Artifact Models

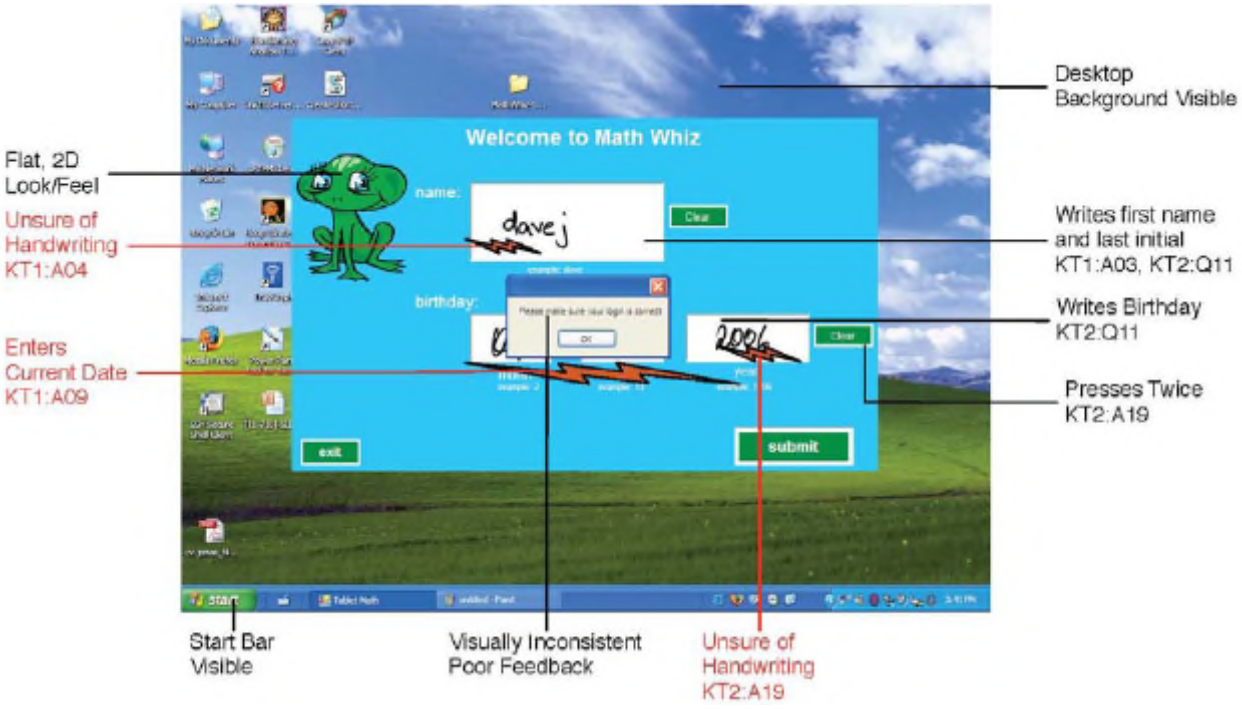


Figure 3-4: Math Whiz Login Screen

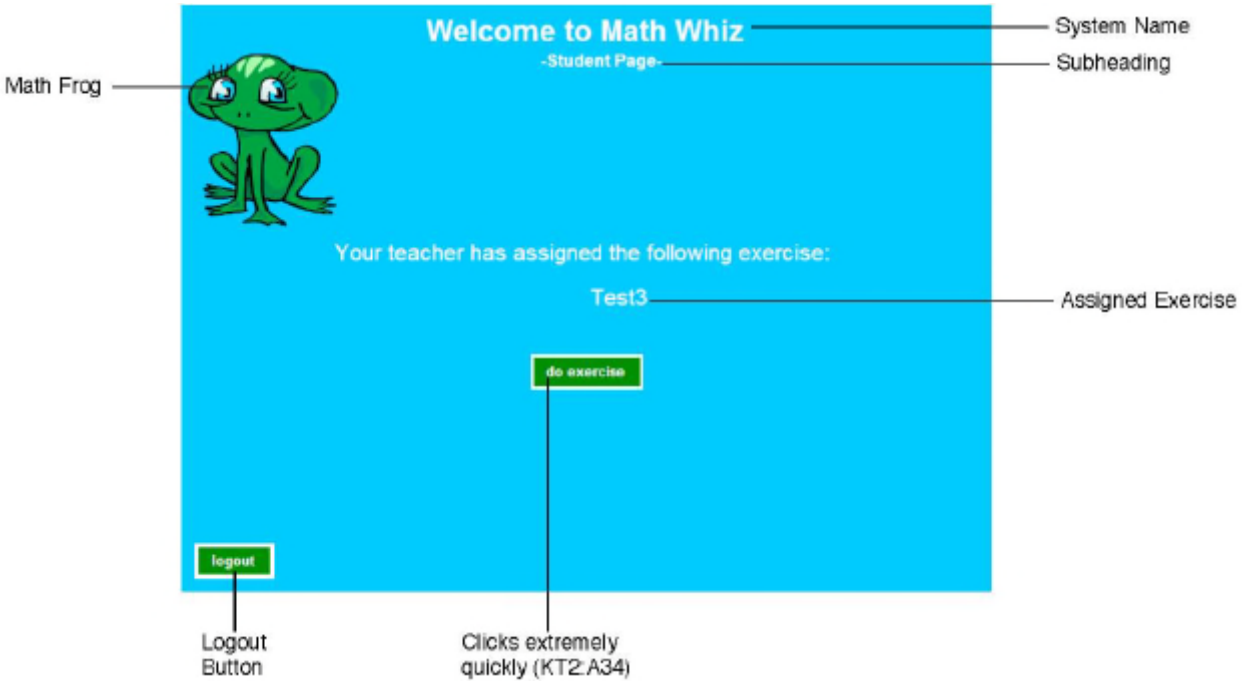


Figure 3-5: Math Whiz Test Start Page

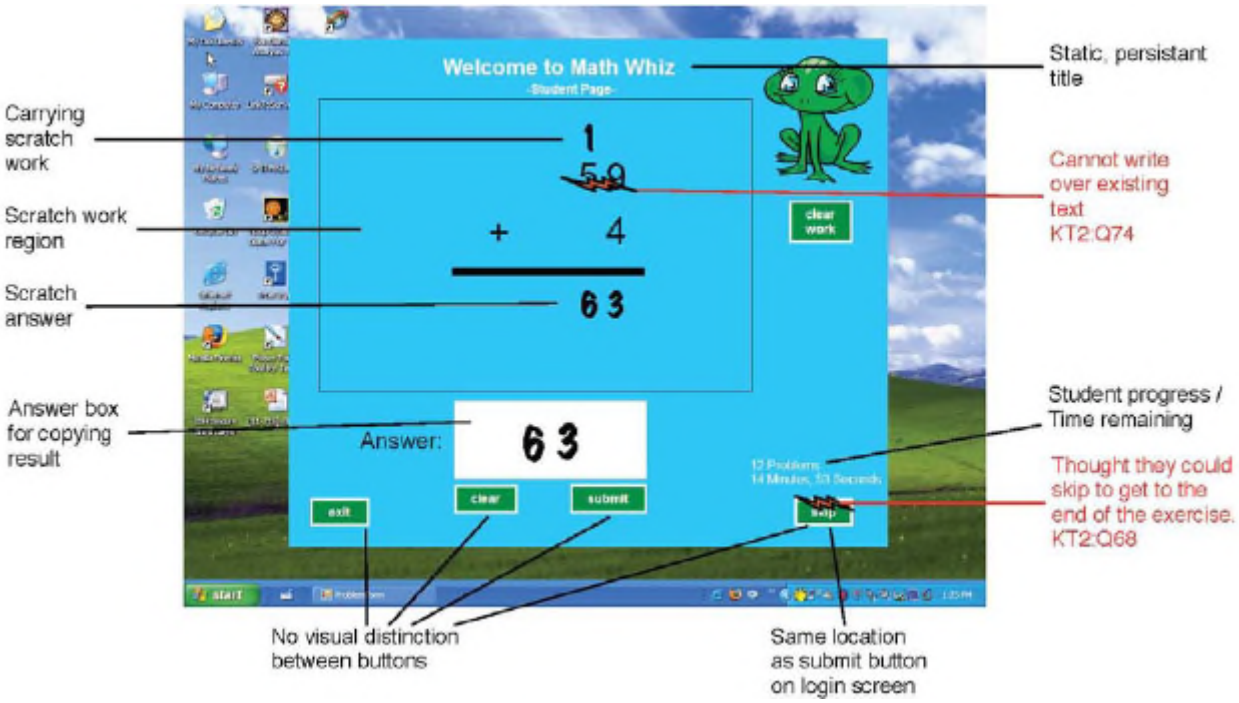


Figure 3-6: Math Whiz Exercise with Scratch Pad and Answer Box (white)

