

Science Kit

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1 Introduction

1.1 Kitchen Chemistry

Kitchen Chemistry is a project headed by Tamara Clegg in the Human Computer Interaction Laboratory (HCIL) at the University of Maryland. Kitchen Chemistry's goal is to develop a curriculum to teach children the scientific process through Life-relevant Learning (LRL) environments. LRL environments help children learn scientific processes. These include making observations, stating claims, or designing experiments in a way which is relevant to them, and better captures their interest.

In Kitchen Chemistry children learn how to design experiments and think scientifically through cooking. One example is learning about leavening agents (eggs, baking powder, baking soda, etc.) through the process of making everyday foods (brownies, cookies, pudding, etc.) The children learn not only what leavening agents do, but additionally why they should only change one variable in an experiment at a time, and how to make claims about how kitchen chemistry works using their observations. Technology is used to help support and scaffold the children's investigations.

1.2 Existing Technology

iPads are used to document experiments, observations, and ideas while the children are conducting their experiments. The two main applications initially used are StoryKit and Zydeco. StoryKit was designed and developed at the University of Maryland's HCIL as a linear story creator which allows users to paint, take pictures, and add text or recordings to pages within the story. Zydeco, which was developed at the University of Michigan, has scaffolding for scientific inquiry, and is designed to get users to collect and organize data. Users can take pictures or record videos, and assign metatags to their data. They can then make claims and tag certain entries as evidence as their proof.

In Kitchen Chemistry StoryKit ends up being used primarily for documenting larger and more intricate experiments, where Zydeco is used more for observation based activities. In the summer 2011 session of Kitchen Chemistry, when given the choice between Zydeco and StoryKit, every team of children picked StoryKit. StoryKit is by far the favorite of the children, but it lacks the scientific structure Zydeco has. This leaves room for new technology to be developed that embraces children's creativity and playfulness, while also scaffolding scientific thinking into the application to encourage children to think critically about their world.

1.3 Project Purpose and Goals

My contributions via this project started in the late summer of 2011, when I assisted the Kitchen Chemistry program for a day. My project has included coding data, assigning data categories and tags that the research team developed, from StoryKit and Zydeco from sessions of the Kitchen Chemistry program. Using that data I created a preliminary design for a new piece of technology called Science Kit. We then brought the design to Kidsteam and to the Spring 2012 Kitchen Chemistry program for the children to give us feedback and design Ideas. I then created a medium fidelity

prototype, which we installed and ran on the Kitchen Chemistry iPads. Subsequently, feedback and design ideas from the low and medium fidelity prototypes as well as first hand experience from facilitating three Kitchen Chemistry sessions contributed to the next iteration of the design.

The goals I have in my design are the following.

- Create a design that will captivate children's attention
- Design a scaffold for scientific thinking that allows for the children to still be creative.
- Design an application that will allow children to use the application independently as well as with a facilitator.

The following paper details my work in gathering primary data, designing, developing, and refining the application Science Kit.

2 Preliminary Research

2.1 Data Collection and Determination of a Coding system

The data used was collected from the Summer 2011 session of Kitchen Chemistry. The session consisted of a week long, all day summer camp. Nine children participated aged nine to thirteen years old, six of which participated through all of the sessions. Researchers from HCIL were facilitators for the week long program with myself participating as a facilitator for one day.

Video recordings of all structured activities were taken. At the end of the day facilitators recorded field notes regarding their observations of that day. Interviews were also conducted with four program participants. The data I analyzed were the program participant's entries in Zydeco and StoryKit. For this data a coding system was developed to categorize the data. I worked with two researchers to code the data and help improve the code system.

