Figure 1.Parent and child reading a TinkRBook containing textual tinkerability.

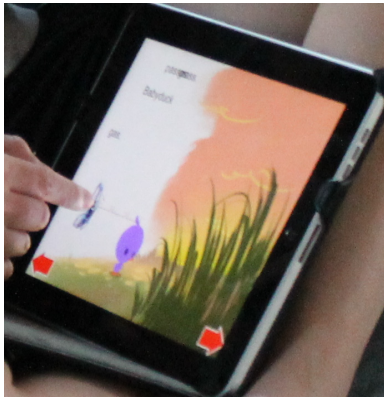

Figure 2. Dragging a story element in a TinkRBook.

Textual Tinkerability: Encouraging Storytelling Behaviors to Foster Emergent Literacy

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Abstract

This paper presents *textual tinkerability*, a new concept for fostering early literacy skills during parent-child reading. Textual tinkerability maps storytelling gestures to changes in animation and text to assist reading exploration and demonstration of the link between text, spoken word, and concept. TinkRBooks are flexible tablet-based storybooks that allow readers to actively explore concepts in text using *textual tinkerability*. When reading TinkRBooks, both parents and children can alter text (character attributes and parts of speech) by manipulating story elements (props and characters) as they read. We demonstrate how textual tinkerability encourages more dialog, print referencing and dialogic questioning between parent-child dyads in shared reading as compared to paper books. In addition, our study reports observations of storytelling performance behaviors that foster playful and socially intimate shared reading behaviors that are closely mapped to the teaching and learning of emergent literacy skills.

Keywords

Textual tinkerability, emergent literacy, parent-child shared reading

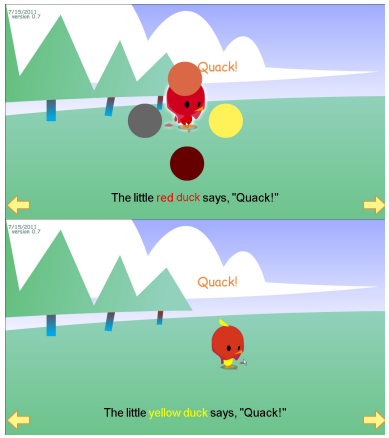

Figure 3. Textual Tinkerability allows readers to alter narratives by interacting with story elements (e.g. changing the color of a character).

Figure 4.TinkRBooks allow readers to explore how changes propagate through a narrative

ACM Classification Keywords

K [Computing Milieux]: K.3 Computers and Education; K.3.1. Computer Uses in Education: Collaborative Learning; K.3.2 Computer and Information Science Education: Literacy.

General Terms

Design, Performance

Introduction

Learning how to read early is a key predictor of a child's academic success and is widely recognized as one of the most difficult things young children learn to do [12]. Today, over 97% of children entering kindergarten cannot recognize a word, or find a word within the context of a sentence [8]. Learning to read increases the general rate at which children learn, so late readers can fall progressively further behind [1]. Shared reading between parents and pre-k children is often cited as one of the most important activities parents can do to prepare their children for school [15].

The Best Reading Scenarios in Emergent Literacy

Studies have found that parents from different socioeconomic status (SES) levels and cultures read differently to their children, resulting in missed opportunities for literacy development in some children. Highly educated parents who have high-socioeconomic (SES) status naturally exhibit many positive emergent literacy behaviors such as print referencing, dialogic questioning, and thoughtful conversation when reading to their children [17]. For children, these behaviors result in better awareness of reading techniques and comprehension.

This work is motivated by the challenge of creating a new kind of reading experience that results in higher quality interaction between parents and their children that is more effective in fostering positive emergent literacy skills. The result is called a *TinkRBook*. The design leverages multi-modal interactivity of touch-screen tablets to make shared reading a more active learning experience for children, guided by Vygotskian theories on play[16] and the Principle of Contrast [3]. Further, we followed an iterative design process guided by user and stakeholder feedback.

Toward this goal, we researched "the best practices" for emergent literacy. We interviewed 30 experts and stakeholders of reading instruction to understand the best practices [4]. Finally, we observed the best-case context for emergent literacy in how highly skilled SES parents read to their children (Figure 1).

This case study reports our lessons learned from the ethnographic study, how we translated these lessons to a set of design principles for a new concept called *textual tinkerability*, and the results from a user evaluation study of these principles put into practice. We compare how parents perform shared reading interactions when using a TinkRBook with traditional children's books.

Textual Tinkerability (tinkRability)

Textual tinkerability is the ability to change story elements to support active cause-and-effect exploration and demonstration of the text-graphic relationship during reading. The purpose is to expose the abstract bi-directional relationships between text, spoken word, and graphics in response to gestural input.

Dialogic reading: a method of prompting children to answer questions about the content they are reading. For example, asking *W* questions *(Who, what, why?)*.

Phonics: a decoding method of breaking down words into component sounds. Phonics teaches children rules for encountering a new word.

Print referencing: a technique of explicitly pointing out the text while reading aloud.

Whole language: a method of teaching children how to read by demonstrating whole words in context.

