

TinkRBooks:
Tinkerable Story Elements for Emergent Literacy

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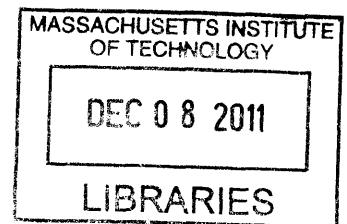
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Abstract

Printed words are an abstract representation of concepts. Today parents teach children how to read by demonstrating how text is related to imagery. I present textual tinkerability, an idea for demonstrating reading by using multisensory gestures to expose and alter the text-graphic relationship within the story. Tinkerability allows readers to physically express words as they read, giving them some degree of control over the narrative.

Two interactive storybooks called TinkRBooks demonstrate how tinkerability supports parent-child emergent literacy. Design guidelines were developed to showcase how tinkerability can be used for creating educationally meaningful interactivity. TinkRBooks allows parents to gesturally modify and discuss how text relates to concepts within a narrative. TinkRBooks allows children to actively explore the abstract relationship between printed words and their meanings, even before this relationship is properly understood.

This ability to explore textual representation changes the way parents read to their children during emergent literacy. When using a TinkRBook, parents spend more time talking, discussing more comprehensive ideas with their children and provoking more meta dialogue than with regular books. TinkRBook also encourages children to drive their reading inquiry, by actively demonstrating the concepts relating to vocabulary schema within the narrative. The result is a new story sharing experience that benefits both parents and children by allowing them to understand how the choice of words impacts the story experience.

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1 Introduction

The importance of emergent literacy

“Reading to your child from infancy onward is one of the most important things you can do to help your child learn language... Reading at home is a big part of a child’s success with language and reading later in school [Honig 1996].”

Studies show that learning how to read early is a key predictor of a child’s academic success [Whitehurst 2001; Moats 1999]. Furthermore, learning to read increases the general rate at which children learn, so late readers can fall progressively further behind [Adams 1990; Bellin & Singer 2006; Neuman 2009; Shore 2008]. By supporting a child’s early interest in narrative, enjoyment and interest in the reading process will result in life-long development of intellect and social skills [Beauchat 2009].

Unfortunately, most children are not learning how to read early (Figure 1-1). Over 97% of children entering kindergarten cannot recognize a word, or find a word within the context of a sentence. Increased reading frequency provides marginal benefit (as seen in Figure 1-2)[NCES 2003]. Some children may never learn how to read unless they are taught in a systematic way using a well-designed approach by a good instructor [Moats 1999]. This is not the case with teaching children how to listen [Gough & Hillinger 1980].

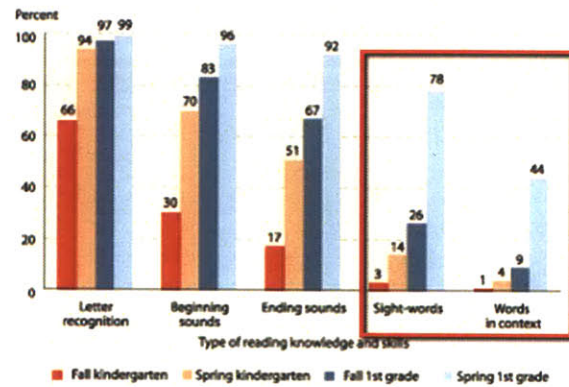


Figure 1-1. More than 97% of all children entering Kindergarten cannot recognize a word or find a word within a sentence. [NCES 2003]

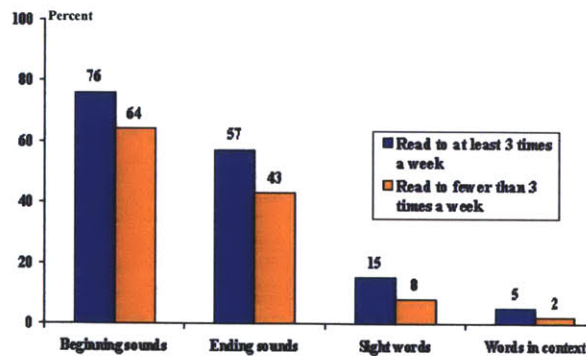


Figure 1-2. Incidental reading is not effective at teaching reading to young children how to read. [NCES2003]

Conceptual parallels between listening and reading

Reading is processing the written word into audible form and mental concept [Ny 1982, p.193; Middleton 2007, p.104; Yuill and Oakhill 1991, p.4]. Figure 1-3 depicts reading as connecting the relationship between the written word to the spoken word and to the abstract concept. Both are connections from mental symbols (e.g., apple). One key is audible, the other is visual. Typically, children understand the link between spoken word and concept by the time reading instruction begins [Lieberman 1995]. Teaching children how to speak is much easier than teaching children how to read, mainly due to the contextual cues in speech [Cambourne 1988; Cambourne 1985; Gelder & Morais 1995; Eysenck & Keane 2005]. “In the evolution of our brain’s capacity to learn, the act of reading is not natural [Wolf 2007].”

Learning from Speech

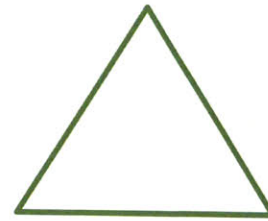
A lot can be learned by comparing how these parallel connections are taught by parents [Snow 1983]:

Context: Parents teach speaking in a world context. They are in control; the words they use are related to the actions they perform, the emotions they express, and the objects they own and employ regularly. Parents are unconfined and can attend to everyday, understood tasks and verbally annotate them. This means that they are experienced performers; they are in control of the plot; they are compelling and convincing. They are delivering their own story, their own content.

Motivations of Children: This context also conveys advantages to children. They can indicate objects, perform, act, affirm and deny. They have a world of objects and actions to gesturally inquire about [Walsh 2009] (Figure 1-4). They can effectively ask and they can test the relationship between spoken word and idea [Goldin-Meadow 2007]. They can drive their own learning: their curiosity can direct the path, and control the rate. Children have been hearing speech since before birth. Children’s speech learning is further compelled by their need to speak with those around them.

Delivery: Spoken words are performed. Prosodic cues such as rhythm, stress, and intonation all help to suggest and clarify meaning [Eysenck & Keane 2005]. Mountains are BIIIIIG; mice are tiny. Shouting is LOUD, whispering is quiet. Gestures are often naturally present for emphasis.

Written Word



Spoken Word

Concept

Figure 1-3. Reading is processing the written word into audible form and mental concept.



Figure 1-4. A child learns about spoken words by pointing at the world around him.

Ease of expression: Anyone with a mouth can speak about what she/he is doing and express the spoken word-idea connection.

Manipulation: Finally, the world can be manipulated. People can arrange LEGO into piles of blue and black pieces. Then they can arrange them into long and short pieces. They can replace a red brick with a yellow one, and narrate as these changes are happening.

Learning from Books

Context: Books contain a contrived context, created by an author. Authors and parents rely on experience (e.g., taking a bath or walking in the rain) to understand stories. Once a child has learned to recognize pictures (around 19 months), they can use pictures as cues to their own (limited) experience [DeLoache 1998]. The context in books is usually out of a parent's genuine realm of experience. The plot is nominally out of the parent's hands. That is to say, any deviation, embellishment or ownership requires a significant effort of creativity.

Delivery: Consequently, parents perform less naturally. They feel constrained to deliver the story's own content [Pappas 1998]. To teach reading effectively requires deliberate performance and creativity on the part of the parent. Children's books are authored in a way that attempts to make understanding easier. However, they lack the comparative advantages associated with the spoken word when it comes to teaching.

Ease of expression: Text is static, typically one format. The text on a page can be strummed (or touched as it is read aloud). However, strumming is one step divorced from performance. Strumming is not particularly demonstrative but the associated vocals may be.

Motivations for Children: Children do not need to read in order to communicate the way they do with speech. Print is a code that children need to learn how to decode before they can say it. As such, print is decontextualized— it does not immediately have the real-time qualities of speech (tone pitch, expression and rhythm that signal meaning). While fonts can be manipulated to embellish delivery, this is limited in normal print, and loses strength if too repetitive.

Manipulation: The book is static. Comparisons that the author intended can be made (e.g., one page can have a rainy experience, the next one sunny), but other types of comparisons are difficult to make. Print is silent and still. Its meaning must be unbundled from print itself [Roskos 2009]. It requires a lot of effort to pick out the meaning from words alone.

Thus, teaching a young child to read is potentially challenging, due to the decontextualized, static nature of text and the constraints of delivering another person's narrative.

And then it happened. "OH, OH, OH!" Sasha jumped out of her seat. I will never forget the look on her face as she finally had her Aha! Moment. Her face lit up and her eyes were sparkling. "Oh the e—when you make word—the e—'nother word!" Aha! Sasha and I quickly went through more and more examples. She could hardly contain her excitement. She finally understood what we were doing, and how the spelling pattern related to the sound of the words.

—Karen Kindle in [Israel 2009, p.9], talking about a child reaching the AHA moment from adding an 'e' to words

The “AHA” Moment

In order to learn to read, children must reach an “AHA moment.” The “AHA moment” has been documented across many learning domains as the moment of comprehension when a student reaches an understanding of material that was previously meaningless [Auble 1979; Israel 2009]. The following paragraphs describe the AHA moment in emergent literacy, when children discover the relationship between written word, spoken word, and concept [Gough & Hillinger 1980; Goetze 2001; Durkin 1993].

Imagine you are a very young child, and your mother is showing you something called “a book.” She points to a picture of something on the surface that is round and colorful, and she says “balloon.” Then she points to some squiggles underneath it and she says the same word, “balloon,” again. She turns the page, and you see the same graphic, among other things on the next page. Some of the same squiggles at the bottom look similar to the squiggles on the previous page. After many readings, you realize that the colorful round shape on that page is

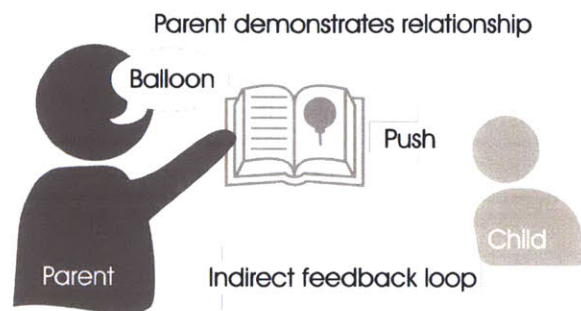


Figure 1-5. Learning how to read is a Push process, teachers control the demonstration.

called a balloon. The balloon picture reminds you of what playing with a balloon is like. The squiggles, however, are harder to focus on. They have a definite form that you can recognize on other pages. After many more readings, you suddenly realize that the squiggles on the bottom are just another representation of the word “balloon.” [Otto 1979; Hirsh-Pasek 2003] This is the AHA moment in emergent literacy, this is how children learn the concept that text is a representation of speech and concept.

Getting to the AHA moment

Traditionally, the way this AHA moment is reached is through repetition. A parent, in the role of the teacher, talks as they gesture between word and associated images (Figure 1-5) in a storybook. Through repeated observation of the parent’s demonstrations, the child learns to associate the abstract relationship between printed word, speech, and concept. This AHA moment occurs when he perceives there exists a connection between printed squiggles and concept [Pratt 2005; Henn-Reinke 2007]. The discovery of this relationship spurs further discoveries, as more representations are learned. This AHA moment might actually be the trigger episode within a larger “AHA stage” of development, as children experience a number of “AHA!” revelations toward the end of early childhood (around 2 years old) [Steinberg 2010]. Their learning rapidly accelerates as they can now query about a printed word’s meaning and sound. [Woolfolk 2009].

Learning by demonstration is what process engineers would call a “push” process, where the rate of information control is not directed by the child (or client) [Ohno 1988]. The parent controls the textual content presented and the rate of demonstration. There may be an indirect feedback loop where the parent can only judge aspects of the child’s thinking which the child has externalized.

In contrast, when children play with flashlights or blocks, they learn through *active exploration* using their own senses [Piaget 1969] (see Figure 1-6). Children control the rate of information when playing with physical objects, in what engineers call a “pull” process [Ohno 1988]. (In pull technology, users request new information specifically [Rutenbeck 2006].) There might be a demonstration by a parent (or someone else) initially, but the child controls the rate of exploration to test their hypothesis, act on their curiosity and gain new information [Sheridan 2011]. With toys, children have direct control and direct feedback, making modifications or choices to a system and observing the effect of their actions in real time [Power 2001; Christakis 2007].

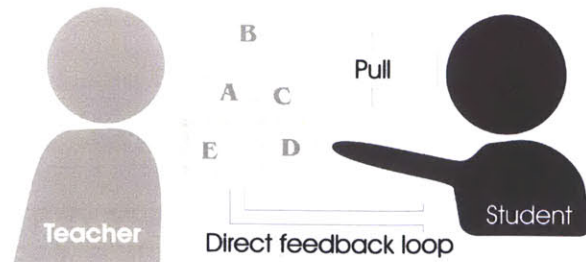


Figure 1-6. Learning from physical toys is a Pull process, children control their exploration of information.

This ability to test new relationships at their own pace gives children a sense of control over their exploration and encourages them to try many different ways of interacting with objects. The exploration is driven by their innate curiosity to touch and see their effect on the world, and is rewarded with personal and immediate feedback.

An Interesting Idea

Today, the way children learn to read is very different from the way they learn from playing with toys. Books present static images and text on the page whereas many toys and games allow for manipulation and interactive exploration of cause-effect relations. The AHA stage must occur before the exploration stage, as in Figure 1-7. Once they [children] reach the AHA stage, they can then drive the exploration by pointing at words to prompt for meanings [Whitehurst 1988].



Figure 1-7. In current emergent literacy practices, understanding results from repeated demonstration.

What if we could allow preliterate children to actively explore text using a pull process?

When we look at how children play with a flashlight or device, the exploration stage comes before the AHA moment (Figure 1-8). The child can push buttons and get immediate feedback in a tactile way. They can control the rate at which they explore, they can explore exhaustively, even doing things that were not demonstrated, such as breaking or banging the flashlight. Their AHA moment comes sooner, perhaps

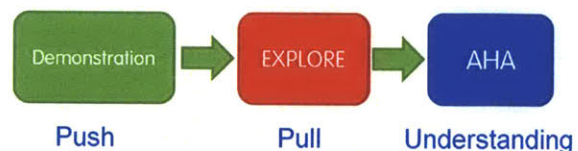


Figure 1-8. With physical objects, children control the rate for information, thus reaching the AHA moment faster.

because children can dynamically explore the relationship between the button and the output. What if we treated words as switches or building blocks for concepts? What if children could test and see how different words affect a story?

Definition of Textual Tinkerability

Children enjoy learning by playing with objects, a self-guided learning process that constructivist Papert called “tinkering” [Papert 1980]. Tinkering allows children to develop a structural understanding of a system through playfully reconfiguring and recombining available parts. Tinkerability is a feature describing the flexibility a system allows for users to reconfigure and recombine elements in constructive play [Resnick 2009]. The Scratch programming environment provides a tinkerable system for technological literacy, making it easier for children to learn about programming concepts like recursion, looping, and variables [Maloney 2010].

In the domain of emergent literacy, I apply the concept of tinkerability to reading stories. I define textual tinkerability as the ability to explore the semantic relationship between text and representation within a story. Referred throughout this thesis simply as tinkerability (or TinkRability), this feature reveals the text-concept relationship during reading. By allowing children to explore the text-concept relationship within a narrative, children can learn about the contributions of words to a story through exploration. They can expose the inherent rules and relationships between narrative and story experience.

What is a TinkRBook?

A TinkRBook is a flexible story book that allows readers to test the relationship between words and concepts during parent-child reading. The story flexes to accommodate narrative changes made as users tinker with story elements.

TinkRBooks use a dramatic metaphor for linking text with animation and input. Readers puppeteer a character to act out the narrative as they read. When a user’s actions trigger narrative changes, new narratives and animations appear to demonstrate the narration. When the user touches an object or word, the corresponding text is highlighted to illustrate the relationship between text and representation.

The storybook subtly encourages readers to provoke discussion about how words relate to meaning. By allowing parents and children to make some narrative choices during storybook reading, children can actively explore the relationship of text to concept before they fully understand how to read.

The following section provides a hypothetical user scenario of a parent-child reading a TinkRBook. In the scenario, the child is about 2 years old, and cannot read. The parent uses tinkerability to tell the story.



Envisioning a TinkRBook

"Story time," says Mama, as I climb into her lap. She holds me in her lap, and puts the TinkRBook in front. "Which story do you want to read?"

"Sophie's Garden," I whisper, already looking for the little house in the garden as the TinkRBook opens. On the first page of the book is a picture of a little girl sitting on a bench, inside a garden. The girl has book open in her lap. This little girl is my character, Princess Sophie.

My character has been sleeping in the garden. The sunlight starts to filter in through the leaves. As the scene fills in, I see her house in the distance. A small hut and flowers appear amid a rose-colored dawn. The day is about to start, and there is much work to do in Sophie's garden.

The text on the bottom says, "Sophie wakes up." I grab Princess Sophie and shake her. Her eyes flutter open softly, but she stays asleep. *Sophie wakes up reluctantly.* I now prod Sophie a bit more firmly. *Sophie wakes up energetically.* Sophie's eyes flutter wide open, and she stands up from the bench, clutching the book.

"Another sunny day, said Sophie," says Mama, as she strums over the words (Figure 1-9). As she hovers over "sunny," the sun winks and glows just a bit brighter. She then moves Sophie toward the garden shed. I want it to be a windy day, so I touch the sun, and pop up the menu to choose the wind (Figure 1-10). Instantly, all the plants in the garden start to move from the wind. Leaves and grasses wave in the wind. I touch Sophie, and her name lights up in the text. "*Another windy day,*" says *Sophie*.



"Another sunny day,"
said Sophie.

Figure 1-9. Hovering over an active word will highlight the corresponding story element.

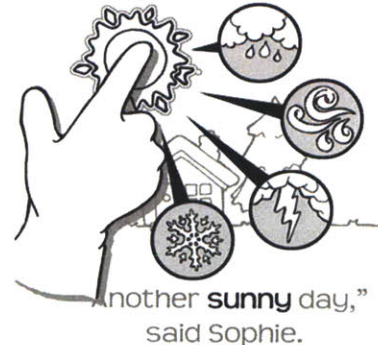


Figure 1-10. Readers can change the narrative by selecting options attached to story elements.



"Another rainy day,"
said Sophie.

Figure 1-11. Changes to the narrative are instantly represented in the scene.

"It sure is windy," remarks Mama. Sophie struggles against the wind. I blow into the book, and another swirl of wind whips through the landscape. I laugh, to see the wind curling the leaves in response to my breath.

"Maybe it's *too* windy," says Mama, as she selects rainy. "We don't want the flowers to fall off." Instantly, the wind dies down and heavy clouds appear in the sky. The words change to say, "*Another rainy day.*" Sophie shivers under the awning of her house (Figure 1-11). Large drops of rain fall from the cloudy sky. "Rain for flowers," I nod.

We turn the page, and Sophie is inside her house now. There is a nice soft bed, with one little pillow in its embroidered coverlet. It looks just like my bed. Sophie has had many pleasant dreams upon the bed. At the foot of the bed is a pair of shoes, and an umbrella stand with an umbrella. The wooden door leads outside, with a jacket hanging on a hook above the doorknob. Through the curtains of the house, I can see the raindrops outside the window. I hear the gentle patter of rain outside.

"Sophie puts down the book," reads the text. So I move Sophie to the table and then put the book on the table. *Sophie puts down the book on the table.* I put the book back in Sophie's hands. *Sophie holds the book over the table.* Mama moves the book back onto the table, but it falls on the floor. *Sophie dropped the book under the table.* I put the book back on the table. *The book is on the table.* I tap the book, and it opens. Sophie starts reading it. *Sophie reads the book on the table.*

Sophie reads the book for a while, one of my favorite scenes. She leans in, squints and points at the pages, and strums the page. After a while, we hear her tummy grumble. "Sophie feels hungry," Mama reads the text on the bottom. I move Sophie to the kitchen area. *Sophie walks to the kitchen.* I move her back to the table. *Sophie walks away from the kitchen.* I hear her tummy growl again, and move her to the kitchen again. *Sophie walks quickly toward the kitchen.*

The kitchen area is on the side of the little house, with a small wooden table, a chair, a stove and cabinets where the dishes are. A saucepan sits on the stove filled with steaming hot chocolate, near a jug of orange juice on the counter, and a pitcher of milk on the table with an empty mug. I grab the milk, and pour it into the empty mug. Sophie nods appreciatively, as she picks up the milk and guzzles it down. *Sophie drinks the milk.* Sunlight streams through the kitchen window. "Sophie still feels hungry," reads Mama. I grab the hot chocolate and pour that in her

mug. *Sophie drinks the hot chocolate.* She drinks it a little less quickly, becomes a shade of red, and gives a little burp. I laugh. "Sophie feels warm and full," reads Mama. Big, fat snowflakes start appearing on the windowsill.

Mama grabs the jacket and throws it over Sophie. "*Sophie puts on the jacket,*" reads Mama. If Mama tugs off the jacket, it would read, "*Sophie takes off the jacket.*" Sophie seems quite happy to be wearing her jacket, so we leave it on. It is time to tend the garden. Before we change the page, I decide to give her the orange juice. Sophie is already full, but she drinks it anyway. *Sophie drinks the juice.* She burps again and we laugh. The snow dissipates and sunlight streams through the window. We turn the page.

"*It's sunny and cold,*" says Sophie. Sophie is standing in her garden again, wearing her jacket near the low stone bench. Under the bench is a rusty watering can, a metal shovel, a wicker basket, and a packet of seeds. Mama comments, "It's a perfect day for gardening, not too hot. What do you want to do? The plants have already been watered by rain, so there is no need to use the watering can."

I look at the rest of the garden and see the plants we have been tending for weeks. Mama drags Sophie over to a pea plant, and she picks the peas. *Sophie picks the peas.* "Peas!" I say in delight. I drag her to the yellow flowers and the text reacts, "*Sophie picks some daffodils.*" "Daff.." I say, not quite remembering how to say it. Mama helps me repeat it a few times. Next, we move her to the red flowers, and *Sophie picks the roses.* "Wo-ses!" I say as Mama nods. The flowers disappear from the garden as she picks them, and appear in her basket. Mama moves her to the apple tree, and pick some apples for her. *Sophie picks apples.* "Apple!" Her basket is now full, and I move her to the bench, where she puts down the basket. "Good job! That's a full basket," Mama says. *Sophie puts down the basket.*

I give Sophie the shovel, and move her to a patch of bare garden. I poke at the empty spot on the ground. *Sophie digs a hole.* Dirt flies as she makes a small hole. I poke again at the hole. *Sophie digs a big hole.* Curious, I move Sophie into the hole. *Sophie is in the big hole.* Mama moves her out. *Sophie is next to a pit.* I just learned the word "pit". "*Sophie jumps OVER the pit,*" says Mama, lingering on the O sound. "Pit!" I say, enjoying the sound of the puff of air that comes with *p* and *t* sounds. Mama moves her around the hole. *Sophie moves around the pit.* Mama repeats the motions to demonstrate the prepositions.

I grab the packet of seeds and sprinkle them on the ground in front of Sophie. Sophie grabs the packet and continues dropping the seeds on the ground. *Sophie plants seeds in the ground.* I poke the ground again, and the cavity fills itself in. *Sophie sowed the seeds in the ground.*

Mama tells me all about how plants grow again. We decorate Sophie's house with the flowers, and Mama and I put the apples and peas on her table. We leave her in her bed this time, until tomorrow.