The Codes that were ultimately decided upon were the following:

- Candid Camera
- Interview Style
- Child as documenter
- Raising questions
- Making Scientific Observations
- Comparison of Experiment Results
- Measurement Procedures
- Making Claims
- Creativity
- Documenting the group experience
- Playfulness

2.2 Process

The data we worked on were the StoryKit stories and Zydeco entries, which were separated by group and day they were entered. For every Zydeco entry and page in a StoryKit story the entry contents were recorded and described in a spreadsheet. Elizabeth Bonsignore, Tamara Clegg, and I worked on recording this information. The quantity of videos, photos, audio, and words entered were recorded as well as a description of what was entered along with transcripts of any audio or video. After the session we went back over the data adding codes, as written above, to categorize the data. Data such as videos, audio, or text had codes applied; In addition, entire pages or Zydeco entries were given codes. We also went over each other's codes to make sure we all agreed on how they were coded.

2.3 Conclusions

	Photos	Titles/Text Boxes	Audio Files	Tags	Videos	Drawings	Entries/Pages
Zydeco	131	153	98	382	22	0	153
StoryKit	303	188	75	0	0	88	188

Figure 1: Totals for the number of Photos, text boxes, tags, etc for Zydeco and StoryKit

The data set we worked from consisted of 153 Zydeco Entries and 188 StoryKit pages. In figure 1 you can see the number of different types of data pieces that were contained in each entry. For any category that has a zero in it, this means the software did not support that capability.

Scientific Practice	Photo Codes - StoryKit	Photo Codes - StoryKit (Normalized)	Photo Codes - Zydeco	Photo Codes - Zydeco (Normalized)
<i>Raising Questions</i>	0	0	0	0
<i>Making Scientific Observations</i>	26	13.82978723	10	6.535947712
<i>Comparison of Experiment Results</i>	33	17.55319149	3	1.960784314
<i>Measurement Procedures</i>	19	10.10638298	4	2.614379085
<i>Documenting Experiment</i>	81	43.08510638	93	60.78431373
<i>Making Claims</i>	2	1.063829787	0	0
<i>Creativity</i>	7	3.723404255	4	2.614379085
<i>Documenting the Group Experience</i>	67	35.63829787	16	10.45751634
<i>Playfulness</i>	21	11.17021277	5	3.267973856

Figure 2: Table showing counts for each code for photos from StoryKit and Zydeco

Through analyzing the tallies of codes, it became evident where each piece of software had its strengths. For instance when comparing photo codes of Zydeco and StoryKit, StoryKit had 33 photos tagged with "Comparison of Experiment Results" where Zydeco had just 3. Even when the numbers are normalized, Storykit still far outweighs Zydeco with 17.55 to 1.9. StoryKit photos also showed a strong trend for "Documenting the group experience". However for audio codes, Zydeco had 65 audio clips tagged with "Making Scientific Observations", where StoryKit only had 10 clips.

Also for the “Playfulness” code, StoryKit always had more text or photos tagged as playful, but for audio Zydeco had more segments tagged as playful.

Through StoryKit, Kitchen Chemistry participants were able to more playful, creative, compare their experiment results, and better document their experience than Zydeco. However, Zydeco still shows that it’s scaffolding induces more observations to be made. StoryKit’s strong attraction for children, and it’s ability to let children compare their experiment results through photos, or looking back at previous stories led to the first design, and subsequent designs, of Science Kit to closely follow StoryKit’s work flow and features. Since Zydeco was so successful in focusing participants’ attention on scientific inquiry, scaffolding was another key goal of Science Kit.

3 Design

3.1 Low Fidelity Mock-up

The first Mock-up of Science-Kit was drawn on paper and was used to have a design session with the Kitchen Chemistry Team. After talking with the team and developing the design further, I created a low fidelity mock-up of Science Kit using Pencil, a design application.



Figure 3: The home page of Science Kit

Figure 3 shows the home screen for the low-fidelity mock-up. To get to this screen the user would first sign-in. Then they would be able to start a new investigation, look at previous investigations, search and view other people’s published investigations, change their settings, or get help. When users look at their previous investigations they can go back and edit their investigation or publish/unpublish it.