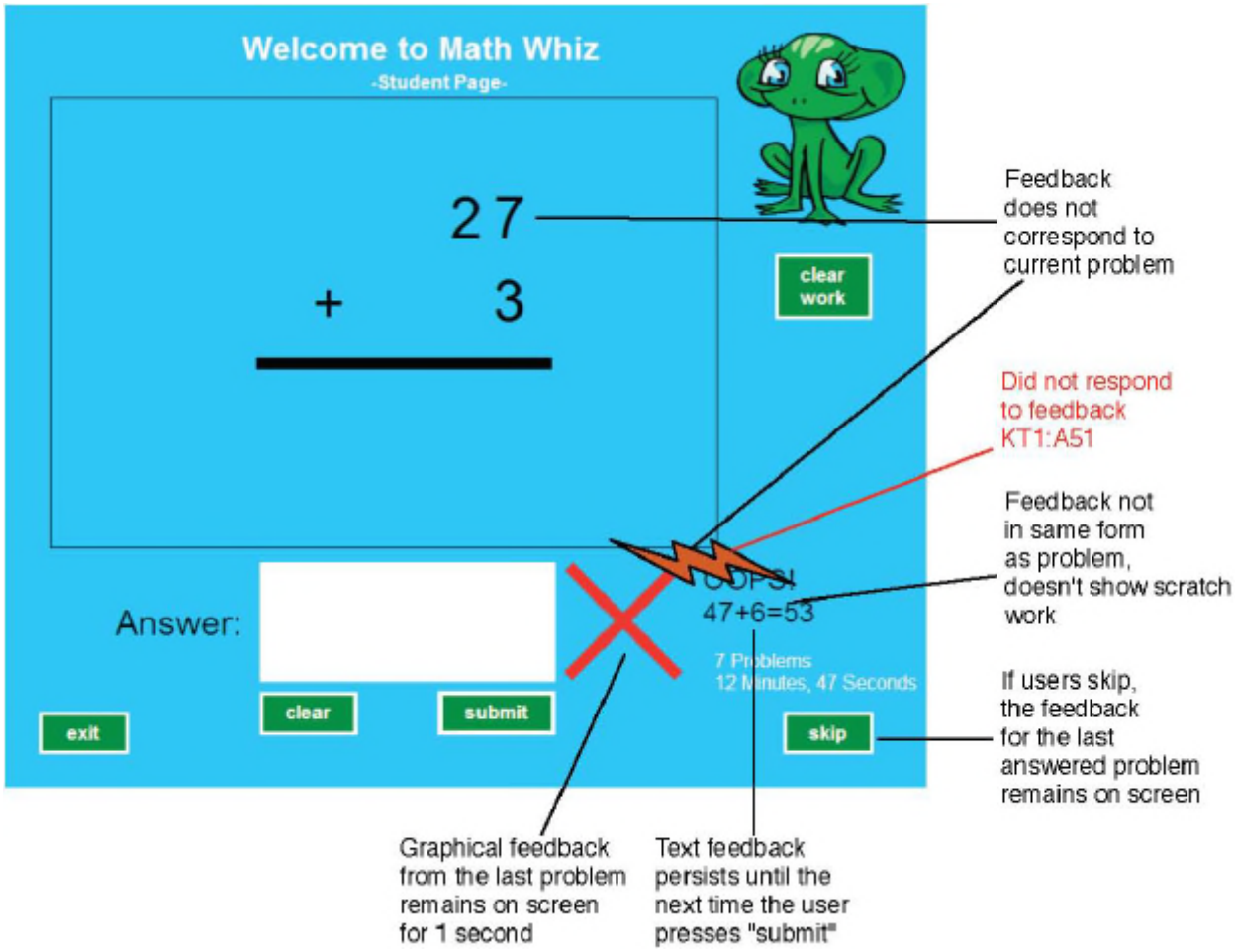


Figure 3-7: Math Whiz Error Indication

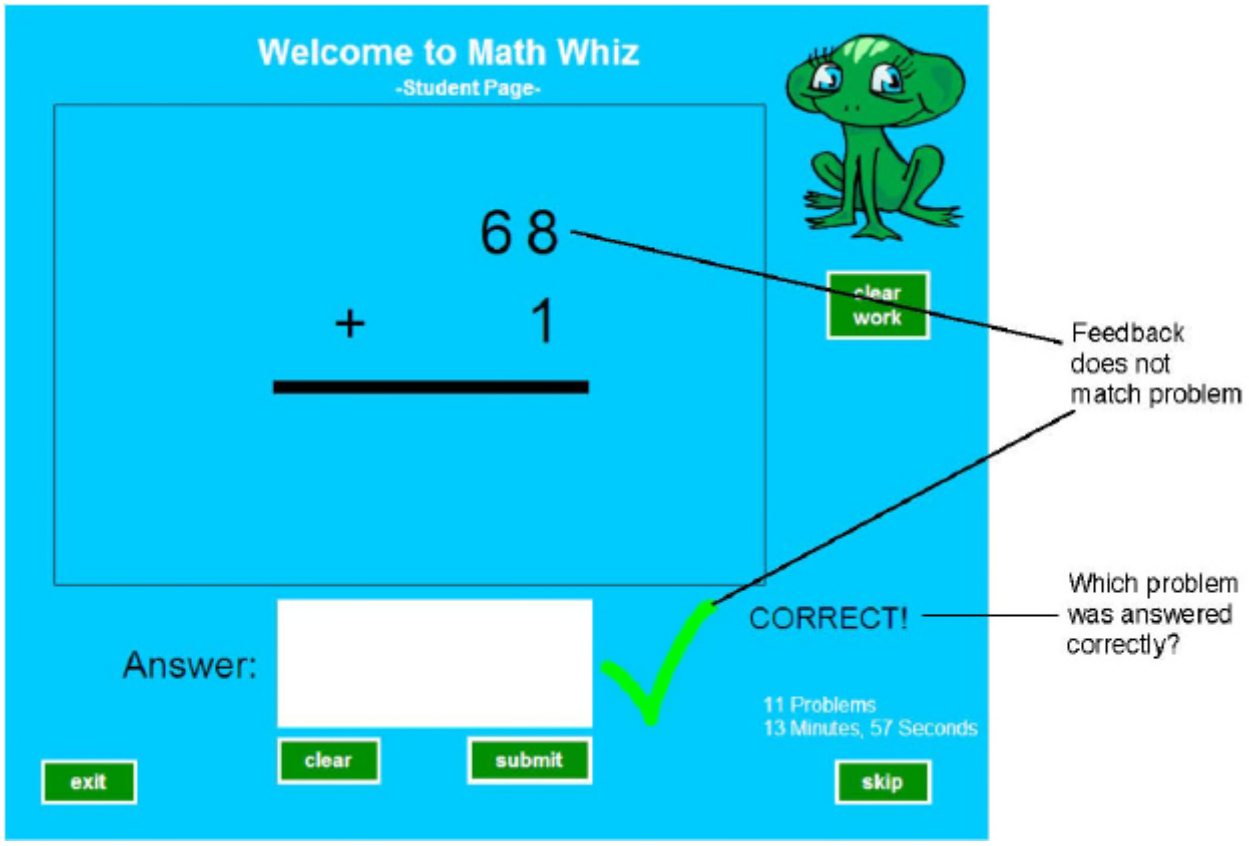


Figure 3-8: Math Whiz Correct Answer

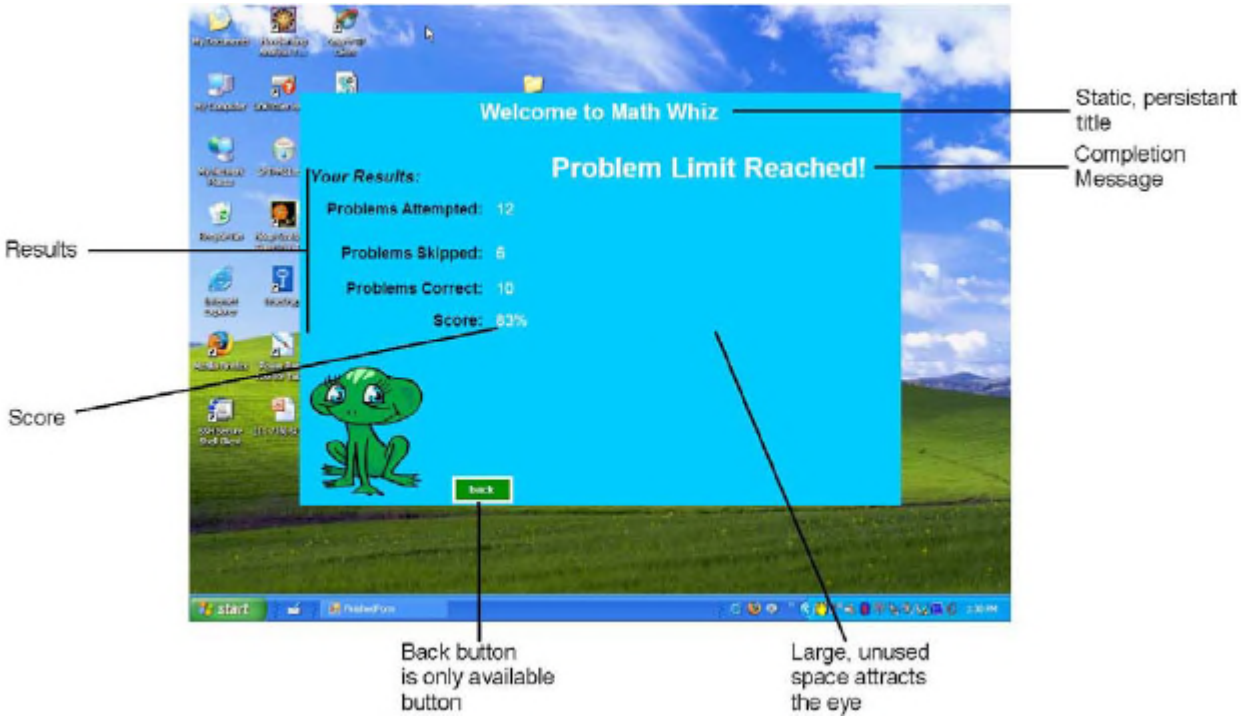


Figure 3-9: Math Whiz Result Statistics

4 Problems with existing interface

Our team applied numerous HCI methods to evaluate the current Math Whiz Interface and identified several issues. Highlighted below are our major findings:

1. The tablet developer's intend was to give feedback to the user. However, students ignore the current feedback mechanism, which is insufficient, poorly visible and disappears after a few seconds. Moreover, student progress is not sufficiently or clearly labeled in the current system (figure 1).