Years pass, and Sophie's Garden is still my favorite book. I enjoy the visits from different insects and fauna who like the types of things Sophie grows. I learn about cross-pollination, farm irrigation, and atmospheric science. The most memorable part however, is the beautiful sound of Mama's voice as she reads and demonstrates the story with Sophie.

Contributions

This thesis is about how parents teach young children to read, with an emphasis on eliciting positive reading behaviors. This thesis presents technology that serves as a expressive communication prompt between parents and their children, to help both people enjoy storytelling during shared reading. I introduce a new concept called textual tinkerability to teach children about reading, to help get them to the AHA moment in learning to read. Tinkerability exposes the text-concept relationship by allowing pre-literate children to grab images and words to demonstrate that the relationship exists. Gestures can also change the narrative, taking some control of the plot during reading. This allows readers to perform the words during story reading, encouraging expressive storytelling behaviors.

A framework for implementing tinkerability is the technical contribution of this thesis. This framework allows readers to demonstrate the text-image connections actively during storybook reading. A series of tinkerability design principles are presented. Two TinkRBook stories highlight how tinkerability works. One uses tinkerability to allow readers to navigate interactive narratives. The second demonstrates how tinkerability can combine with known educational paradigms.

This thesis also demonstrates how tinkerability is useful as a method for teaching reading. Evaluations of parents and children reading TinkRBooks together have been positive. Tinkerability enables parents to become better storytellers when reading to their children. Children are empowered to actively explore the concepts of text. These positive reading behaviors contribute to children become early readers, and make shared reading more enjoyable for both parents and children.

Thesis Outline

This document concerns a concept called textual tinkerability in parent-child emergent literacy. The following chapters describe the application of Tinkerability to creating interactive storybooks, called TinkRBooks. The next chapter (Chapter 2) introduces the relevant child development theories and prior art. Chapter 3 discusses in some detail the design choices and design principles for using tinkerability in TinkRBooks. Chapter 4 describes the implementation features of two TinkRBooks. Next, Chapter 5 presents an evaluation of TinkRBooks showing how tinkerability encourages positive reading behaviors in both parents and children. Chapter 6 discusses a thoughtful critique of tinkerability in relation to the idea reading instruction scenario. This work is the first step toward a larger vision of an educationally evolving narrative, discussed in the future work chapter 7. The final chapter (Chapter 8) concludes with a summary of the contributions of this thesis. Appendix A acknowledges all the experts who provided their assistance on this endeavor.

2 Background

In emergent literacy, there are two participants, the parent and the child. Both of them can exhibit behaviors that get the child closer to the goal of becoming literate. This project focuses on helping children learn to read earlier through parent-child shared reading. The research questions are:

R1: How can an interface help parents exhibit the behaviors that a good reading instructor performs?

R2: How can an interface allow and encourage children to exhibit behaviors to actively explore learning of text?

This section reviews the relevant stages of child development, emergent literacy recommendations and media literacy theories. Research on parental behaviors that encourage emergent literacy is presented, along with behaviors children exhibit in active learning. I follow with a discussion of how these concepts have been employed in existing books and toys, and a critique of features that are missing. A review of various useful features for children's educational media is presented, resulting with a summary of good design considerations to inform the design of tinkrability.

Children's cognitive development during emergent literacy

Emergent literacy is the stage before reading, when children *begin* to understand the concept of reading [Zeece 2001]. From birth to five years old, children are exposed to learning about reading. At around age two, children's cognition begin to develop past the sensorimotor stage [Piaget 1969], allowing their language skills to develop. Each child reaches the AHA stage at a different time [Woolfolk 2009].

Vygotsky's Zone of Proximal Development

Parents are the primary source of instruction for young children. Vygotsky's Zone of Proximal Development (ZPD) Theory [Vygotsky 1978] describes how parents can assist or *scaffold* their children's development by considering each child's individual experience and abilities. Parents are uniquely positioned to provide this support, and can guide their children more effectively than children learning alone.

Throughout these stages, parents adjust their dialogue based on their assumptions about the child's development [DeLoache 1984, Vander Woude 2009]. The shared reading experience relies heavily on the judgment of the parent to assess these developmental milestones and to present information when

appropriate. Parents can reference their children's experiences, knowledge, and emotional state to guide their children to provide learning opportunities, materials, hints and clues [Steinberg 2010]. Learning to read is a *social experience*.

Cambourne's Theory of Literacy Learning Conditions

Brian Cambourne's Theory of Literacy Development attempts to guide parents in developing supportive literacy learning environments. His theory was based on observing how easily toddlers learn speech in comparison to reading [Cambourne 1988, 1995]. According to the theory, engaging and encouraging children in literacy practices is the key to literacy learning. Cambourne proposes that parents demonstrate literacy behaviors and provide opportunities to involve children in everyday literacy.

Implicit in these arguments is the importance of the environmental settings and the intentional engagement of participants in helping the child learn to read. In emergent literacy, when children are not yet reading, parents can encourage children to *act literate*. Cambourne hints at giving the child the ability to write, to output text or act as if they have this ability. Parents should ask children to read aloud letters from Grandma, write a shopping list, or help read a recipe. Engaging in literate behaviors within the context of everyday life helps children understand the use and need for literacy. Although this is not the focus of my research, some existing research platforms focus on providing means for children to "write" their own stories from scratch [Parette 2008; Druin 1997; Steiner 1992].

In recent years, the casual environment of reading practice has changed radically. Computers, mobile phones, and tablets have become ubiquitous platforms for reading. Adults currently spend approximately 9 hours a day using media such as television, computers, cellphones, tablets [Dill 2009, p.39]. One study reports that 67% of U.S. preschoolers are using computers [eSchoolNews 2005]. It is interesting to consider whether Cambourne would advocate the use of technology for emergent literacy. Contemporary researchers of interactive media suggest that technology can and should be used to aid parents in supporting their children in literacy behaviors [Chiong 2009].

Joan Ganz: Content to assist parents in informally educating children

In 1966, Joan Ganz observed that "most children's TV programs were commercially sponsored, noisy and mindless." As with video games today, children were attracted to stimulating noise and excitement, but there was little educational content in cartoons. Ganz asked, "Would it be possible to design children's programming that would be attractive and fun and at the same time realize serious educational aims? [Ganz 1967]" This question spurred decades of development on informal learning through a show called Sesame Street.

Ganz's method of informal education consisted of 1) utilizing parents as guides for creating an educational setting, and 2) incorporating education into storytelling to create an engaging discourse between children and their parents. Studies have demonstrated that Sesame Street does increase the literacy and learning skills of children [Mielke 2001]. A key aspect of Sesame Street was the idea of a dual audience. Content was made to

encourage parents to watch *with* their children. Material included sophistication so that parents could appreciate it. Much credit for the successful educational outcome is attributed to using adults to guide, reframe, and discuss the content with children. We will revisit Cooney’s design principles at the end of this chapter to inform the design of tinkability.

In summary, Vygotsky, Cambourne and Ganz’s theories call for parents to introduce their children to literacy. Specifically, they encourage parents to guide their children, by talking and demonstrating literacy on a daily, informal basis. The following section describes parental behaviors that encourage emergent literacy behaviors.

Parental Behaviors in Emergent Literacy

The way parents read to their child can influence the development of literacy skills [Reese 1999]. Parents can learn about various pedagogies through intervention programs and research (as discussed below) [Whitehurst 2001]. In general, these methods are designed to draw the child’s attention to the print and help the child learn to develop conversations about the story. According to the National Reading Panel, knowledge of these behaviors helps adults guide children toward mastery of literacy (see Figure 2-1) [Armbruster 2010].

Positive Emergent Reading Techniques

- Dialogic reading
- Phonics
- Print referencing
- Vocal expression
- Whole language

Figure 2-1. A list of positive emergent reading behaviors.

The following literacy methods are positive emergent literacy behaviors that parents can provide:

- Dialogic reading, (asking “What/Where/Why” or open-ended questions) to the child. The purpose of these questions is to engage the child’s interest in the narrative, and to help the child think critically about the story. The goal is to maintain a back-and-forth dialogue with the child.
- Phonics is a decoding method of breaking down words into sound. Phonics teaches children rules for encountering a new word [Adams 1990].
- Print referencing is using verbal and nonverbal cues to encourage the child to focus on the printed words.
- Vocal expression of a wide range of speech sounds, to demonstrate how text is composed, will help children draw attention to the sound of words. Books that use rhyme and repetition help children learn to play with sounds, which enhances awareness of the oral language.
- Whole language is a method of teaching children how to read by demonstrating whole words in context. Children are encouraged to memorize words as whole units, and experience words in context of reading, using pictures for meaning, and by “pretend writing” a journal. [Raines & Canady 1990]
- Conversation or general discussion with adults is a very effective way for children to learn new vocabulary and develop oral language skills [Ezell 2005; Roskos 2009]. Developing oral language skills is a prerequisite of literacy via this method. [Roskos 2009].

In the classroom, educators have argued over whether which of two methods - phonics or whole language - were the best ways to teach. There is now a compromise called “balanced reading” which advocates both approaches [Feitelson 1988]. In balanced reading, children may receive instruction on decoding phonics and then discuss language use and construction. The *dialogic reading* technique has been most effective for small groups in schools and parent-child dyads [Whitehurst 1988; Whitehurst 1998]. In any case, the most basic behavior that adults can do to prepare children for literacy is having conversations [Reese 1995; Honig 1996; Blewitt 2009]. The amount of time parents spend talking to their child in early childhood is linked to future literacy development [Dodici 2003]. Having basic language skills is fundamental in developing print literacy [Roskos 2009].

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 [Aram 2004; Ninio 1980]. Many of the positive emergent literacy behaviors occur naturally for parents of high-SES and high education [DeLoache 1984; Feitelson 1988; Whitehurst 1988]. Some behaviors, such as asking open-ended questions during reading, result in better awareness of reading techniques and comprehension learning in the child [Whitehurst 1988; Senechal 1997]. There are many intervention programs that aim to teach low SES and minority parents how to talk and read to their children [Steinberg 2010]. Direct efforts at changing parental behaviors can be met with resistance [Finders 1994]. It can be limiting for parents to follow a script on how to act with their children. Well-educated parents might find explicit advice pedantic. These programs can be costly, but have been used extensively to reach communities [HHS 2011].

So why are parents not universally effective or more effective at teaching emergent literacy, even those that read regularly with children? Perhaps designing a system that implicitly prompts parents to perform these behaviors can support existing positive literacy behaviors. Instead of teaching parents to perform new behaviors explicitly, a subtle approach is possible using technology.

On the other side of the coin, what are children doing to learn literacy? The following section examines some effective behaviors regarding how children learn language.

Children’s Active Explorations with Language

Many non-academic texts on emergent literacy encourage parents to introduce young children to oral storytelling [Trostle-Brand 2001; Browning-Wroe 2010]. Storytelling is the oral interpretation of a traditional, literary, or personal experience story [Peck 1989; Hamilton 2005]. Storytellers use audience participation techniques to provoke active listening, allowing children to develop critical listening skills [Maguire 1985; Myers 1990; Mason 1996]. Props, music, and costumes also help to dramatize the narrative, helping listeners feel immersed in the story [Lehrer 1995].

Good storytellers also make good reading instructors [Raines 1990, Larrick 1960]. One study found that preschoolers learned more vocabulary and comprehended better when listening to oral storytelling in comparison to hearing a book reading [Isbell 2004].

Another approach to using storytelling in emergent literacy is to ask children to tell and act out their own stories [Paley 2004]. When children use language to repurpose patterns of story structure, they develop oral language and comprehension skills [Peck 1989]. Paley describes how children collaboratively create stories in preschool. They attempt to understand the world around them by reframing scary or inaccessible viewpoints, such as re-enacting a tragedy [Paley 2004]. Storytelling serves a social and psychological function, as children were observed to be more friendly and confident through dramatic play [Paley 1993].

How does dramatic play foster literacy? Storytelling is active exploration with language. Children can demonstrate their use of language, and ask for feedback from others. Being able to act on the world and observing the result is a strong motivator [Pink 2009]. Three-month old infants smile and coo to elicit a response from others [Watson 1972]. As described earlier, toddlers learn through physically manipulating objects (at 7-9 months) to develop generalizations about the world (18 months- 6 years) [Piaget 1969]. Through active exploration, a child can develop understanding of the underlying principles of a system [Zuckerman 2007].

Perhaps a system can be designed to open up the relationship of text and concepts for both parents and children to facilitate discussion through tinkering.

Principle of Contrast in Language Acquisition

In *active exploration*, children can observe how something they control changes. Contrast is a powerful tool for understanding. The Principle of Contrast [Clark 1987] is a linguistic theory where the meaning of a new word is deduced by comparison with a known word in context. Even when two words seem synonymous (or interchangeable) in context, there are other contexts in which they differ. These implied differences help children to quickly understand the new words when spoken in dialogue.

For example when looking at Figure 2-2, if a child hears, “Give me the chartreuse box, not the blue one,” they can quickly deduce that *chartreuse* is a bright green color, due to knowledge that blue is a color (Figure 2-2). Apparently, children only need one exposure to a word casually spoken in this context to discern words relating to color, shape and textures [Heibeck 1987]. If the context is compelling, children may not even need to hear an explicit language contrast. They might implicitly infer color even if someone said “Give me the chartreuse book, not the *other* one.” Even 2-year olds can learn a new word after only a 3-second exposure [Halberda 2003]. This rapid ability to learn new words is called “fast-mapping” and increases in accuracy if adults provide more cues in extended and rich conversations [Mintz 2005].

Principle of Contrast



Give me the chartreuse block, not the blue one.

Figure 2-2. Children use the principle of contrast to learn a new word quickly from context.

Tinkerability uses the principle of contrast, demonstrating how various words result in different meaning. Another simple design can be seen in “lift-the-flap” type books, where a reader flips a word and the corresponding image changes. Another research designs could use cameras to read words on flash cards. Readers might put words on a table and see projected images and animations relating to the words that are visible. When a reader swaps out a word the presentation changes to reflect the meaning of the new word.

Review of Related Research Fields

Essentially, this work is influenced by three main fields: educational games targeting emergent literacy, interactive storybooks, and interactive narrative. We examine lessons from previous work on *interactive stories for children* (interactive storybooks) where the *narrative changes in response to what users do* (interactive narrative) as a way to *demonstrate the abstract concept of text* (educational literacy games).

Educational Literacy Games and Media

Infant and early toddler literacy toys focus on physical development and stimulation appropriate to the sensorimotor stage [Piaget 1969]. Video shows can stimulate and engage children through visual effects and sounds. However, many passive experiences, such as ©Baby Einstein DVDs falsely claim to improve cognitive skills in children [Bronson 2009] as shown in Figure 2-3.

Storytelling gadgets, such as ©Teddy Ruxpin [Kessler 1992], use recorded audio to recite stories to children (Figure 2-4). These passive products tend to replace parental involvement rather than support parental interaction, becoming “electronic babysitters” [Bronson 2009, Chiong 2010]. However, the educational value of many interactive literacy offerings for children is largely unproven, but parents buy them anyway [Reuters 2009].

Educational psychologist Benjamin Bloom noted that there are different classification levels of intellectual behavior used in learning [Bloom 1956]. This hierarchy, called Bloom’s Learning Taxonomy, describes behaviors that students perform at each level and can be used to structure learning activities so learners progress from basic skills toward mastery [Anderson 2001].



Figure 2-3. Headline: Baby Einstein DVDs being detrimental to children’s vocabulary development. [McPherson 2007]



Figure 2-4. Teddy Ruxpin



Figure 2-5. Alphabet flash cards



Figure 2-6. Vtech Touch and Teach Turtle



Figure 2-7. Fisher-Price Laugh & Learn Storybook Rhymes

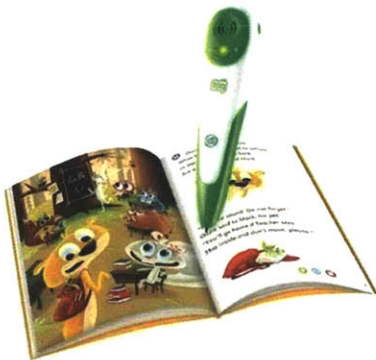


Figure 2-8. Leapfrog Tag Reader

Educational literacy games for toddlers usually are designed to practice visual recall and recognition, such as learning phonics or alphabet recognition using flash cards (Figure 2-5). Word matching games help children become familiar with letters and words. These games are fun for young children who enjoy repetition. According to Bloom’s learning taxonomy, repetition and recall require the lowest level of cognitive activity. Memorization is a needed step for learning the mechanics of reading, but there is opportunity to involve higher levels of cognition, as well.

Electronic preschool literacy games rarely integrate stories to contextualize the lesson, focusing exclusively on repetition and recall activities instead. The touch-and-hear toys (Figure 2-6, Figure 2-7, and Figure 2-8), for example, encourages children to touch a button or image to trigger audio related to the concept. Children can learn the labels for things through repeatedly triggering an element. This is consistent with the literacy experiences in board books for those ages which target the labeling of colors, size relationships, and counting.

Some literacy games do use stories to frame the game, such as in Figure 2-8. Children can observe words in context, and then play a game that focuses on repetitive stimulation. Children can trigger animations repeatedly, to learn to recognize words. Examples for older toddlers are story reading gadgets like the ©vTech reading tutors [vTech 2011] and the ©LeapFrog tag system [Leapfrog 2008]. These point-and-hear electronic books are similar to click-and-see CD-ROMs, like the ©Living Books [LivingBooks]. Simple narratives about topics of fascination, such as fire engines, princesses, or dinosaurs serve to distract children by letting them click-and-observe. Although these games are easy to design, designs addressing higher levels of cognitive activity are required [Hirsh-Pasek 2003].

More thoughtful activities could be designed to invite preliterate children to apply, analyze or synthesize knowledge from the story. For example, mad libs (Figure 2-9) offer an experience about the misuse of words, but do provide a story structure [Mad-Libs 2011]. This type of game allows children to explore vocabulary and then comprehend the humor of syntactically correct words that result in nonsense. Although this is not as sophisticated as writing a story, these activities can help children build skills in applying vocabulary.

Educational video games for older children may also focus on repetition and recall, such as recalling story events [Roszak 1984]. One can imagine games involving writing, or perhaps games that ask children to analyze and understand text in order to progress. More thoughtful software, like ©Itza Bitza [ItzaBitza 2009] presents children with reading puzzles. Children have to comprehend the reading to navigate through the story. These games are usually beyond emergent readers, but serve as examples of higher-level cognitive experiences by using storytelling creatively [Gee 2007]. Some newer games demonstrate novel input methods to create story elements: ©Scribblenauts supports the ability of a system to create story elements based on interpretive drawing gestures for puzzle solving [Scribblenauts 2009]; ©Drawn to Life allows children to customize the visual representation of characters and objects within the story [Drawn 2007]. These games may also contain a social component where children may connect to others on the internet, allowing them to develop language skills through discussions on online forums [Bers 2001; Forte 2007].

Electronic Storybooks for Children

Electronic storybooks, or ebooks, are adaptations of books onto computer interfaces. Some of them might claim to teach reading to children. However, I would argue that ebooks do not teach the *concept of reading* to preliterate children. At best, electronic storybooks help children *practice existing reading skills*. The design of these storybooks often assumes human-computer interaction (HCI) interaction design paradigms,

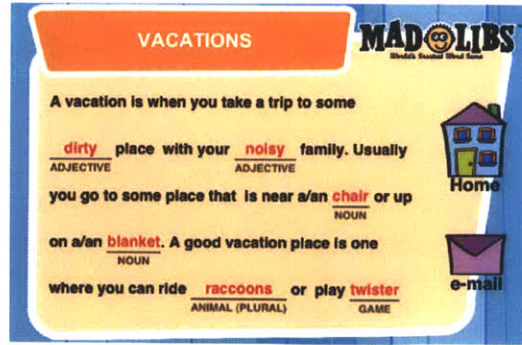


Figure 2-9. Mad-Libs

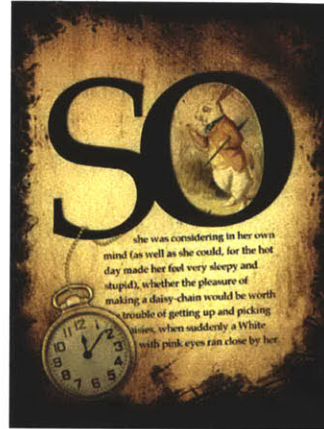


Figure 2-10. Alice in Wonderland

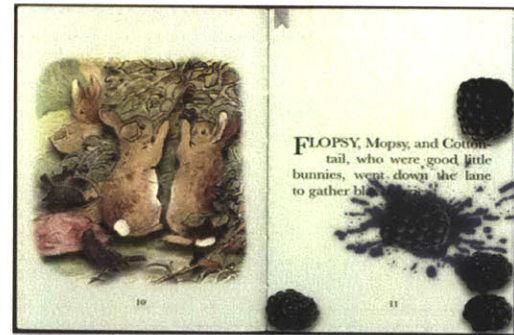


Figure 2-11. Tale of Peter Rabbit

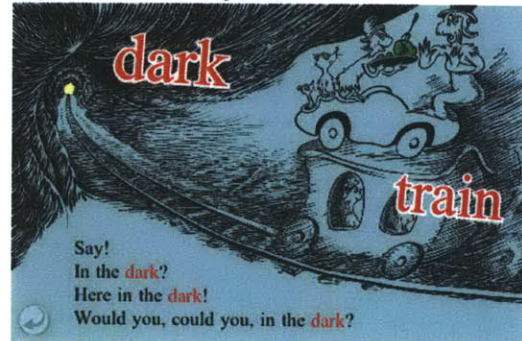


Figure 2-12. Green Eggs and Ham

such as menus and checkboxes that require a preexisting understanding of text.

In children's ebooks, quality relates to aesthetics and engagement (Figure 2-10, Figure 2-11, and Figure 2-12). These books are valued because they can entertain children (in the guise of reading) with animations, textures, music and celebrity voice actors. Their engagement value distracts children so that parents can feel good about giving their child "a book." Text is typically adapted from existing books, and can include aspects from physical books, such as animations that mimic page-turning.

Often these books have no "designed" instructional literacy methods beyond static books. The text may animate or draw attention to itself when touched or read by the recorded voice. These features may assist fluency, the rate at which a child reads. For example, in *Alice in Wonderland* (Figure 2-10), the user can tilt the book and cause the watch to swing from the chain. In *The tale of Peter Rabbit*, Figure 2-11, the user can tilt the book to cause the berries to make a splatter on the page. These graphics provide amusement, but they are clearly not designed to illustrate the meaning between the text and the content.

In the *Green Eggs and Ham* (Figure 2-12), the text is responsive and draws print awareness in users. Readers can touch a story element and see and hear the word appear in the page. Each word can be highlighted and is read aloud when tapped. Children can then match the appearing word to the word in the prose. This activity is useful for emergent literacy, fostering print awareness, even if it only engages repetition and recall. Although very young children *can* have significant memories, and will engage in these activities for hours "beyond the parent's endurance"—is repetition and recall teaching them how to think [Ganz 1967]?

Often, the multisensory stimulation does not connect to higher levels of cognitive activity for literacy progress. Again, the use of interactivity (pre-recorded audio and stimulating games) tends to replace parental involvement and dialogue [Chiong 2009]. These most important elements of emergent literacy are missing. Parents are needed to explain the material. Most ebooks for children are intentionally designed to exclude the parent, by including a "Read to Me" and "Auto-Play" mode with recorded voice actors, interactive games and animations.

