WORDCRAFT

Team:
Ashley DeSouza
Divya Anand
Shreyas
Sonali Sharma
Victor Starostenko

Advisors:
Marti Hearst
Kimiko Ryokai

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*"and the moral of **that** is - take care of the sense*

and the sounds will take care of themselves"

~ The Duchess, Alice in Wonderland (Lewis Carroll)

Introduction

Learning a language involves an implicit focus on the meaning, or the intention of what one is trying to communicate. Our team believes we can enhance the experience of learning to write by providing children with immediate visual feedback as a sentence is being constructed. We believe that this will help children develop their metalinguistic awareness.

Problem Statement and Hypothesis

Our hypothesis is that *metalinguistic awareness can be strengthened through an understanding of parts of speech and how they link together to form a sentence*. Metalinguistic awareness is defined as the *ability of children to analyze and explain the process of language itself - to talk about language as if it were an object of study*[1]. We therefore envisioned an interface where children can use a broad set of words to create sentences, and see those sentences visualized. In this way, we help to create a concrete representation of oral language by making individual parts of speech more visible. We also allow for linguistic manipulations, which allow children to observe how the different parts of speech can impact their eventual sentence.

We chose to create this interface for a tablet application based on the current trends in tablet adoption, and the increased number of educational and other games for children[2].

The format of the app is game-like in order to encourage play. There is a large body of research to support the importance of play in successful cognitive and emotional development, and yet it is largely overlooked in the current educational environment. According to Vygotsky[3], play sets the stage for abstract thought and representational abilities, which are central to literacy development. While the app is designed to encourage play, it does not use a formal scoring system in order to ensure that the learning goals are not overtaken by a desire to get to a high score.

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[1] Owocki, Gretchen, and Yetta Goodman. *Kidwatching: Documenting children's literacy development.*

[2] http://www.parenting.com/blogs/children-and-technology-blog/jeana-lee-tahnk/kids-love-ipad-parents-love-these-top-education-a

[3] Rogoff, B. (1980). Apprenticeship in Thinking (Chapter 7).

Literature Review

Zigler emphasized the *importance of play in learning vocabulary, concepts, a variety of abilities, self-confidence, motivation and an awareness of needs of others*[4]. The focus goes beyond learning how to read and write, to also developing metalinguistic skills, where children are able to clearly articulate how language works. In their defining work on emergent literacy, Teale and Sulzby point out "*listening, speaking, reading and writing abilities develop concurrently and interrelatedly, rather than sequentially*"[5]. Our app takes inspirations from these ideas and hopes to address a deeper awareness of how parts of speech contribute to the structure of language.

For our app design, we were inspired by the constructionist approach to teaching programming as seen in the case of Scratch (http://scratch.mit.edu/). The constructionist paradigm envisioned by Papert refers to the concept of 'talking to a computer' to guide that design of a system that teaches children how to program[6]. We explored how we could use the concept of movable word blocks to allow children to apply this approach to learning a language. Just as children use Scratch to understand how to think like a programmer, using Wordcraft will allow them to think of how sentences are structured. For instance, understanding the difference between "the cat IS sleeping" and "the catS ARE sleeping" would be a key takeaway. Children will have the opportunity to move word blocks into slots to form a sentence. If they move a block into the wrong slot, i.e. "the cats IS", the block won't fit and this will guide them to think about why one type of word works, but not the other.

Design Principles

Our literature review helped us identify the following key design principles:

Building powerful ideas: In 'Mindstorms'[7], Papert suggested the concept of powerful ideas, which are, '*ideas that can be used as tools to think with over a lifetime*'. In Wordcraft, the objective will be to allow children to explore and make sentences in different contexts (e.g. a farm, outer space, library etc.). In this way, they will be designing sentences for a different 'world', but they will still explore the same underlying ideas of how sentences need to be structured. The repeated use of this structure will help them apply these grammar rules to other contexts. For this version of our prototype, we chose to use the farm context.

Fostering Collaboration: While this game can be played individually, it will allow for learners to play in pairs and help one another. Our broader vision is to allow children to share the sentences they

[4] Zigler, Edward F., Dorothy G. Singer, and Sandra J. Bishop-Josef. *Children's play: The roots of reading*. ZERO TO THREE/National Center for Infants, Toddlers and Families, 2004.
[5] Teale, William H., and Elizabeth Sulzby. "Emergent literacy: Writing and reading." (1986).
[6] Papert, S. (1980). Mindstorms: Children, Computers, and Powerful Ideas. Basic Books.
[7] Papert, S. (1980). Mindstorms: Children, Computers, and Powerful Ideas. Basic Books.

make with others who can then modify those. We also hope to have features that allow children to see sentences that others created with a set of words, thereby giving them ideas on the various ways in which the same words can be used.

Be accessible[8]: have an interface that is ergonomic, intuitive and easy.

Finally, we plan to use the iterative design approach in developing our prototypes. Our design process follows John Maaeda's design philosophy - *imagine, realize, critique, reflect, iterate*[9].

Personas

We targeted children aged 4-8 for the app, based on the teaching guidelines outlined in Common Core standards, which suggested this would be the appropriate age range for a sentence building app. Our personas are crafted based on informal conversations with teachers and parents of children in our target age range.

The Reader: Annie, 5 years

Favorite app / website: Sprout online

Annie's parents have been reading to her since she was a baby, so even though she's only 5, she can identify most common words. When she's not reading, she watches Dora the Explorer or plays on "her" iPad. She likes "writing", where she opens the Notes app on her mother's iPhone and randomly types into it.

Functional Goals

- Reading ("all by myself")
- Learning to write

[8] Raffle, H. (2004). Topobo for Tangible Learning.

[9] Resnick, M., and Silverman, B. (2005). Some Reflections on Designing Construction Kits for Kids. Proceedings of Interaction Design and Children conference, Boulder, CO

Emotional Goals

- Spending time with her dad on weekends
- Making new friends at the 'railway' park near her house

Frustrations

- Hates waiting for games / activities to load

The Explorer: Aiden, 9 years

Favorite app / website: Angry Birds

Aiden loves LEGO. His favorite pastime is to use LEGO bricks to create things that they're not meant to do, like "building a car with my city set". He doesn't like studying, and only enjoys going to school so he can meet his friends.

Functional Goals

- Exploring and discovering tricks that others don't know about

Emotional Goals

- Getting an A at school to make his mom happy
- Being the first among his friends to get an Aviation Adventure Lego set

Frustrations

- Doesn't like to be told what to do when he's experimenting with something

Concept Testing (Paper Prototypes)

We first tested our concept using paper prototypes. At this stage, our objective was to gauge whether the idea of visualizing a sentence was interesting to children. We came up with a few sentence combinations around the context of 'a day at the park' and took photos to simulate the image generation. We cut our word cards and pictures related to the context and conducted a Wizard of Oz style test with two children where a moderator changed photos based on paper words dragged by the children into a sentence. Not all possible scenarios could be addressed through this method, but we were able to support enough iterations to allow for a 25 minute long session with each child.

Insights

The concept appeared to be engaging. With the paper prototype, we observed that children enjoyed moving around words and observing how the sentence construct changed the images they saw. However, this round of observations was only indicative of the probable engagement that this idea offered. None of the interactions could give clear evidence for design choices, as the children required a lot of verbal scaffolding to understand the concept through this method of testing.

We therefore decided to work on a medium fidelity mobile prototype for more in-depth observations.

Design Process

App Map / UX Walkthrough

The app map was created to outline the key flows and possible interactions. For this project we focused on prototyping and testing the create sentence flow. We did not include the login / sign up flow because it was not central to the hypothesis. The login flow is, however, an integral part of the overall product idea because it helps us support collaboration amongst users.

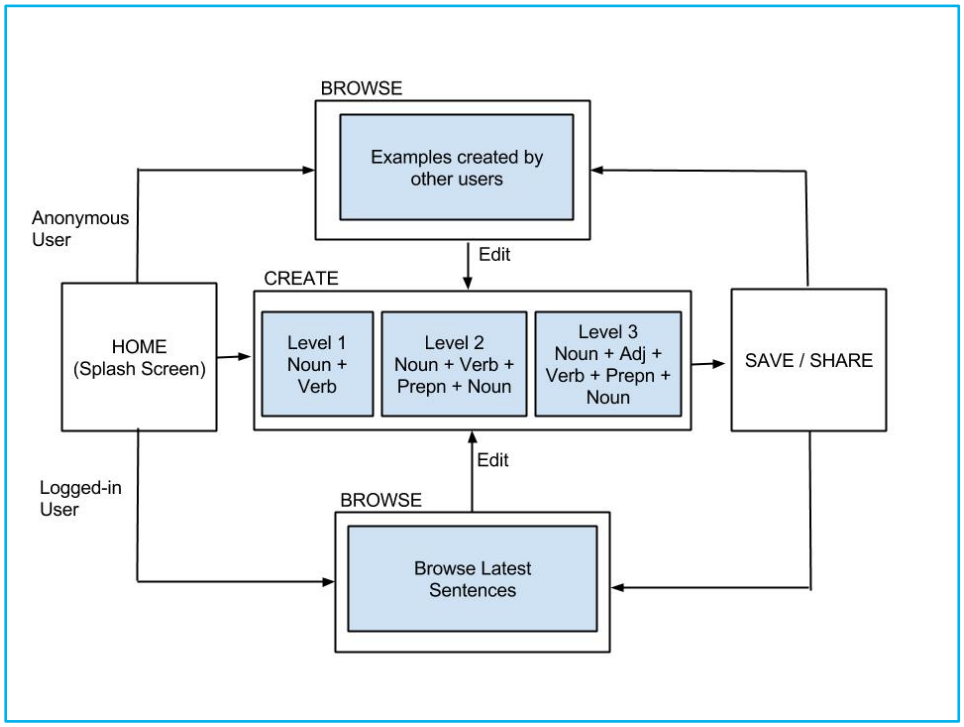

Figure 1: App Map

Wireframes

We created wireframes to illustrate and evaluate our key flow and elements. At this stage, we envisioned the 3 stages as 'levels' within the game, where each level built onto the next one. We had 3 options for the main screen -