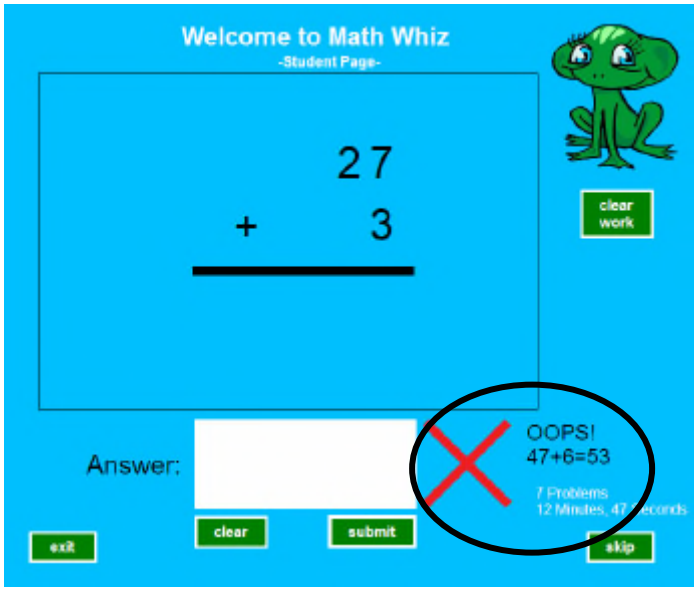


Figure 4-1: Poor feedback

2. Teachers do not have enough time to spend on working with tablets in class. Moreover, with six tablets, teachers often face the problem of keeping the other students in class occupied while they wait for their turn to use the tablet.
3. Teachers adapt the material provided from the SAXON system because it does not entirely fit their needs. With the Math Whiz system, integration seems to be a challenge for the teachers. For instance, teachers want their students to learn units and number sentences, but the tablet does not support such exercises.
4. During our study, we observed that several students had problems using the log in functionality in the current system. The system uses the student's birth date and last name for log in (Figure 2), and this often led to confusion where students had difficulty logging into the system.

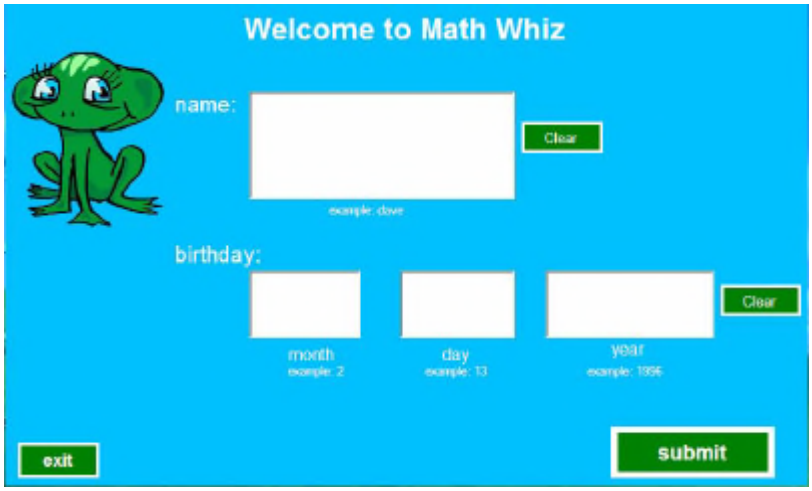


Figure 4-2: Log in mechanism in Math Whiz

5. Our analysis revealed that copying the answer from the scratch area to the answer box was redundant. Students spent unnecessary time in copying their answers to the answer box and making sure they copied them correctly(Figure 3)

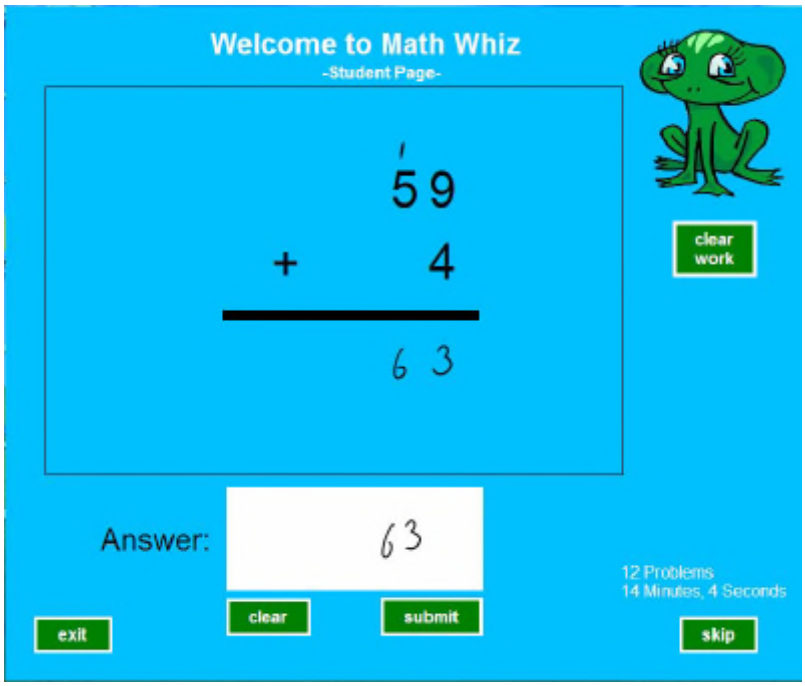


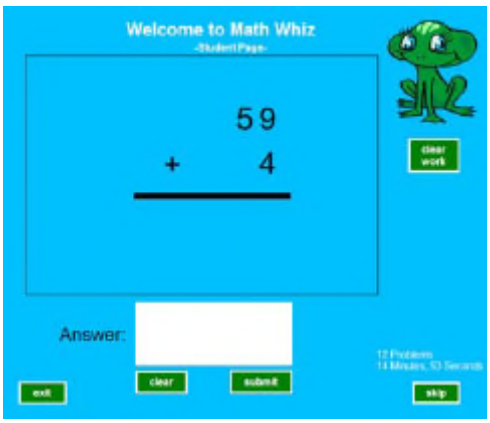
Figure 4-3: Redundant answer boxes

6. While observing the students using the Math Whiz system, we identified that the system had problems with handwriting recognition. During multiple observations, we came across scenarios where the student's answer was correct, but the system graded it as incorrect. The absence of a visual answer confirmation system to students before they submitted their answer was frustrating to the children.