Table 1. Sample positive emergent reading behaviors

Referred throughout this paper simply as *tinkRability*, this feature allows readers to act out the text-concept relationship during story reading. By dynamically reinforcing the meaning of text in response to reading gestures, textual tinkerability encourages emergent readers to become more conscious of print and the concept it represents through exploring cause and effect relationships at textual and narrative levels.

TinkRBooks are interactive tablet-based storybooks that implement the principles of textual tinkerability into an interactive story (see Figure 2 for an example). TinkRBooks provides readers with narrative choices, encouraging readers to act out the words in the story and explore how word changes propagate throughout and impact the narrative. Changes range from those with immediate textual-graphic impact that propagate throughout the whole story— such as changing the color of the duck in Figure 3, to those with deeper narrative impact, e.g. changing the duck's attitude about cleanliness alters the narrative arc (Figure 4). This allows readers to explore how different word choices or graphical changes affect the narrative arc to enable the child to learn using The Principle of Contrast [3]. The Principle of Contrast is a linguistic theory where the meaning of a new word is deduced by comparison with a known word in context.

BACKGROUND

Teaching Reading in Emergent Literacy

Emergent literacy is the stage where young children (ages 2-5) typically can begin to understand the concept of print [1,10,14-18]. Parents or caregivers are their children's first instructors, reading to them at home by repeatedly demonstrating how text maps to speech and pictures. Eventually, the child reaches the "aha!" moment when they comprehend the concept of reading where textual representation maps to spoken word and concept.

Current Parental Reading Instruction Methods

How parents read to their children heavily influences the development of literacy skills [13]. Parents can learn about various pedagogies through intervention programs and research. Knowledge of these behaviors helps adults guide children toward learning literacy skills and knowledge [2]. Some example methods are shown in Table 1.

No one method has been demonstrated to be far superior to others, and effectiveness varies for each child. In any case, the most basic behavior that adults can do to prepare children for literacy is having conversations. Basic language skills are fundamental in developing print literacy [14].

An Iterative Co-Participatory Approach

We conducted an iterative co-participatory design process to reflect the needs of the special setting of home literacy with preschool age children. Our design methodology consists of reaching out to two key groups of people: parent-child users and stakeholders (children's authors, children's game designers, educational psychologists, educational technologists, teachers and librarians [4]).

Although parental behaviors in emergent literacy have been the subject of much study, we decided to look deeper into how skilled, high-SES parents actually read to their children. The context of parent-child reading is quite specific, due to the intimate setting and personal

relationship between the parent and child. What really happens in people's homes when they read together?

Parent-child Reading Ethnography

Because the nature of parent-child storytelling is so intimate, it made sense to perform ethnography inside people's homes. Reading participants (parents with a child between 2-7 years) were recruited by advertisement and word of mouth. Fifteen parent-child pairs were studied in total.

METHOD

Participants were told that the purpose of the study was to gauge baseline storytelling behaviors during parent-child reading. Parents and children were video recorded as the parent read a story of their choosing to their child. Afterwards, parents were asked questions about reading rituals, parent's assessment of their reading routine, and both parents and children could suggest preferences about potential book content for our TinkRBook. The resulting observations are summarized below:

PHYSICAL INTERACTION BETWEEN BOOKS AND PARTICIPANTS

Physical books enable physical proximity. The child was usually on or touching the parent (usually in the adult's lap, but could also be in other positions within touching proximity). The book was visually accessible to both parent and child (often in front, although positions shifted dynamically). To navigate the book, both parties might turn the pages or change the orientation of the book. Despite parents' best attempts to focus on reading, very young children often shifted interest between items on the page and items in their environment.

STORYTELLING RITUALS AND CONTEXT

Parents reported reading nightly to their children, and set aside special time for this activity. The ritual often occurred before bedtime, and parents and children had a wide range of favorite books that they often shared. Repeat reading was common; it was usual for children to ask to repeat a reading of a favorite book. Children chose the content from among their many books. Younger children often read from multiple books at a sitting, perhaps due to the short amount of time they spent on each book.

THE PAGES OF A BOOK MARK A SPECIAL MOMENT

Children direct their attention to books discontinuously. Children often look at the book, particularly when a page is turned to show something new. Parents purposefully attempted to direct the child's attention, and they spoke meaningfully about the content when a new page was turned. Many parents took turns with their children when pointing at the book. Some parents demonstrated explicit dialogic reading behaviors, such as prompting for answers, making intentional mistakes that their child could correct, or asking their child comprehension questions.

STORYTELLING INTERACTION ROUTINES

With favorite books, there were familiar jokes and routines that were shared. Ritualistic interactions were observed. For example, mimicry occurred when the parent would say a phrase and the child repeated it. Physical mimicry occurred too, when one person (usually the parent) pointed at the word or image and the other would then point at the same object. In audio coincidence, they both chimed in to say the last phrase of a sentence together (Figure 5). Spoken turns, where a parent said the first part of the sentence and the child

said the last words (the punchline) were observed (Figure 6). Gestural turns occurred, too, as one pointed at an object and the other pointed afterwards. Gestural coincidences occurred, too, as both might point together to refer to the shared attention. There were also multisensory turns, where one person (usually the parent) would say something and the other would gesture or vice versa (Figure 7).