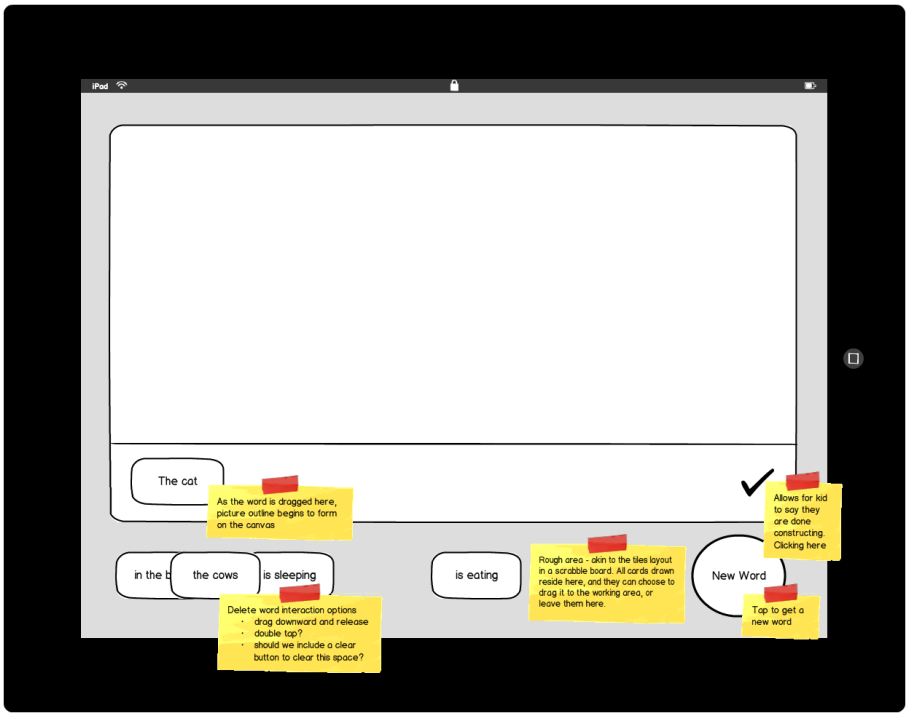

Figure 2: Main Screen Layout - Opt 1

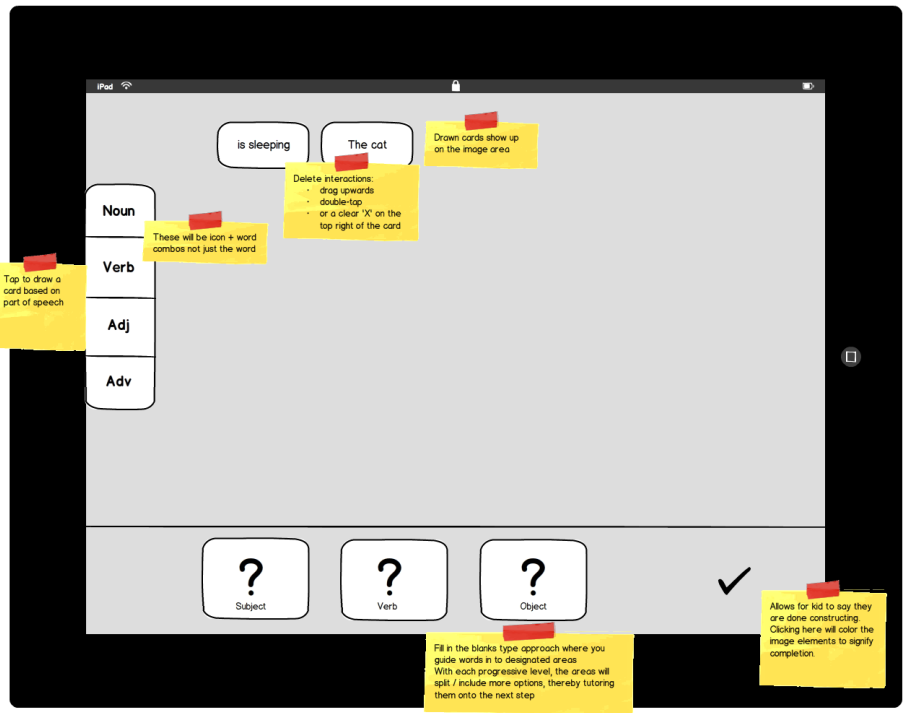

Figure 3: Main Screen Layout - Opt 2

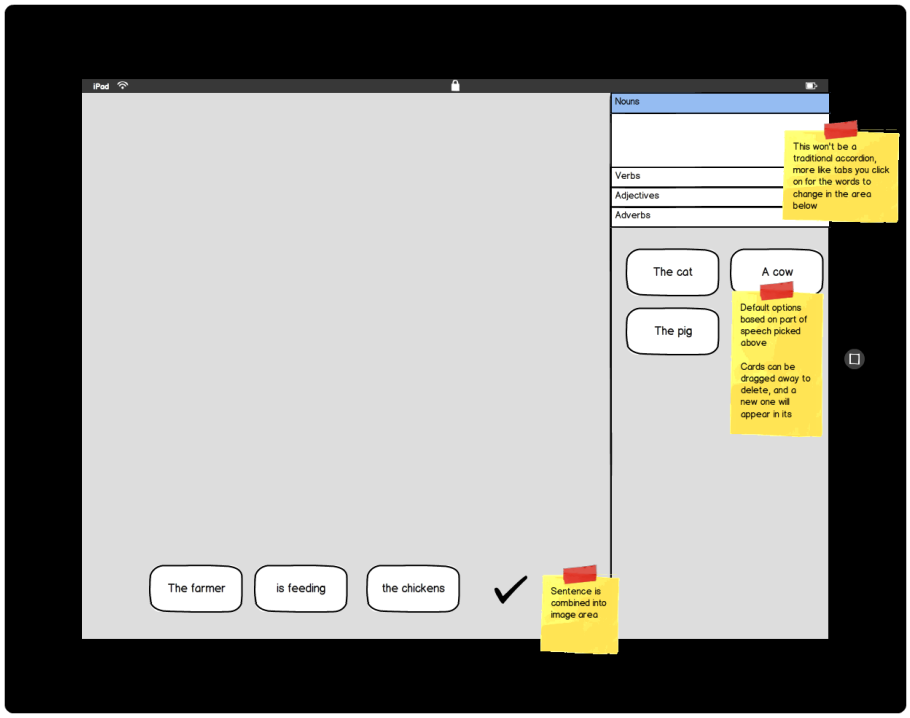

Figure 4: Main Screen Layout - Opt 3

Expert Opinions

We chose to get expert feedback on the wireframes instead of testing this with children directly. The reason for this approach was that concept testing had shown that a lot of verbal scaffolding is required to get children to understand this concept before they can see it live in action. So we chose to speak with experts to evaluate our choice of layout and approach to gameplay. Our experts included our advisors, and a teacher.

Based on their feedback, we made the following modifications:

- Overall Design
    - Option 3 was rejected because it was seen as likely to be overly complex for younger children
    - Options 1 and 2 were combined to create a more intuitive interface
    - The idea of a hand of cards and working within the constraints was seen as effective for reducing the overall project scope, but we were also encouraged to evaluate a rolodex scroll option to allow children to pick words and avoid constraining them to the default draw from the system
- Buttons and other Visual Elements
    - We removed '?' on the blanks because it was likely to confuse children by making them think there was a question they had to answer, instead of a blank where they had to drag a word block
    - The 'Done' button was highlighted as something that needed to be evaluated in research, as the green check mark was not seen as being intuitive enough

Final Wireframes: Site Flow and Rules Structure

Our final wireframes further explored the idea of 3 levels. For this prototype, we chose to use the *subject-verb* and *subject-verb-direct object* structures. This decision was based on how sentence construction is taught, where children are first taught to make sentences in these constructs, and they then move on to advanced structures[10]. If this were part of a full-fledged game, we could consider this to be the basic lesson in sentence structures and have other lessons to address permutations and combinations, similar to the way that Duolingo (www.duolingo.com) offers multiple lessons.

In Level 1, children make 3 word sentences in a noun-verb combination. In Level 2, children build on the 3 word sentences to make 5 word sentences in a noun-verb-preposition-noun combination. In Level 3, they further build on the sentences to make 7 word sentences in a noun-adjective-verb-preposition-

[10] http://everydaylife.globalpost.com/esl-sentence-structures-teach-young-learners-28249.html

noun combination. Here again, in the interest of overall project scope, we chose to use *nouns, verbs, prepositions and adjectives* to illustrate and test the concept and flow. We believe that the same structure and logic can be expanded to incorporate other parts of speech, and other sentence constructs as we go along.