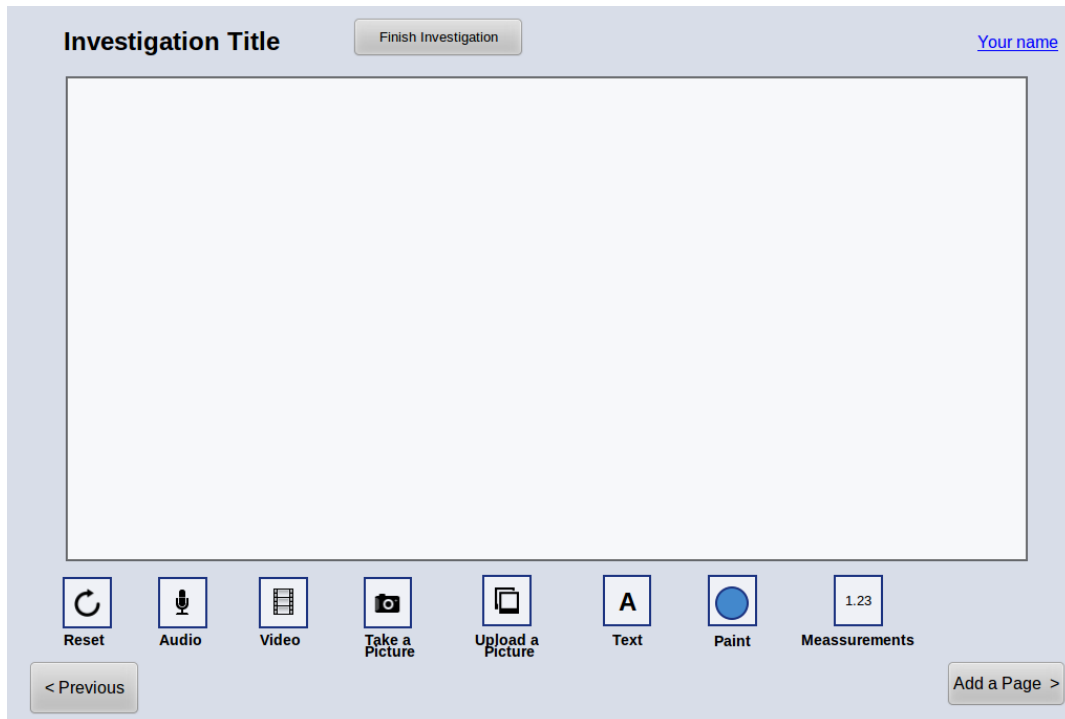


Figure 4: Third page of the mock-up, this page is for documenting the investigation

Figure 4 shows the main documenting page for investigations. Before this screen preliminary questions are asked about the investigation, such as, the title, if there are other authors, and the questions the investigators are trying to answer.

In Figure 4 there is a large canvas that is the predominant feature of the page. Here investigators can add pictures, text, audio, video, or paint to create pages for their investigation. This closely follows StoryKit's linear development of story telling. However, scientific specific features will be included, for example a Measurements widget is shown here on this page, and is shown in detail below. Users can also navigate to previous pages by hitting the previous button, or they can add a page with the add a page button. When they finish they hit the Finish Investigation button, which takes them to a closing page.