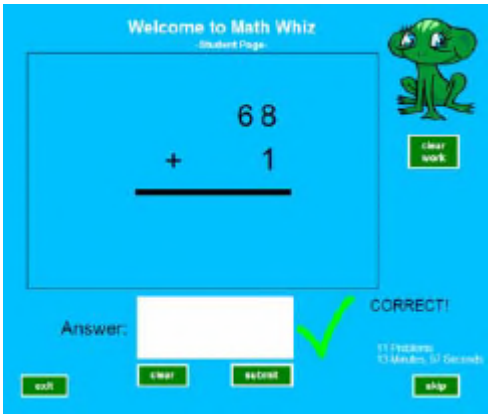
5 Evaluation of Redesign

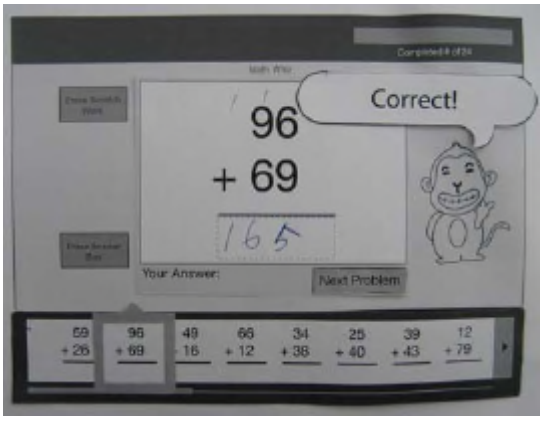
The old log in screen for Math Whiz was not so intuitive to use. Kids entered the current date in the birthday section. Instead of making students to write their birthday, we changed the interface so they can choose an animal from the main screen. The animal would be assigned to each student differently by the teacher, and this avatar will constantly appear on other pages as if it is guiding the student from start to end. Students seemed to understand the new system without having any troubles, and like to have animal avatars.

The new interface has a list of problems showing on the bottom of the screen. The purpose of having this list is to make students to choose the next problem they would like to do. However, students did not seem to enjoy this new feature, because they did not have preference of selecting math problems.



The new interface has the avatar saying whether students got the problem right or wrong, and they seemed to like it. Student can move to the next problem either by clicking Next Problem or choose a problem from the list. However, students did not jump to other questions from the list, and it is because they have 'Next Problem' button shown on the screen.



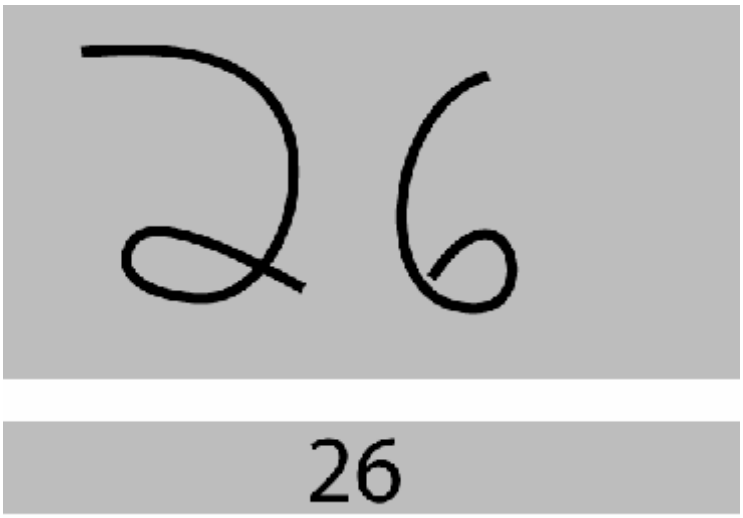


6 Final Design Recommendations

6.1 Continuous Handwriting Feedback

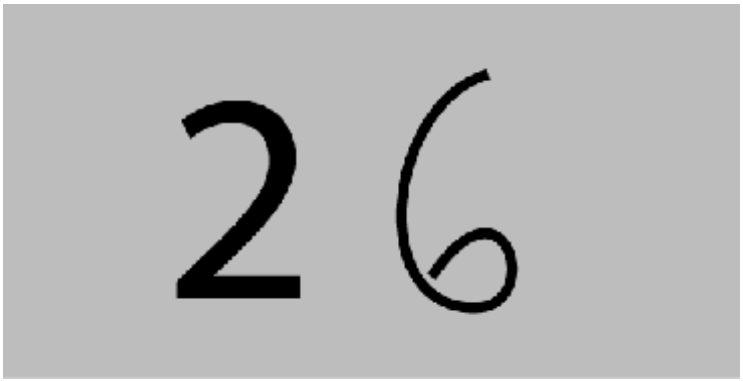
Throughout the Math Whiz user interface we observed consistent problems with user perception of handwriting recognition. When a user could not log in to the system or received feedback that she had answered a problem incorrectly, the system did not give the user cues as to whether the error was due to a problem with handwriting recognition or was simply an incorrect input. Two solutions to this problem were developed.

Preferred Solution - Recognition Feedback Display



The areas of the UI most susceptible to this error were the login fields and the answer box. In both cases, a text display should be included underneath the field such that recognized text is printed continuously as it being recognized. A label indicating the functionality of this new field would aid in user understanding

Alternate Solution - Recognize then Replace



An alternate solution would be to replace the user-created, handwritten text with recognized text as it is written.

6.2 Picture-based log-in

We observed users failing to log in due to a conflict with their existing work practice: while students routinely write the current date on their homework, Math Whiz login requires their birthday.

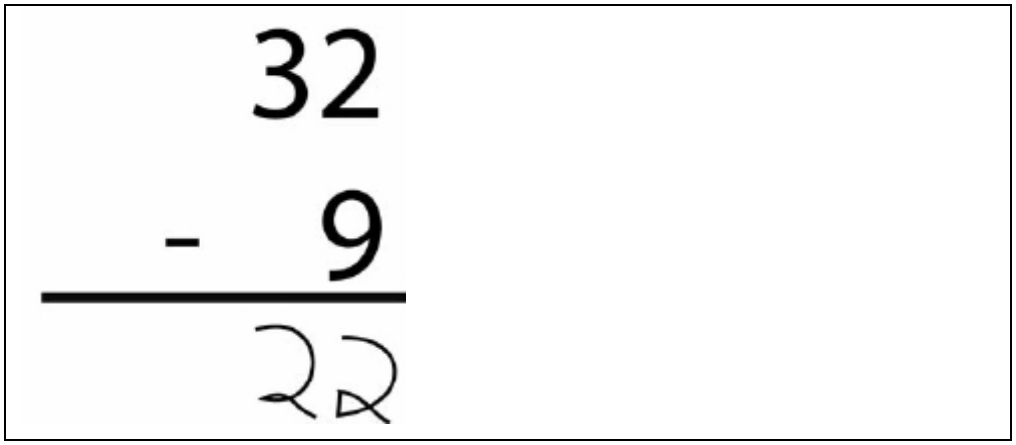
An alternative log-in procedure might require the user to select a unique picture or avatar after entering their name. The avatar could then replace the frog in the existing interface and follow them through their problem set, possibly even providing feedback (see below inline step-by-step walkthrough below). This mechanism would be sufficient to allow students with the same name to have unique accounts on Math Whiz. If additional security was required, the students could name their avatar and use this name as a password.