Older children expressed their love for these storytelling behaviors. One parent said that his son (now 7) recently revisited a book they read when he was very little. As they read it together, they practiced a familiar routine of performing the story (e.g., listing all the colors and counting all the cows on the page). We noted that many of the interactions during these rituals were fun; they promoted social bonding and intimacy between parents and their children. These behaviors are discussed in more detail in the next section.

STORYTELLING FLOW

Parents use a wide range of storytelling behaviors, particularly vocal expressions and hand gestures, to perform the story. All parents made expressive sounds and gestures to draw attention to the content. Many of these behaviors served to entertain or draw attention in a social way, such as demonstrating mock surprise: *"Oh, what's that?"* or *"Hey, who do we have here?"* Parents sometimes pretended they were characters in the story: e.g., mooing, making car noises, or making laser sounds. Some children would also make noises, pointing and gesturing to mimic their parents. Sometimes the children started the expressive action (such as slapping the book or pointing) as soon as they saw the object on the page. These gestures and

Figure 5. Audio mimicry and coincident sound effects

Figure 6. Completing each other's sentences

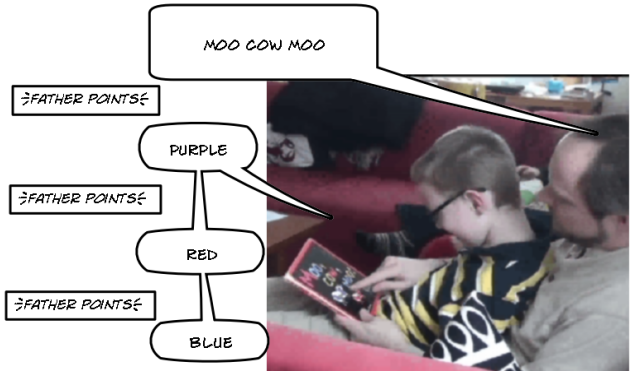

Figure 7. Multisensory Performative Reading Ritual

conversations were designed to keep a flow of activity directed toward the story.

PARENTS ARE ADAPTIVE SOCIAL TEACHERS

If a child was very fidgety, he might stop reading temporarily or altogether. Parents responded to interruptions with much patience and good temperament. *"It's okay, let's do it later."* The parent's role was mainly to entertain the child with conversation about the book by commenting and pointing to arouse interest (e.g.,"*Whoa, look here! [point at rabbit on page] This is a mistake, right?"*). Parents paid close attention to their child's reactions and expressions of interest, mainly using conversation to gauge their child's interest (for example, by saying *"What do you see?"*). They often made witty comments or emphatic motions to keep the child entertained, sometimes taking great liberty in amusing the child rather than focusing on the textual content.

Parents responded quickly by pointing at the images or commenting on the child's change in focus, such as *"Oh, are you looking at the car now?"* Parents deviated from the plot long enough to ask questions. When attention was focused on print, however, they read each word and did not deviate from the print. Despite all the effort that parents exerted to keep their child focused on reading, a book reading lasted an average of 3-8 minutes. Parents were not talking about the books with their children for very long. Most of the books averaged 32 pages, with each page having simple small amounts of text (typically less than 10 words) to read. Parent's made creative attempts to sustain conversations about the simple narratives.

DIALOGIC READING BEHAVIORS

Depending on the child's age, parents and children took on roles in augmenting story content during shared-book reading [15]. With very young children, parents described the images rather than read word-for-word. They used oral language to help make the content more understandable to the child. This dialogue often focused on labeling and listing information. (For example, one parent pointed and asked, *"What's this?"* and *then* supplied the answer to model a conversation.) As children started to learn about printed words, parents read more closely from the text. They might strum the text with their fingers as they read. Older children might interrupt and ask questions. They would infer information from the text, moving discussion away from the printed text. In turn, parents might also ask questions to gauge the child's interest and comprehension. These encouraged the use of descriptive vocabulary and provoked conversations. All parents in the ethnography performed dialogic reading instruction, consistent with reports about how well-educated parents usually read to their children.

Performative Storytelling Behaviors

The most exciting ethnographic finding was the observation of physically demonstrative behaviors and storytelling interaction routines. Parents and children enjoyed these *performative storytelling behaviors* immensely. These demonstrative social interactions involved the dual audience. Parent and child played a key part in shared-reading.

Our literature review on parent-child reading rarely mentions these sorts of multisensorially expressive behaviors. Terms such as "vocal expression" or "dramatic reading" are sometimes used, but these

Figure 8. Physically acting out the narrative as a balloon flies away and waving goodbye together.

descriptions were not detailed [7,9,10,12,14,17]. In this section, we describe these performance behaviors in detail as we found these vocal and physical demonstrative reading acts to be quite important:

Vocal expression

Exaggerated vocal expressions were made to direct the child's attention to topics of conversation. When children are very young, parents read by labeling items. *"Look, it's a cow! [point at cow]"*

Voice-acting, pretending to be a character in the story, also occurred. Parents also made sound effects, play-acting the actions happening from events reported in text (like *"Whoosh, goes the car!"*) Children sometimes imitated these noises, mimicking their parents exuberantly.

Older children asked and answered questions during reading play [7]. As reported above, parents often asked "W" questions (e.g. *Why did this happen? What do you think of this? Where did he go?*) in order to stimulate thought about the story. Much parent-child reading research focuses on this questioning dialogue between parent and child [17].