Figure 5: Wireframe - Splash Screen

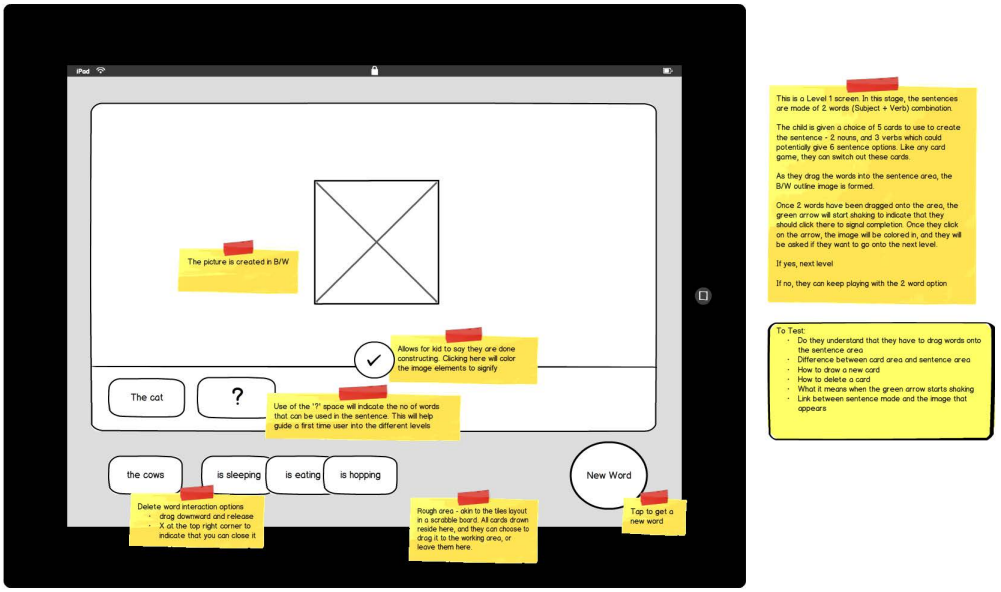

Figure 6: Wireframe – Level 1

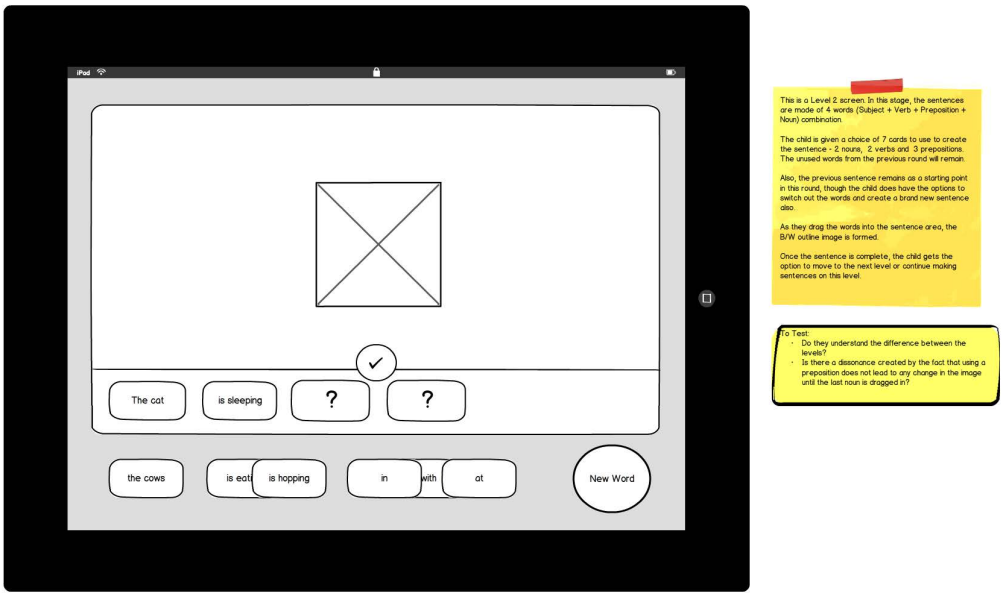

Figure 7: Wireframe - Level 2

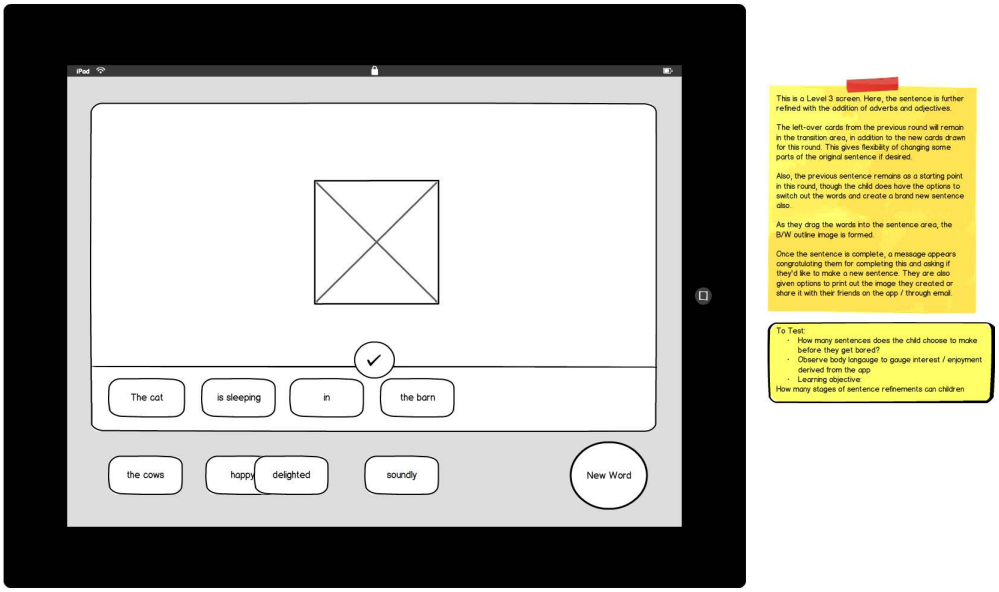

Figure 8: Wireframe - Level 3

The flow and elements outlined in these wireframes were used to build the first version of the mobile prototype.

Mobile Prototyping: Technology Stack

In order to develop a scalable taxonomy, we chose to restrict our app to the context of a farm. We picked this because of its popularity with children, as seen in children's books and games. The logic used in this scenario can be applied to other contexts in the future.

We also optimized our development for the *7.9" iPad* and used this device for our testing as well.

Architecture

Our architecture is a variation of the Model-View-Controller (MVC) Architecture.

- **RuleFiles & RuleMaker logic (Model)**: These are the set of files that are used to create the grammar rules for the sentence and output a JSON that could be parsed in JavaScript at the front-end. [adj_source.csv, nouns_source.csv, nouns_source.csv, prep_list.csv, prep_source.csv, verbs_source.csv , JSON_maker3.py]
- **SentenceLogic (Controller)**: SentenceLogic consists of a grammar rule engine created from scratch, using JavaScript. Using the data generated from the model, we create the grammar

rules. These rules get re-applied in response to user's manipulation of words on the sentence pieces, every time a word is dragged or removed from the word list area onto the sentence area, the rule engine runs and determines the next set of words that are allowed in the adjacent spaces to formulate a grammatically correct sentence. The application thus allows only valid words to be dragged on the correct location. Invalid words are dropped back to the word list area. Once a valid sentence is created, the controller passes an input to the Viewer in order to render the images on canvas.

- **CanvasLogic (Viewer)**: The CanvasLogic takes care of rendering and positioning the object on the scene and manipulating the rendered object with animations, driven by the controller.

Corpus of Words and JSON structure

The corpus of words (nouns, verbs, adjectives, prepositions) was created from wordlists[11] designed for new readers. We narrowed the wordlists down to a set of words that were best depicted visually while also allowing for multiple combinations of sentences.

The model in our Model View Controller (MVC) structure is the JSON data structure, which drives the rules engine. There are three main sections in the data structure: *Noun, Verb, and Adjective*. For every noun in our model we had to capture parts of the SVG image, its size, and position on the canvas.

```
"noun" : {
    "sheep" : {
        "svg" : {
            "src" : {
                "eyes" : "happy",
                "mouth" : "happy",
                "skin" : "positive"
            },
            "dimension" : {
                "width" : 200,
                "height" : 235
            }
        },
        "canvaspos" : {
            "plane" : "ground",
            "defaultY" : "middle",
            "defaultX" : "center"
        },
        "pos" : "nn",
        "exec_after" : [],
        "type" : "object",
        "before" : ["the", "a"]
    },
```

The verbs required much more structure and detail to be captured in the model. This is mainly because the verbs in our application drive animation. In some instances, a verb can express two or more kinds of

[11] http://www.havefunteaching.com/worksheets/english-worksheets/word-lists

animations. For example, "hopping" uses two types of animation - "translateY", which moves the object on canvas vertically, and "translateX", which moves the object horizontally.

```
"animation" : [{
        "duration" : "none",
        "animation_params" : {
            "start" : "0",
            "end" : "1",
            "mid" : "2"
        },
        "speed" : "fast",
        "scale" : "",
        "animation_type" : "translateX"
    }, {
        "duration" : "none",
        "animation_params" : {
            "start" : "-2",
            "end" : "0",
            "mid" : "2"
        },
        "speed" : "fast",
        "scale" : "",
        "animation_type" : "translateY"
    }
```

We went through several iterations and our final structure of the verb object captured animation, prepositions that are related to the verb, change in emotion, sound, and speech bubble. The sound and speech bubble are features that are not currently implemented in our prototype, but in order for our application to scale well to future expansion we included these items in our data structure.

The adjectives object captures emotion, color, and size.

```
"happy" : {
    "svg" : {
        "src" : {
            "eyes" : "happy",
            "mouth" : "happy",
            "skin" : "positive"
        },
        "properties" : {
            "color" : "",
            "size" : "normal"
        }
    },
    "pos" : "adj"
```

Note: Refer to Appendix A for the complete JSON structure.

Grammar Rules

The grammar rules that we created in the application were based on the sentence structure that we chose to enforce in this version of the prototype, as outlined.

One of the key decisions we made early on was to handle computations *client-side, (*instead of server side). There were several reasons for that:

- A general survey of children using tablets, specifically the iPad as a medium showed that most tablets are restrictive in terms of Internet access and user access. So our app had to be *standalone.*
- Young children require immediate feedback while playing. In order to enable our users to really play with the various combinations of words, we would need to support multiple permutations of the scene being rendered. Hence, a client-server model with multiple http requests could result in slowness and loss of reliability. Therefore we chose to support a client-side computation mention in order to ensure the most responsive experience.

For accomplishing the client-side computation of our app, we decided to use, html5 technologies for scene rendering, because most of our objects or nouns in the game / app were not drawn on the fly but rendered pre-hand-drawn vector files (svg).

Of the many platforms we tested in trying to embed NLP logic on the client side, whether using Python or using the built-in APIs (NSLinguisticTagger etc.), we didn't find any acceptable solutions that were consistently portable across all platforms: Android / iOS etc.[12].

So, we decided to use Phonegap (http://www.phonegap.com) as our platform and develop our own NLP logic on the client-side using JavaScript. We chose to build a grammar rule engine from scratch. There are several advanced natural language processing (NLP) libraries available, but we decided to create an engine on our own because we wanted the app to be *self sufficient and deployable on devices* (iPads, Android tablets) without external dependencies.

The grammar rules are applied iteratively, rule 1 is followed by rule 2, which is followed by rule 3. When a user drags and drops a word into the sentence area, the rules are re-applied. The application thus ensures that only a valid word can be dragged into a specific location in the sentence area. An invalid word will be dropped back to the word list area.