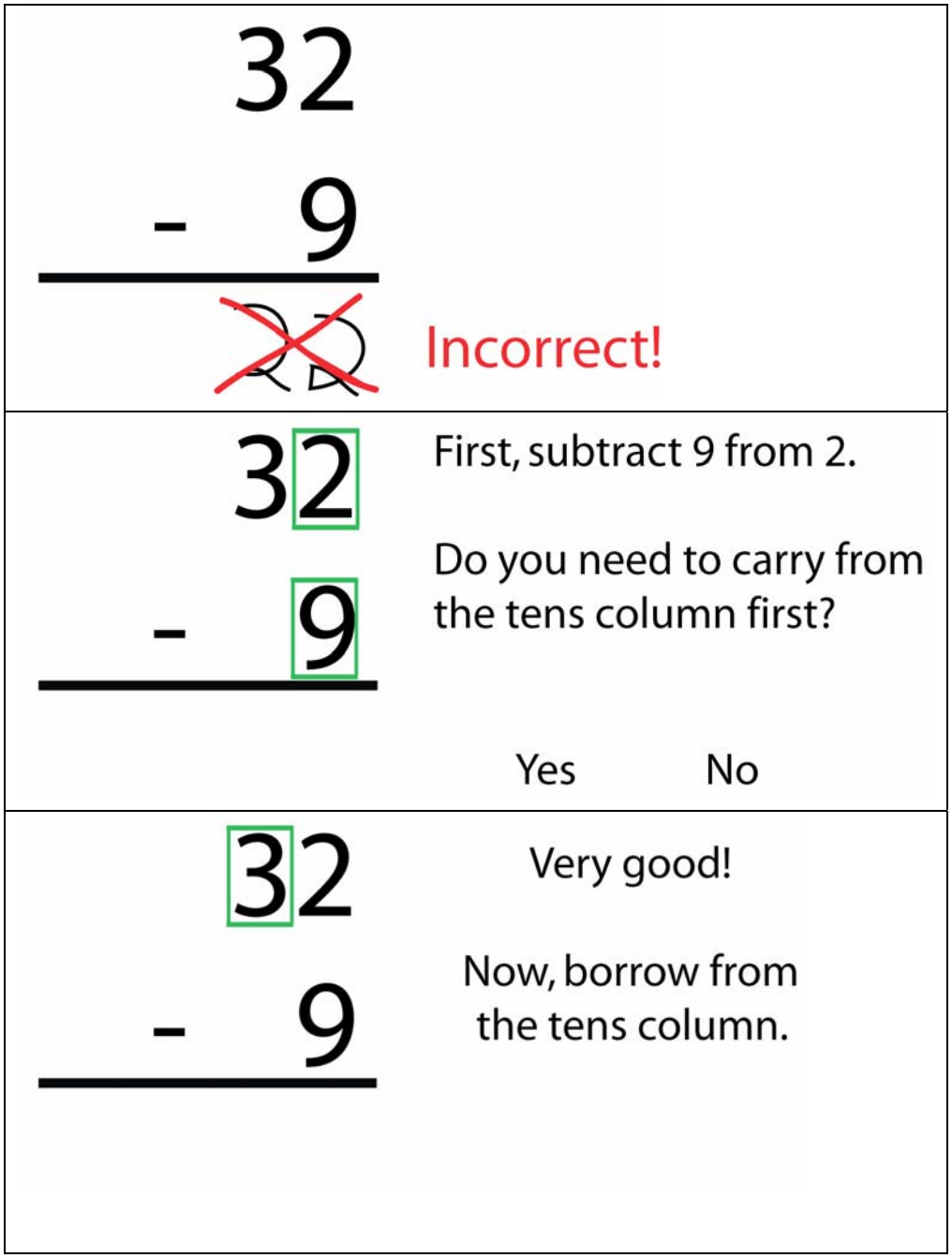
This approach could be taken a step further by asking students to draw their own avatar using the pen and basic paint tools when they started using Math Whiz. This drawing exercise would both give the students an introduction to the tablet in general and allow them to customize their experience.

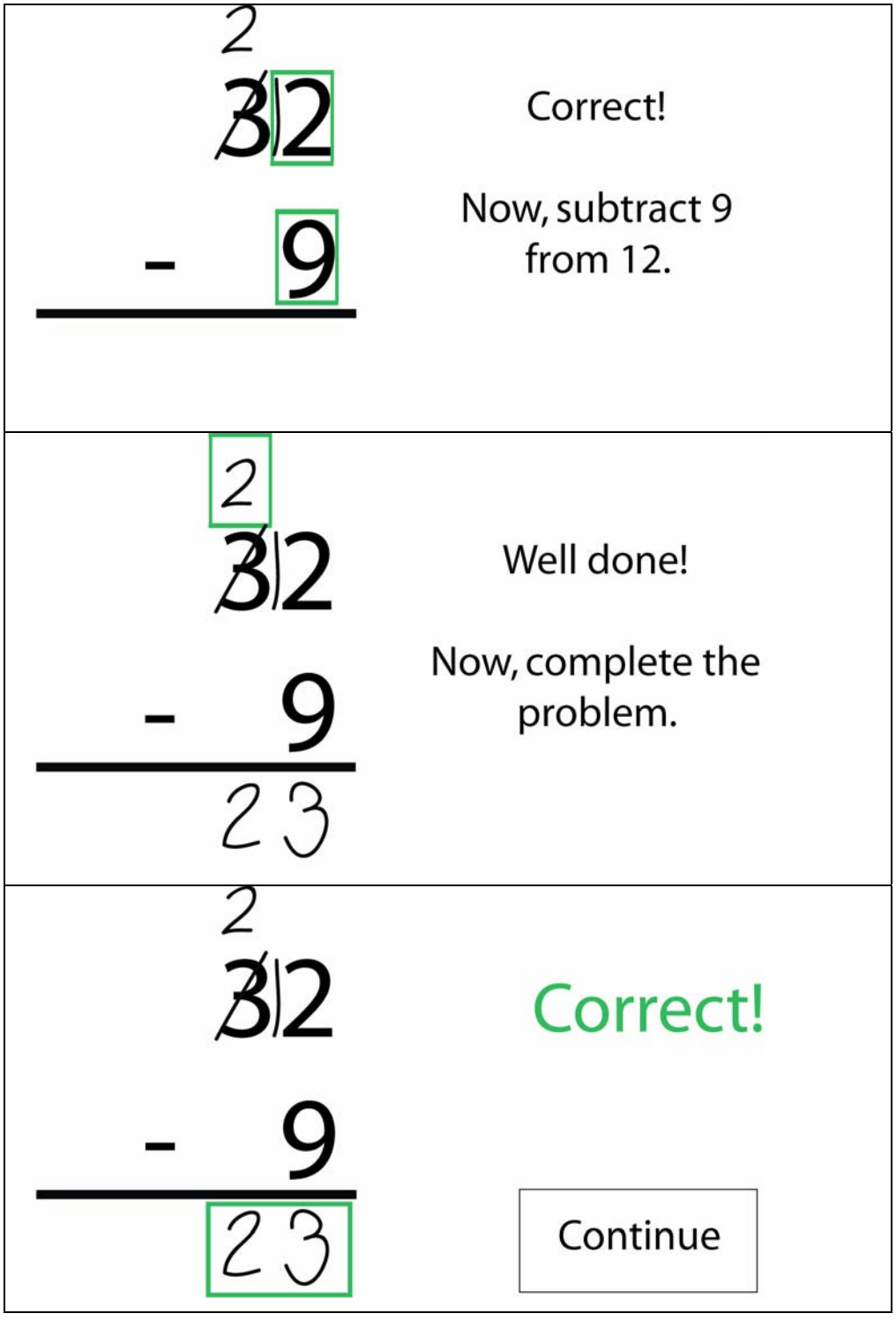
6.3 Inline Step-by-Step problem walkthrough