Physical gestures

Parents use pointing to demonstrate the relationship between text and image in books [7], and also out in physical space. Demonstrating nouns seemed very common, as a precursor to the question *"What's this?"* or *"Look at that (object)!"* Parents would point to direct the attention to the object to which they were referring. When there was action occurring in the story, parents might also move the fingers to demonstrate verbs (such as driving away) as they were talking.

One mother read about a balloon flying away. She lifted the book into the sky to help the child imagine the book floating away (see Figure 8). She stood up, with the child in her lap, and they both waved bye at the balloon (Figure 9).

Figure 9. Physical gesture demonstration of a balloon flying away

In the research literature, there were few descriptions of parents acting out what words mean physically. However, these expressive physical behaviors seemed particularly relevant to reading demonstration. Parents were *performing*, as they gestured to explain directions, shapes, and actions. Parents were demonstrating how actions correspond to words by drawing attention to words, by physically pointing, gesturing, and acting out the meanings of words.

Children gesture, too, to point at images of interest. Younger children were likely to wander around or explore interactions outside of reading [9]. Their movements and intentions extended beyond the book, such as putting objects on top of pictures on the book. One child moved a toy cup over an image, perhaps testing if the cup would change the image. Yet another child tried to grab or trace outlines of pictures.

Older children's physical actions demonstrated that they knew what was going on conceptually in the book. Older children pointed and gestured to indicate that they comprehended the content and storytelling flow well enough to play (e.g. pointing at relevant objects, making motions to act out the story).

Overall, all the parents in the study were good storytellers and good reading instructors. They all exhibited dialogic reading, print referencing and engaged their children in conversations about the stories. These behaviors were consistent with research on the correlation between reading behaviors and high SES.

However, each parent-child pair had a unique set of performance behaviors, both vocal and physical. Some parents had inspired routines for reading, with special jokes and questions that they had developed with their children. Reading was a familiar activity, with parents and children using rhythm and repetition to create an enjoyable reading experience. In our literature survey, these performance behaviors have not been widely reported on, yet they play an important role in the best-case scenarios we observed. These storytelling behaviors seemed to help parents make reading fun and engaging. More importantly, they help children learn how to read by giving rich context to the printed words.

In sum, parental storytelling performance behaviors were highly correlated with positive reading behaviors. Children's storytelling performance behaviors,

Figure 10. Beginning scenes in "Baby Duck Takes A Bath". When the reader hovers over the word, the image is highlighted and *vice versa*.

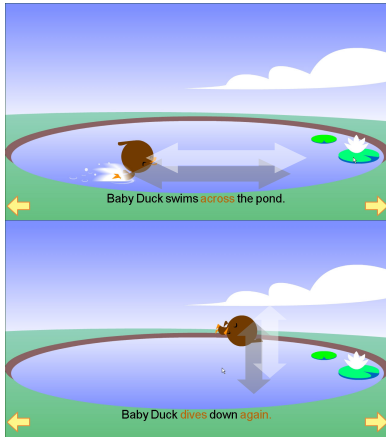

Figure 11. Readers can puppeteer the character to demonstrate verbs. (Arrows demonstrate the movement, but are not seen in the story.)

accompanying those of the adult, were highly correlated with active learning behaviors that foster early literacy skills and knowledge.

Applied Design of Textual Tinkerability

Having discovered the occurrence of these particular storytelling behaviors, our objective was to design a new kind of tablet-based reading experience that would support and enhance these positive reading behaviors. Given prior studies that have shown that merely adding interactivity to literacy-based games can actually diminish parental involvement [6], identifying the right kinds of interactivity that enhances and increases parent-child interaction and dialog is one of our key design objectives.

A key design principle is to support the parent's creativity in demonstrating the concept of text. Two principal insights were gained from the ethnography: 1)our design must support how parents and children talk to each other in ways that would prompt discussion about text concepts, and 2) our design must encourage parents and children to use expressive voice and physical motions to act out the narrative. Below we list the resulting design elements of textual tinkerability.

Design Elements of Textual Tinkerability

We have implemented a series of TinkRBooks to explore and evaluate how people use textual tinkerability (a.k.a. tinkRability) and how it impacts the quality of shared parent-child reading practices. When a reader makes gestures to read the story, tinkRability draws attention to the text-graphic/concept relationship. More directed storyteller actions (touching, gesturing) with story elements (characters and props) cause changes in the text (nouns, verbs, adverbs) and narrative.

STRUMMING NOUNS

Parents naturally point to words they are reading to focus attention to the correlation between print and spoken words. Tinkerability leverages this *strumming* (the act of pointing at the words when reading) to trigger implicit semantic highlighting (by automatically emphasizing how words correspond to story elements). The highlighting is *bidirectional*, touching the graphic animates the related text. This link is also *multisensory*, as touching any object results in simultaneous sound, animated text and graphic animation. This dynamically contextual active mapping between text and a graphic object helps children match the word to the object. Figure 10 shows strumming in the first pages of a TinkRBook story about a little duck taking a bath.