[12] http://stackoverflow.com/questions/22276342/mobile-app-architecture-python-as-backend-to-mobile-apps-web-based

Rule 1 (3 word sentence)

a) Singular noun | is | Verb

A cat | is | walking

b) Plural noun | are | Verb

The cats | are | walking

Rule 2 (5 word sentence)

a) Singular noun | is | Verb | Preposition* | <Singular noun or Plural noun>

A cat | is | walking | near | the fences

A cat | is | walking | near | a fence

b) Plural noun | are | Verb | Preposition* | <Singular noun or Plural noun>

The cats | are | walking | near | the fences

The cats | are | walking | near | a fence

*Valid verb to preposition mapping is defined in the JSON file

Rule 3 (7 word sentence)

Determinant | Adjective | <Singular noun or Plural noun> | <is or are> | Verb | Preposition* | <Singular noun or Plural noun>

a) Determinant {An} | Adjective {Starting with a vowel} | Singular noun |is | Verb | Preposition* | <Singular noun or Plural noun>

An | excited | cat | is | walking | near | the fences

An | excited | cat | is | walking | near | a fence

b) Determinant {A} | Adjective {Starting with a consonant} | Singular noun | is | Verb | Preposition* | <Singular noun or Plural noun>

A | fierce | cat | is | walking | near | the fences

A | fierce | cat | is | walking | near | a fence

c) Determinant {The} | Adjective | <Singular noun or Plural noun> | <is or are> | Verb | Preposition* | <Singular noun or Plural noun>

The | happy | cat | is | walking | near | the fences

The | happy | cats | are | walking | near | a fence

*Valid verb to preposition mapping is defined in the JSON file

Object and Canvas Creation

Object Illustrations

The noun objects were all illustrated using a circular drawing style, with layers of features (eyes, ears and mouth) that were defined based on verbs and adjectives. This helped in creating multiple nouns using the same set of shapes, and thereby helped in optimizing the illustration process by allowing for easy addition of new objects. We identified and delineated 5 key emotions that impact a change in features - happy, happier, sad, sadder and angry. The comparative scale allows us to show nuances of different facial expressions for the same emotion, like for instance 'sad' vs. 'crying'.

We created 8 animals and 3 inanimate objects (fence, barn and sun) using this construct. This can be further expanded to incorporate new objects by following the same structure, thereby allowing for scalability by expansion of the word set.

Note: Refer to Appendix B for all asset illustrations

Canvas Construction

Constructing the canvas for the objects mentioned in the sentence involves 3 key tasks:

1. **Rendering the Object:** The noun(s) are compound objects created from individually illustrated parts as outlined in the image

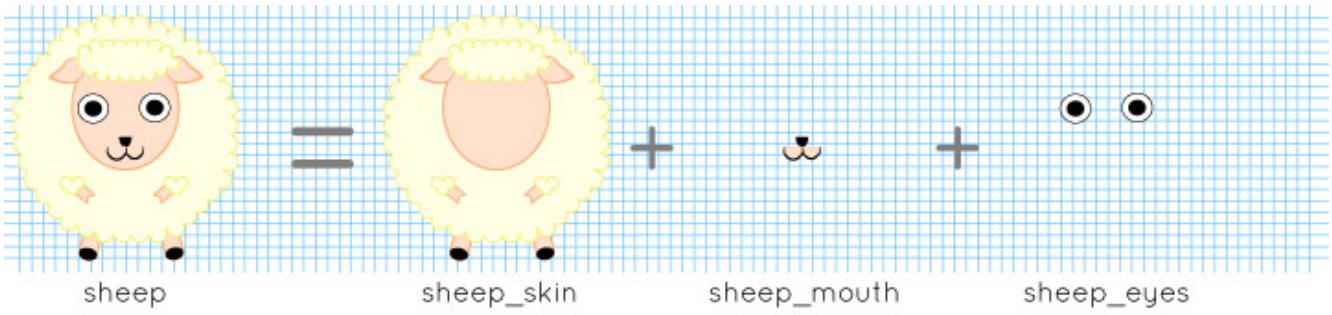

Figure 9: Object Rendering

2. **Manipulating the Object:** Objects are manipulated by animations that depend on the context of the verbs and prepositions as defined in the sentence

3. **Placing the Object:** depending on the context of the noun (and in some cases prepositions) in the sentence

Object Mapping

With the outdoor farm scene context, we got a vanishing plane, which separates ground and sky planes. For each of these planes, we developed 9-grid positions within each plane. As parallel lines meet on vanishing plane, each of the grid positions on x-axis (left, center, right) were adjacent whereas those on the y-axis (front, middle, back) were co-linear but at increasingly greater distance from each other.

Also, to give the illusion of perspective, the objects were scaled down in their relative positions. The scale factor was a function of the perspective angle.

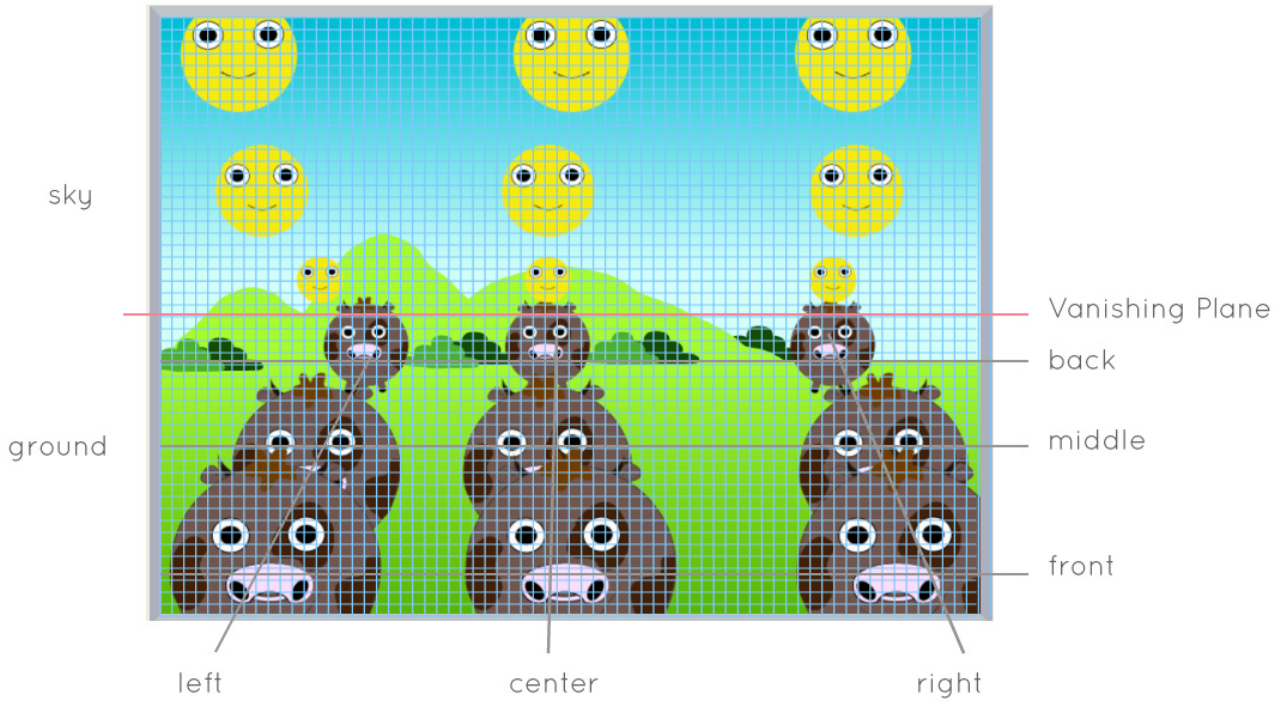

Figure 10: Canvas Grid Mapping

User Research and Design Iterations

Usability Study 1: Pilot

Findings

We conducted a pilot usability test on the initial version of our mobile prototype.

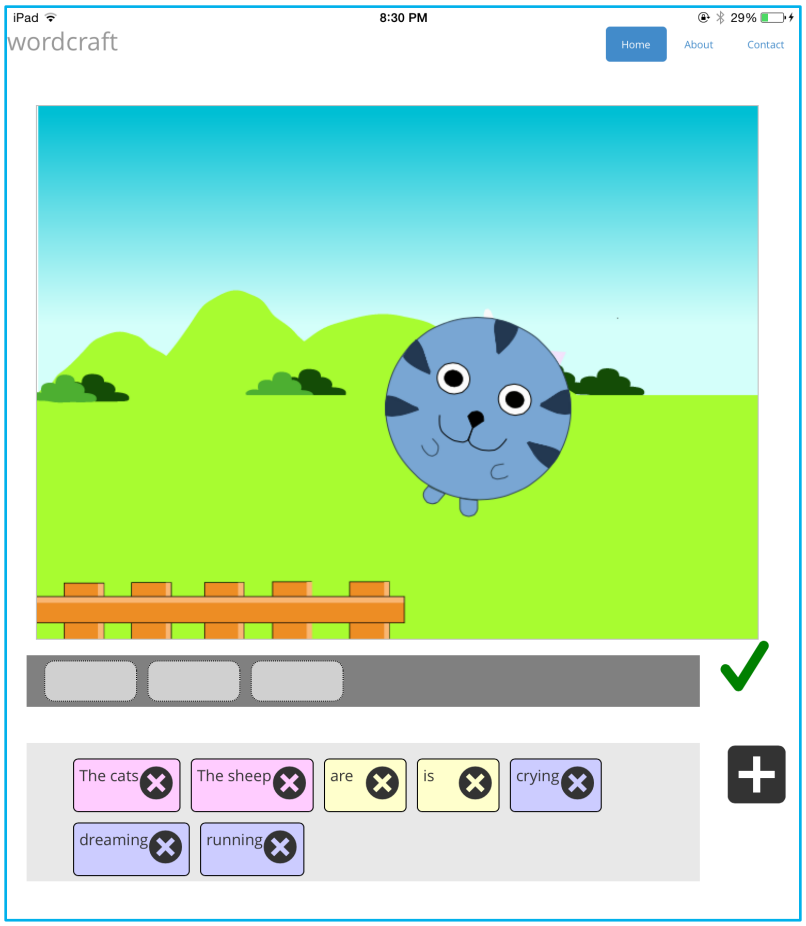

Figure 11: Wordcraft - Prototype 1

At this stage, we had a bare bones version of our prototype, and children could form a few sentences. We were yet to implement preposition references, and so we used a stationary fence object to create an illusion of moving the other objects to a different part of the canvas. Our vocabulary of words was limited at this stage, and so the app could not be tested independently. This meant that we could not use these tests to evaluate if there was any potential for learning.