Math Whiz's current feedback display is problematic. After the student completes a problem, the next problem is shown at the same time that brief feedback is given on the completed problem. Students were observed overlooking this feedback entirely. An immediate solution is to display the feedback on the completed problem itself. If the student answered the problem correctly, this feedback would be shown briefly before the next problem loaded. If the student answered the problem incorrectly, they would be asked to click a button to continue. The difference is small, but will force the student to acknowledge that they answered the problem incorrectly.

A larger feedback problem is that Math Whiz is missing an opportunity to help students learn from their mistakes as they make them. Rather than simply progress to the next problem when a student makes a mistake, Math Whiz could step them through the problem and show them a step-by-step method for solving it. This would help students focus their efforts on improving their weaknesses. The option to require the students to work over their mistakes could be set by the teacher on a per-exercise or even per-student basis.




32
- 9
Incorrect!
32
- 9
First, subtract 9 from 2.
Do you need to carry from the tens column first?
Yes
No
32
- 9
Very good!
Now, borrow from the tens column.


2
3 2
- 9
Correct!
Now, subtract 9 from 12.
2
3 2
- 9
2 3
Well done!
Now, complete the problem.
2
3 2
- 9
2 3
Correct!
Continue

6.4 Gaming Options

Both the students and the teachers reacted extremely positively to the idea of math games on the tablet. Exploring this idea was outside of the scope of our evaluation, but we hope that another team could pick up where we left off. We do have some suggestions to leave for future teams:

Creating team-based games where individual contributions are averaged into a team score might help weaker students avoid embarrassment. The types of games implemented should be inspired by the institutional culture. At Glendale, football would be the obvious choice.

Games like Puzzle Pirates might make a good model for a cooperative, team-driven math game. In Puzzle Pirates, players undertake vaguely nautical puzzles in parallel. Taken together, the success of the players at their individual puzzles allows the group to collectively control a pirate ship and compete with other ships.

7 Visual Design Ideas

Based on the results of our Think-Aloud we created a new design without the nonlinear navigation elements. This is not a complete design, but rather a vision of how Math Whiz might look with our recommended improvements implemented and a refined visual style. This design is intended to add to the high-tech appeal of Tablet Math Whiz while remaining playful and approachable. The following two mockups show the same problem being answered correctly and incorrectly.