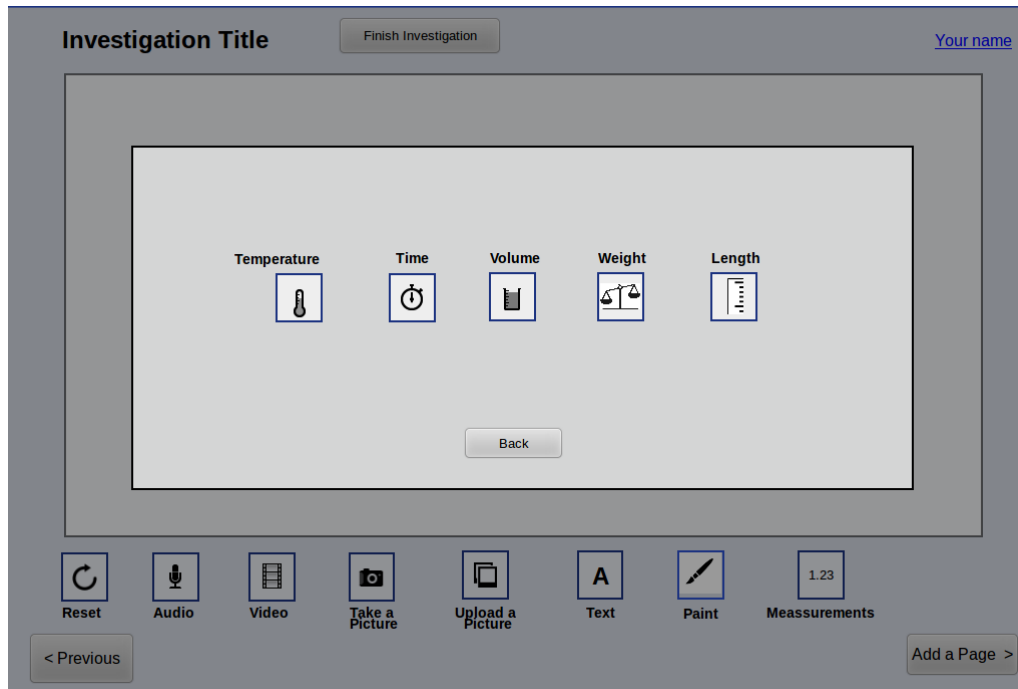


Figure 5: This page shows the beginning stage of the Measurement widget

Figure 5 shows the Measurement widget, which pops up as an overlay over the previous page. Here the user can choose what they're measuring: temperature, time, volume, weight, or length.

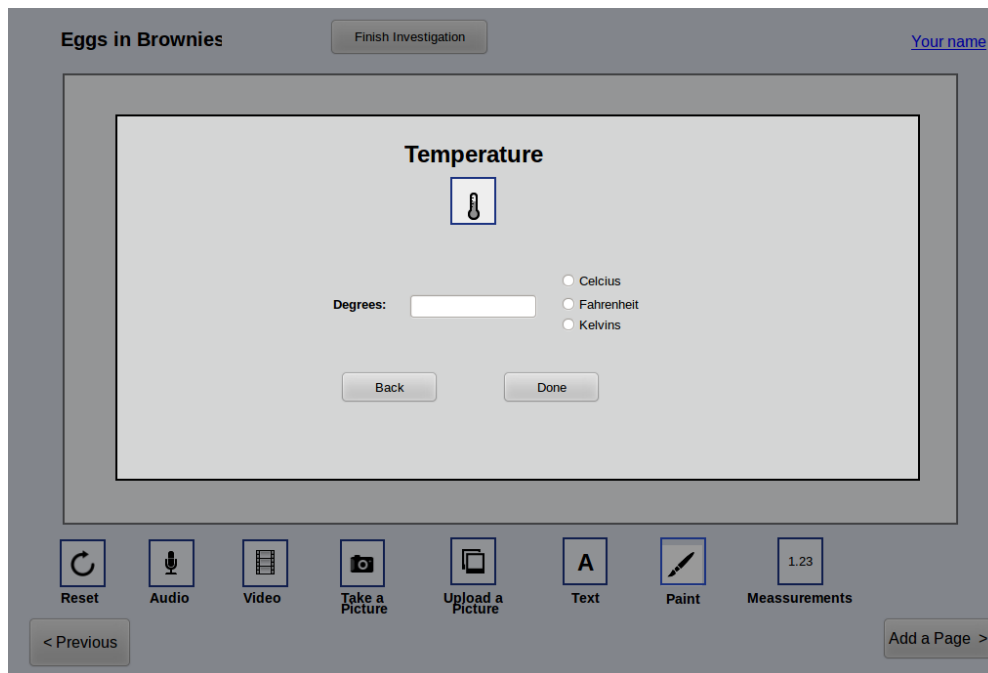


Figure 6: Temperature option for the Measurement widget

Figure 6 shows the temperature option for the Measurement widget. Here the user can input their measurement and choose Celsius, Fahrenheit, or Kelvins. When they hit done the measurement is added to the canvas as a text object.