ACTING OUT VERBS

Readers puppeteer a character to cause the text to change. Verbs are acted out through explicit gestures while moving a story element. Adverbs are demonstrated dynamically in the same way. These spatial and temporal concepts would be hard to demonstrate using static text. This also leverages kinesthetic learning by physical performing the gesture and style that corresponds with the verbs and adverbs.

For instance, the user can puppeteer the duck to splash, waddle, or dive as shown in Figure 11. The page begins with *"Baby Duck swims in the pond."* inviting users to drag the duck into the pond. The words respond to the gestures made by the user: the duck can *dive down*, *swim across* or *splash around* the pond. "Diving down" is an up-down motion, while

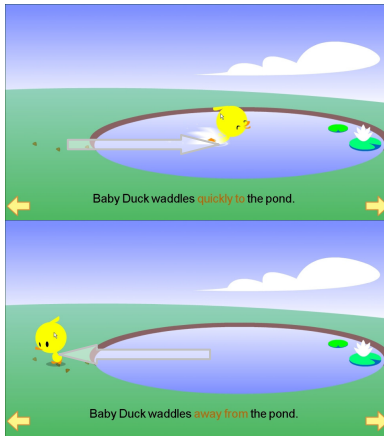

Figure 12. Spatial and temporal prepositions can be taught by dragging the duck toward or away from the pond.

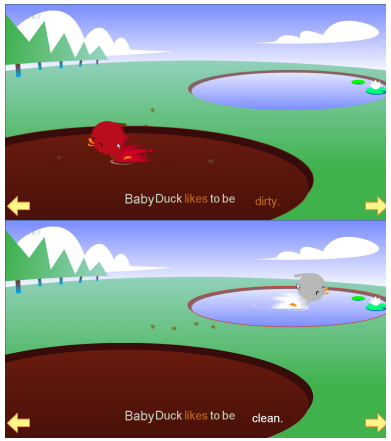

Figure 13. Demonstrating the concept of preference by immersing the duck in a body of water.

"swimming across" is a side-to-side motion. Splashing around is a circular motion. There is some common sense interpretation for repeated gestures. Moving from one side to the other causes the text to display *"Baby Duck swims across the pond/mud."* Repeating this motion will append *"again"* to the statement (Figure 11, bottom).

Temporal and Spatial Adverbs

TinkRability allows users to act out the combination of these parts of speech. Spatial adjectives, such as *near*, *close*, *toward*, or *away* can be determined by moving the character around. Temporal words, such as *quickly* or *slowly*, map to the character's speed of movement. Relationship words (such as *together* or *one at a time*) are acted by moving the character relative to other story objects.

In Figure 12, the duck can be dragged toward or away from the pond. The system analyzes the direction of the movement and inserts the proper adverb into the sentence. *"Baby Duck waddles (quickly/slowly) (toward/away) (from/to) the pond."*

Teaching Abstract Concepts Through Narrative

TinkRability enables interactive narratives, allowing exploration of even more abstract concepts such as how changing the likes or dislikes of the duck impacts the narrative arc. The reader can experiment with a character's motive, emotion, and agency. In Figure 13, dragging the duck to a body of water teaches the word *"likes"* to indicate preference of one thing over another. If the user drags the duck into clean water, the words change to say, *"Baby Duck likes to be clean."* If the duck is put on land, it will then walk to the clean water and away from the mud. Alternatively, if the user drags the duck to mud, the text updates to narrate this change. *"Baby Duck likes to be dirty."* Now if the user moves the duck to dry land, the system demonstrates the preference of the duck by automatically having it walk to the mud.

The duck's preference, as indicated by its agency in going toward the object it prefers, determines whether a mud puddle or a clear pond appears on the next scene. The story can only end if the duck is clean, where the Baby duck is praised by Mama Duck. If the duck is dirty, the story loops back to the agency, adverb, and gestural scenes until the reader chooses for the duck to prefer being clean (Figure 4). Thus, the simple moralistic outcome of this story is that being clean is good.

Evaluation

A TinkRBook introduces new ways for parents and children to interact with one another as they share an interactive story. With tinkRability, readers now have some control of the text and graphics. How does tinkRability change the way parents and children read together?

If parents are performing known positive reading behaviors, then they are doing something right. By the same token, if children are demonstrating active learning behaviors, then they are also on the road to literacy. Specifically, we want to know:

1. Does textual tinkerability result in parents exhibiting more behaviors that are characteristic of good reading instructors?

2. Does textual tinkerability encourage children to exhibit more behaviors to actively explore and learn about text?

To investigate these questions, we implemented a TinkRBook story *"Babyduck Takes a Bath"* using Adobe Flash on a wireless touch screen tablet and recruited parents with young children (ages 2-5) to participate in our study. In this study, we considered comparison other tablet-based reading applications for children. However, simply adding interactivity has been shown to actually reduce parental involvement if not designed properly [6]. Thus, we decided to use a traditional book as our control given that it is the standard scenario for shared parent-child reading in emergent literacy [9, 10, 14, 15].

Our study followed a "within subjects" design that compared two conditions: the TinkRBook (tinkr) verses the baseline condition of a traditional book (book). We found that parent-child interaction behaviors, as described in the ethnography, were varied and distinctive to each pair. It would be reasonable to assume that different parents would use tinkRability uniquely. For the most useful assessment of tinkRability, it makes sense to do a within-subjects study rather than try to compare behaviors across all parents.