The objective of this test therefore, was to *evaluate the interface and identify design interventions*. The moderator monitored all interactions very closely and provided a great deal of verbal scaffolding to compensate for the limitations in the prototype.

The pilot usability study was conducted with 2 children, aged 5 and 6 respectively. Our key observations were:

- Concept

    - Children were very excited when they saw that the sentences were leading to different images. This excitement was also followed by disappointment in the cases where the app did not live up to their expectations
    - For a beginning reader (like the 5 year old in this case), the moderator had to read out many of the words. We believe that a full version of the product should support audio feedback, where a user can tap on the word to hear it read out aloud (similar to how words are read out in reading apps).
- Illustrations
    - The illustrations did not place emphasis on exaggerating the expressions of the animals. Therefore, the change in expressions was often subtle, and was lost on the children. For instance, one of the children, when asked if the cow was laughing, clearly said – "No. The cow is not laughing. If it were laughing, it would say hahaha"
- App Flow
    - We had crosses on the word cards to allow children to delete them. However, these were extremely touch-sensitive and children were unable to use them to remove words, thereby causing frustration.
    - Children were able to understand the sentence-building paradigm of refining the same sentence across levels, however, we stopped at Level 2 because the third level was not fully functional during this round of testing.

Based on these findings, we worked on improving the interface and ensuring that kids could play with it independently.

Design Modifications

Based on our observations, and some suggestions from our advisors we made the following interface changes to enhance usability:

- The concept of levels did not necessarily imply an increase in level of difficulty. Hence, we removed the additive concept, and instead allowed a scroll between what we now termed 3 types of sentences – "3 word". "5 word" and "7 word" sentences. Children could now play based on their personal preferences. We however maintained the building onto a sentence combination while moving from 5 word to 7 word sentences because the 7-word combinations in our sentence structure meant that many valid combinations would not work, and we did not want to confuse children who were making the right sentence. By allowing for building onto a sentence, we let them observe the sentence structure in action before constructing a fresh sentence.

- Inclusion of a *'Refresh' button* to signify completion of a sentence, and allow the user to reload the screen with a fresh draw of word cards
- Inclusion of a *'Replay' button* to allow children to replay animations and thereby give them more time to observe the link between sentence and image
- Removal of the intrusive cross button in favor of a *trashcan*. This way, children could drag words into the trashcan to remove them.
- We also created a *tools section* at the bottom of the interface, which included all these buttons. Our key consideration was to ensure that the drag radius from the sentence area and word list area was as short as possible in order to minimize any drag errors.

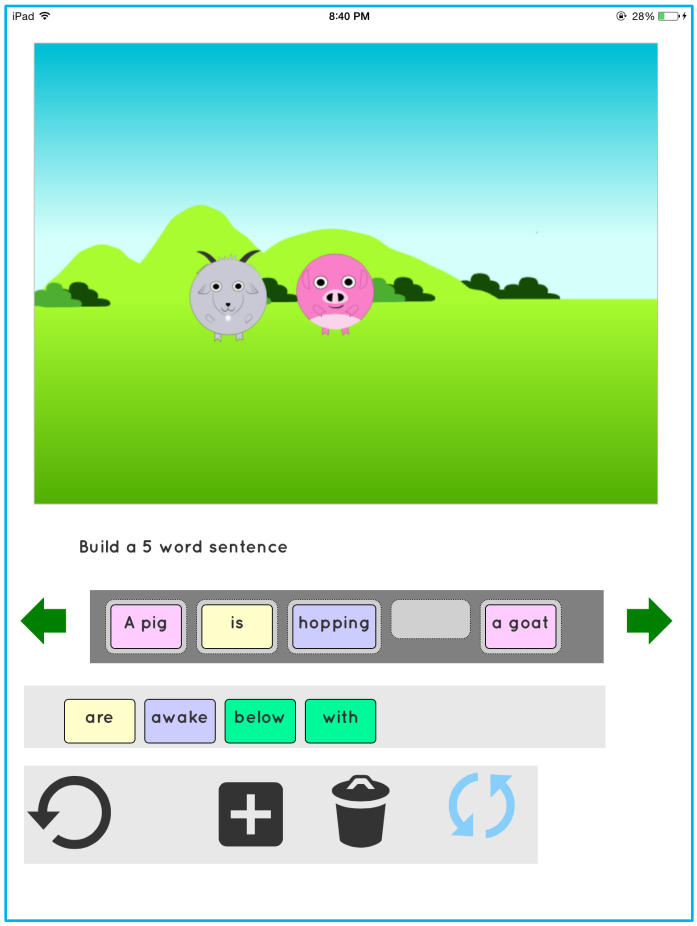

Figure 12: Wordcraft - Prototype 2

Usability Study 2

Findings

Our second round of testing was done with 4 children between the ages of 6 – 8 (6 years, 8 years, 7.5 years and 7 years respectively). During this phase, the moderator did not have to provide as much

verbal scaffolding and children were able to play independently with the app. Children were asked questions as they played, in order to identify issues with the interface. Some of our key findings from this stage include:

- The 'Refresh' button wasn't intuitive – the iconography used for Refresh and Replay were very similar and this resulted in confusion over what each of the buttons would do. At this stage, we merely differentiated them by referring to 'Refresh' as the blue button, but the children had difficulty with this.
- Our noun cards were made of differentiators and nouns. For 5 word sentences, we had built the interface such that if a noun card was moved into the last slot, the capital case at the start of the determinant would automatically convert to lower case. However, 2 children refused to move the word into the last slot because, "there is a capital letter, that means it will not fit in the last space".
- The animations needed fine-tuning. For instance, 'rolling' was identified as looking the same as 'walking'.
- The arrow to move between different types of sentences was green in color and it was often tapped in excitement, much before a child was ready to move onto the next type of sentence, resulting in them looking very surprised when the screen changed to reflect a bigger sentence and more words.
- The trashcan wasn't sensitive enough, and so children had trouble dragging words into it.
- The illustrations were not big enough to make children notice them. They were scaled in reference to the background, but were not exaggerated like 2-dimensional animations are done to give more prominence to the objects with respect to the background.

Design Modifications

Based on these observations, we made the following key modifications:

- Made the arrows between types of sentences a more neutral color.
- Reword the 'Refresh' button so the canvas was cleared when it was clear, and not just the word list area.
- Increased the sensitivity of the trashcan to ensure that even a partial drag would be supported
- Reworked animations to ensure that they were more nuanced. We also modified our offsets to account for nuances defined by prepositions, for e.g. "near", "behind", "with" etc.
- Removed capitalization of determinants in noun word cards.

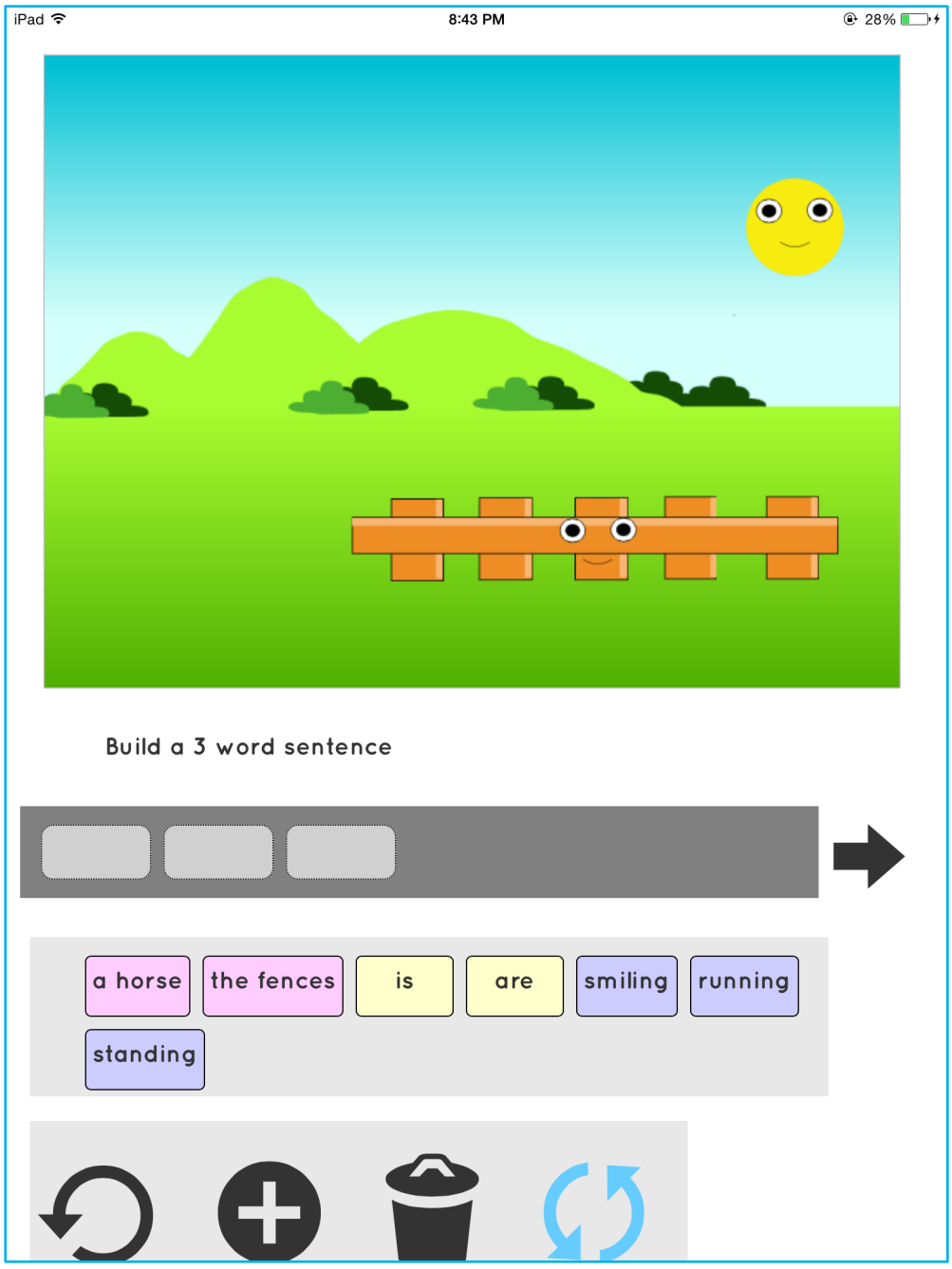

Figure 13: Wordcraft - Prototype 3

Usability Study 3

Findings

Our last round of testing had the most participants. At this stage our prototype had been through 2 rounds of user testing and we had addressed most of the usability issues. We tested this version with 13 children between the ages of 4 - 8. Additionally, we also allowed for pairs of children (same age, friends)

to play with the app together. This helped us observe how engaging the app was in a collaborative play scenario.