A Design Opportunity for Meaningful Interactivity

I note an opportunity for developing meaningfully interactive experiences for emergent literacy explicitly designed for parents to read *with* their young children. "Meaningfully interactive" is interactivity that goes beyond repetition and recall to encourage higher level thinking about the text. Existing products available for emergent literacy often do not allow children to "act literate." Nor do they support *parents* in *shared reading practices* as suggested by the background research. Dialogue and read-aloud story sharing between parents and their children are the most important elements of emergent literacy [Zeece 2001]. Most interactive literacy games are designed for the child alone, and tend to exclude parents from their role as storytellers and literacy guides.

Exceptions to the norm are sophisticated reading applications designed to provoke dialogic questioning, explicit reasoning about causality and suggest discussion topics. Interactive storybooks designed for tutoring might use explicit prompts to guide or take the place of teachers. The Universal Design Language (UDL) book builder, designed by CAST (a nonprofit organization that develops educational technology) (Figure 2-13), can be used to create digital books that support reading instruction [CAST 2011]. Teachers create animated characters (or agents) who present scripts to prompt critical thought and discussion as adults read with children [Bob 1995].

When explicit prompting is provided during parent-child reading, parents might become better reading instructors. However, extraneous text might distract from reading the story. Children, because they cannot read, might be confused about the extra visual information they cannot understand. Adults may assume a more authoritative role in how to communicate with their children. This approach can also be limiting the creativity of parents who have their own style of teaching or reading.

An interface that implicitly prompts parents to discuss a story, by using tinkerability, can help readers feel some control over story content. Another example of a literacy learning game that provokes higher cognitive skills is PBS Kid's SuperWhy Storybook Creator (Figure 2-14)[SuperWhy 2011]. Children can select a word from a menu and see how it applies to a scene. The use of text-based menus may be confusing for children who do not yet recognize text, but nonetheless, gives children access to meaningful interactions with text. Children can learn vocabulary quickly by using the principle of contrast, and see the vocabulary in context. Unfortunately, the different word combinations available are nonsensical. What does it mean for Jack (in *Jack and the Beanstalk*) to plant trains or balls? It would be more useful if the selections maintained narrative cohesion, so that children

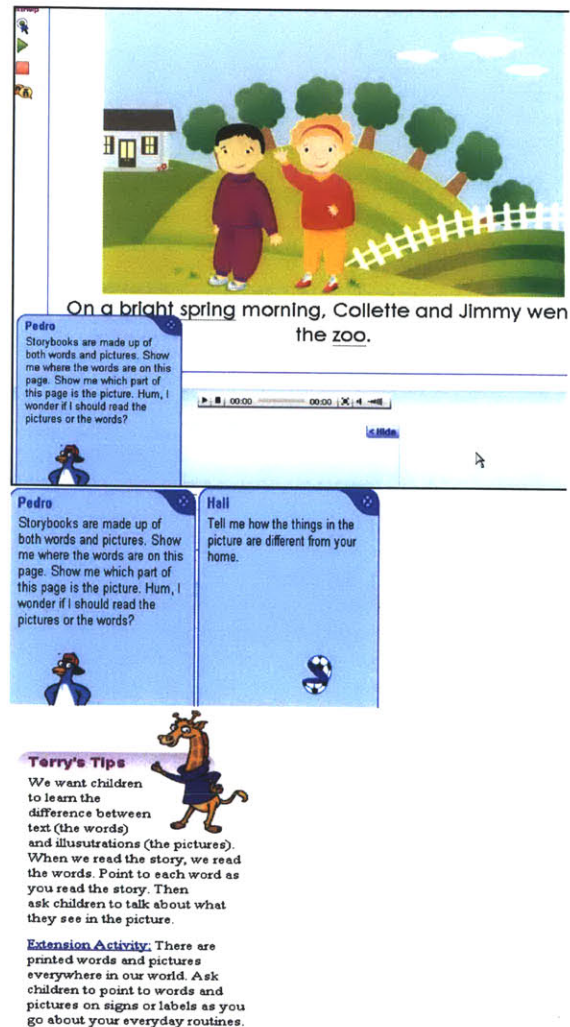


Figure 2-13. The Universal Design Language Book Reader, by CAST.org and close-ups of the tutors.



Figure 2-14. PBS SuperWhy Storybook Creator

could understand the impact of coherent choices within the larger context of the narrative. At the moment, children can only see the local effect of their choice. It might be more educational if the readers could control the plot somewhat by seeing how different word choices propagate through the story.

One application that allows children to control the plot is Toontastic (Figure 2-15), a storyboarding application where children can create stories by recording their gestures and voices [Toontastic 2011]. For each scene, the system records the audio as they puppeteer their characters around the scene. The storyboarding application then guides the children to select from cartoon assets, cinematic music scores, and background templates to create the setting. Each character's limbs move as they drag the character around, combining with their voices to create dramatic effects. Surprisingly, the high-quality assets combine with children's creativity to create watchable stories. Although Toontastic does not address print literacy directly, children develop oral language skills in dramatic play [Paley 2004]. Children collaborately tell stories and then upload their creations for others to view, rate, and discuss.



Figure 2-15. Toontastic storyboarding application for creating voice and gesture animated cartoons.

Interactive Fiction (IF)

Perhaps giving readers some control of story plot also prompts social interaction relating to the text. Interactive fiction (IF) is a form of literature where the story responds to the readers' choices. Readers choose options within the story to determine the plot outcome. [Mateas & Stern 2005; Montfort 2007; Harrell 2007]

In general, IF is not targeted to young children and there is no overt pedagogical intent in the design of the narratives. Choose Your Own Adventures, for example, is a form of interactive fiction designed for juvenile audiences (10-14 year olds) [Packard 1979]. Complex story worlds and intricate story arcs consisting of long chains of causality are considered too sophisticated for young children, but there is nothing proven about this.

A few IF works claim to be suitable for children, such as *A Bear's Night Out* [Dyte 1997] or *Wishbringer* (Figure 2-16) [Infocom 1985]. These works reference childhood themes (e.g., teddy bears or postal mail) and use simple language. These "children-oriented" works provide a simplified plot compared to what exists in adult-oriented pieces. A playful dialogue diffuses the sense of danger or urgency that normally surrounds interactive fiction [Chang 2010]. Although these adaptations are accessible to young audiences,



Figure 2-16. Interactive fiction works *A Bear's Night Out* and *Wishbringer*

I am interested in looking further at how to construct educationally meaningful literacy experiences. In particular, I am interested in how to design IF for children who are learning how to read.

The group dynamics of IF are interesting, as this art form seems to compel people to come together to play IF. The nature of narrative choice fosters collaboration; IF readers value discussing multiple perspectives

during puzzle solving and appreciating the beauty of language represented in this art form. A key part of learning for young children is the social aspect of communication. I note that young children do not tell stories alone; they tell stories to other children and adults [Paley 2004]. An adult IF story that supports children's cognitive requirements and explicitly includes social cooperation could be quite enjoyable. Such a story could also be enjoyable for multiple children.

Club Floyd (http://www.allthingsjacq.com/interactive_fiction.html#clubfloyd) lists over 200 playthrough transcripts of people meeting online cooperatively to play interactive fiction. This archive is littered with people thinking out loud and using collaborative discussion to understand, solve and socialize while playing fiction together. IF poses a shared puzzle to readers. My analysis of the archives suggests that people enjoy contributing multiple perspectives to understanding a shared puzzle. The puzzle provides a venue for presenting different viewpoints people can bring to a discussion. All the people on the site seem to love the beauty of the prose, and sharing that common interest is enjoyable.

IF gamers exhibit their prowess at describing their knowledge of the game, showing off different facets about the game they know (e.g., the back story), and telling "in-jokes" and hidden commands. There is also an appreciation of human intelligence, where people like to see how others perceive a situation while solving puzzles. The shared puzzle aspect equalizes the roles of all the parties involved. The whole time people are playing, roles are shifting as some people are narrating and others are socializing. IF provides a forum for scaffolding learning and sharing, much like a book. People can demonstrate how they think. 'Experts' provide a supportive environment, and watch empathetically as novices flail. These experts can guide others in a public way which helps their ego in an altruistic way.

DavidW says, "I should note that all the stuffed animals in this game actually exist; I've seen photos of them."

Jacqueline says (to DW), "They've visited me. We carried them all around Alaska taking photos of them. heh"

DavidW says, "cool"

Jacqueline says (to Taleslinger), "But I'll pass along the transcript to David for sure."

schep says, "see also the ifMUD verb waylay"

DavidW says, "I don't know the history of the WAYLAY command. It's an in-joke of some kind."

Spinster says, "I don't think the game has made it clear enough that we're a teddy bear yet"

DavidW says, "yes it has"

Spinster says, "Yes, that is what I was trying to imply through my labyrinthine layers of sarcasm"

Taleslinger says, "Curses."

schep says, "(There's a special remark if your first command in Curses is >D, but you win anyways.)"

— Club Floyd Transcript playthrough excerpts
A Bear's Night Out [Dyte 1997] on May 25, 2008

The Sesame Street Effect

Unlike prior approaches at educational literacy games, the aim is to design an interface to stimulate parental involvement rather than replace it. Sesame Street is one example of a dual-audience experience that succeeds in improving emergent literacy skills [Davis 2008; Gikow 2009; Lesser 1974; Morrow 2006; Mielke 2001].

Two example short video clips highlight design characteristics of why Sesame Street was successful: *Geometry of Circles* and *That's About the Size of It*.

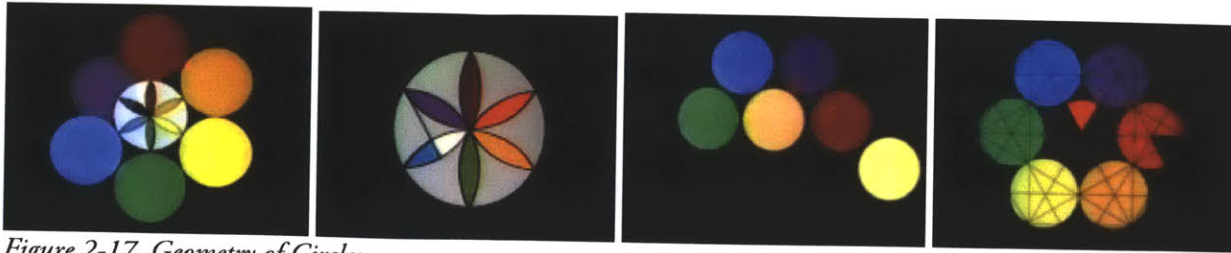


Figure 2-17. *Geometry of Circles*

In "Geometry of Circles," six colored circles (each a different color of the rainbow) dance to music orchestrated by Philip Glass (Figure 2-17). The circles dance to form and split up to form various geometric patterns. The abstract forms of flowers, stars, pinwheels and various polygons are demonstrated as the circles are animated to Glass's minimalist enchanting chords. The resulting aesthetic is sophisticated, demonstrating mathematical concepts such as arcs, lines, angles and the possibilities resulting from the configuration. The musical harmony showcases choral chanting consisting of layered arpeggios.

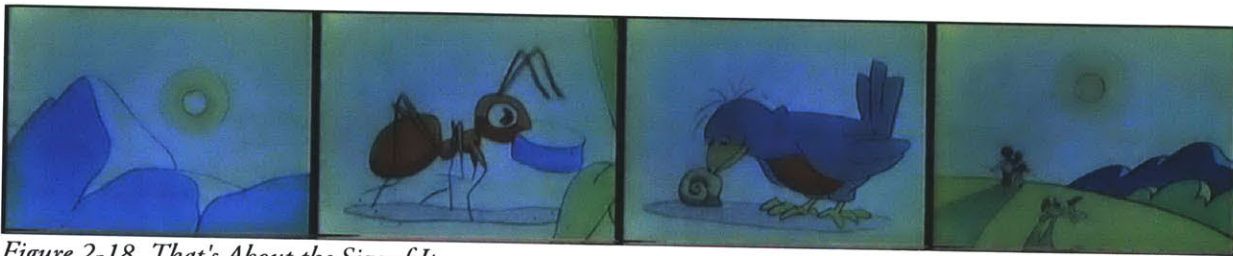


Figure 2-18. *That's About the Size of It*

"That's About the Size of It" showcases the beauty of an infinite perspective lens. The scene starts with the sun rising over mountains (Figure 2-18). The camera zooms out, and the mountains are actually the surface of a tiny rock in the jaws of an ant. The camera continues, making big things seem smaller in comparison with even bigger things. The ant is smaller than a beetle, which is smaller than a snail, which is smaller than a bird, which is smaller than a dog that is walking along with two boys at the zoo. The camera continues to pull back to reveal a giraffe and elephant at the zoo within a large city, then the entire country, then the whole planet Earth, and then out to other planets orbiting around the Sun. Then the camera zooms in on the two boys and their dog walking under the sun as it sets, and night falls over the Earth.

The design characteristics of the example clips demonstrate how content and presentation successfully foster parental involvement and dialogue. Unlike many child-oriented media experiences, these features support parent-child interaction rather than replace it. The following features appear to pervade most of the successful media.

a) *Aesthetic quality.* Both clips demonstrate high production values and sophisticated content. Each clip expresses ideas with sophisticated presentation and a unique storytelling style. The music and animation are tightly coupled, providing an overall effect of coherence in the narrative. The animation is of sufficient quality to demonstrate how concepts transition smoothly from one state to the next. Props, when used in a skit, are often iconic and detailed enough for suspending disbelief of a story world. Ganz wrote "If we are

going to attract children to quality children's programs, they must have many of the production values (meaning pace, humor, professional performing talent, film inserts, animation and so forth) to which today's young children have become accustomed (in advertising and mainstream media)." [Ganz 1967]

The implicit assumption is that viewers appreciate high quality presentation. They also assume that children have visual and musical sensibility, and that exposure to material beyond their cognitive abilities or immediate experience (e.g., demonstrating how a carpenter builds a stool) is okay.

b) *Creativity*. Sesame Street presents a creative variety of storytelling approaches "presenting different material and activities in a variety of production styles (i.e., film, studio, animation, etc.)" The content is tied together to stimulate logical thought about order, relationships, and analysis. The presentations are meaningful, expressing high-level ideas in creative ways. It's a clever exposure to figurative language, while touching on the topic of size and relationships. Unlike other media, where a progression of sensorialism results in an illogical combination, the presentation employs meaningful subtlety in telling a story. Rather than presenting one level of obvious explicit statements to demonstrate an idea, these clips support multiple interpretations that invite reflection by the audience. There is an implicit assumption that children can also appreciate hidden meanings and witticism that keep parents interested. There is play on language to highlight multiple dimensions of meaning, while visually offering different perspectives on a topic. For example, "that's about the size of it" is a phrase to say "this is existence." The use of creativity is designed to provoke ongoing discussion and thinking, so that a conversation can occur about the different ideas relating to the skit.

c) *Progression and parallelism of pedagogy*. Unlike other TV shows that cater solely to children, Sesame Street attempts to offer parents insight into a variety of educational concepts, spurring discussion with their children about these concepts. A variety of pedagogical approaches throughout the show combined with a variety of storytelling methods results in educational learning. Multiple filmmakers produced content for the show around a theme, allowing viewers to learn different ways to discuss educational concepts. The content often progressed from simple to more complex. For example, a letter recognition episode might demonstrate different ways to form letters, finding letters within arranged objects, showing how a letter changes the meaning of word, or having a letter tell its story (e.g., "brought to you by the letter A"). The use of repetition was thoughtful, where repetition was used to reinforce important information. Representing information in different formats (puppets, animation, human characters) allowed children to review information to reinforce the lessons [Kozma 1986]. These variations on a learning theme create a cohesive experience that highlights and demonstrates many ways that parents can discuss the educational theme they observed. Rather than explicitly tell parents to talk about these subjects, the creative, multifaceted entertainment invites curiosity, provocative thought, and fosters discussion.

d) *Cueing the audience to interact*. Children were encouraged to interact with the program through cues to sing, dance, clap, and answer questions. Television is a push medium, but the creators created explicit cues to allow parents and children to react to the material. Craft activities (such as growing plants in cotton wool) were demonstrated that could be performed at home following the program. Skits included prompts for home viewers. Children were encouraged to touch or point to the screen in skits like "One of these things is not like

the others.” The pacing of the show, and provided visual and audio cues drew attention to specific segments important for learning. For example, there were sound effects and laughter at the end of counting episodes like Baker #5, where the baker falls down with “five fancy fruitcakes.” They were asked to touch their toes in exercise skits, move their arms to music, or curl up, pretending to be seeds in winter. Children at home could participate actively in the experience by “marching like a soldier, walking on tiptoe, waddling like a duck.” [Ganz 1967]

These features of Sesame Street resulted in educationally meaningful interaction between parents and children, which I will use as initial guidelines for developing tinkerability. A TinkRBook is designed to encourage parents and children to exhibit positive reading behaviors by prompting discussion and exploration of the conceptual link between text, concept, and speech. Each TinkRBook will aim to provide meaningful interactivity by allowing children to have *control of text* and prompt discussion between readers by drawing attention to the text using tinkerability. Tinkerability will use the principle of contrast to allow readers to examine the relationship between text and context, providing readers some narrative control. This control may help parents expressively demonstrate print as they read to their children.

The next section describes the identification of positive reading behaviors affecting the design of tinkerability. These behaviors shape the features of tinkerability to help parents to demonstrate the concept of text. Two TinkRBook stories demonstrate the features and insights in developing this new form of interactivity. A set of design principles conclude the next section, with general comments about designing interfaces for young children.

3 Design

Key Assertions and Research Questions

Based on my background research, I now have two key assertions: 1) Good reading instructors perform in ways that have a positive effect on literacy learning. 2) Giving preliterate children a means to explore words can help them get to the AHA moment faster.

R1 How can an interface help parents exhibit the behaviors that a good reading instructor performs?

R2 How can an interface allow and encourage children to exhibit behaviors to actively explore learning of text?

Inspired by Ganz [1967], the design methodology consists mainly of reaching out to two key groups of people: parent-child users and content creators. 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? Developing a reading interface for this context requires some understanding of the parents who actually read to their children and an awareness of the relevant educational theories. An iterative co-participatory design process was chosen to reflect the needs of the special setting (home literacy), the young population (preschool kids), and incorporate established paradigms on how to design for emergent readers. The design was iteratively revised based on users and stakeholder feedback (Figure 3-1). The human subjects protocol for this work is filed under MIT Committee On the Use of Humans as Experimental Subjects (COUHES) Application number 0905003264.

Two Sociocultural Investigations

Two sociocultural investigations were performed initially to understand the values and context for the design.

The first investigation focused on learning how parents actually read to their children. By performing ethnographic studies in people's homes, I could directly observe how books are used in emergent literacy activities. This study was also used to confirm research reports on parental reading behaviors.

ethnography

design

interviews

Figure 3-1. A formative cycle of ethnography, interview and design

The second study involved expert interviews on storytelling performance and content. Experts were chosen on the basis of their professional credentials in designing, implementing or evaluating content for emergent literacy. They were librarians, schoolteachers, reading experts, publishers, educational psychologists, educational technologists, game designers (people who think about games), and game developers (people who implement them). See Appendix A for the list of experts consulted.

Parent-child Ethnography

Because the nature of parent-child storytelling is so intimate, it made sense to perform ethnography inside people's homes. Reading participants were recruited by word of mouth. Many people were direct friends, but there were also people who were recommended through friends. I asked my network to assist in finding families that had a child between the ages 2-7 to research how parents read to their children. I initially started with five pairs, and added more participants as the research progressed.

Based on the reported research, I expected to observe certain parental reading behaviors in the context of parent-child reading. In particular, I wanted to understand where a TinkRBook might assist behaviors such as dialogic reading and print referencing. The following section reports the observed shared reading behaviors and how these behaviors correlate with the research literature.

Observations of parent-child reading behaviors

Method: Once participants agreed to the study, they were told the purpose of the study was to gauge baseline storytelling behaviors during parent-child reading. Afterwards, questions were asked about reading rituals, parent's assessment of their reading routine, and suggested preferences from both parent and child about potential book content. 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 do not attend to books they are being read from continually. Children often look at the book, particularly when a page is turned to show something new. Parents purposefully attempt to direct the child's attention and talk meaningfully about the content when a new page was turned. Many parents took turns with their children in 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.

With favorite books, there were familiar jokes and routines that were shared. For example, there was mimicry, when the parent would say a phrase and the child repeated it (Figure 3-2). 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 (also in Figure 3-2). Audio tradeoffs, where a parent said the first part of the sentence and the child said the last words (the punchline) were observed (Figure 3-3). In audio coincidence, they both chimed in to say the last phrase of a sentence together. Gestural tradoffs 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 was also multisensory tradeoff, where one person (usually the parent) would say something and the other would gesture or vice versa (Figure 3-4). These behaviors are discussed in more detail in the next section.

Older children expressed their love for this ritual. One parent said that



Figure 3-2. Audio and physical mimicry



Figure 3-3. Audio tradeoff, with child providing the punchline

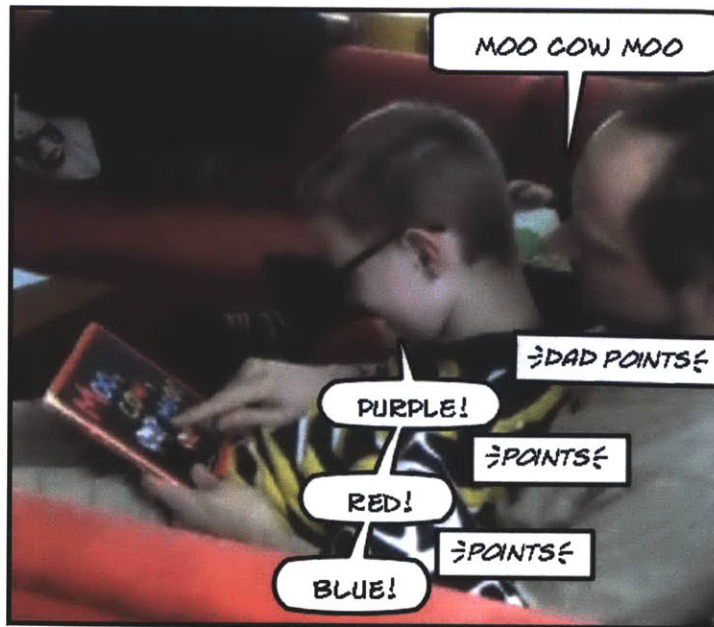


Figure 3-4. Multisensory tradeoff

his son (now 7) recently revisited a book they read when he was very little (around 3). As they read it together, they practiced a familiar routine of performing demonstrative activities (e.g. listing all the colors and counting all the cows on the page).

Some parents reported feeling tired of reading the same book over years, particularly if they had multiple children of different ages. Other parents said that they had trouble focusing on reading (particularly tongue twisters and books with energetic narratives) after a long day, but were happy to perform the ritual.

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

One of the key challenges parents faced was balancing a very young child’s short attention span with the intent to teach. Young children were fidgety and tend to move actively around while reading. As younger children become tired or bored, they start getting distracted. Parents spent most of their time helping children focus on the activity.

Children as peers: Older children, however, actively participated in thoughtful conversations about the book, their interests, and socializing. Some parents seemed to treat their older children as young peers, letting their children bring up topics or responding with conversation or thoughtful comments. One mother read a book about the now-demolished World Trade Center building, and afterwards the two discussed the emotions she felt about it:

Mother: “That always makes me a little sad. (pause) You know why?”

Child: “Because they’re not there anymore.”

Mother: “Right, remember, we talked about that, they used to be there, but they’re not anymore? It makes me a little sad to think that.” (The mother is reflecting on the tragedy of the World Trade Center collapse.)

Other empathetic expressions were also employed:

Mother: “Can you imagine walking between the two towers over the big city? I’d be so scared.”

Child: “Yeah, I’d be scared, too.”

Another example of peer communication was the child’s attempt to expound on the figurative use of the word *print* with a sentence:

Mother reads: “But in memory, as if they were printed on the sky, the towers are still there.”