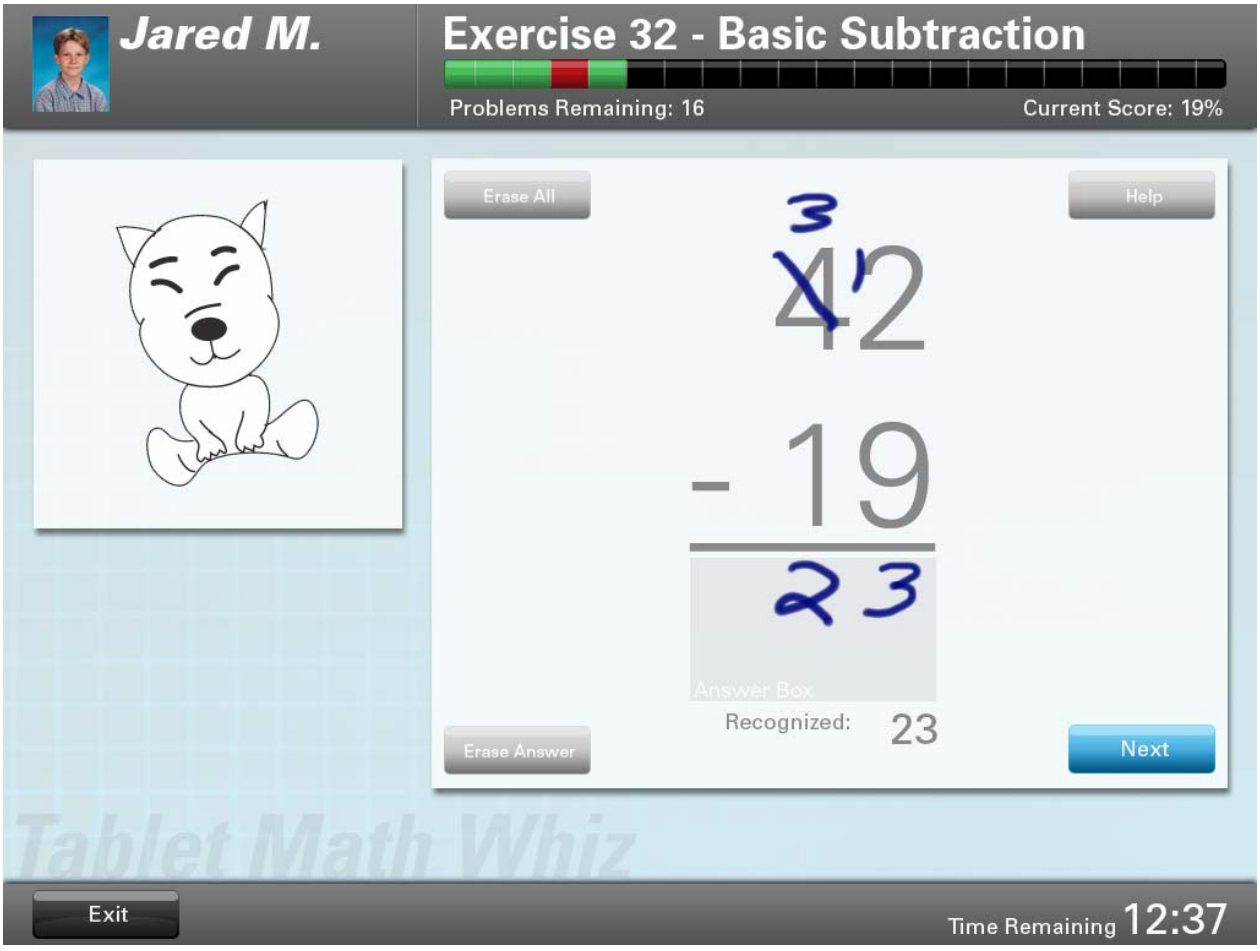


Figure 7-1: Final Visual Design for revised Math Whiz Interface, Correct Answer

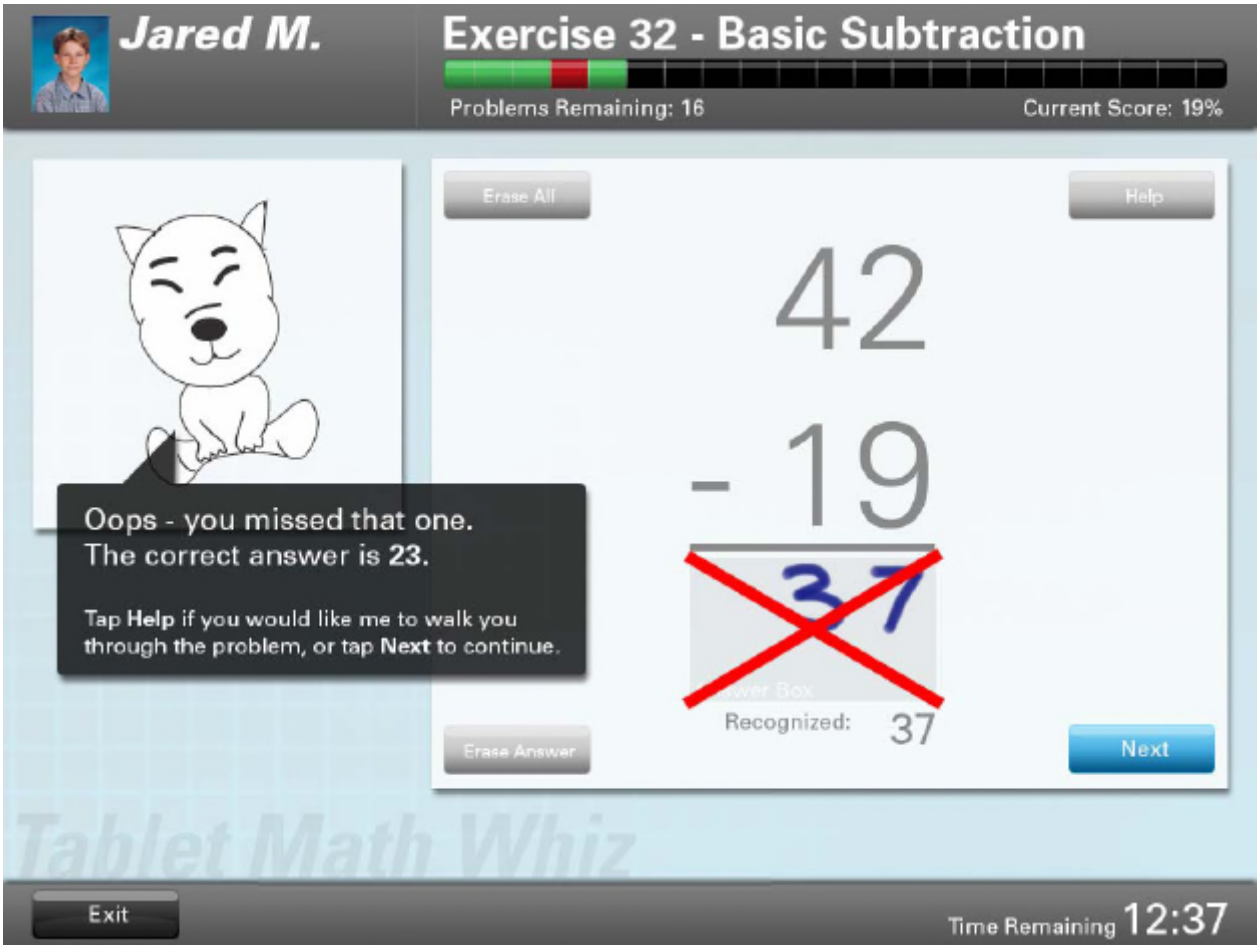


Figure 7-2: Final Visual Design for revised Math Whiz Interface, Incorrect Answer

8 Conclusion and Next Steps

Overall, we felt our redesign was successful, although not all aspects of the interface panned out as well we we'd initially hoped. However, there are a couple of directions that we think would be very fruitful, based on positive feedback from the stakeholders.

The first of these is providing the Math Whiz interface in the form of an interactive, possibly collaborative game, where the children solve math problems in order for their side to win. One suggestion that seemed popular was a football game in which the class could be divided into teams and play over a network. The details of this interaction are still vague, however the teachers and students both seemed to think it would be very useful and popular for engaging the students in math.

Another redesign issue that needs to be addressed is that of the teacher interface. Although for the purposes of our work we decided not to focus on the teachers' interaction with the system, we did notice in our initial interviews that there were a number of usability problems with the teacher interface that should be addressed. Although we have no specific recommendations for this interface, we feel a second look and evaluation of it would be worthwhile, to ensure the teachers feel comfortable using and adopting the system.

Based on the feedback we received from the stakeholders, we think the Math Whiz tablet PC still has some hurdles to overcome, but will be accepted into the curriculum if it carves out its own niche, perhaps by providing a fun, game-like outlet for the kids, rather than trying to compete with existing educational learning tools such as Saxon.

9 References

[1] Children as Design Partners http://www.cs.umd.edu/hcil/kidsdesign (accessed 20. Oct 2006)

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10 Picture Index