Our key observations were:

- There was a clear improvement in the drag to the trashcan. As opposed to the previous round of testing, there was no confusion here.
- The change in color for the forward arrow button also worked well to deflect unintentional taps on it.
- The new animations were extremely entertaining and elicited a lot of attention and excitement from children, of all ages. Playing in pairs also increased engagement and children helped each other explore the interface.
- There was still some difficulty observed with the concept of using '+' to get more words. Further, children didn't understand the concept of a draw of cards for every round so often they were tapping on '+' for new words and left wondering why it had no result, leading them to think the interface was unresponsive.

Design Modifications

Post this round of testing we made only a few key changes to our interface:

- Iconography: We used 'play' button for Replay, and the standard 'Refresh' button for refresh, as seen across all children's sites. We chose to use the most common icons in order to eliminate any confusion.
- We implemented a scroll-like modification for the word list area through which children can locate words that they wish to use. Currently, it has arrows to navigate through the word cards, but the final product should also incorporate support for the swipe gesture.
- We allow for words to be replaced in the sentence area by moving other words over the used slot. This is an added functionality that we hope will be exploited by users who are more inclined to explore the interface.

Understanding Impact on Metalinguistic Ability

We only considered our research observations from the second and third rounds of testing to understand the implications that this app could have for helping children develop metalinguistic awareness.

Methodology

We had a total of 17 children, who played with the app over the course of the two weekends. We tried two different modes of evaluation:

- With 7 children, we had a moderator explain the interface to them after which they played with the app for about 20 – 30 minutes, until they stated that they wanted to do something else, or they displayed signs of fatigue. The moderator made 1 sentence as a demonstration and did not go in-depth into the features of the app, but instead let them explore and find out for themselves what various things did. As they played, they were asked questions if they appeared to be struggling or if they did anything out of the expected behavior.
- With the other 10 children, we let them play with the app in pairs for about 20 – 30 minutes. We ensured that the children were paired based on age, and also that they were playing with a friend. The moderator showed them a demo and then allowed them to explore on their own, only interrupting play to ask questions when needed.

Earlier studies by Donker and Reitsma[13] suggest that children often do not talk much during a think aloud session, and need to be probed more than adults. Their research also suggests that pair testing will help resolve some of these issues, by *allowing researchers to observe children's conversations and interactions with one another*, something that we observed in our research as well. The pair testing scenarios helped us get a better understanding of their thinking.

Pre-Testing and User Classification

In the absence of a pre-test to gauge ability prior to playing with Wordcraft, we chose to ask children to read the words (combination of 2 nouns, 3 verbs) displayed on the screen when they first saw the app. Based on their ability to read these words, we were able to classify them into 3 broad groups -

- **Beginners:** They were just beginning to read, and could either spell out words or sound them out phonetically. They needed help from the moderator to be able to read words, after which they picked the ones they wanted to use in the sentence.
- **Intermediate:** They could read most words, but had trouble with more complex words, like 'depressed'. Even if they didn't know how to read a word, they were able to sound it out. They were not always aware of syntax - they were more prone to errors pertaining to use of verbs in singular-plural scenarios as well as the use of adjectives with 'a' and 'an'.

[13] Donker, Afke, and Pieter Reitsma. "Usability testing with young children." *Proceedings of the 2004 conference on Interaction design and children: building a community*. ACM, 2004.

- **Experts:** They could read all words, and had experience with making sentences. They also tried variations of sentences that went beyond the current scope of the project. Some of their parents indicated that they were comfortable with concepts like sentence diagramming which indicate that the sentence structures used in this app would be more elementary for them. However, the novelty of seeing sentences visualized still resonated with them.

The groups are determined based on reading ability of the children, and not their age owing to the wide variation in reading ability that we observed in children within our target age range. For future studies, we would also want to calibrate reading levels prior to playing with the app, and also survey parents to get a better understanding of the child's existing exposure to sentence construction and understanding the nuances of language.

Observations

In this study, we only showed the app to a child once for anywhere ranging between 20 – 30 minutes. We have observations that indicate areas that can be explored during future research, where ideally we would want to conduct a longitudinal study and observe how children's awareness changes before and after playing with the app. We would also want to observe how the repeated use of words in different contexts enhances understanding.

Beginners

We had 4 beginners (aged between 4 - 6 years), all of whom had trouble reading words without help. The moderator helped them with difficult words. Beginners spent a lot of time with the 3 word sentences. Those of them who had observed other children playing with the app before them were far more motivated to try 7 word sentences than those who were playing by themselves. They also often went back from 5 and 7 word sentences to keep trying out the easier 3 word sentences.

Using Sentences to Reading Words

For a child who is still beginning to read, the interface allows exploration to understand what spelling corresponds to which word. For instance, Sarah[14] was able to identify that 'p,i,g' was "pig" after seeing the resulting image on the screen. After playing with the app for about 15 minutes, she was also inspired to state, "I can make 10 sentences", and then came up with 5 sentences that followed the sentence structure in the app ("The cat is fighting with the mouse", "The cow is fighting with the robot" and so on).

Learning New Words

Madison was able to learn a new word. She wanted to know what the word "amused" meant, and so

[*] All names changed to protect privacy

she used it in a sentence. After seeing the image, when asked by the moderator, she was able to state that amused meant 'happy'.

Understanding of Vowel Contexts

None of the beginners had prior exposure to the context of words used after vowels. When they tried 7 word sentences, they often got stuck while trying to use words like 'excited' after 'a'. In two of these cases, the moderator explained that 'excited' would not work with 'a', after multiple tries to use the word, and when they finally asked for help. Once they were told about this, they were careful to avoid repeating that behavior. This would be an interesting area to explore in future research – even if a child isn't aware of vowels or how they work, the feedback from the interface could move them toward creating a correct sentence.

Using color as a substitute

After a few rounds of the game, beginners also realized there was a color pattern and began moving words using the colors. They were completely unaware of parts of speech, but were able to see patterns in how colors were being used in the interface. For instance, one of them said, "in 3 words, you use one of each color to make the sentence".

Intermediates

We had 7 intermediates (aged between 5.5 – 8 years), all of who could read most of the words and were quite comfortable with making sentences. They moved from 3 words quite quickly, and seemed to be interested in trying 5 and 7 word sentences. Some of them clearly expressed the interest to make "bigger" sentences when they were playing with 3 words, suggesting that this was very easy for them and they needed a challenge.

Awareness of Locational Contexts

All of the intermediates were able to point out when the images were not generated as expected. For instance, when Brad made the sentence "the cows are crying with the pigs" he pointed out that the image was inaccurate because "only the cows are crying, but even the pig should be crying". The beginners when presented with a similar context all said that the image generated was as per their expectation.

Explaining Verb-Adjective Inconsistencies

The current interface allowed children to make sentences that had conflicting emotions in a 7-word sentence, for e.g. – "the fierce goat is smiling near a fence". The intermediates, who tried some of these cases were able to explain the inconsistencies in the resulting image (which only depicted 1 of the 2

emotions in the sentence) based on their understanding of language and emotions. For instance, Serena explained, "how can a fierce goat smile? That doesn't make sense. If it's fierce, it means it will be angry." They also tried harder to come up with these explanations because the interface only showed one emotion, often explaining away these inconsistencies before the moderator probed. This could be indicative of them trying to make sense of why the picture didn't change, and that repeated instances could help them develop their metalinguistic ability in terms of reasoning through how emotions are conveyed (in a simplistic manner).

Understanding 'funny' sentences

Wordcraft allows children the flexibility to make 'funny' sentences, where even inanimate objects can move, talk etc. The idea behind this was to allow for the creation of sentences that are grammatically correct, even If the ideas expressed in these tends to be illogical. All the intermediate level children were able to clearly verbalize why they found these sentences funny, when they were asked. Alice said – "barns don't roll in real life, but in this game they can roll. That's because it's make believe." Here again, it would be interesting to observe if over a longer period, children move away from making silly sentences to making more logical ones.

Connect between colors and parts of speech

Many of the intermediates were not aware of the parts of speech, but they were able to verbalize what the different color codes could mean. Their responses ranged from "the purple words are the actions", to "the red words are nouns and purple words are verbs". For future work, it would be interesting to explore if children are able to make the connect between what they observed the words did in this app, to parts of speech when they are exposed to them in school curriculum. Being able to make that connection when they first learn what a noun or a verb is, would indicate a strong learning outcome.

Experts

We had 5 children (aged between 7.5 – 8 years) who were clearly experts. They could read all the words and had some degree of comfort with making sentences. Like the intermediates, they skipped through 3 word sentences and went into 5 words. Even though they were experts, they still spent approx. 20 minutes or more exploring the interface and playing with it. The novelty of watching the images appear when a sentence was made, was a driving force for this engagement.

Learning New Words

Even though they could read all the words, they weren't always aware of the meanings of the words they saw in the interface. For instance, Ella said – "wailing, waving, I don't know what that means" and then when she saw the image she said, "oh, wailing means crying!" showing that making sentences is an

interesting way to learn the meaning of a word.

Trying out Different Constructs

Since they had prior exposure to working with sentences, they were also more inclined to try out sentence structures that the app did not support. In 7 word sentences, many of them tried to move words like 'weeping' into the spot for the adjective – an accurate way to use the word in its adjective form, but the interface had the word tagged as a verb and hence did not allow this. For future work, we will need to explore the concept of allowing more complex sentence structures and then tag each of these as lessons in order to observe if experts are then able to use the interface to learn the more complex sentence structures.