We expected to observe that the TinkRBook prompts more positive emergent reading behaviors by parents and children. Our two hypotheses are:

Hypothesis 1: Parents will exhibit more positive reading behaviors with the TinkRBook than a traditional book. In particular, parents will demonstrate more vocal expression, gestural expression and dialogic reading techniques with TinkRBook.

Hypothesis 2: Children will exhibit more active explorations of text with the TinkRBook. Active exploration behaviors are interactions where children exploit textual tinkerability to explore and discuss the meaning of text with their parents.

Participants

Twelve parents (ages 25-50) were recruited to participate in the study with their child in their home. All but one of the parents was female. Of the children, half were boys and half were girls. All parents were college educated and reported reading to their children every day. It was obvious that parent-child reading was an established ritual in each house as children had many books. From observations, all of the children were in different stages of emergent literacy[18]. Two 5 year olds were in the experimental reading and writing stages of emergent literacy, where they were learning to become familiar with print and could decode sight words (common words).

Procedure

Introduction: The investigator introduced herself to the parent as a researcher interested in parent-child storytelling behaviors, researching a new type of storybook designed for parent-child shared reading. The investigator interviewed each parent to survey each family's reading habits, the current interests in reading, and the age of their child who would also participate in the study.

The study was conducted around the bedtime ritual of reading books. The investigator was introduced to the

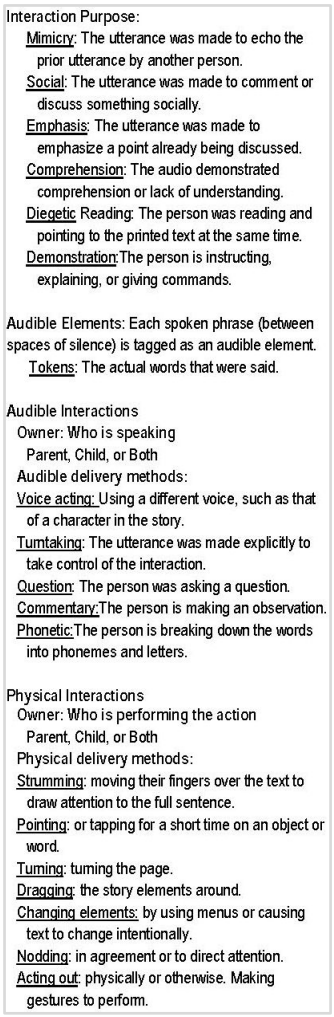

Figure 14.Video annotation elements used for evaluation

child by the parent as a friend who was curious to listen to their bedtime story that evening and record it.

Each parent read to their child using a personal book of their choosing from their home library. Due to the young ages of the children involved, it made sense to introduce TinkRBook second, since children already anticipated reading their favorite book and we wanted to cause minimal disruption to their normal ritual. Both interactions with the TinkRbook and regular book were video recorded.

In the second condition, they read using the sample TinkRBook. The investigator informally demonstrated some of the textual tinkerability interactions showing that they could change the words of the story by dragging and touching story elements. The investigator stayed in the background as much as possible, but did provide assistance if they had questions. Afterwards, an oral survey was conducted about their overall experience reading with the TinkRBook. Comments and improvements for features were noted. The child was allowed to continue playing with the TinkRBook as much as they liked. Older children participated in the oral survey, and often parents and children both restarted the program to discuss features and observations.

After the reading, parents answered questions about their reading practices. Parents were then offered a $10 gift card or a $10 ice cream voucher for their time. They were given contact information for any follow-up communication about this project.

Data Annotation

The video recordings were annotated using Anvil [11] for the multisensory interactions shown in Figure 14. One coder, who was blind to the hypothesis, transcribed and annotated the physical and audible interactions. The interactions were annotated according to gesture owner, execution, and purpose. Currently, analysis of *N=10* pairs has been completed and reported here.

Results

Hypothesis 1 was upheld. Figure 16 shows the amount of time spent reading each story. The sample TinkRBook is comprised of 7 interactive pages, whereas the paper book averaged 35 pages in length. Overall, traditional book readings averaged approximately 5 minutes, compared with an average of 8 minutes reading a TinkRBook. People spent dramatically more time, about 8 times more, on each page of the TinkRBook. This is a statistically significant measure ($t(10)=-5.53$, $p=0.0004$, standard error=0.18) of how long the pairs were actually focusing on the experience of a page. All the pairs spent more time with the scenes of a TinkRBook than with pages of their familiar book.

Also, parents spoke a bit faster with the regular book; talking at about 2 words per second with their own book as opposed to 1.24 words per second with the TinkRBook. Taking into account the number of words spoken per page, slower and more dialogue occurred with the TinkRBook.