Child: “It does look like it’s printed.”

Mother: “It means *imprinted* in people’s memory. Printed can mean printed in your memory.”

Parents are adaptive 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 the print, however, they read each word and did not deviate from the print.

With all the effort that parents exerted to keep their child focused on reading, I had expected the sessions to last longer. On average, 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. I was impressed with parent's attempts to sustain conversations about the simple narratives. At the end of the reading parents usually put their children to bed, or let their children play nearby while we talked.

Identified behaviors that were expected

Dialogic reading behaviors: Depending on the child's age, parents and children took on roles in augmenting story content during shared-book reading [Vander Woude 2009]. 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, the parent pointed and asked, "What's this?" and usually 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. This print referencing was casually performed in my observation.

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.

1. Expressive storytelling demonstration

In general, the reported research did not do justice to the richness of the parent behaviors. The flow of interaction between parent and child occurred naturally, and was enjoyable for both. Even though I was a new presence in their homes, the parents and children seemed to be actively engaged in reading together. There were a few sidelong glances in the beginning, but after a while, both participants seemed to forget I was there. Parents and children were sharing a special moment and enjoying each other's company in a familiar

ritual. I was struck by the rich nature of these interactions. The academic literature might have mentioned “vocal expression” or “dramatic reading” but these descriptions were very rare and mentioned with little elaboration in prior reports. In the following section, attempts are made to describe the richness of these behaviors. Participants employed vocal and physical behaviors for demonstrative reading described below:

Vocal expression: When children are very young, parents read by labeling items. “Look, it’s a cow! (point at cow)” Novelty in dialogic interaction stimulates new readers to learn expressive and receptive vocabulary [Cassell 2001]. More exaggerated vocal expressions were also made. Mothers used expressive intonation, slow tempo, and high frequency to emphasize phonemes and syllables when talking to children [Bredenkamp 2011], like “uh-huh” and “awww”. Infants and young kids responded well to *motherese* [DeLoache 1984; Dwyer 2008] with syllable-like babbling and vocal play. An even more sophisticated vocal behavior that occurred was voice-acting, pretending to be a character in the story. 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 (“Whoosh!” they might reply to the previous utterance). Older children asked and answered questions during reading play [DeLoache 1984]. As reported above, parents often asked “W” questions (e.g. Why did this happen? What do you think of this? Where did he go?) to stimulate thought about the story. Much parent-child reading research focuses on this questioning dialogue between parent and child [Whitehurst 1988].

Physical gestures: Parents use pointing to demonstrate the relationship between text and image [DeLoache 1984] in books, 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 they were referring to. When there was action occurring, 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 (Figure 3-5). She stood up, with the child in her lap, and they both waved bye at the balloon (Figure 3-6). 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.



Figure 3-5. Physical gesture demonstration of a balloon flying away

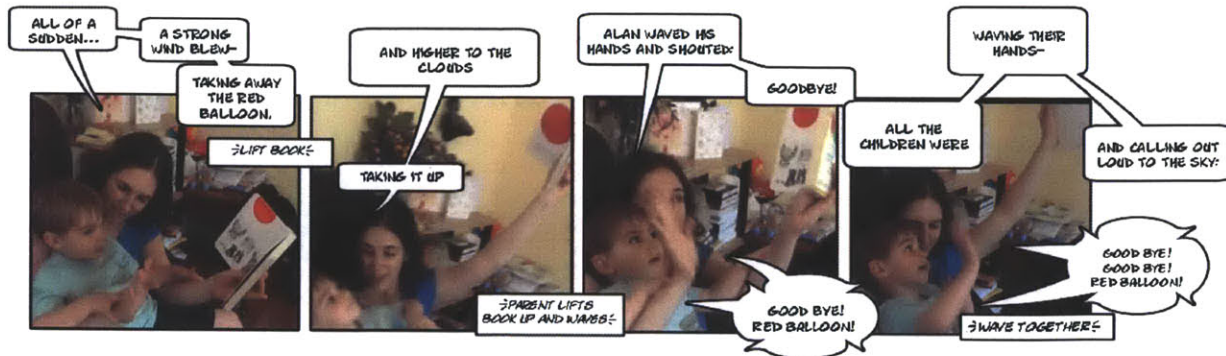


Figure 3-6. Physically acting out the narrative as a balloon flies away and waving goodbye together.

Children gesture, too, to point at images of interest. Younger children were likely to wander around or explore interactions outside of reading [Goldin-Meadow 2007]. 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. Another was observed climbing and clinging around their parent during reading. Yet another child tried to grab or trace outlines of pictures. Another leaned close, waved fingers toward pages, and physically imitated motions described in the text as their parent read to them. Another child jumped up and down because he saw his favorite character, externalizing his excitement. When they were older, children’s physical actions demonstrated that they knew what was going on conceptually in the book. These children were all demonstrating active exploration behaviors. When they were older, they were indicating that they comprehended the content well enough to play with it.

Performative Behaviors	Description and examples observed in ethnography
Spatial interactions	Parents hold both the child and the book while visually sharing. The form factor also allows both parties to grab and manipulate the device easily, as children move, climb and maneuver around their parents. Parents tried to keep the book in shared visual view, moving the book to places the child could observe. They might move the book to the floor if the child moved off their laps, or was wandering around.
Physical gestures	Pointing between text and graphics while talking to demonstrate a link between word and image Strumming their fingers over the words as they are being read. Slapping the surface of the book to punctuate a statement. Talking while making physical gestures to demonstrate verbs or story action.
Vocal expressions	Imitative voices to mimic characters, sound effects to demonstrate actions, turn-taking cues to draw attention. Wide range of intonation and prosody to draw attention to narrative.
Dialogic reading behaviors	Prompting questions to ask about the story. Evaluation questions to gauge what the child understands or is interested in. Expanding on answers that a child asks. Repeating a child’s responses so they can clarify their response if desired.

Table 3-1. Summary of observed parent-child story reading interactions.

Table 3-1 summarizes some of the observed parent-child story reading interactions. The dialogic reading behaviors and vocal expressions have been reported in emergent literacy research (DeLoache 1984; Neumann 2009).

The most exciting finding was the observation of these physically demonstrative behaviors. Parents and children enjoyed these performative storytelling behaviors immensely. In fact, the research reports on parent-child reading scarcely mention such physically expressive behaviors. These demonstrative social interactions involved the dual audience, and played a key part in the eagerness of both people in participating in shared-reading. Here are some more examples of these performative interactions (Figure 3-7 and Figure 3-8):



Figure 3-7. Audio tradeoffs, physical gesturing, and audio coincidence



Figure 3-8. Audio trade-off and coincidence

Design of tinkerability based on initial ethnographic study

All the parents in the study were great storytellers, and good reading instructors as well. They all exhibited dialogic reading behaviors, print referencing behaviors and engaged their children in conversations about the stories. Two principal insights were gleaned from the ethnography to suggest how tinkerability could support these reading behaviors:

- Tinkerability should support the parent’s creativity in demonstrating the concept of text. Parents tried to talk to their children in ways that would make reading interesting. Parents used expressive voice and physical motions to act out the narrative. TinkRBook should encourage talk and gesture.
- Each parent-child pair had a unique set of performance behaviors, both vocal and physical. Some parents had inspired routines for reading, with familiar jokes and questions that they had developed with their children. The use of rhythm and repetition in stories was enjoyable because parents and children could create a familiar routine from this type of content. TinkRBook should not interfere with these behaviors, or prevent the development of these behaviors.

From these insights, the first features of TinkRBook were developed to support parents in their role as story performers in demonstrating text. In particular, tinkerability should subtly allow parents to demonstrate text concepts as seamlessly as they demonstrate using speech. Tinkerability would allow parents to impart meaning to text using gestures. Additionally, might tinkerability passively and flexibly encourage these behaviors in others who don’t have such predispositions? The following existing and enjoyable parent-child reading practices could be supported by tinkerability to provide meaningful interactivity Table 3-2:

Features and actions of shared book reading to support	Features interactivity might provide
Demonstrative vocal expression	Vocal responsiveness to encourage sound making, linking voice to text
Demonstrative physical interactions	Illustrating the relationship between text and graphics when pointing
	Animation resulting from gestures made on the book
Dialogic reading behavior	Supporting strumming text and pointing at images

Table 3-2. Latent design features of book sharing that interactivity will support.

The physical ergonomics and affordances of a TinkRBook should support the close proximity and dynamic movements between readers. Wireless touchscreen tablets seemed to be a natural choice. Adobe Flash CS5 software could be used with a wide range of tablets to provide the experience to many different people and platforms.

Unlike the vast majority of prior art, tinkerability would map expressive behaviors to text to provide meaningful interactivity. At a minimum, it would support the strumming behaviors that other applications already support, by semantically highlighting relevant words and images as they are touched. The key difference, though, is the intentional support for parents as storytellers. Tinkerability would support *how* a parent demonstrates the meaning of text, as described in the following section.

2. Mapping actions to text

An added function Tinkerability provides is to correlate these storytelling features to emergent literacy behaviors. When a parent makes gestures to act out a narrative, they will inadvertently draw attention to the text-image relationship. This highlights the concept-text relationship in an implicit way.

The following lists how storyteller actions (touching, gesturing) with story elements (characters and props) will cause changes in the narrative (nouns, verbs, subjects).

Nouns: Correspond to graphical objects. A one to one mapping between text and a graphic object helps children match the word to the object. In moving a character through scenes, words change to demonstrate the effect the character performs in the story world. Parents naturally use gestures to demonstrate the relationship between nouns and the represented images. There is bidirectional multisensory highlighting of word and image when related text or graphic is touched.

Verbs: By making gestural motions to puppeteer a character, users can explicitly demonstrate words that are temporal or spatial. When explicit movement cues are visually mapped to words, the idea of verbs (words that represent action) can be demonstrated.

Adverbs: Temporal words, such as *quickly* or *slowly*, are mapped 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. Spatial adjectives, such as *near*, *close*, *toward*, or *away* are demonstrated this way.

Adjectives: Adjectival choices should be explicitly offered through narrative. For example, to choose between colors you might have the words "Red, Green, or Blue" mapping to different color choices. If adjectival choices are not provided in a narrative, visual pop-up menus can be used (e.g. a menu showing wind, rain or sun to control weather).

Stakeholder Interviews

A second socialcultural investigation was conducted through interviews with content creators, literary and educational experts. The intent of this stage of study was to capture the best practices of storytelling and education. Artists, storytellers, authors, educators, librarians and game designers are part of the sociocultural ecology of emergent literacy. Thus, it makes sense to ask content creators and other educational experts what design techniques they would recommend for an interactive educational narrative.

Method: During the course of this study, I met with 24 domain experts (16 were parents, 12 males, 12 females): educational psychologists, educational technologists, teachers, professional game designers, storytellers and publishing professionals. All were contacted because of their expertise in the domain of children’s educational media. All parents had experience in parent-child shared reading.

The one-on-one interviews occurred in informal settings, such as in offices or coffee shops. The participants received an overview of the project, a demonstration of the interface in progress, and approximately 5-10 minutes to test out the interface. During the interview, they made comments and suggestions in response to a demonstration and questionnaire. They reviewed the fun and educational value of the interactive storytelling experience and suggested improvements.

Summary of Stakeholder Recommendations

The following table summarizes the main advice from storytellers. We note that most of their advice relates to presentation and content to engage children.

Stakeholder Advice	Features for an interactive storybook
Focus on narrative content	Use a story structure for showing how words are related to concepts. Tinkering with story elements within a scene can show how the text changes within a sentence. A causal chain of tinkerable sentences could be considered a narrative.
Use culturally based elements	Incorporate moralistic values into the story. Perhaps puppeteering a character could foster empathy from the audience.
Presentation Aesthetics	Every active element should visually appeal to invite interaction. Similarly, after any demonstration, some animation or sound should reward the user for their effort.
Dramatic arc	Use repetition and rhythm where possible in language or audio elements.
Developmental appropriateness	Introduce ideas in an order sensitive to children’s developmental appropriateness. Use multisensory approaches to gain attention, e.g. use sound and animation.

Table 3-3. Summary of stakeholder advice mapped to interactive storybook features

Storyteller Summaries and Advice

Performance behaviors are what makes storytelling engaging to the children. Independent of medium, professional storytellers gave advice on how to engage and connect to children. The storytellers from these interviews were interested in creating “enchanted” and “inspiring” experiences between performer and user. They shared their insights and professional experience about particular behaviors and philosophies they had developed for achieving this goal. If possible, I was given access to an event or a link to download media to watch, play, or experience their storytelling performance.

Focus on narrative content: Storytellers (oral storytellers, graphic artists, animators, game designers, and game developers) used their medium as a way to create connections between ideas and their audience. They aspired to create long-term evocative narrative experiences, stories, games, or ideas that people would remember and revisit. Crafting the story was seen as the most important element of the experience to develop.

Culturally based elements: Storytelling (the expressive act in describing a sequence of events) can evoke powerful experiences that serve to educate, entertain, and inspire. The storyteller provides just enough information for the audience to imagine the events occurring. Placing a character within a story context helps people empathize and focalize on that character, creating a sense of closure by filling in an imaginary world [McCloud 2008]. Introducing a character implies the existence of living in a story world, suggesting inherent rules and history that might parallel the audience’s own experience. The character is immersed in a fictional world where the audience fills in the sociocultural details with their own experiences, which helps them personalize the story. This emotional tie strengthens the motivational desire of the audience to care for the protagonist. The goals of the story usually connect with an aspiration, cultural value, or lesson. Some examples of culturally based narrative elements that grab attention are: money, leadership, innovation and love [Quesenbery & Brooks 2010].

Presentation aesthetics: A story is a particular way to represent reality, and better connections are made through multisensory stimulation. Oral storytellers play musical instruments or bring props to stimulate different senses to keep the audience stimulated. Sometimes the stimuli is the storyteller’s physical actions (leaning forward, stooping to get to eye level, making gestures), as they rhyme and chant. The appeal of toys and objects causes mounting anticipation in the audience. Children lean forward and wait expectantly for the storyteller to use an item, or perhaps the chance to go onstage and participate.

Similarly, game designers talked about designing subtle sounds or animations to turn every action into a satisfying experience. People need to be rewarded for paying attention, either through audio or visual stimuli. Interactive media designers suggested focusing on settings that provoke curiosity. Visual appeal can invite users to touch or perform an action. Their action is rewarded by the system. Variables for controlling and enhancing presentation are: timing (using the pacing of the voice, rhythm of words, or reoccurrence of visual and auditory stimuli) and voice (of a character, and tone of the character).

Dramatic Suspense, Rhythm, Repetition, Humor, Curiosity, and Surprise: to keep an audience engaged for a long time, storytellers try to control the audience’s focus of attention. They might give detail to the story

world by bringing props. One storyteller pulled out pictures of animals and held them up as they appeared in her story. Exaggerated motion and emotive expressions help children become immersed in the story. As part of the story, the same storyteller made exaggerated efforts to stuff the animals into a mitten. They might ask questions (“what flavor cake should she make today?”), have children use props (put on hats) or play music (give a child drums to bang). Engaging children in active participation helps them immerse themselves in the story world.

Building suspense through repetition is a key feature of children’s books and stories. Children often ask adults to repeatedly tell or read a story. Repetition in stories allows children to develop and fulfill their expectations (because they can predict what to say or what will happen). Children enjoy rhyming stories because they can chime in on repeated verses. Humorous or surprising endings, after a suspenseful buildup, are very rewarding.

Librarian and Educator Advice

Developmental Appropriateness: Librarians, educational psychologists, and educators focused on the content being developmentally appropriate. Books for this age group are usually easy for children to hold, not too heavy, and have rigid pages. Some books may have multisensory appeal, with holes, flaps, and textures to encourage touch. The books typically convey some type of sociocultural values, such as moralistic lessons (like valuing cleanliness) or convey information about daily rituals (e.g., saying goodnight, brushing teeth, and going to bed).

In traditional picturebooks, concepts are introduced in a particular order consistent with children’s development [Dwyer 2008]. First, objects that are easy to label are introduced. Nouns are introduced first. Then colors and numbers help children learn how to distinguish things in groups. Then, concepts relating to ordered relationships, such as sizes and counting. Patterns are next, combining colors, shapes and sizes. Patterns introduce the notion of abstraction and complex compositions. Finally, even more abstract ideas, such as time and verbs appear. With the notion of time, causality and logic can be introduced. Story concepts for preschoolers are often a mix of fanciful animal characters performing familiar activities like taking a bath, eating, or sleeping.

Another consideration is regards the assessment of children’s attempts to learn. At this age, children are attempting to understand language and may try all forms of combinations. Professor of Developmental Psychology Edith Ackerman advises, “The notion of a *wrong* sentence is a bit naïve. For a child, making an effort to understand something is *huge*. It should be rewarded if they are going in the right direction. (Ackerman Aug, 17, 2011, Personal Interview)”

Design principles based on stakeholder advice

From these interviews, it was also clear that there were three types of design guidelines. First, tinkerability must support the dramatic performances. Second, tinkerable elements must maintain narrative cohesion. Finally, the function of the story as a conversation prompt must be maintained.

The key principle in designing tinkerability is to note that the textual narrative is a prompt for storytelling. To that extent, the text must support the diegetic actions being performed while a parent narrates a story. Storytelling flow must be preserved. This implies design choices that are subtle in how they demonstrate the text-concept relationship. The gestural demonstrations that parents perform while reading (strumming, pointing, gesturing) should control how the narrative changes. They may be manipulating something other than text, (e.g., story elements or using voice), but the intent is to support their expression. In summary, tinkerability is imparting dynamic context to the printed word so that it can have some of the context of speech.

1. Dramatic principles: enhancing performance

Following the suggestion of the content creators, I use a dramatic metaphor for developing tinkerability. Like a play, a TinkRBook consists of a sequence of scenes with characters and props. Story elements, such as characters and props, are the handles for demonstrating action mimetically (while the narrative changes diegetically).

- **Puppeteering A Character:** Create a character to puppeteer throughout the story, to help users act out the story. Engaging in puppetry helps storytellers empathize with a protagonist to articulate the character's thoughts and feelings aloud. By channeling the perspective of a story character, readers would assume the role of storytellers. The activity of dragging a character across the screen helps readers feel "in character" and encourages the use of voice acting.
- **Vocal control:** Parents loved the simplicity of vocally controlled characters. Many parents thought the audio driven animations would be useful in focusing a child's attention to the screen. Some parents wanted explicit control of the audio-driven graphics. They suggested having audio-driven animations active only at certain times. For example, the treetops move only when the words "wind" or "leaves" were touched while speaking.
- **Story element dragging and placement:** Pointing at objects is a natural interaction for 2-3 year olds. Parents said that even though the reading is a complex idea for early readers, demonstrating the link between text and graphics helps children focus on elements of the screen. The control of graphic placement also allows children to participate in the control of the story world.
- **Gestural Interpretation:** The text is responsive to the user's actions in a way that demonstrates the meaning of the text. Simple movements are interpreted by the system to change the story text. The use of gestures to change the story circumvents traditional HCI paradigms, like text-based menus and checkboxes. Where possible, try to avoid using explicit menus as they interfere with the flow of performing.
- **Story element choices:** One way to eschew menus is to present choices using active story elements. For example, a "red, green, or blue shampoo bottles" can be used to change a character's color. The choices correspond directly to narrative text and allow the concept-text relationship to be explicitly obvious.

- Reducing Ambiguity/Repeatability: To facilitate demonstration, effects need to be obvious and reliably repeatable. Only a small set of gestures are recognized by the system to map to different types word choices.
- Multisensory Interaction: Every touch of an active story element responds with sound or animation.

2. Narrative cohesion principles: facilitating active exploration of text-concept connection

The goal of these guidelines is to achieve suitable narrative cohesion so the overall effect is a narrative that parents can enjoy talking about. Authors should choose the text wisely to provide narratives that are enjoyable and consistent within the overall theme of the story. TinkRBook automatically assists in making the relationship between text and concept explicit by using the following techniques:

- Diegetic suggestion: When a user first reaches a scene, the text will suggest what narrative text can be changed through subtle highlighting. Words relating to actions that the user can perform will draw attention to themselves to hint at their increased tinkerability.
- Semantic highlighting: Semantic highlighting supports the existing demonstrations of “strumming” behavior, when a reader moves the finger over the text as they read each word. The automatic demonstration of semantic highlighting supports the pointing between graphics and text they already do, by automatically highlighting the related object and text together.
- Presenting diegetic story choices: Where explicit selections need to be made, laying out the choices within story elements helps unambiguously demonstrate the relationship between text and concept. If the use of menus is unavoidable, reduce the choices to representations that children can decipher. For example, in a color selection menu, use actual colors for menu items instead of text (e.g., “red, green, gray”).
- Gestural linkage and replay: When the user performs a recognized motion and it is recognized by the system, have the system mimic that motion with the corresponding text highlighted.
- Dramatizing the text: If the user creates a sentence that can be performed by the character, have the story character act out the sentence.
- Accept valid constructions: Consider valid sentence possibilities from the child’s point of view. If a scene prompts users to rearrange words such as “Babyduck passes the grass,” but the user makes some other grammatically correct sentence (e.g., “Grass passes Babyduck.”), allow that as a valid sentence. Children will try syntactically correct sentences even if they do not complement the narrative. The system should acknowledge steps in the right directions, even if it does not give the full reward for the “right” answer. When users make a valid answer, alternate animations can help them learn which constructions are more desirable for advancing the narrative. It is important that any experience respect children’s perspectives [Ackerman 2010; Winner 1982; Wolf 2007].

3. Sociocultural principles: preserving a book’s social role as a communication prompt

Any new technology should fit within the existing activities and sociocultural system of parent-child reading. Parent-child storytelling is a ritual, providing more than just a shared experience. Books communicate cultural values and mark a special opportunity for parents to explain, educate and play with these values through storytelling. The following design choices pertaining to sociocultural integration are discussed in detail.

- **Explicit Page Turning:** Pages encapsulate a particular concept, and serve as a shared reference for discussing a particular set of ideas. When pages are turned, there is a change of topic or scenario. By allowing readers to turn the page explicitly, readers can control the rate of advancement through the narrative. This allowed readers to spend time pausing and discussing the idea encapsulated on a page, like in physical books.
- **Representing Time:** In regular books when the user goes back a page, the narrative goes back in time. In TinkRBook, when the user goes back a page, they are not going back in time as in a paper storybook (Figure 3-9). Choices made in one frame are reversible, meaning that the user can revisit the decision by visiting a particular scene. When users go backward through the frames, time is still moving forward. This is an explicit lesson that reality is altered.
- **Moralistic outcomes:** The opportunity to discuss social values is inherent in children’s storybooks. TinkRBook uses short causal chains to demonstrate how an interactive narrative can promote moralistic discussion. For example, an agency change can return the user back two frames if the protagonist is dirty.