Connect between colors and parts of speech

They were able to clearly articulate what each color meant, though even they couldn't always name the parts of speech. This suggests that the color code could be very helpful in helping them build this understanding.

Unwillingness to make 'silly' sentences

The experts were clearly operating with a pre-existing mental model of how sentences would work, and what makes a valid sentence. They tended to avoid making sentences like 'the fences are rolling' on their own. Nadia went looking for an animal noun while making the sentence "The cat is laughing with _____". When she was probed about it she said, "the word in the sentence is with. That means there should be another animal." She was unwilling to try making the sentence with an inanimate object. This shows a clear understanding of not just the grammatical correctness, but also logic. For future work, it would be interesting to observe if repeated use of Wordcraft can lead to moving beginners and intermediates to the expert stage.

Visual Design

Color Palettes and Fonts

Post user research, we worked on adding visual design elements to the interface we had created. In order to direct our visual design, we carried out a brand definition activity where we decided our brand attributes through a brainstorming exercise. Our chosen attributes were: vibrant, playful and discovery. We created a mood board incorporating the color palettes and fonts that we felt went best with these brand attributes, and used the colors distilled from this for our visual design.

Figure 14: Moodboard

App Design

Since our app is intended to be a fun way to learn, we decided to create an immersive visual experience, as envisioned below. The key metaphors here are that the sentence building area (including the block area and the tools), are set up on a table, and the canvas is set up as a scene that the viewer is observing through a window.

Figure 15: Wordcraft - App Design

Future Work

Some interface enhancements that we considered but could not implement include incorporation of sound into the interface; allowing for more animation styles; allowing for user generated words to be added into the corpus. We would also like to incorporate a 3-stage feedback cycle for error handling – the first time an error is made, the interface uses a simple prompt like "oh, oh. That's not right". The second time an error is made, the interface restates the goal along with the error prompt. The third time the error is made, a suggested answer is also included in the prompt. Research by Sesame Street [15]has validated that this method of scaffolding error handling contributes to the learning process, and therefore we would like to incorporate this into our interface as well.

We need further research to evaluate the impact of Wordcraft on metalinguistic ability. One key feature used by language learning apps is repetition to understand if a new word has been assimilated and learnt. We could set up the interface to evaluate if a child is able to correctly make a sentence with a certain set of words that were incorrectly used in the past, signifying that repeated play has helped them learn a particular concept. We would also need to carry out a longitudinal study with pre and post evaluations to understand the specific impact this interface has had on learning and the ability to construct better sentences.

A key future application for this interface would be to expand the contexts and illustration styles to allow it to be used by adults in ESL classes. The ability to use the images to understand the nuances of language would be applicable in that case also.

Finally, for expert users who are already able to construct different kinds of sentences, the concept could be expanded to allow them to explore storytelling and narratives through this format. So the interface could prompt the child to string together sentences to make a story-cum-graphic novel of sorts. This would help them move on from just making sentences to also understanding how the sentences can be structured together to form a compelling narrative.

We believe that with more research, we will be able to further fine tune our app and test our hypothesis with more conclusive results.

[15] http://www.sesameworkshop.org/our-blog/2012/12/17/sesames-best-practices-guide-for-childrens-app-development/

Appendices

Appendix A: Taxonomy (JSON Structure)

```
var newDefaultSceneObj = [{
                        "body" : {
                                "eyes" : "res/img/animals/sheep/sheep_part_eye_happy.svg",
                                "skin" : "res/img/animals/sheep/sheep_skin.svg",
                                "mouth" : "res/img/animals/sheep/sheep_part_mouth_happy.svg",
                                "color" : "", //there will be a default color for every animal
                                "size" : "normal", //"normal is default.
                                "width" : 200,
                                "height" : 255
                        },
                        "pos" : {
                                "plane" : "sky",
                                "plane_pos" : "center_front",
                                "plane_matrix" : [0, 0]
                        },
                        "animation" : [{
                                        "duration" : "", //(none)
                                        "animation_part" : "eyes" //(eyes, mouth)
                                        "animation_params" : {
                                                "start" : "0", //(1)
                                                "end" : "2", //(1)
                                                "mid" : "" //(-1)
                                        },
                                        "speed" : "normal", //(very_fast, fast, normal, slow, very
slow)
                                        "scale" : "",
                                        "animation_type" : "rotate"
                                }, {
                                        "duration" : "", //(none)
                                        "animation_params" : {
                                                "start" : "0", //(-10 to 10)
                                                "end" : "2", //(-10 to 10)
                                                "mid" : "" // (-10 to 10)
                                        },
                                        "speed" : "normal", //(very_fast, fast, normal, slow, very
slow)
                                        "scale" : "",
                                        "animation_type" : "translateX"
                                }, {
                                        "duration" : "none", //(none)
                                        "animation_params" : {
                                                "start" : "0", // (-10 to 10)
                                                "end" : "0", // (-10 to 10)
                                                "mid" : "5" // (-10 to 10)
                                        },
                                        "speed" : "normal", //(very_fast, fast, normal, slow, very
slow)
```

```
                        "scale" : "",
                        "animation_type" : "translateY"
                }, {
                        "duration" : "", //(none)
                        "animation_params" : {
                                "revolve" : true
                        },
                        "speed" : "normal",
                        "scale" : "",
                        "animation_type" : "revolve"
                }

        ]
}, {
        "body" : {
                "eyes" : "res/img/animals/cat/cat_part_eye_happy.svg",
                "skin" : "res/img/animals/cat/cat_skin.svg",
                "mouth" : "res/img/animals/cat/cat_part_mouth_happy.svg",
                "color" : "",
                "size" : "large",
                "width" : 200,
                "height" : 255
        },
        "pos" : {
                "plane" : "sky",
                "plane_pos" : "center_front",
                "plane_matrix" : [0, 0]
        },
        "animation" : [{
                        "duration" : "",
                        "animation_params" : {
                                "start" : "0",
                                "end" : "2",
                                "mid" : ""
                        },
                        "speed" : "normal",
                        "scale" : "",
                        "animation_type" : "rotate"
                }, {
                        "duration" : "",
                        "animation_params" : {
                                "start" : "0",
                                "end" : "2",
                                "mid" : ""
                        },
                        "speed" : "normal",
                        "scale" : "",
                        "animation_type" : "translateX"
                }
        ]
}];
```

Appendix B: Image Assets and Object Deconstruction

Figure 16: Asset Illustrations

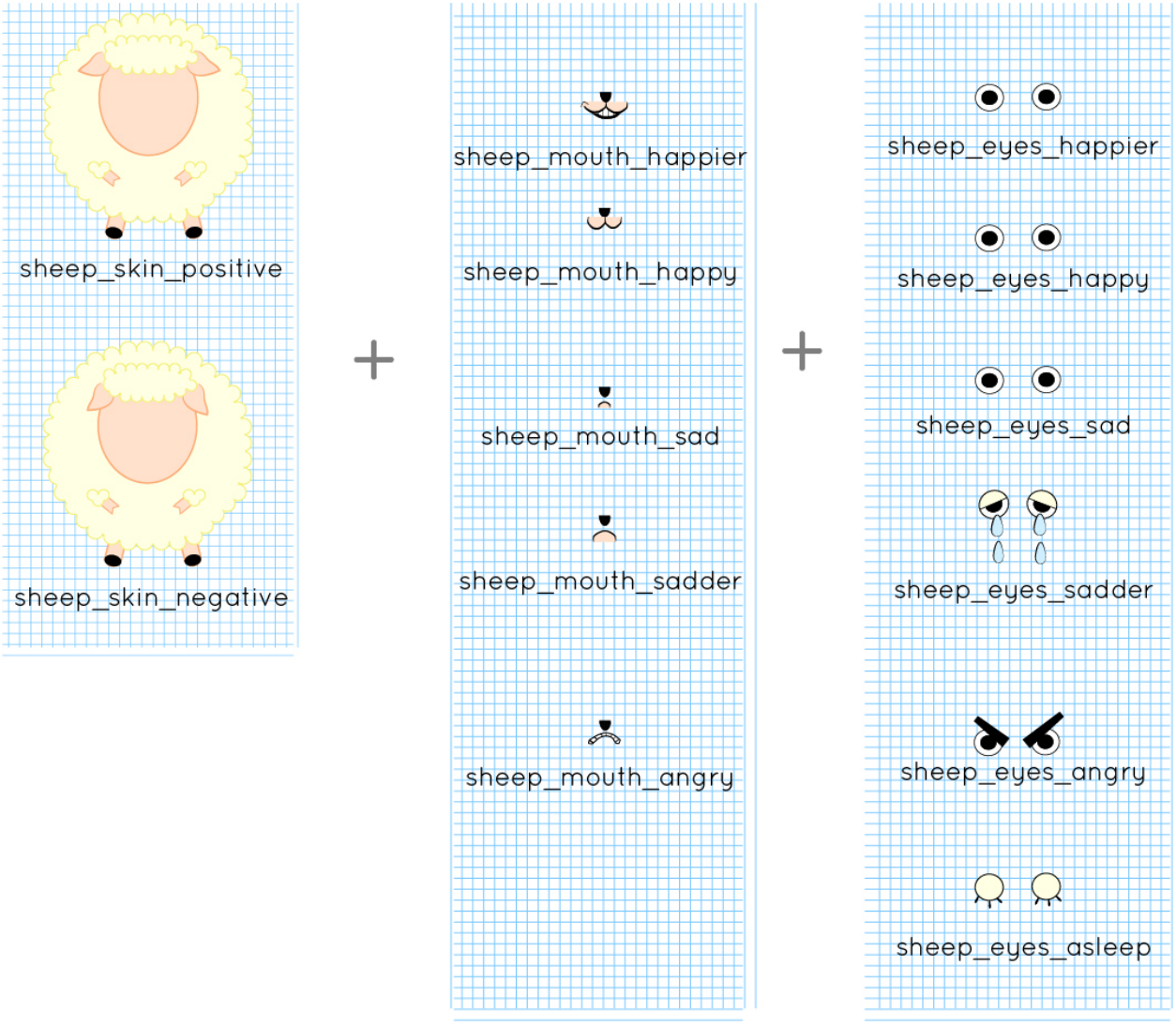

Figure 17: Object Deconstruction

Appendix C: Research Script

Questions for Research

- Are children interested in playing with this app?
- Are they able to identify how to get new words, and how to form sentences?
- Do they understand why they shouldn't be placing a certain word in a certain place?
- Do they understand parts of speech and what they mean?
- Based on their experience, are they likely to play with this app again?