The finish investigation page is much like the start page for investigations, it is a form that asks the questions: “What did you discover?”, “What did you learn? What evidence helped you make those conclusions?”, and “What would you do differently?”. The goal of asking questions before and after the investigation is to focus the user’s mind on the investigation and thinking scientifically.

3.2 Using the Mock-up



Figure 7: Example of layered elaboration

To test the design five pages were used in a Kidsteam session, where they had a design session using layered elaboration. Layered elaboration is where each page has a clear sheet of plastic added when the next person or team gets the page each team can see what was done before and add to it. Also it means information is not lost as the page goes from team to team. The same design session was also run with the Spring 2012 Kitchen Chemistry participants.

The structure for both design sessions was three different teams, with each team having 2-3 children. Before the team started designing Science Kit was explained to them, and they saw all the pages for Science Kit, even ones not given to them to design on. Each page was explained. Each team got one page for five minutes and a colored sharpie. They were able to brainstorm and draw for these five minutes, then they presented to the group for one minute about their design ideas. They were given five pages to work with: the home page, the start investigation page, the documenting the

investigation page (figure 4), the temperature widget page (figure 6), and the finish investigation page.

3.3 Design Session Results

The following is a summary of the results of both design sessions organized by page.

Home Page:

- More pictures, videos, and color.
- Show relevant examples of science in action.
- Need more detailed explanation of what buttons do.

Start Investigation Page:

- Record video (perhaps as an introduction)
- Random title generator
- Want speech to text functionality.
- Show the profile picture of the authors
- Needs a hypothesis box
- Help functionality for those who don't know what to do, or need inspiration
- Start with one question, but you can add multiple questions in

Document Investigation Page:

- Auto generated scaffolding, such as a procedures list, materials chart, results, or paneling (like those used to make comics).
- Home button
- A clip board where information can be saved then dragged and dropped where wanted.
- Reference button that gives you more information about the investigation
- Drag off the page to the trash or "delete all" button
- Tutorial for how an investigation would work/look

Temperature page:

- Multiple forms and representations temperature (numbers, thermometer, picture)
- Input temperature differently using gestures, slider, or coloring in a thermometer.
- keyboard can be numbers only in certain situations

Finish Investigation page

- Use integrated media (audio, pictures, etc) for the conclusion
- Use a picture or page as evidence
- Needs a prompt to talk about the hypothesis and whether or not it was correct.

3.4 Medium Fidelity Prototype

After the low-fidelity mock-up was completed, I developed a medium fidelity prototype for the iPad. The prototype was developed with Phonegap, a mobile development package that wraps html5 and Javascript so it can run natively on mobile platforms. Along with Phonegap I also used jQuery, jQuery Mobile, and a Javascript library called Fabric.js, written by Juriy Zaytsev, which is used to add the canvas functionality.

The screenshot shows a mobile application interface titled "New Investigation". At the top, the status bar displays "Carrier", "5:00 PM", and "100%". The main content area contains several text input fields: "Investigation Title", "Authors", "What questions are you trying to answer?", "Investigation Hypothesis:", "First Question:", and "Second Question:". At the bottom, there are two buttons: "Back" and "Start Investigation".

Figure 8: Preliminary questions for starting an investigation for the medium-fidelity prototype

Figure 8 shows the first page of an investigation, which now has a Hypothesis field. The back button goes back to the home page, which was fairly uninteresting in the prototype.