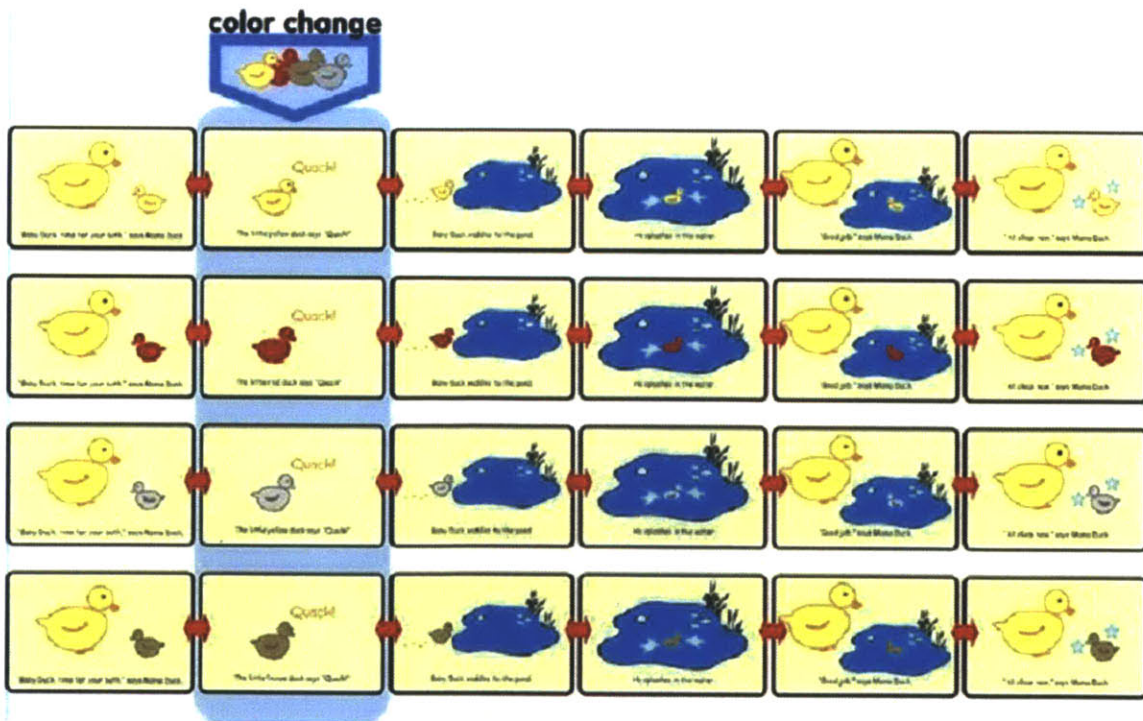


Figure 3-9. Illustrating a user-controlled change on an asset propagating through the entire storyline.

4 TinkRBook Implementations

Two versions of TinkRBook were created. Essentially, both versions demonstrate the idea of tinkerability. The differences between the two versions are improvements in interaction design and aesthetics. The first version, the interactive narrative, more cleanly represents how different parts of speech are demonstrated. It also follows the traditional picture book approach of introducing concrete ideas first, and then moving on to more abstract concepts. The second story, the educational pedagogy showcase, demonstrates how textual tinkerability combines with multiple existing educational approaches to provide meaningful interactivity for creating an educational joint media experience.

TinkRBook Interactive Narrative

This first story introduced parents to the idea of a TinkRBook. This story implemented explicit support for semantic demonstration behaviors. Parents and children could experience the ability to tinker with story elements to change text. This version also tested whether very young children could understand the concept of an interactive narrative.

Each page consists of small amounts of text within a graphic scene. The initial narrative text provides a subtle suggestion on how to move the characters.

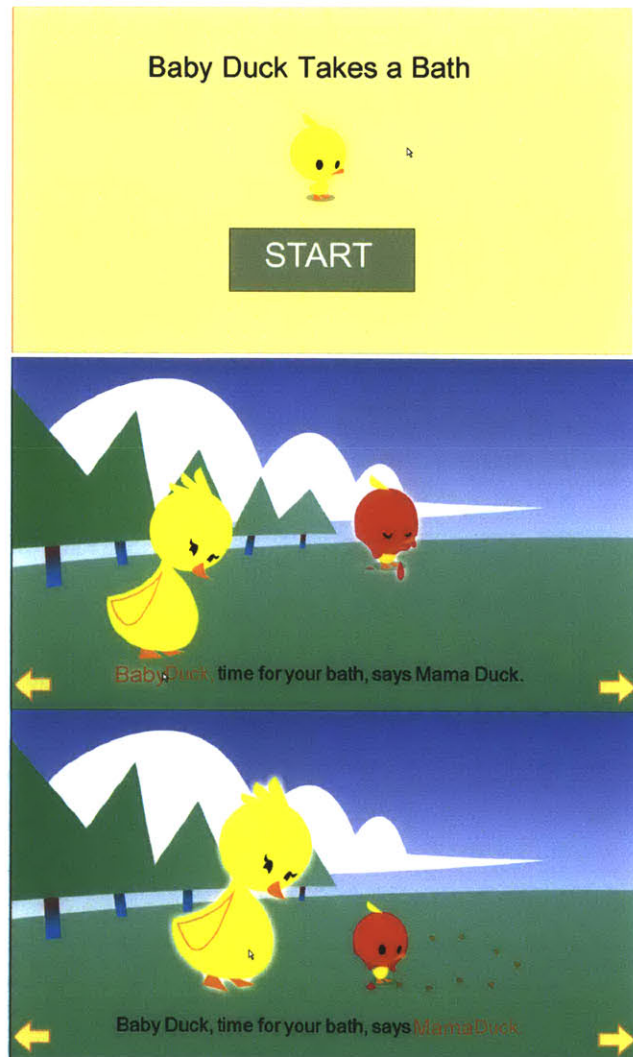


Figure 4-1. Beginning scenes for Baby Duck Takes A Bath.

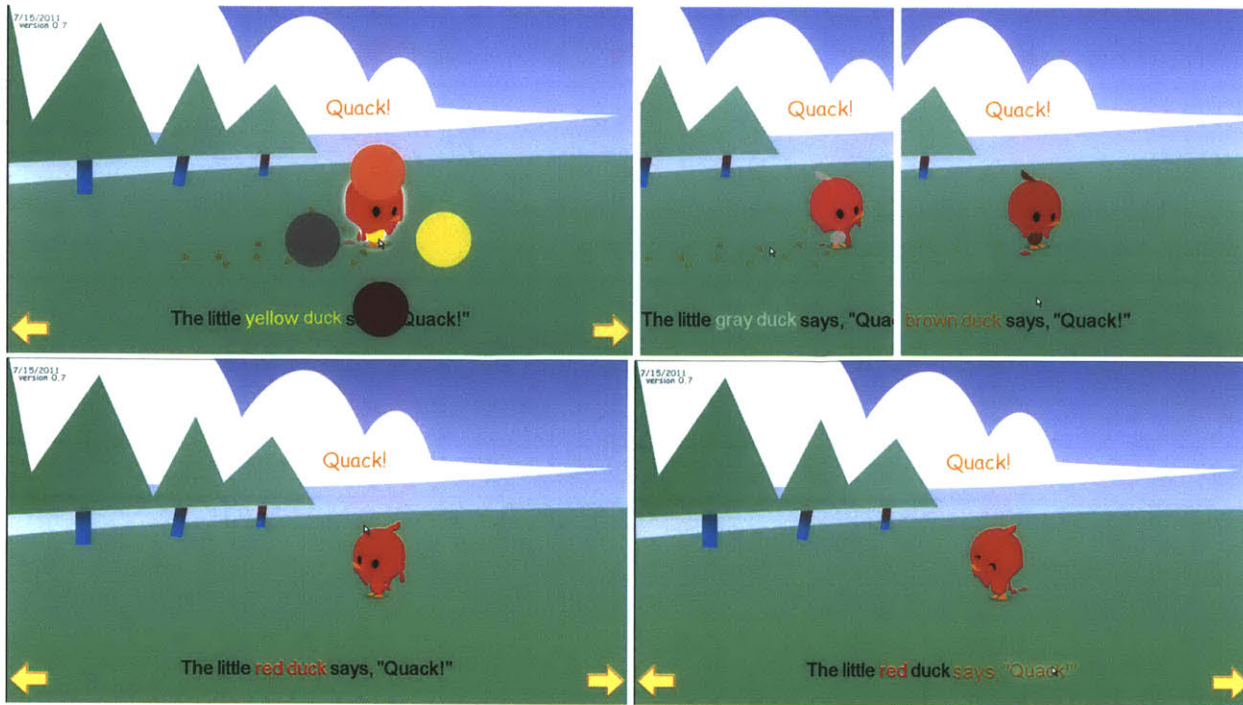


Figure 4-2. Coloring the little duck on page 2 will change the duck color throughout the whole story.

Throughout the book, readers can strum the words to semantically highlight conceptual links between the text and graphic relationship. When readers touch an active story element, the corresponding text is highlighted.

“Baby Duck Takes a Bath” is a story about a baby duck learning to value cleanliness. Readers puppeteer a baby duck through the scenes, acting out the words on the pages (Figure 4-1). The story follows educational expert recommendations on the progression of concepts from my survey.

The first page sets the stage for the storyline. The second page contains a voice command “Quack!” that suggests that readers quack (Figure 4-2). When it is touched, or when the words “says Quack” is touched, the little duck quacks. Additionally, the second scene allows users to color the little duck, from a popup menu of four colors (red, brown, yellow, gray)(Figure 4-2).

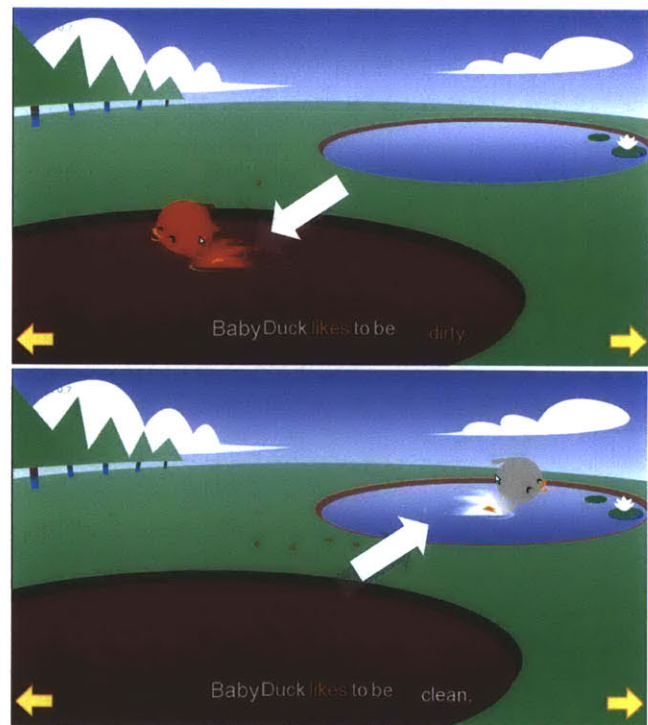


Figure 4-3. On page 3, Baby Duck’s agency can be changed by dragging the character to either pond. The text updates the narration automatically.

When the duck is colored, the user can now page forward or backward to note that the color change has permeated through the storyline. This is an interesting consideration from the interactive narrative perspective, because it is unlike *Choose Your Own Adventure Books* [Packard 1979] where the changes only propagate forward. The color selection affects the prior pages. Another alternative considered is that this change only propagates forward, which would be more consistent with many interactive narrative books.

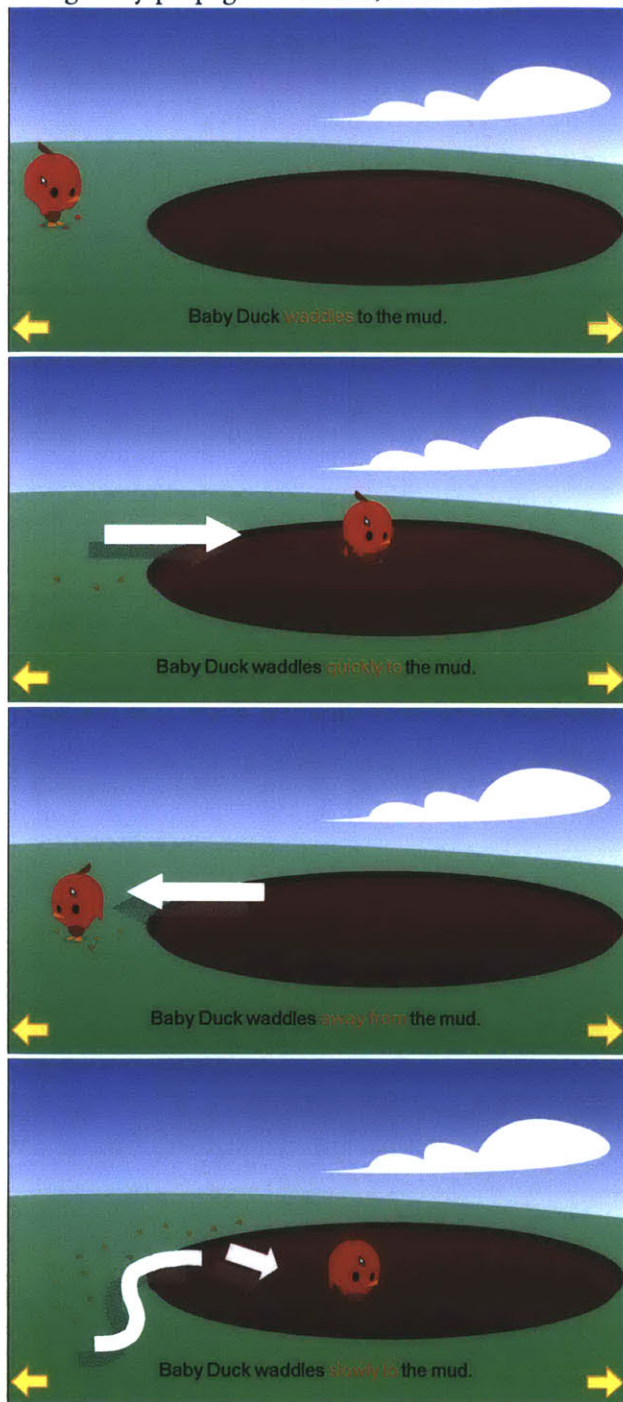


Figure 4-4. If the duck prefers to be dirty, a mud pool becomes the scene of interaction.

The reason for the backward propagation is that the purpose of allowing word alteration is to teach how word choice affects the story elements. This implementation casts the duck color as a story element akin to changing a prop in a play (such as a cinematic director might perform). So a noun or adjective choice persists independently of the notion of a timeline, like swapping out an actor in mid-play. If the character revisits a scene, the new actor would be performing.

On the third page, the agency of the duck is demonstrated (Figure 4-3). The page starts off with the words “Baby Duck *likes* to be dirty.” The user could change the duck’s motive by dragging the duck to the other body of water. If the user drags the duck

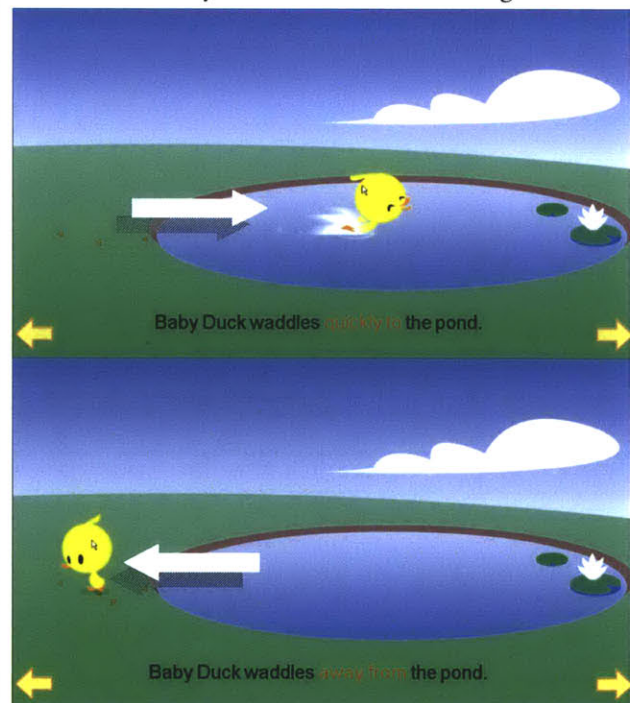


Figure 4-5. If the duck prefers to be clean, the body of water is a pond.

into the pond, the words change to say, “Baby Duck likes to be clean.” If the user drags the duck to the mud, the text updates to narrate this change. “Baby Duck likes to be dirty.” If the user moves the duck to dry land, the system demonstrates the preference of the duck by automatically moving the duck toward the desired body of liquid.

The duck’s agency determines whether a mud puddle or a clear pond appears on the next scene (Figure 4-4 and Figure 4-5). On this page, time and spatial relationship words, so that actions can be compared. The duck can be dragged toward the pond. The system analyzes the direction of the movement, so that it can determine if the duck is dragged towards or away from the pond.

This movement is also analyzed for speed, so the user can demonstrate the time word quickly or slowly. Tinkerability allows users to demonstrate the combination of these parts of speech: “Baby Duck waddles (quickly/slowly) (toward/away) (from/to) the pond.” These spatial and temporal concepts would be hard to demonstrate using static pages.

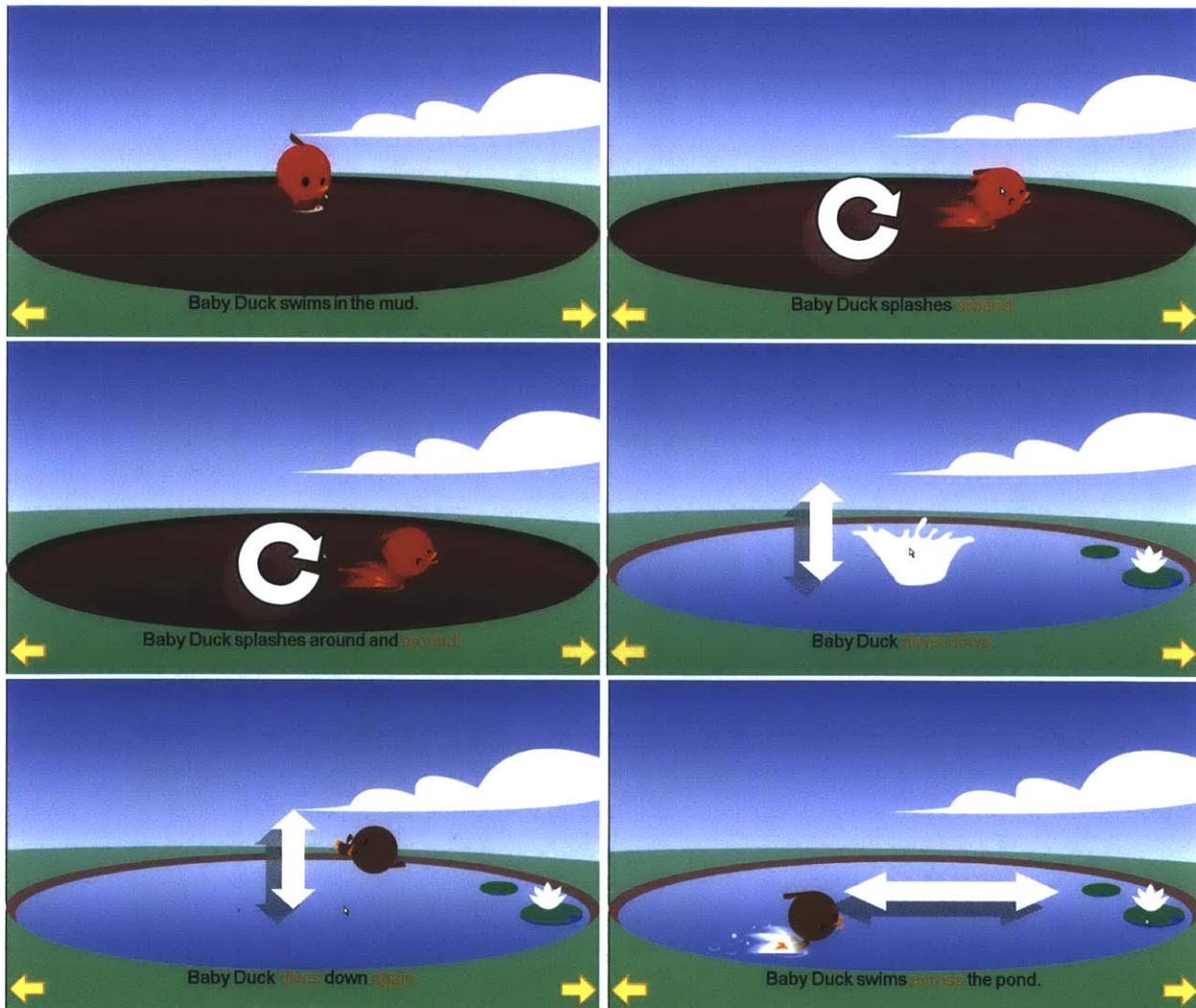


Figure 4-6. Different spatial gestures map to text

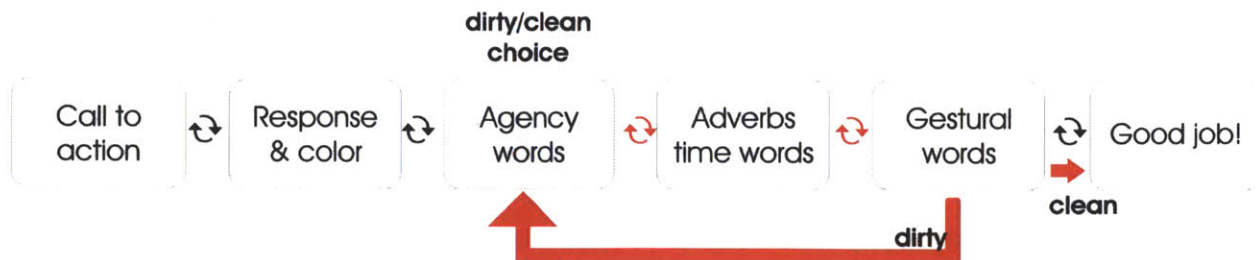


Figure 4-7. The ending is reached only if Baby Duck is clean, as shown by this interactive narrative diagram loop.

The fifth page provides an opportunity to use gestures to describe the duck’s swimming motion (Figure 4-6). The page begins with “Baby Duck swims in the pond,” inviting users to drag the duck into the pond. Depending on the gesture made by the user as they drag the duck, the duck can dive down, swim across or splash around.

Diving down is an up-down motion, while swimming across is a side-to-side motion. Splashing around is a circular motion. There is some common sense interpretation for repeated gestures. The first time moving from one side to the other, the text reads “Baby Duck swims across the pond/mud.” If the motion is repeated, the text reads, “Baby Duck swims back across the pond.” If they dive down twice in a row, it reads, “He dives down again.” Or, if he splashes around the pond twice or more, the text reads, “Baby Duck splashes around and around.”

The last page is reached only if the duck is clean, thus completing the larger story goal of being a clean duck (Figure 4-7). If the duck is dirty, they repeat the relationship word, action, and agency scenes until the duck is clean (Figure 4-8).



Figure 4-8. Final scene for the story

Discussion on touchscreen usability for children

On the question of usability, almost everyone was able to use touchscreens effectively (Figure 4-9). Initially, younger children needed some help in the dragging scenes and in the coloring scene.

Very young children who were unfamiliar with touchscreen interfaces have a tendency to drag their knuckles, causing the device to miss their touch. This problem was sometimes corrected by giving them a stylus, or explicitly demonstrating how to point at the interface. Still, very young children near 2 years old have problems dragging for long distances greater than approximately 2 inches.

Another usability issue was that young children take time to select from menus. Many times they would point at a color in the pop-up menu after it had timed out and disappeared. The menu itself might also have added to their frustration, since they might not be familiar with this abstract selection method. Adding a delay for the color popup menu to approximately 2 seconds or longer was one workaround. These problems disappeared if they spent a lot of time on those pages. Some children revisited the color selection over 7 times.