Discussion Guide

Introduction

Hi <name>. I'm <name> and this is <introduce rest of the team>. We are going to show you a game we made, and we'd like to know what you think of it. If you don't like something, please be sure to tell us. If you want to stop playing at some point, let us know and we can stop. Before we start playing the game, I have a few questions for you/

Pre-Questions

- Do you (your mommy / daddy) have an iPad?
- How often do you go online?
- What do you do on the iPad?
- What is your favorite website?
- What is your favorite game? Why?
- Can you go online whenever you want?

Tasks (with breaks)

Now I'm going to show you the game. It's called 'Wordcraft' and it helps you make sentences. So let's start. I'm going to make a sentence now. <walk through the 3 levels, and point out how the image changes>. Now you can try it for yourself.

<allow the child to play with words and see what happens>

<help with reading out the word if they don't know them>

- Ask what it means if they try a word that doesn't fit in the right spot
- As a follow up, ask them what the colors for the words means
- Ask them if they'd like to see more words, and then see if they realize what the '+' mark does
- Finally, see how many iterations they try, and whether they try changing words or using the same sentence. Ask them if they'd like to try changing words to ensure they know that they can.

There are 3 versions of the interface that we have created, each with some tweaks. We will use these to test which features are intuitive and engaging by showing different children different versions and asking them to perform the same tasks with each. Based on the feedback we receive from these

interactions we will make a prototype that combines the best features, and test it again to create the deliverable prototype.

Measures / Analysis

- Understand if the app presents the child with opportunities for discoverability
- Observe body language and comments to determine if they enjoy playing with the interface
- Assess understanding of parts of speech through follow-up questions (why do two greens not go together?)
- Assess learning through the quality of sentences being created - without experimentation

Follow-up questions

- Did you have fun playing with this?
- What was your favorite part of the game?
- What did you not like about the game
- Would you play with this again?
    - Why?
    - Why not?

Alternate Test Flow:

To test whether the activity is more entertaining / interesting in a group, we will also conduct a few rounds of tests where children play with it in pairs. The format of the tasks will remain the same, but we will additionally observe how they interact with the app when they are playing together, and whether that impacts their learning. Key questions:

- Do children find it more enjoyable to collaborate on an activity like this?
- Assess learning by seeing if they are able to create better sentences through a paired activity than when they were trying it by themselves
- Any other findings from the paired interaction that distinguish it from the sole interaction?

Question to Parents (if possible)

- Child's favorite game?
- How often do they play?
- What do they like about that game?

Appendix D: Usability Evaluations

Part of Interface	Observation	Interpretation	Recommendation

Canvas Animation	Says "The cow slides" for when the word was walking	The 'walking' animation looks like sliding	Use swap with two leg positions to see if walking can look more like walking.
Refresh Button	Needs help to figure out how to start a new sentence	The 'Refresh' button isn't intuitive	Use the 'Done' button to reload the canvas and sentence area afresh
Trashcan	Understood that the trashcan is where words needed to be dragged but hesitates to drag	The drag does seem to be cumbersome for kids	Some kids tried tapping the card and then tapping the trashcan - that may be a way to address this issue
Words	Wouldn't use a capitalized word in the last slot (2/4)	Capital indicates start of the sentence	All words to be un-capitalized.
Feedback	"Only one goat is behind. But the word is goats so both need to be behind the fence"	Animation rendering did not take into account the right context of the sentence	Revisit animation values to ensure they are in-line with syntax
Words	Child wanted to see more words	Variety of words allows for more engagement, else the app starts to get repetitive	While this is a concept prototype, a full fledged product could include different contexts and allow for adding words and expanding the corpus
Forward Arrow	The green arrow is clicked out of excitement, almost as if it were a 'Done' button	Assumption that the 'green' signifies some sort of completion and resulted in moving on to a bigger sentence before grasping the concept with a smaller sentence	Arrow button to be in a more neutral color so it does not lead to conclusion
Trashcan	Child dragged the word 'below' into trashcan, then realized he wanted to use it and couldn't figure out how to reuse it	The younger kids did not go looking for a word, but older kids did, suggesting there should be a way to find a word too	Allow for other interface options that can help get more words - maybe start with colored arrows for parts of speech, scroll for selecting (will get cumbersome with a big corpus), maybe allow a text entry option to get auto-suggest?
Feedback	"I don't like dragging. You should let me tap - the first tap fills the first blank, second tap the second blank and so on" "I'm not used to dragging"	Dragging is annoying to children. Tapping is seen as an easier interaction (also seen with the other kids where the first reaction is to tap, followed by remembering that they can drag)	Explore ways to allow tapping - maybe tap the word, and then tap the slot to be able to pick slots that words go into
Feedback	Drag got stuck, the child said "come ON, come ON"	Frustration at slowness / something not working	Need to explore optimizations to ensure that things move smoothly
Feedback	"I want to make a six word sentence"	When told about 3 and 5 word sentences, the child automatically wanted to go to 6 words. This was more because he seemed to think a "bigger" sentence would be more complicated and therefore an achievement to solve.	After 2-3 rounds of 3 word sentences, the interface could have a prompt where the child is asked if they would like to make a bigger sentence
Forward Arrow	Attempts to move a word back to the stack (Multiple occurrences)	If a word isn't liked, the impulse is to leave it back where it came from, not move it to trash	Should allow kids to drag words back into the stack, instead of only requiring a delete
Feedback	"Why is it not working"	Level 3 had cases where valid	Level 3 needs to have more rules

		syntax wasn't working, leading to this comment from a child who was able to easily clear the other levels	relaxed to allow syntactically correct options to work and not force the adj-noun-verb structure
Feedback	Initially when asked if something was different, couldn't answer (happened with 3 kids)	When attention is taken up by the writing, the image is not focused on	Image needs to be bigger, or have some sort of sound or 'ta-dah' reveal to get attention towards it once the sentence has been made
Canvas Animation	Thought 'rolling' was 'walking'	Animation for rolling and walking are similar	Need to incorporate revolution for 'rolling'
Trashcan	Tried dragging trashcan to the word instead of the other way around (2 instances)	While the understanding that everything in the interface works on drag existed, the understanding that the word would be dragged to the trashcan was absent	Dragging things seems cumbersome, and based on other observations maybe tapping card and tapping trash may be a better idea
Replay Button	Was able to figure out what the replay button does once the other tools were clear	Confusion between replay and refresh occurs if there is no clear communication about which does what	Tools area needs clearly differentiated icons, and maybe text or an introductory guide to explain what everything does before they start playing
Refresh Button	"The blue button is confusing, it should look like an arrow"	The tools need to be clearly explained. Also mentioned that the replay button icon looks like a restart button	
Trashcan	Understood that the trashcan is where words needed to be dragged but hesitates to drag		
Words	Trying to figure out why an adjective should go into the specific slot was too complicated	The 7 word sentences have edge cases that were not considered and therefore behaved very counter intuitively	By the time 7 words come up, it looks like we shouldn't be stopping words from being dragged but should instead highlight if a wrong word is used. For interface consistency, if we chose this mode of error handling we should apply it across all types of sentences.
Feedback	"You can't get the words you already used?"	Probed to discover that having seen a particular word in a previous round, the child wanted to use it in another case	Allowing for word selection could be important to older kids (in this case 8 years old)
Plus Button	Knew that clicking on + would bring new words but couldn't understand why they wouldn't come when it was clicked	Very hard to explain the concept of a set of cards to use	Either explain at the start about the number or just allow for all words being scrolled through
Feedback	The background is just grass, it should have more - like a barn	Context of farm was not established with the simplistic background	Design choice to have a simplistic background - nothing to be done
Words	Could figure out how to go from 3 words to 5 words when the child was told that there was a way to do that	Through exploration of interface they are likely to figure this out	After 5 rounds (?) of a particular type, the arrow could move or get zoomed to give them an indication that they can try something else
Feedback	"Colors got me confused" (this was said even		Most kids could verbalize the logic of the color coding, including this child so

	though the child had begun making sentences in the color order, without completely reading in the last round)		we choose to stay with using the colors
Trashcan	Tried tapping on the trashcan for delete instead of drag	1 child found dragging to the trashcan so difficult that there was a repeated attempt to use two fingers to do this	Tapping may be a better interaction than drag, especially since all the other tools are taps
Canvas Animation	"Cows should be here because the sentence is "in front of""		'In front of' needs to have positioning corrected (in level 2 both are behind. In level 3, one is in front)
7 word	"Lets go back, how can we go back"	Annoyance with 7 words not following structures	Allowing valid combinations to work in this structure
Canvas Animation	"Let's do that again"	Tried repeating animations multiple times. Found it very enjoyable	
Refresh Button	Pressed Restart to go back to a shorter sentence		Clarity on navigation between 3, 5 and 7
7 word	Once the color paradigm is explained, then the ability to make sentences here is easier	Very hard to keep driving by color and eliminating valid options	Allowing valid combinations to work in this structure
Replay Button	Pressed Refresh instead of Replay	Both were pointed out initially so its possible its hard to keep this in memory	Differentiated icons
Canvas Animation	"It doesn't look like shivering. It only moved to one side"	The animation needs work to convey the accurate meaning	Shivering needs to run on loop to make it look like shivering
Words	Trouble with dragging into slot	Some kids find it hard to pay attention to the zoom of the slots	Support partial drags?
Canvas Animation	"the horses are wailing with the cats" both have to be crying	Even if they cannot articulate that its with, they expect them both to exhibit the action	With animation
Words	Restarted midway through a sentence because the word 'horse' wasn't there and she wanted to use it	Ability to look for specific words	Swipe incorporation to allow viewing all possible words
Canvas Animation	"he is walking. he isn't running"	Running and walking look similar	Increase speeds for running

Figure 18: Research Observations

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