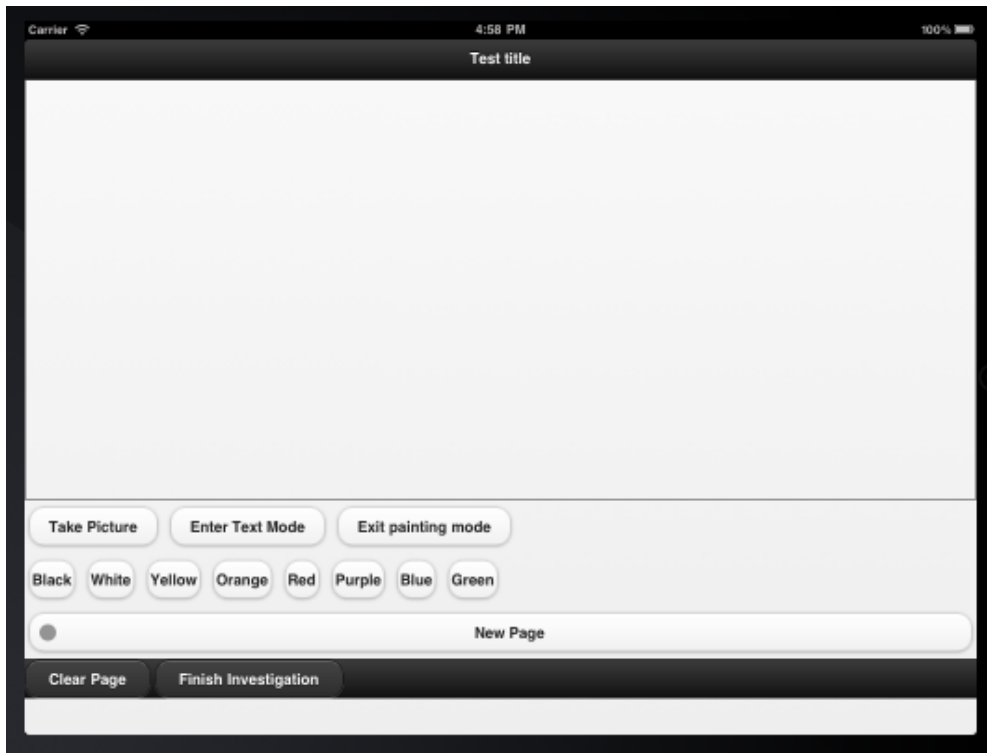


Figure 9: Shows the documenting feature of the prototype.

Figure 9 shows the canvas and documenting functionality of the prototype. For simplicity and time's sake the only functions implemented are painting, taking pictures, and adding text to the canvas. At the bottom of the page are buttons that can add a new page, clear the current page, and the button that takes the user to the finish investigation page.

Carrier 4:58 PM 100%

Finish Investiagtion:
Investigation Title

What did you discover?

What did you learn? What evidence helped you make those conclusions?

What would you do differently if you repeated the investigation?

Back to Investigation Save and Exit

Figure 10: The finish Investigation Page

Figure 10 shows the final page for finishing an investigation. Three questions are asked, “What did you discover?”, “What did you learn? What evidence helped you make those conclusions?”, and “What would you do differently if you repeated the investigation?”.

3.5 Using the Prototype

The prototype was tested with the Spring 2012 Kitchen Chemistry program participants. There were six children in total, who paired off into teams. Each team had one or two facilitators working with them. The prototype was tested, by being used to document a short experiment about thickening agents. The experiment was to mix water and a type of thickener (corn starch, tapioca flour, arrowroot flour) with water, then cook the mixture on the stove (facilitators managed the cooking part), and time how long the mixture took to thicken. Then they observed the mixtures, and compared each variation of the experiment.