The most troublesome feature was audio integration. Initially, I implemented vocal control of a story element. When a person read a particular line (“The little yellow duck says Quack!”), the loudness of their voice controlled the size of an onscreen graphic depicting “Quack!” Baby Duck would also quack if a certain audio level was reached. This control was very enjoyable (although it could be distracting) when it worked. I could not get it to work reliably, as different platforms had feedback or were missing

microphone support. On platforms that supported the microphone, there would inevitably be feedback between the speakers and the microphone, resulting in cacophony. It became a nuisance instead of being demonstrative of text. Some parents expressed a desire to have explicit control of the microphone. They suggested having turning on the microphone only when the relevant words “says Quack!” were touched, and then allowing their voice to control the story element. I experimented with just having the quack animation occur when the words or duck were touched, and parents and children quacked anyway.

Every stakeholder and parent who saw the first TinkRBook was encouraging about the idea of textual tinkerability. One storyteller said, “You’re building a storytelling prompt.” Adults instantly understood the interactive narrative and enjoyed gesturing to demonstrating words.

Children however, take some time to understand that the text is changing, and to appreciate it. This finding made sense, particularly for preliterate children who haven’t quite figured out the meaning of text. To balance their short attention span and give parents enough time to demonstrate and talk, a second version attempted to combine tinkerability with meaningful educational activity (Figure 4-10). From prior reports on media, just adding interactivity sometimes discourages parents from interacting. Thus, we sought to incorporate a wide range of educational literacy pedagogy, informed by educational experts and interviews with preschoolers.

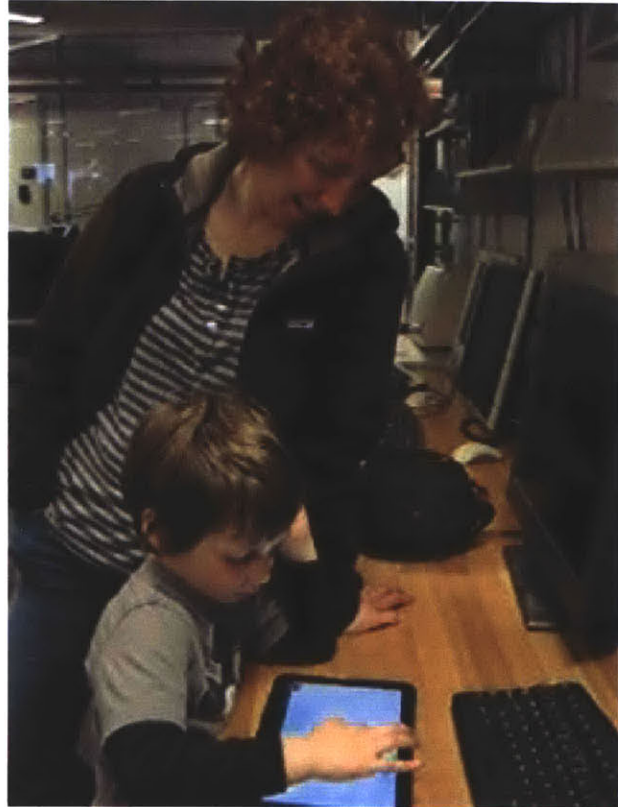


Figure 4-9. Field trip of preschooler from Tech Day Care trying out TinkRBook guided by parent.

TinkRBook pedagogy showcase

The second implementation was collaboratively developed with an animator and programmer named Fardad Faridi (Figure 4-11), who co-developed many interaction design and aesthetic ideas. The different pages demonstrated other educational pedagogies, influenced by many stakeholders. It also incorporated some lessons from the earlier interactive narrative one, mainly regarding developmental appropriateness.

The goal of this version was to work with a professional storyteller and education experts to create a new TinkRBook to:

1. Test if the codebase could be used by a professional storyteller.
2. Demonstrate TinkRBook's design principles combined with other educational pedagogy approaches.
3. Address the dual audience better by engaging the child in educational activities to give enough time for the parent to discuss the concept of text enabled by tinkerability.

Fardad and I held slightly different value systems regarding TinkRBook.

Fardad is from an animation background, with a keen sense of visual storytelling. He envisioned a cleaner separation of text and graphic areas. For example, at one point we even discussed not showing any text until something was triggered. I wanted the inherent “book”-ness to remain intact— meaning that if nothing was done by the user, they would have a narrative that would read like a book.

We negotiated many novel concepts and ended up developing some principles for combining textual tinkerability with different pedagogies. He was able to implement many of the ideas using the basic dynamic linking framework of TinkRBook. I technically supported his creative vision in certain aspects of tinkerability, but he successfully developed many innovative ideas with only the basic codebase. The following section describes how these principles apply to features of TinkRBook pedagogy showcase.

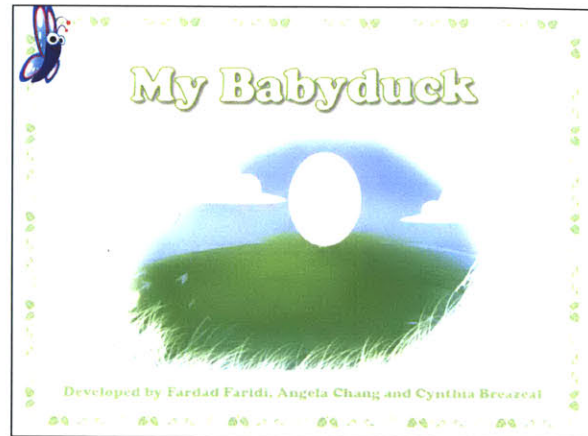


Figure 4-10. The opening scene of TinkRBook2

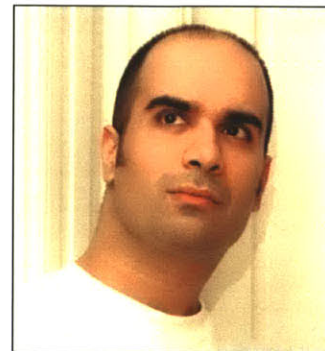


Figure 4-11. Fardad Faridi, co-designer of TinkRBook2

Principles for combining Tinkerability with existing educational pedagogies

Principle 1: Persistent Story World Elements

If adding a new feature is planned, try to maintain the idea of a persistent story world [Winner 1982]. For example, when adding an audio voiceover, we considered having different ways to allow users to switch the mode from “Read to Me” and “Read by Myself.” Other applications do this with a button on the interface, or only allow you to change modes in the beginning. These solutions are extradiagetic commands that break out of the story world. Instead, we created a new character for the story world that would perform the function of a narrator.

Example: Butterfly Narrator

We again employ the technique of puppeteering a character to narrate the story vocally. The butterfly narrator (Figure 4-12) acts as an assistant that can provide an audio narration for the story. The butterfly narrator is always at the sidelines, as a persistent but unobtrusive story character. The butterfly supports the parent’s memory in suggesting information for parents to comment on the story while the child is playing. For the color mixing scene, the butterfly displays hint words “orange, purple, cyan” that could be used by parents to demonstrate vocabulary schema relating to color.

In respect of the parent’s role as the oral storyteller, some physical effort is necessary to trigger the character. The character is designed to be a facilitator for suggesting information, but not take the role of the parent in commenting or providing guidance. Another helpful role the butterfly performs is audio narration to help users quickly hear one word or sentence vocalized. Essentially, this helper is supposed to provide hints only when explicitly triggered by grabbing it and strumming it over the words. This effect is designed to look like the character is flying over the words as they are being verbalized.

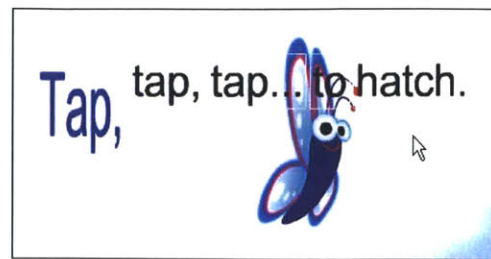


Figure 4-12 The butterfly narrator

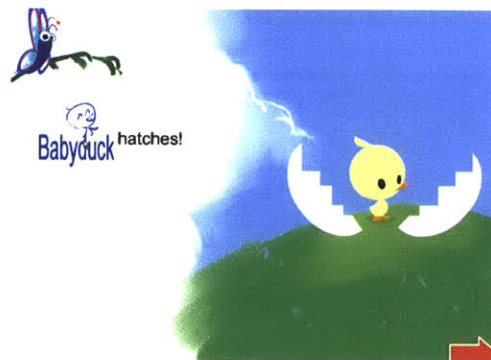


Figure 4-13. Hatching scene



Figure 4-14. Color Mixing

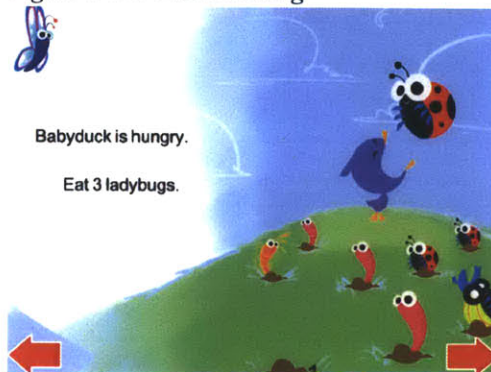


Figure 4-15. Feeding the duck using counting.

Principle 2: Foster emotional engagement and motivation from users

To increase the child's motivation to play with the story character, motivational concepts are added to help the child develop a sense of ownership and responsibility. These motivational elements follow the story world principle in being consistent with staying in the story world, such as replacing the "start" button with a story scene showing an egg slightly vibrating. This version of the TinkRBook included activities centered around the theme of caring and responsibility. For example, a scene was added to allow children to hatch the duck (Figure 4-13), rather than have the baby duck existing before the story. The users get to personalize the color of the duck and feed the duck. An ending scene was added where the readers create a lullaby to lull the duck to sleep. As a consequence, the mother duck character is also removed, so that children feel as if they were the duck's parent.

Principle 3: Layering Educational Pedagogies

Sesame Street proved that adding interactivity to engage the child can be highly educational, through the use of high quality aesthetics, creative and thoughtful presentation of content, and layering educational ideas. We implemented these principles by adding a number of new educational content scenes, with textual tinkrability as a motif throughout the story. Notice that all elements are consistent with the story world. The following scenes were added:

Color mixing – Readers can explore the concepts of color blending by coloring the duck using red, green or blue shampoo bottles (Figure 4-14). Meanwhile, parents, with the assistance of the butterfly narrator, can provide commentary on the vocabulary schema of different colors.

STEM ideas – A feeding scene exposes readers to science, technology, engineering and mathematical (STEM) concepts (Figure 4-15). Readers can collaboratively feed the duck different bugs, dictated by the duck's preferences. This scene introduces concepts such as counting ("Eat 2 beetles."), sequencing ("Eat 3 ladybugs, and then 2 worms."), and patterns ("Eat 2 things different from/similar to a centipede."). Children often need the adult to help them decode the challenge, and the butterfly narrator helps the adult keep track of the progress. The scene is parametrically generated, so each time users return to this page, a new challenge is presented. When the users have finished feeding the duck, the duck is full. Children are rewarded humorously by patting the duck's belly and hearing it burp.

Music and animals – The penultimate scene is a music creation experience using animals in the duck's environment (Figure 4-16). In this scene, different animals surround the duck in his bed. If the reader taps on an animal, a sound that animal makes is heard. For example, the owl hoots, while the cricket chirps. Parents can discuss different animals (frog, cricket, owl, and firefly), while children tap out a rhythm that lulls the duck to sleep.



Figure 4-16 Animals sing a lullaby.

Principle 4: Layering Explicit Emergent Literacy Pedagogies

The main motivation in this research is to teach emergent literacy behaviors. We focused on introducing other ways to present literacy education paradigms, such as phonics and word blending.

Iconimation: We developed the idea of iconimation to make the demonstration of each word more explicit (Figure 4-17). When users tap on a word while strumming over the words, an animated icon appears over the word. With actions, there were audio-visual animations (e.g. “hatch” depicted an egg cracking, “tap” showed a finger tapping). If the word is related to an onscreen object, then the object will respond with animation (e.g. the duck quacks in addition to displaying an iconimation of a duck waving).



Figure 4-17. Iconimation examples

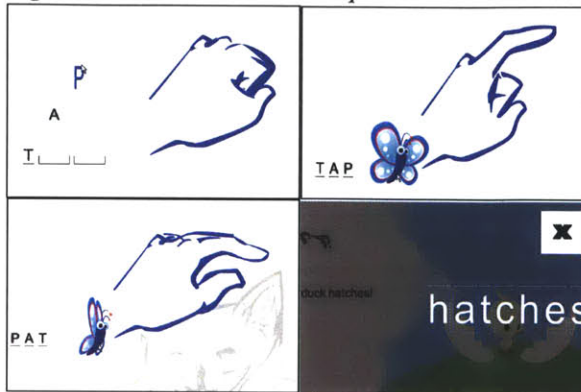


Figure 4-18. Users can zoom into a word to explore how different words are phonologically blended.

Phonology and blending– We added the ability for parents and children to zoom into words to demonstrate phonology (how words are made up of phonemes and letters). When a user pushes on a word for a long time, the word dynamically zooms and breaks into letter components (Figure 4-18). This invites parents to help their children sound out the letters and encourages blending (combining letter sounds to make words).

Sentence completion – This scene allowed users to drag and drop words to create a sentence (Figure 4-19). This engages the higher level cognitive process of synthesis and categorization of words. In the example shown, the sentences required to progress forward is “Babyduck passes the grass.” When users drag the words to the correct locations and strums, the duck rewards them with an animation that acts out the sentence. A humorous animation (Figure 4-20) is the reward for the sentence “Babyduck psses the gas.” The performance of the duck passing the grass is the reward for “Babyduck passes the grass.” Other valid combinations (from the child’s perspective [Singer 1998]) are not currently animated on completion, such as “Grass passes Babyduck.” However, the child can still move the butterfly over each word to sound out the sentence. In future, more reward animations can be added.

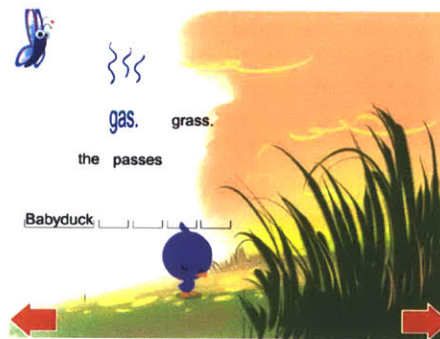


Figure 4-19. Sentence completion and word ordering

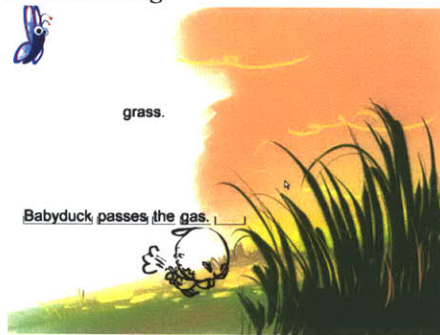


Figure 4-20. Humorous reward animation

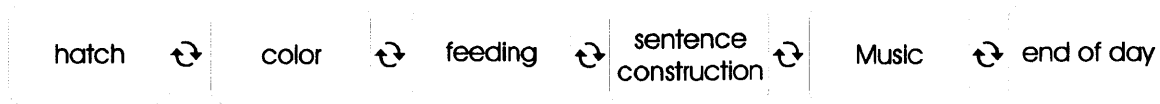


Figure 4-21. Educational pedagogy path for TinkRBook

Discussion

Explicit Page Turning

The ability to turn pages is a key part of the ritual of reading, allowing readers to control the rate of advancement through a narrative. Pages encapsulate a particular idea. Each page or scene provides an opportunity for new discussions about the narrative. We decided to explicitly let users control how the story progresses between pages to give readers an opportunity to reflect.

However, we did experiment with automatic page progression in the sentence completion scene (Figure 4-21). Because this scene was more sophisticated than the previous scenes, we decided to imitate the automatic of the flow of general computer games where the character automatically advances to the next stage when the sentence is completed. When users completed the puzzle in the sentence completion scene, the duck runs off the stage. The duck's automatic behavior can be a restful break for the user in this case because the user has been physically moving objects on the screen a lot during this scene. Because of the level of thought and manual dexterity required by the mechanics of the puzzle, users would have plenty of time to discuss the concepts on the page. The automatic page progression in this scene can be considered a reward for spending so much time on this page. Granted, if users did not want to solve this puzzle, they could just turn the page.

The sociocultural system of children's emergent literacy experiences

Tinkerability is a new way to introduce reading to preschool children in parent-child reading. The introduction of this new method affects many more people than just the key users. For educational theorists and psychologists, it was important for them to understand how they could incorporate the idea of tinkerability into their existing pedagogical approaches. This second TinkRBook was used to demonstrate that the idea of tinkerability can work with existing approaches.

I encouraged stakeholders to consider tinkerability as a flexible tool for enhancing the educational presentation of content. For story authors, this allows them to focus on the meanings of words within a scene. They could design how different text could be represented conceptually for single pages, rather than building a large story world. Content creators could focus on how to best implement elements relating to educational ideas within just one scene. Authors are also encouraged to think about alternate parallel narratives that can create rich and interesting experiences with turns of phrase. For example, playing with words for "passing gas" and "passing the grass" encourages readers to appreciate narrative as a form of humor and creativity. Authors then can have the opportunity to explicitly create a rich educational narrative by offering a constrained set of vocabulary schema based on words they choose to be tinkerable.

Narrative cohesion

In a way, the pedagogical showcase demonstrates how a community can design a flexible educational narrative. Reflecting on Sesame Street's guidelines from Chapter 2, the second version offers higher aesthetic quality, more creative educational approaches to emergent literacy and a progression of educational content.

TinkRBook is a research platform to investigate how a storybook that provides tinkerability could affect emergent literacy. The first TinkRBook showcases how a different parts of speech could use gestures could map to actions within a flexible narrative. The second TinkRBook showcases how different educational ideas could be integrated with tinkerability (Figure 4-21). Future versions of TinkRBooks can be designed to tighten the narrative cohesion within the different scenes, perhaps by rewriting the sentences to rhyme.

The key goal is to provoke parents to perform stories while reading to their children, rather than watch a show with them. In the emergent literacy narrative context, this active learning and sharing experience can provide more intimacy and provoke social bonding between parent and child. According to Cambourne's theory of literacy learning, intimate parental involvement is key to creating an environment that fosters enjoyment of literacy learning.

Process for Making a Story Tinkerable

If someone told me they wanted to use tinkerability in a story for emergent literacy, what would I tell them? First I would educate them about what tinkerability is. Tinkerability is the ability to test and manipulate the text-concept relationship while reading. With tinkerability, the fact that there is a relationship between text and concept is demonstrated, but the nature of the relationship still requires insight.

Evaluate the story content for performance possibilities. Does this story lend itself to performance? Are there words that can be mapped easily to gestures? Is there a character that can be puppeteered? Are there physical interactions between that character and other characters that would be enjoyable to act out in text? The key idea is to allow readers to act out the meaning of text.

Choose alterable text that allows children to use the Principle of Contrast. Decide which words and phrases should lend themselves to demonstration. These words should have counterparts that allow demonstration using the principle of contrast. Certain words, such as prepositions and adverbs are more easily tinkerable than others. Other words, like nouns and adjectives, may be tinkerable through use of menus.

Map gestures to text using story elements. When puppeteering a character or using voice control, how will the user's actions correspond to narrative changes. Decide which gestures will be triggered, and what animations and assets are needed. Decide which words should have visual appeal and how to reward actions. The mapping should be as simple as possible.

Design features and assets that perpetuate the idea of the story world. Associate the text to corresponding asset animations, iconimations, and input triggers (e.g. voice, touch, strum, or gesture).

Design Principles for Tinkerability

Once the basic narrative of the story and any interactive narrative traversals are designed in text, consult the guidelines from stakeholders earlier in this section. Follow these design principles (Figure 4-22):

Design Principles for Tinkerability

1. Design with Performance in Mind
 - a. Identifying tinkerable words
 - b. Simple gestures and vocal expressions for demonstration
 - c. Small gestures for small hands
 - d. Direct narrative actions
2. Design for narrative cohesion
 - a. Causality of actions, abstract thoughts
 - b. Referencing children's experiences
 - c. Moralistic outcomes, sociocultural principles from existing storybooks
 - d. Resolution of dramatic arcs
3. Encouraging participation
 - a. Dual audience- design for readers to control conversation time
 - b. Using rhyme and repetition with words and actions
 - c. Subtlety of interface feedback (visual & audio)
 - d. Clarity vs. clutter

Figure 4-22. Summarized Design Principles

- 1) Design with performance in mind. See the dramatic performance principles suggested by stakeholders on page 48.
 - a) Create a character which can be puppeteered so that users will act out the character's actions. What would be the most obvious gestural mapping for this word? What are the degrees of performance for this action/concept? The variations in performing a word will map to tinkerable alternatives. Then decide how the text will be controlled by gestures or audio and create a dynamic link between text and gestures. Look at the type of behaviors parents perform on page 39.
 - b) Identify tinkerable words. Choose words that can be tinkerable in the narrative by deciding which simple gestures and vocal expressions could be used to demonstrate those words. The protagonist should be referred to in the narrative. See page 44 for ways to map actions to text.
 - c) Remember the little guy. Remember that small children require special interface consideration (avoid large dragging areas, and longer time-outs in menus) [Druin 1996; Resnick 2005]. Every active element in the story should be responsive in a repeatable way, to facilitate demonstration.
 - d) Direct narrative actions by creating the initial text that suggest what users will do when they reach a page. For example, a page that reads, "Sophie runs/walks under the tree," will direct users to move the character under the tree.

2) Design for narrative cohesion. This principle highlights the importance of creating a persistent story world, including text, graphics, animations and sounds. Any features (such as voiceovers) should be embedded using a dramatic metaphor (e.g., triggered by using a prop or gesturing with another character). If users do nothing but strum or turn pages, the story should still read like a book. Tinkerability provides some control of the narrative, and the purpose of this control is to demonstrate concepts in print. Reference the guidelines from stakeholders on page 49.

- a) Causality of actions to abstract thoughts. Tinkerability lends certain words more importance than others. The story world provides the backdrop upon which children can explore the Principle of Contrast. The idea is to allow readers to observe the differing impact each word/phrase will have on a narrative. For each scene, think about a chain of actions that allow children to understand abstract ideas (such as time, spatial relationships, or agency). Let them *act literate* to explore a concept.

What is the scope of different words on the narrative? Are there words that should have impact beyond the page? Think about how the story will flex but remain consistent. There are certain elements (props and characters) of a story that define it. These elements should be persistent throughout the story world so that children can observe the effect of words upon these elements. For example, with *Jack and the Beanstalk*, you know you need a character named Jack and a beanstalk. You probably want beans to persist throughout the story. Otherwise, you may have a nonsensical story where Jack is planting trains.

- b) From simple to complex ideas. In general, a TinkRBook should follow the introduction of concepts as with picture books. Following the advice of schoolteachers and Sesame Street, an educational experience should start with the simplest idea and then progress by building upon it toward more abstract concepts. Typically, start with nouns, then colors, etc. Use some common sense expressions in how ideas are expressed in text. For example, if demonstrating the meaning of a verb is desired, position the character so that people want to pick up the character and gesture with it. Then, if they repeat it, you can chain the word “again” to the end of the sentence. Think about layering tinkerability with other educational paradigms as discussed on page 57.
- c) Reference children’s experiences. Remember that children find comfort in familiar ideas and repetition. Think about combinations of already known experiences and concepts with words. Chaining words together can be interesting. Also think about using repetition in the form of variations on a theme. Parallel sentence structures creates opportunities for children to observe the Principle of Contrast.
- d) Resolution of the dramatic arc. Dramatic elements can help to build suspense through repetition and exaggerating. Each page should have a resolution that is coherent within the framework of the larger story. The sequencing of different scenes should result in a resolution that achieves narrative closure (e.g. baby duck finally achieving cleanliness or going to sleep after a lullabye). Humorous or surprising endings, after a suspenseful buildup, are very rewarding.