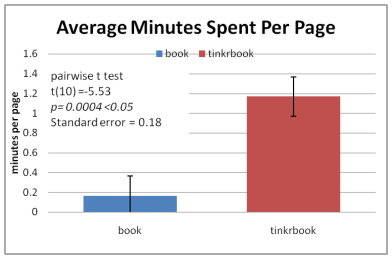

Figure 16. Average minutes spent per page

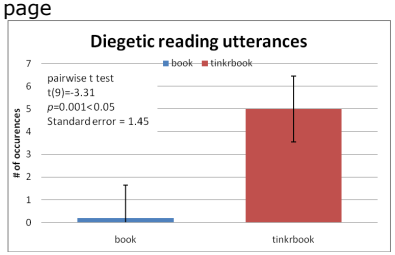

Figure 17. Diegetic reading utterances

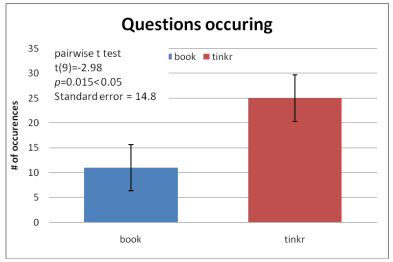

Figure 18. Dialogic questioning

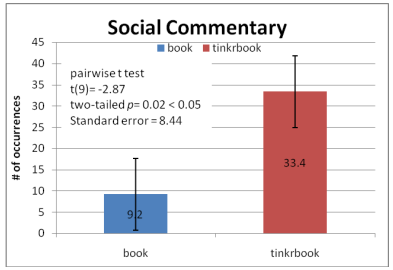

Figure 19. Social Commentary

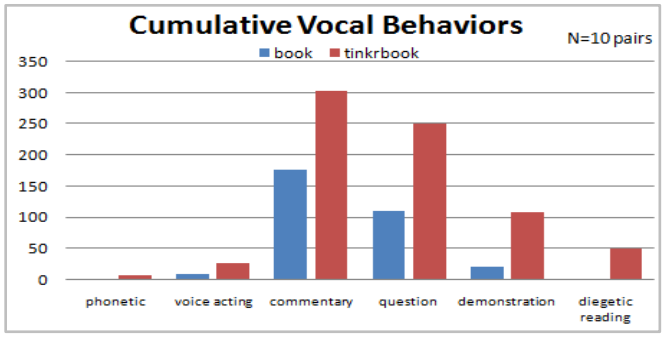

Figure 15. Cumulative vocal behaviors reported for 10 pairs

What was the content of this dialogue? Figure 15 shows that in the TinkRBook condition, conversations between parents and children contained more phonetic instruction, voice acting, social commentary, dialogic questioning, demonstration, and diegetic reading (e.g., pointing to text as they read). These specific behaviors are highly relevant to positive emergent literacy [2, 14,18].

For instance, parents were much more active in pointing out the text in the TinkRBook. In fact, they pointed at the words approximately 10 times as much (Figure 17). With their regular books, the annotator reported that people rarely pointed to the words as the pages were read aloud. With the TinkRBook, pointing at the words while reading aloud was common (t(9)=-3.31, p=0.001, standard error=1.45).

On average, the number of questions asked more than doubled with the TinkRBook, as shown in Figure 18 (t(9)=-2.98, p=0.015, standard error=14.8). An increase in these two behaviors indicates that the TinkRBook enhances the focus of the shared reading experience on explicit dialogic questioning and strumming of the text. These behaviors contribute to understanding concept of print.

Furthermore, the TinkRBook encouraged parents to engage their children in language. Note that simply encouraging parents to talk exposes children to rich language and adult conversation.

The nature of this conversation was also more social (Figure 19). Social communication was more frequent with TinkRBooks, occurring more than 3 times more often (t(9)=-2.87, p=0.02). In general, these were remarks to comment on the story, e.g., *"He's having fun in the water!"* or *"What's he doing, oh- it's so silly!"* Some of these remarks were also collaborative, e.g. *"Good job!"* or *"Do it again!"*

Parents also made a greater effort to see whether children understood the meanings of certain words as they were reading in the TinkRBook condition. For example, when describing the word "dirty", parents would mention how they valued cleanliness in general. Parent-child pairs discussions focused on comprehension 300% more with the TinkRBook as shown in Figure 20 (t(9)=-4.37,p= 0.001, standard error=3.13).

Our second hypothesis was also upheld by our data. Our results support that children engage in more active exploration of the concepts in text with the TinkRBook. For instance, TinkRability provides support for physical expression of words. This includes actions such as pointing to text and graphics, strumming text, dragging story elements around, turning the page, etc. Children exhibited an increase of six times more physical or gestural activity (t(9)=-3.55,p=0.006). See Figure 22.

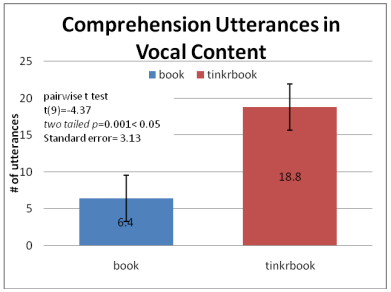

Figure 20. Comprehension utterances

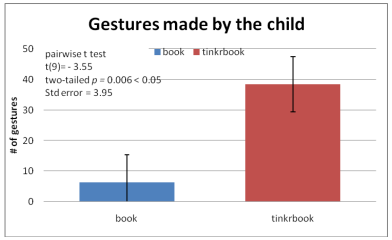

Figure 22.Gestures made by the child

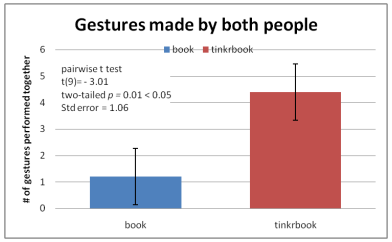

Figure 23.Gestures by both people

Figure 21. Active exploration by child, along with performance demonstration by parent.