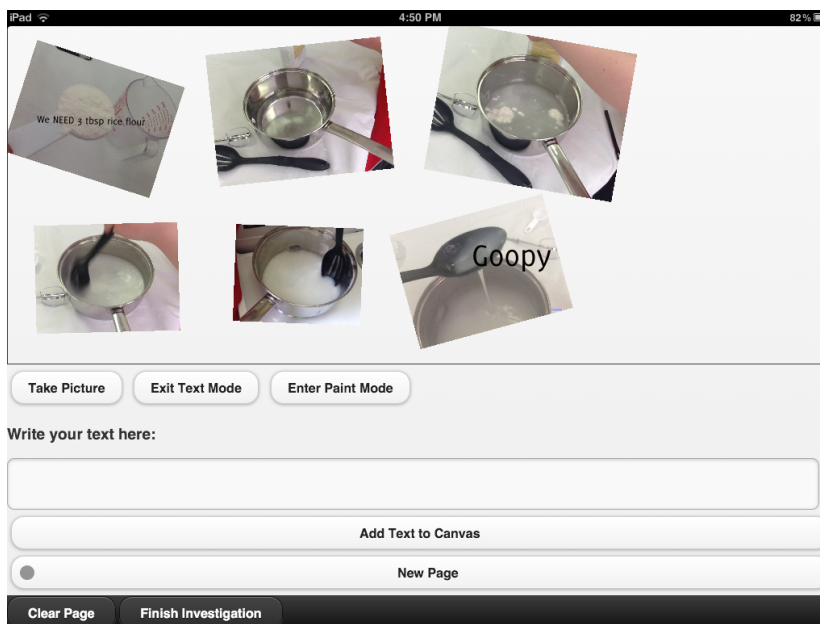


Figure 11: an example of one of the pages made during the testing of the prototype of Science Kit

3.6 Prototype Feedback

Through Facilitator observations, some key things became apparent about the prototype design. First, and most importantly was the majority of test participants did not like the form-like beginning and ending pages. They were not engaged by these sections, and they felt it was too much like work. It was suggested by the research team that a more loose scaffolding would be more effective for the start and finish of an investigation. Instead of having a form, have the questions directly put on the canvas of the documenting page for the start and end, so users can directly manipulate the page and format it as they wish. Other discoveries were more specific to the technology used; Fabric.js object manipulation points were small and hard to use, so moving images around on the screen was quite hard.

Other design suggestions from the participants of the program were: rainbow paintbrush for the paint functionality, Delete an element on the canvas, needs redo and undo buttons, a tutorial, games, and adding the question “What did you find interesting?” to the last page.

4 Next Iteration of Design

Based on the results from the design session with Kidsteam and Kitchen Chemistry, and the testing of the prototype quite a few changes had been made to the design of Science Kit.



Figure 12: New Mock-up of the Science Kit home page

The home page needs to be more exciting and inspiring. To achieve this relevant pictures would rotate through the main page exhibiting scientific exploration, photos featuring children and young adults exploring science would be extra effective. Figure 12 shows a mock-up of the new home page, which uses generic stock photography as a placeholder.

Instead of having two forms at the beginning and end of an investigation to scaffold in scientific thinking, the entire investigation will occur within the canvas workspace. The scaffolding questions, such as “what is the hypothesis?” or “what were the results of the experiment?” will allow the users to use audio clips, photos, or painting to express their answers to the prompts. Other scaffolded questions could be made so users could easily drag and drop them on to the canvas.