- 3) Encourage participation. Tinkerability is designed to draw attention to the concepts represented in text. Remember that the purpose is to enhance discussion by subtly giving handles to control words. Preserve the sociocultural functions of the book, as described on page 50.
- a) The dual audience revisited. Remember that the content should be interesting to parents, and relate to topics they want to discuss. Allow readers their conversation time by using explicit page turning. It is okay to have automatic page progression, but use it sparingly to give readers a chance to reflect on the ideas within the scene.
 - b) Using rhyme or repetition with words and actions. Repetition helps children to create predictions about how they can interact with the story elements. They can repeat something that the parent does to perform the meaning of the word to *act literate*. Children feel confident when they can chime in on repeated verses.
 - c) Subtlety of interface feedback (visual & audio). For tinkerability to effectively encourage parents and children to interact, it must be subtle. Music and amazing animations can be used as rewards for action, but try to keep these short so that users actively explore the story.
 - d) Clarity vs. clutter. Give choices diegetically, within the flow of performance, as much as possible. If a choice needs to be made, create on-screen assets that represent the choice. Avoid text in menus or selection boxes, as too much text will probably confuse a preliterate child. Think critically about whether a feature helps illustrate an idea (relating to text, or education).

With these principles in mind, new TinkRBooks can be created to assist parents in teaching children to read. I'll discuss the evaluation of tinkerability more deeply in the next section.

5 Evaluation

In this section, I evaluate how well tinkerability, as implemented in the TinkRBooks answers the following research questions:

R1 How can an interface help parents exhibit the behaviors that a good reading instructor performs?

R2 How can an interface allow and encourage children to exhibit behaviors to actively explore learning of text?

A TinkRBook introduces new features into reading instruction. With tinkerability, readers now have some control of the text. Their prior emergent literacy experiences have involved reading from static text. How does tinkerability change the way parents and children read together?

Identifying behaviors vs. reading assessment

The best way to answer these questions is to observe how parents and children use a TinkRBook compared with a baseline of how they read a traditional book. Tinkerability is designed to assist reading instruction by connecting parental demonstration behaviors to text. In the same manner, textual tinkerability is designed to facilitate children's active exploration of text.

I considered current analysis models of reading instruction. These tests usually ask children about their recognition and meaning of vocabulary. Another type of test is to ask the child to answer questions about reading comprehension. Still another test might be to ask the child to retell the story from pictures (the famous "frog story" [Berman & Slobin 1994]) to elicit their narrative and note whether their language use has improved. These tests are often performed with older children who have better oral language and literacy skills. One major problem with these assessments is the oral language skills and attention spans of very young children. Preliterate children (particularly 2 year olds) are still learning to express themselves through language.

In parent-child reading, the effectiveness of instruction is highly correlated with parental reading behaviors. The motivation of this thesis is to assist preliterate children in reaching the "AHA" moment by observing that both parent and child are exhibiting the right behaviors. Thus, it makes sense to examine both parents and children, and observe the behaviors they perform during shared reading. 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.

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 tinkerability uniquely. For the most useful assessment of tinkerability, it makes sense to do a within-subjects study rather than try to compare behaviors across all parents.

The following paragraphs describe the evaluation method to determine the effect of tinkerability in prompting positive reading and learning behaviors.

Hypotheses

I expect to observe that TinkRBook prompts positive emergent reading behaviors by parents. I hypothesize that I will observe incidences of people demonstrating the intended behaviors:

Hypothesis 1: Parents will exhibit “positive reading behaviors” with TinkRBook. For reference, these positive reading behaviors are presented again in Figure 5-1. In particular, I expect that parents will be able to demonstrate vocal expression, gestural expression and dialogic reading techniques with TinkRBook.

Hypothesis 2: Children will exhibit active explorations of text with TinkRBook. Active exploration behaviors can be considered interactions where children are controlling tinkerability to discuss the meaning of text with their parents.

The null hypothesis is that none of these behaviors will be facilitated by the TinkRBook. $N_o(\text{behaviors}) \leq 0$. The alternate hypothesis is that storytelling performance and text demonstration behaviors will occur more often with TinkRBook (difference in reported gestures > 0). $N_o(\text{behaviors}) > 0$.

Participants

I used a “within subjects” design to compare how pairs read with TinkRBook in comparison to reading a personal book. Due to the young ages of the children involved, I used oral surveys and video ethnography so that data entry would not take too much time. I aimed to leave the participants’ house in 1 hour. The consideration was that durations over an hour would contain considerable carryover effects with TinkRBook, as kids start to get tired (it was usually their bedtime). It made sense to introduce TinkRBook second, since people already have a history of reading their favorite books. The goal was to get the baseline of existing behaviors, then compare with how they used the new experience.

I asked 10 parents (ages 25-50), all college educated) to read to their child (ages 2-5) using their personal books at home. After the reading, parents answered questions about their reading practices. Parents were then

Positive Emergent Reading Techniques

- Dialogic reading
- Phonics
- Print referencing
- Vocal expression
- Whole language

Figure 5-1. A list of positive emergent reading behaviors.

offered a \$10 gift card or a \$10 ice cream voucher for their time. They were also given contact information for any followup questions and communication about this project.

Procedure

Introduction: I introduced myself as a researcher interested in storytelling behaviors. I explained that I was working on a new type of storybook that was designed for parent-child reading.

Next I obtained consent and explained the procedure. I also asked about each family's reading habits, the current interests in reading, and the age of the child. I explain that I am there to observe, and will try to stay in the background as much as possible. I discuss how I will record their interactions on video.

Condition 1: Ask the dyad to read a traditional book from their collection. This provides me a baseline of observable storytelling behavior with a static book. I also note the quality of their discussion and interactions with each other.

Condition 2: Next, I ask them to try a sample interactive storybook (TinkRBook Interactive Narrative) where they can change the plot of the story. In general, they can change the words on the screen by dragging the duck around. I mention how they can change elements of the story, such as changing the color or agency of the duck. I tell them that I will be in the background as much as possible, but I may provide them assistance if they get stuck or have questions. The idea was for them to try to read without me intruding as much as possible, but they could stop anytime they like.

An oral survey is taken to ask about their overall experience reading with the TinkRBooks. I ask them to comment and suggest improvements for features. I also let the child repeat the playthrough as much as they liked while I get feedback from the parents about their impressions using the device.

Optional Condition 3: If there is time, I ask the parent-child if they would like to read using the TinkRBook Pedagogy Showcase. I note how often the parent points, strums across words, gestures, and talks about concepts, and how often the child does the same. I offer the second TinkRBook if it is available (sometimes it is undergoing revisions).

I then ask another series of questions to compare and assess whether they enjoyed playing with the TinkRBook pedagogy showcase (in comparison with TinkRBook Interactive Narrative). Finally, I ask the participants for any suggestions to improve the interaction.

Evaluation Method

The video data was annotated by an undergraduate researcher using Anvil Video Annotation software[Kipp 2001]. They were asked to transcribe the audio and to code physical and audible interactions. The interactions were annotated according to gesture owner, execution, and purpose. The list of gestures are described in Figure 5-2. Pairwise t-tests were performed to test for statistical significance to answer the research questions and confirm the hypothesis. I also sought to answer the following additional questions:

Audible Elements – Each distinct phrase (between spaces of silence) is tagged as an audible element.

Tokens- The actual words that were said

Interaction Purpose: The underlying function of the interaction

Mimicry– The utterance was made to echo the prior utterance by another person.

Social – The utterance was made to comment or discuss something socially.

Emphasis – The utterance was made to emphasize a point already being discussed.

Comprehension – The audio demonstrated comprehension or lack of understanding.

Diegetic Reading – The person was reading and pointing to the printed text at the same time.

Demonstration – The person is instructing, explaining, or giving commands.

Audible Interactions

Owner: Who is performing the action

Parent

Child

Both

Execution: The way in which the purpose of the audible element is delivered:

Voice acting – The person was using a different voice, such as that of a character in the story.

Turntaking – The utterance was made explicitly to take focus of the interaction.

Question – The person was asking a question.

Commentary—The person is making an observation.

Phonetic—The person is breaking down the words into phonemes and letters.

Physical Interactions

Owner: Who is performing the action

Parent

Child

Both

Execution: The way in which the physical element is delivered:

Strumming— moving their fingers over the text to draw attention to the full sentence.

Pointing— or tapping for a short time on an object or word.

Turning— the page.

Dragging— the story elements around.

Changing elements— by using menus or causing text to change intentionally.

Nodding— in agreement or to direct attention.

Acting out— physically otherwise. Making gestures to perform.

Figure 5-2. Video annotation elements used for evaluation

- A. Do parents and children talk more with a TinkRbook?
- B. Does the TinkRBook foster social bonding and educational instruction? What is the conversational content (comprehension or social conversation)?
- C. Do parents and children gesture more with a TinkRBook?

Results

The 10 parent-child dyads are described in the population chart in Figure 5-3 and Table 5-1. All except one of the parents were female. The children were mixed genders (5 male and 5 female). All parents reported reading to their child every day. It was obvious that parent-child reading was an established ritual in each house, as children had many books to choose from. There was only one 2 year old. From observations, all of the children were in different stages of emergent literacy [Whitehurst 1998]. 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).

Note: This evaluation is performed to identify how people use TinkRBook. In particular, I am trying to ascertain whether certain positive emergency behaviors occur in using TinkRBook, and compare with the frequency of these behaviors among conditions. These charts do not represent *the content* of the books or TinkRBooks. When looking at charts like Figure 5-4 and Figure 5-5, the point is to compare the interactions occurring between the two experiences. These charts demonstrate that many categories of interaction are represented in both books and TinkRBook. Again, please see Figure 5-2 for a list of interactions that were studied.

A) Basic Metrics

First, I looked at the cumulative metrics between the two conditions. Figure 5-6 shows the amount of time spent reading each story. In general, traditional book readings averaged approximately 5 minutes, compared with an average of 8 minutes in reading a TinkRBook.

Figure 5-7 shows the amount of words spoken. The average number of words spoken between conditions were significant. However, the content of the two experiences were different, as a TinkRbook has 7 pages (cover included). This is much fewer pages than the average book that was read (35 pages).

	Child age	Child Gender	Parent Gender
Pair1	2	F	F
Pair2	3	M	F
Pair3	3	F	F
Pair4	3	F	F
Pair5	3	F	F
Pair6	4	F	F
Pair7	4	M	F
Pair8	5	M	M
Pair9	5	M	F
Pair10	5	M	F

Table 5-1. Demographic breakdown of parent-child dyads

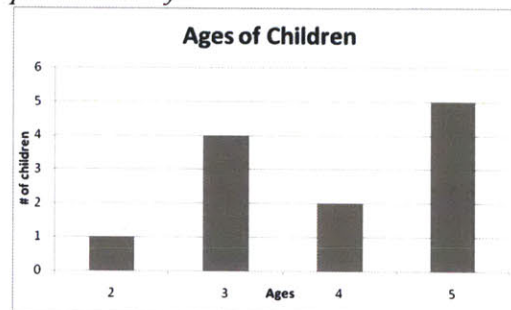


Figure 5-3. Ages of children in the study

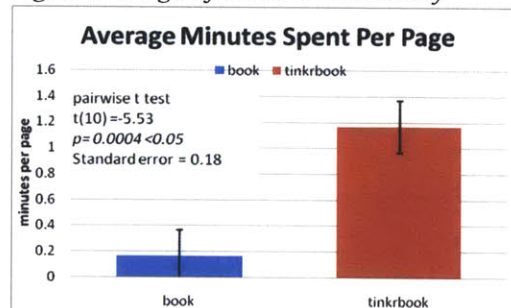


Figure 5-4. Average minutes spent per page

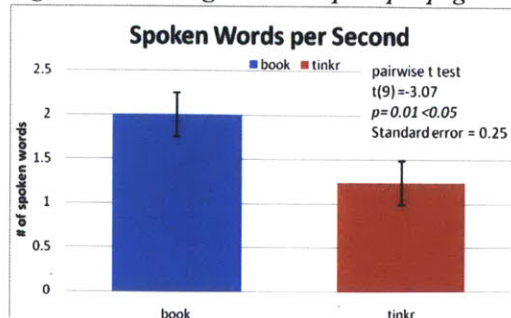


Figure 5-5. Spoken words per second

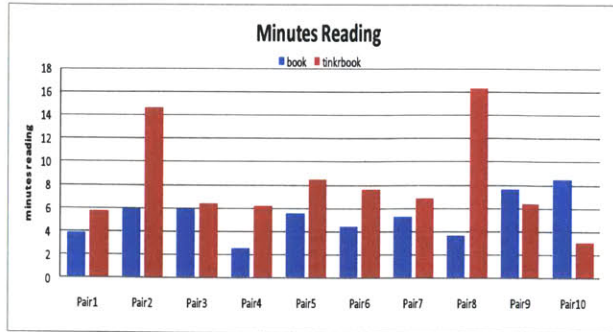


Figure 5-6. Amount of time reading for each pair

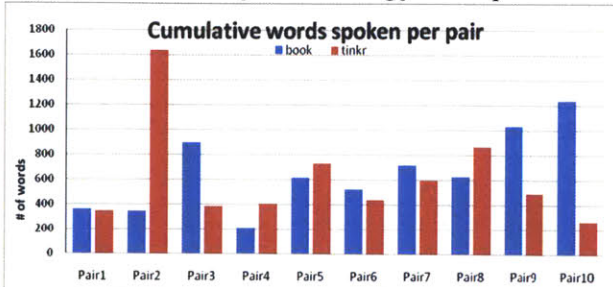


Figure 5-7. Words spoken during readings for each pair

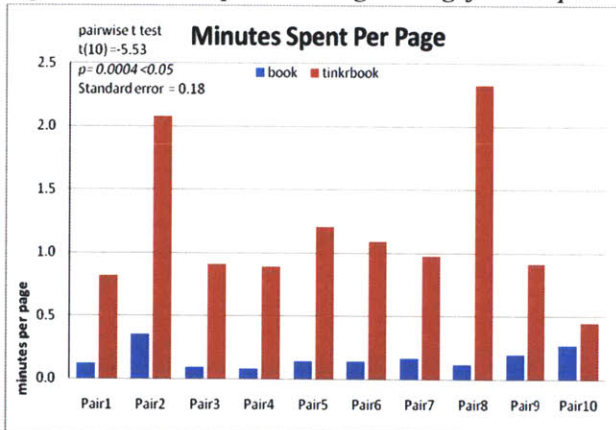


Figure 5-8. Minutes spent per page by each pair.

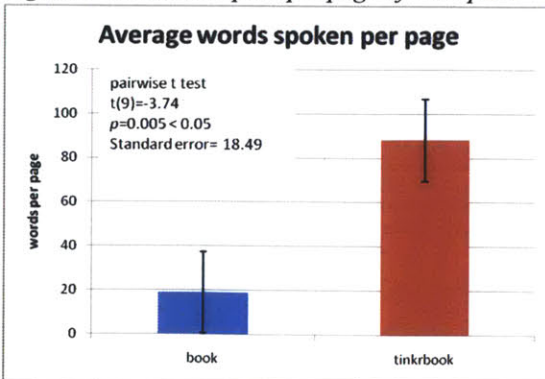


Figure 5-9. Average words spoken per page

Number of spoken words: When the number of spoken words was normalized for the number of pages, even for such a small sample size (Mean difference = -69, Standard Deviation = 58.5, N=10), there was statistically significant difference ($t(9) = -3.74$, two-tailed $p = 0.005$, $n = 9$) in the pace of talking with books and TinkrBook (Figure 5-9). People tended to average 19 spoken words per page, compared to 88 words a scene for TinkrBook. For each page, people talked 4 times as much. So we can say that parents talk more with a TinkrBook.

Reading Pace: Also significant was that parents read much faster with a regular book than with a TinkrBook. People spent about 9 seconds (0.16 minutes) per page on their traditional book, while they spent about 72 seconds (1.2 minutes) per page with TinkrBook (Figure 5-4). They spent about 8 times as much time on each page of the TinkrBook. This is a statistically significant measure ($t(10) = -5.53$, $p = 0.0004$) 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 a familiar book (Figure 5-8).

Speaking Pace: However, one Tinkrbook page could theoretically be considered many pages in parallel, comparing words per page might be skewed. Another calculation compared the number of spoken words per second occurred across pairs. Figure 5-5 shows that people spoke a bit faster when talking with regular books; talking at about 2 words per second with their book as opposed to 1.24 words per second with TinkrBook. Taking into account the number of words spoken per page (Figure 5-9), faster and less dialogue occurred with familiar books.

B) Content of parent child discussion

The next thing to look at is what is being said within the sessions. The breakdown of vocal behavior between groups can be seen in Figure 5-10. In general, the interaction behaviors cumulatively occurred more often with TinkRBook. The specific behaviors that are interesting are the diegetic reading and explicit questioning techniques. Asking questions during reading is dialogic reading, an effective instruction technique. Diegetic reading (pointing to text as they read) indicates print referencing.

Specific behaviors to note are the average amount of questioning and diegetic reading techniques occurring between the two conditions. These two behaviors indicate that TinkRBook increases the focus of the experience on explicit dialogic questioning and strumming of the text. Both behaviors are explicit reading instruction techniques (refer to Figure 5-1).

Parents were much more active in pointing out the text in the TinkRBook, pointing at the words approximately 10 times as much (Figure 5-12). This might be due to the novelty of words in the TinkRBook, of course.

On average, the questions more than doubled when they encountered the TinkRBook (Figure 5-11).

A most conservative finding for TinkRBook is that it encourages parents to engage their children in language. Figure 5-13 demonstrates that parents talk more with TinkRBook. Just encouraging parents to talk allows children to be exposed to rich language and adult conversation. TinkRBook is a good conversation prompt.

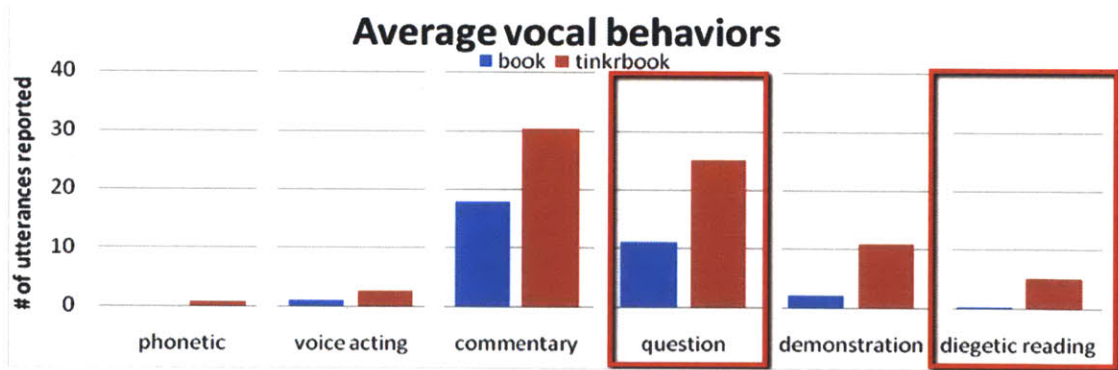


Figure 5-10. Cumulative Vocal behaviors occurring between book and the TinkRBook

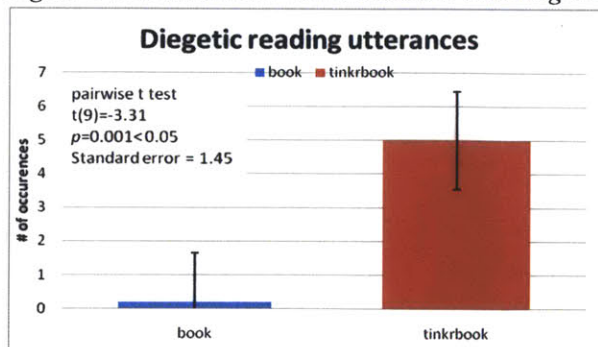


Figure 5-12. Average diegetic reading utterances

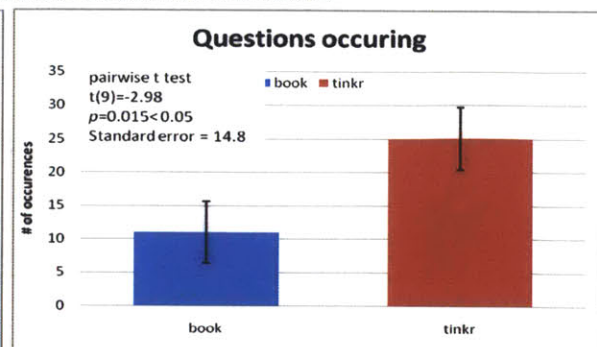


Figure 5-11. Average number of questions occurring

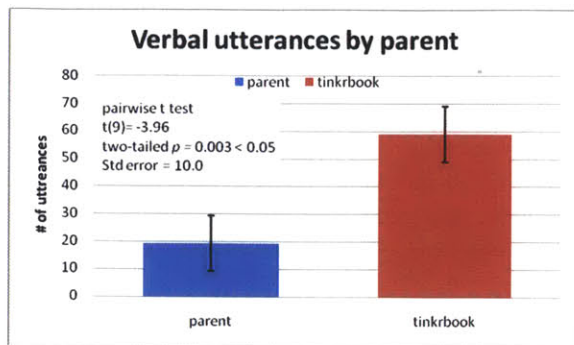


Figure 5-13. Verbal utterances by parent

C) Social Interactions

We can describe the purpose of the audible interactions in more detail. Social communication was more frequent with TinkRBooks, occurring about 4 times more often (Figure 5-14). 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!”

People discussed issues relating to each other’s comprehension more than twice as often (Figure 5-15). Parents made an effort to see whether children understood the meanings of certain words as they were reading. For example, when describing the word dirty, parents would mention how they valued cleanliness in general.

Pairs exhibited more emphasis, elaborating upon points they made 5 times more often (Figure 5-16).

From these observations, TinkRBook encourages both social and instructional communication.

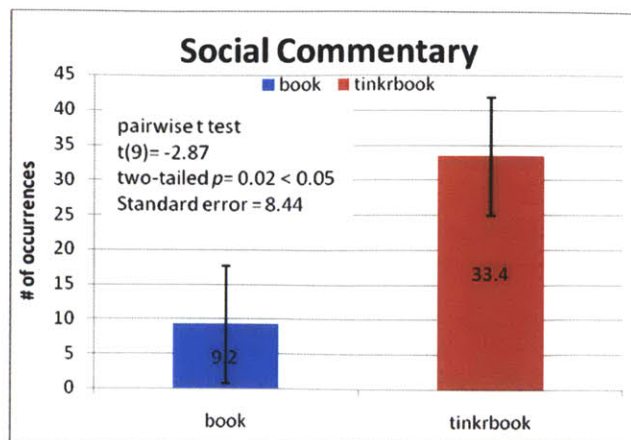


Figure 5-14. Pairs engaged in more social commentary with TinkRBook

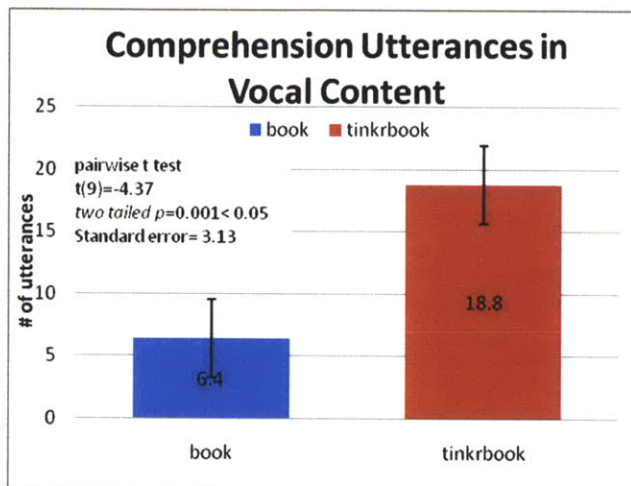


Figure 5-15. Pairs made more efforts to demonstrate or discuss comprehension while reading TinkRBook

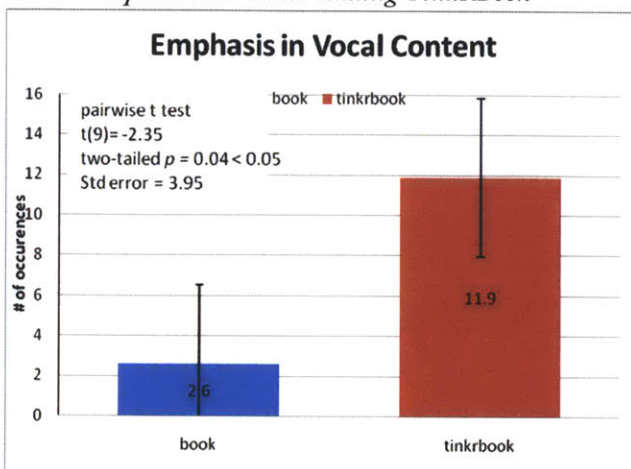


Figure 5-16. They followed up on conversations points more with TinkRBook

D) Physical behaviors comparison

Tinkerability attempts to provide support for physical expression of words. Next I examine how people physically used tinkerability.