Also parent and child gestured together more with TinkRBook compared to a regular book. This indicates that tinkRability prompts active textual exploration by children, as well as collaborative exploration between parents and children (see Figure 23).

Again, these statistics really do not convey the richness of the behaviors expressed by parents in reading. The photos in this paper attempt to shed light on how parents used TinkRability. For instance, in Figure 21, the child is actively exploring the text by trying to read out loud as he points. He encounters a word that he doesn't recognize. The parent starts to use phonics, but then demonstrates the action of waddling by both dragging and acting out the word physically. In Figure 24, a parent explicitly prompts the child to reference the text using semantic highlighting.

Discussion

Our research approach examined how parents who are skilled in reading to their children behave in order to design a new kind of interactive book experience that is designed to explicitly support and encourage more of these sorts of positive emergent literacy behaviors. In this study, high SES and skilled parents exhibited dramatically more of these positive behaviors than when reading a paper book. Also, their children engaged in more active learning and discussion with their parents in the TinkRBook condition.

Although one could argue that the novelty of the TinkRBook could result in a greater length of engagement over a traditional book – novelty alone does not account for the fact that those specific positive reading behaviors were made much more prevalent. The design of the TinkRBook supported and prompted these behaviors in particular.

It remains to be seen how different populations might use tinkRability, and whether the system can encourage positive emergent literacy behaviors in these other populations. Our design process assumes that one person in the dyad is a guide for the other. At the same time, the knowledge gap between the two people may not have to be large for tinkRability to be useful. Parents who are slow readers themselves may progress

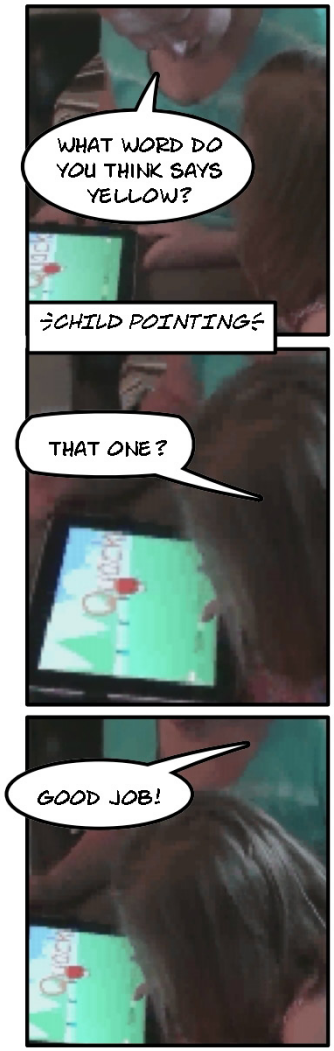

Figure 24. Explicit print referencing with a 3 year old

differently, as may children who read to other children. The immediate feedback provided by tinkRability is itself an educational tool that could be used to practice whole language reading.

TinkRability allowed parents and children to talk about concepts in print without drawing too much attention away from their communication. Furthermore, tinkRability encouraged people to act out the concept of text, rather than just reading it. People effectively used gestures to act out the story despite the unfamiliarity of the TinkRBook story. It is encouraging to know that parents and children were able to exhibit performative reading demonstrations with TinkRBook, indicating that storytelling rituals would develop over time.

These performative behaviors and storytelling rituals are the kind of interactions that make reading enjoyable. Voice-acting, social communication, and physical gestures combine to create intimate social moments relating to reading. Perhaps these emotional aspects are what encourage children to continue to love reading long after they have mastered the basics.

It would be interesting to examine a longitudinal study, to determine if the behaviors actually lead to the development of intimate shared reading rituals and faster achievement of literacy in children. We also intend to study different populations, such as low-SES parent-child populations or older children who are struggling readers tutoring younger pre-readers or early-readers. It is our hope that tinkRability can promote literacy for those who are the most in need of additional support and engagement in reading.

Conclusion

In this paper we introduce the idea of *textual tinkerability* in the context of emergent literacy for fostering early literacy skills. Textual tinkerability (or tinkRability) is the dynamic mapping of a reader's gestures to expose the triadic text-spoken word-concept relationship. The technology is subtle by design to encourage and enhance the conversation and interactions that naturally occur between parents and their children. Textual tinkerability aims to support parents in their dual role as story performers and reading teachers.

Our ethnography reported how skilled reading instructors exhibited important performative reading behaviors and storytelling rituals in shared reading during emergent literacy. The observation of these intimate and social parent-child interactions led to the idea of textual tinkerability and TinkRBooks.

Our study demonstrated that tinkRability enhanced the teaching behaviors that parents naturally perform while reading to their children, resulting in more social and comprehension-related conversation. TinkRability was shown to encourage parents to perform a range of positive emergent literacy behaviors by 3 to 10 times more than with reading physical books. Additionally, children were observed to take a more active role in exploring the concept of text. The results hint that textual tinkerability can make emergent literacy teaching more effective.

Acknowledgements

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