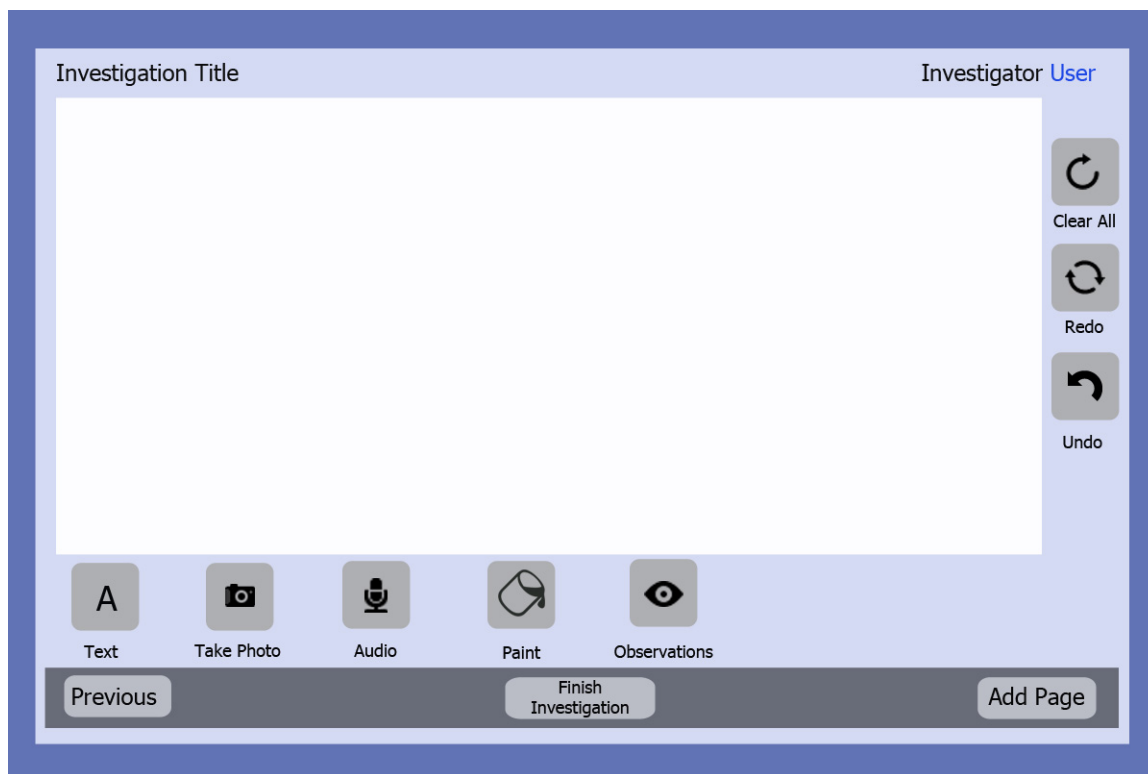


Figure 12: A mock up of the new canvas functionality, does not show complete and final functionality (ie buttons)

For the Documenting functionality, more scientific process scaffolding needs to be put in place. For measurements, a slider is used to quickly input measurement data. Other widgets will be added, such as an Observation widget. The Observation widget would help users make observations. Many Kitchen Chemistry participants have trouble describing things, especially in the beginning of the program. Too often an observation is, “it’s good” or “it’s yummy”, or simply they do not know how to describe what they see or smell. The observation widget would suggest different descriptors for the five senses, for instance for taste it might suggest bitter, sweet, sour, acidic, or sharp. It would also pick up on words such as good or yummy and prompt the user to be more specific.

For overall design and functionality it is important to have speech to text capabilities where possible. While not only does this make it easier for users to input text, it also makes the application more accessible for different audiences. Often during Kitchen Chemistry the program participants are reluctant or frustrated with entering text into programs, they much prefer recording audio or taking photos to capture their ideas and observations. Often Facilitators end up entering text for a group. A tutorial is also necessary to show how to use the application, but also to give the users an idea of what an investigation looks like. Users will also be able to publish their investigations, and view other user’s published investigations.

5 Conclusions and Future Work

My work with the Kitchen Chemistry team and on Science Kit has found an opportunity for technological improvement for teaching aids. While there are good aids available already, they are not specialized for scientific inquiry, and lack scaffolding for learning scientific process. The Science Kit prototype has also show that while scaffolding is necessary, it is important to not stifle creativity or force too much adherence; otherwise the users lose interest in the technology. It is important to make science fun, and not make it feel too much like schoolwork.

Science kit is now ready for the next iteration of design and evaluation. Using the prototype I developed, it is easy rapidly develop additional functionality. Once deployed, the new version of Science Kit can be tested by working with Kidsteam or Kitchen Chemistry program participants. The next prototype will be much more complete and will be used to investigate a whole cooking experiment, instead of a small experiment. Focus would be placed on the quality and quantity of scientific thinking evident in the experiment process and their digital investigations.

Whether or not the final application is built in Phonegap, is changed to be an online web-application, or is re-written as a native application depends on the needs of the Kitchen Chemistry team, and the performance of Phonegap

Attributions

Icons:

Glyphish icon library (cc)

DesignContest – Pain bucket icon (cc)

Interactivemania – Undo Icon (cc)

Photos:

Blowing Bubbles – Artist: Scott Liddell (cc)

Plane – Artist: Johnsense (cc)

Rocket – Artist: Steve jurvetson (cc)