Across the board, parents and children are more physically active with the TinkRBook (Figure 5-17). People on average gestured at TinkRBook almost 3 times more often (Figure 5-19). Figure 5-18 demonstrates a drastic increase of physical activity by all participants.

Notice, in children exhibited a 6-fold increase in either physical activity (Figure 5-20). Also parent and child gestured *together* more with TinkRBook compared to a regular book (Figure 5-21).

Again, these statistics really do not do justice to the richness of the behaviors expressed by parents in reading. The subsequent pages attempt to shed light on how parents used tinkerability (Figure 5-22-Figure 5-24).

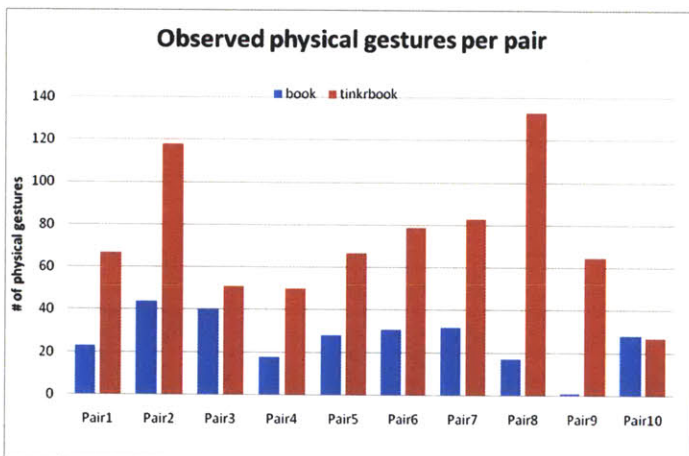


Figure 5-17. Observed physical gestures increased for each dyad

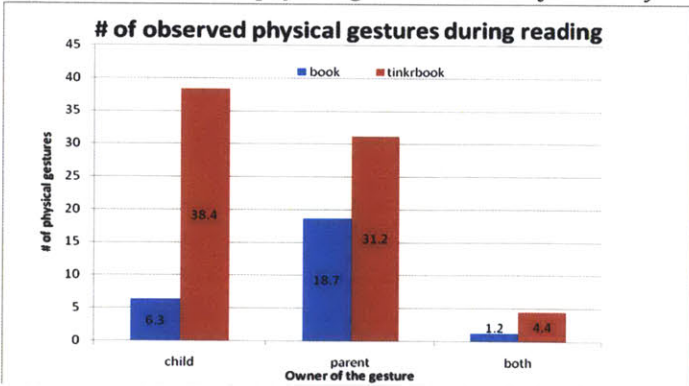


Figure 5-18. People gestured individually and together more.

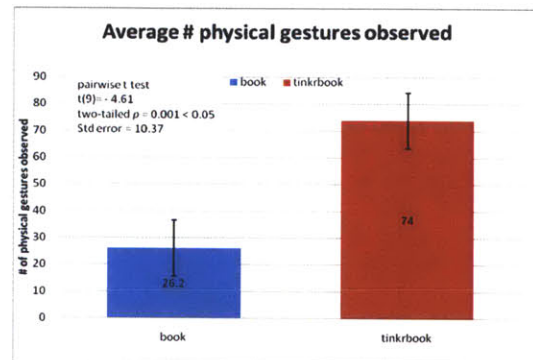


Figure 5-19. Physical gestures initiated by the child.

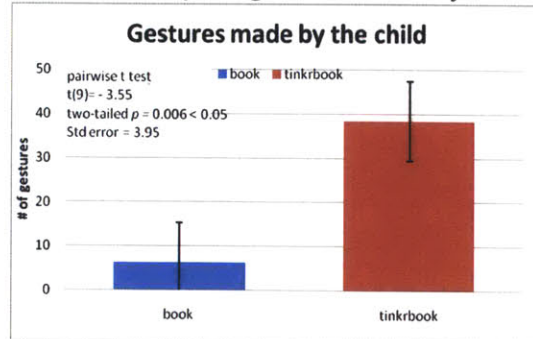


Figure 5-20. Gestures made by the child

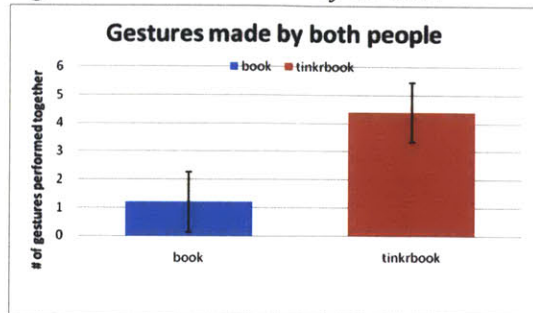


Figure 5-21. Gestures made by both people

Detailed Results

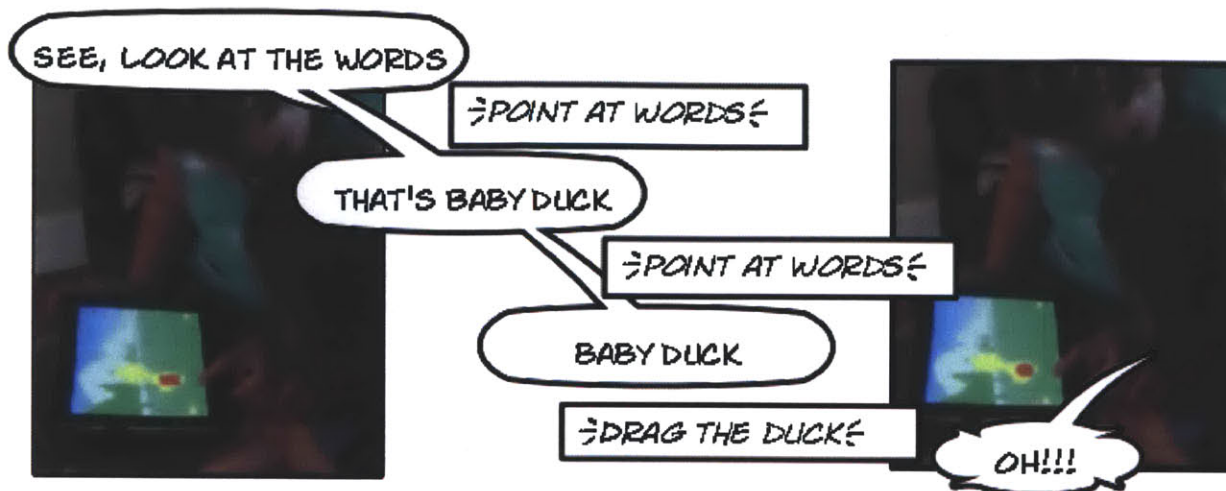


Figure 5-22. Print referencing behavior using the semantic highlighting provided by tinkrability (3 year old)

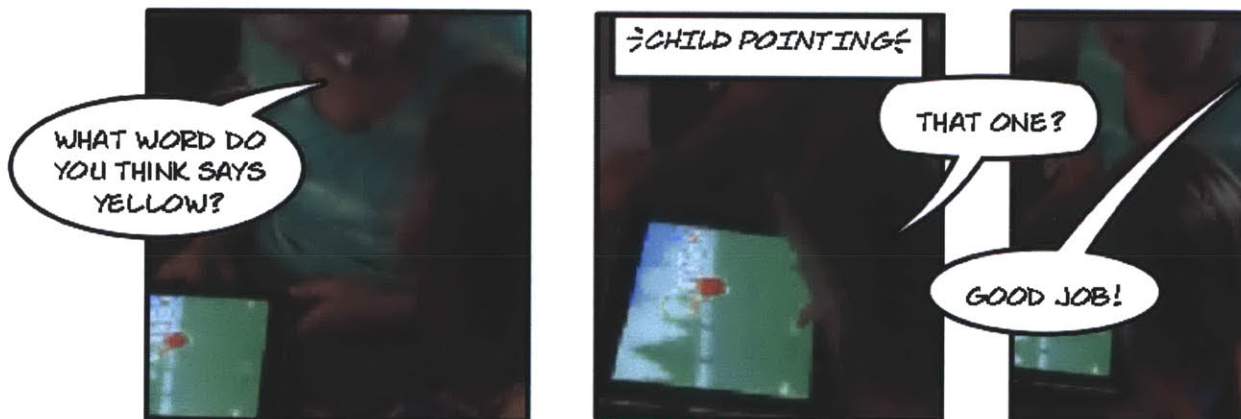


Figure 5-23. Dialogic questioning with a 3 year old



Figure 5-24. 5-year old child active exploration, along with performative demonstration by parent

As reported, parents were shown to exhibit the positive reading instruction behaviors with TinkRBook. Note that in the last frame, Figure 5-24, 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.

Evaluation Summary

Let's revisit the research hypotheses:

Hypothesis 1: Parents will exhibit "positive reading behaviors" with TinkRBook. For reference, these positive reading behaviors are presented again in Figure 5-1. In particular, I expect that parents will be able to demonstrate vocal expression, gestural expression and dialogic reading techniques with TinkRBook.

Hypothesis 2: Children will exhibit active explorations of text with TinkRBook. Active exploration behaviors can be considered interactions where children are controlling tinkerability to discuss the meaning of text with their parents.

According to the data, TinkRBook does result in more positive reading behaviors in both parent and children. Parents were asking more dialogic reading questions, and referencing the print more (see above section B). In addition, parents are talking more, which is the most basic way to improve oral literacy. Children were also actively exploring, by pointing and gesturing more at the book (as shown in section D). My hypotheses are confirmed solidly that TinkRBook successfully encourages more positive reading behaviors.

Now let's examine more closely the additional research questions regarding the behaviors.

- A. Do parents and children talk more with a TinkRbook?
- B. Does the TinkRBook foster social bonding and educational instruction? What is the conversational content (comprehension or social conversation)?
- C. Do parents and children gesture more with a TinkRBook?

For all these questions, the answer is a resounding yes. Tinkerability allows parents and children to talk about concepts in print without drawing too much attention from their communication. It is encouraging to know that parents and children were able to exhibit performative reading demonstrations in communication as with TinkRBook. The TinkRBook is a new story and the novelty effect could account for some of this change. The TinkRBook's novelty may account for the longer time spent on the book, and the added conversation.

Furthermore, tinkerability allows people to act out the concept of text, rather than just reading it. It is exciting to see that people could use it to act out the story despite the novelty. These performative behaviors 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.

6 Discussion

The previous section described how technology was designed to cause positive behavioral changes during emergent literacy. This section will introduce and discuss the larger vision regarding the 'ideal reading instruction scenario' and describe my attempts to realize this vision. The section will conclude with a critical assessment of the contributions put forth in this dissertation, and suggest future work.

The ideal reading instruction scenario

In instruction, parents have an image in their own minds. They aim to reproduce roughly that same image in the child's mind using different strategies; they may encode the image by translating to words, gestures, drawings, sculptures, assemblies, and tapestries, etc. At the other end, the child then attempts to decode this stream into his own mental image. The child then gives feedback about what they've understood of the image. Thus, 'success' depends not only on the parents' ability to convey, but also that of the child. This is an iterative process, where the parent questions the child's image and modifies or corrects it.

For this to be an effective process:

- 1) The parent must have a clear image or understanding of the image in her mind.
- 2) The parent should have a good strategy for conveying that image.
- 3) She should be good at encoding (speaking, drawing, gesturing) the image.
- 4) The child must be able to decode.
- 5) The child must be good at encoding his own image (to close the communication loop).

This suggests that a familiar teacher will be the best person to demonstrate the reading process, because that person is the best at understanding the previous communication experiences of the child. This history of interactions will facilitate both people recognizing and appreciating the subtleties of communication each person possesses. That is to say, the parent will be familiar with specifics of the child's ability to encode and decode.

What are the best practices for reading instruction? What if there were a 'magical' system, akin to a mind-meld, that reproduced the content from one person's mind to that of a receiver's? Of course, the success of this could only be truly assessed if the receiver had a similarly efficacious system to convey understanding.

In an 'ideal' book storytelling scenario, parents would be able to manipulate plot, imagery and text as they tell their story to their children. Parents would be able to convey their story, with animations and sound effects as they spoke, acting on individual strengths, as well as known 'best practices' for the child's receptiveness. Their child would be able to give them similar feedback, by similar means, as they experienced the story.

The value of iteration and feedback from the child is essential to the creation of the story, perhaps to allow children to identify with characters by observing the child's interest [Quesenbery & Brooks 2010]. Some well-known stories were written this way: *Alice in Wonderland* was begun after Lewis Carroll told the story to three young girls during a boating trip. He expanded upon the story on their request during a subsequent trip, and got feedback from many children as he wrote it down. Other examples include not iteration for content, but for venue. *Peter Rabbit* was written by Beatrix Potter in a letter to the son of her governess to entertain and cheer him up while ill. *Watership Down* began as a story Richard Adams told his two daughters during a car journey. He based the animal's struggles on his own experience as a soldier. His daughters insisted he write it down. Iteration turned verbal 'yarns' into written tapestries, presumably necessitating a richer narrative.

Note however, that this type of iteration can be rather slow: Carroll took 3 years to complete *Alice in Wonderland*, Potter took 7 years, and Adams took 18 months. *Nevertheless, one point to consider is how a 'living narrative' can be an improvement over a static one, and the best practices to optimize this benefit.*

The special context of emergent literacy

Emergent literacy is a particular form of storytelling instruction between parent and child. In addition to the above scenario of communication and conveyance of a narrative or image, the parent is trying to help the child learn the meaning of text, and hence a tool for independent reading at a later time.

According to the above description, books supply the content and serve as a shared visual reference for communication. Books preserve the author's story in visual form for later retrieval by future readers. Readers still need to interpret this code. This mechanism for preserving thoughts works well enough, particularly if the readers can decode the information and understand the author's motivations.

In emergent literacy, parents transmit the book's content during the reading process by interpreting the text, image and plot for their children. The background of this thesis discussed how parents were relaying someone else's story during reading. 'Good' reading instructors develop effective, student-dependent strategies for conveying the image, and can communicate well. Parents point out the pairings between words ('squiggles') and images by conversing. They ask questions about the plot in an attempt to guide their child through the story. If the parents are 'good' reading instructors, they might try to perform the story to impart more meaning to the text (see chapter 2).

Children receive that demonstration by seeing the images and squiggles associated with the spoken words. Young children might be able to interpret the pictures, and get an indication of how far along they are in the process from the thickness of the book. They might externalize some feedback to the parent, by pointing or echoing the spoken words to demonstrate their understanding.

Through repeated exposure and interaction, children eventually learn to comprehend both the mechanics of the printed words and the full plot of the story. When they are better at oral language and able to demonstrate their level of understanding children may reciprocate—by dramatic play (playing with the content or rearranging the elements of the story) or asking their own questions about the plot.

Throughout the process, parents try to gauge a child’s mental image so that they can guide the process. Often the parent controls the rate of reading, by generating the comprehension questions and controlling the spoken delivery of the words in the book.

‘Ideal’ emergent literacy instruction would require expressive typography.. The technology would allow the parent’s spoken words and gestures to generate text and images as she told the story. Children would be able to use this sytem as well, as they described what they experienced of the parent’s storytelling. This would be something akin to Blonk and Levin’s *Ursonography* combination of poetry and vocal performance to generate real-time textual animations during a recital (Figure 6-1) [Blonk & Levin 2005]. *Ursonography* is the display of the real-time generation of expressive typography.

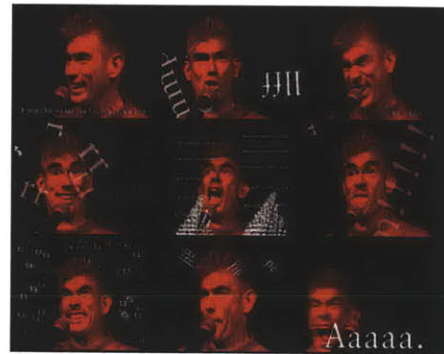


Figure 6-1. *Ursonography* [Blonk & Levin 2005]

In practice, the emergent literacy instruction process is far from efficient. At all stages of the process, things can break down: On the first read, parents may not have sufficient information about the ‘next page’ to achieve benefit of upcoming events for temporal context. They might not know ‘good’ strategies for conveying information so that children learn how to read effectively. Likewise, preliterate children do not know how to decode text and may be unable to understand a parent’s communication fully. At this age, they are usually also unable to describe their own understanding in a way that the parent can confirm what they actually comprehend. *These all suggest areas for insight, innovation or improvement, addressed in part by this dissertation*

Textual tinkerability endows print with dynamic properties

This thesis approaches the above problem by doing away with altogether the static nature of print. Print within books, taken at face value, is devoid of dynamism, which makes it hard for preliterate children to interpret. The appearance of the text typically, with some exceptions, does not help convey its meaning. The purpose of *tinkerability* is to actively expose the relationships between words and concepts during reading instruction. Tinkerability endows text with dynamic properties and allows storytellers (parents) to encode text with semiotics, by linking words to gestures performed by the storytellers. By demonstrating this link between

words and concept, tinkerability attempts to provide children with more contexts with which to associate words and meaning.

Manipulating story elements exposes the word-concept connection (like pulling a string and seeing what the other end is attached to). This is a subtle but important link in learning how to read. The real-time visualization of this connection allows parents to more effectively demonstrate which parts of a sentence are relevant to the conversation. Conversely, parents can observe what interests their child, using it as a form of feedback about their child's interest and state of comprehension. Furthermore, when a child is allowed to manipulate the connections between words and their meanings (symbols and ideas) directly, he can better understand that a symbol and idea are connected. Eventually, they can see words as representing ideas in and of themselves. This form of context-feedback may provide a comfort zone which helps children reinforce basic reading concepts as well.

Tinkerability allows children to learn using familiar methods, that is to say through active exploration. Analogous to playing with a light switch for the first time and seeing which lights turn on and off, functional associations and understandings begin to form.

Principle of Contrast: Tinkerability leverages the Principle of Contrast (see section 2) to quickly demonstrate the meaning of a word in a *usage* context. Children can learn new words by encountering them in print, and eliminating familiar ones. For example in one TinkRBook scene, they may be asked to help the duck eat a worm and a centipede. If they already know what a worm is, they can learn that the centipede is the other worm-like insect who has lots of wavy legs.

In essence, this concept uses simple and available technology to begin to explore the potential of control-animation-word connections, and the effects on reading improvement. Note that, as stated above, there are several aspects to the assessment of a child's understanding; accordingly in this dissertation the 'improvement' was sought and observed in several aspects of parent-child interaction, known to be important to and indicative of the learning process itself.

The importance of narrative

Tinkerability alone might teach children the 'dictionary' definition of a word, perhaps by dynamically illustrating the pairings between words and images. Parents are better able to demonstrate the immediate concept of print, by pointing out how these two representations connect to their speech. Grammatical concepts (e.g., noun vs verb) are more easily demonstrated. In some cases, tinkerability is sufficient to teach all the connotations associated with a word. For example, spatial relationship and time words can be demonstrated through manipulation (of story elements) making these abstract ideas more obvious. Another example is using tinkerability in a scene where changing the weather causes the associated clothing and facial expressions to change. This can reveal information about how people react to weather.

However, there are words whose connotations are key to their generally accepted meaning. Many of these connotations cannot easily be revealed outside a story context. For example, jealousy and greed can be

topically understood through the character's actions within a tinkerable scene. The dictionary definition of 'greed' is to have an excessive desire for food, drink, wealth, profit or praise, or rather to "want too much." With ever-inquisitive children, this may raise the question of, "how much IS too much?" This flexible concept is *tinkerable*, or explorable by not only dynamically altering the 'greediness' of a character, but also the response of the immediate environment. In this way, understanding is improved.

Narratives lend themselves to performance (and performance can reinforce understanding). Each word can be emphasized in a way which suggests its meaning. "Narratives that lean in the direction of coherence lend themselves to performance [Duranti 2007, p279]." Some stories (such as first-person folktales) have qualities that help people imagine themselves dramatizing the story [Browning-Wroe 2010]. Performance delivers content in a revealing way. Using the performer's intimate knowledge of the audience allows for an even more compelling delivery. Presumably, in the context of reading, a parent will have such knowledge of a child, or be in the process of developing it. Tinkerability can *accelerate and enrich* this process, thus making parents 'better' performers.

Narrative also provide dramatic tension or suspense, which is the basis for a reader's interest or curiosity. Repetition in story structure allows anticipation as well as audience participation in the performance of the reading. Children can imagine and also express what they think will happen next. Tinkerability allows them to participate in highly enhanced discussions on what will happen, and sometimes the events themselves. This lends itself to increased interest, and by extension, reception to learning.

TinkRBook provides a narrative framework for tinkering.

A TinkRBook is a narrative framework that supports tinkering. With TinkRBooks, parents gain more control of the plot, helping them become more expressive in performing the story, as described above. Parents can now use gestures and dynamism to convey the plot, improving fluency [Krauss 1998]. The Principle of Contrast has obvious applications at very small scopes, or immediate tangible properties, e.g. 'swapping' colors or fruit. But it can also be used to illuminate words and phrases relating to emotion, motivation, and intent. Active contrast provided by TinkRBook allows not only spatial contrast, as in two colors juxtaposed, but also temporal contrast, as in a box changing color, at the whim, request or query of a child.

TinkRBook demonstrates vocabulary schema in context.

TinkRBook allows readers to appreciate words as a group, and explore each word's singular properties within distinctive 'common sense' contexts. There are books that say "I had apples and bananas and cherries for lunch" but that layout does not automatically convey interoperability in the same way. By being able to change the fruit graphic within a story as they change the word, they can observe that fruits are a group; but each word has an individual distinct representation. Children are not only learning vocabulary, but also what happens to the world when a 'word' is added or removed.

This tinkering can be flexibility in the reach of its impact. Changing the agency of the duck to dirty of course causes a change in the duck's visual appearance, but also causes the reader to encounter different

narrative traversals and story experiences. For example in “Baby Duck Takes A Bath,” being dirty can result in a longer, more frustrating story in comparison to the clean duck. *Choices have different layers of consequence, and this is implicitly demonstrated.*

TinkRBooks aid narrative quality. *However, narrative aids TinkRBook*; this is why I pursued a TinkRBOOK (and not TinkRNOTES, etc). Obviously some kind of interaction would aid in immediate aspects of vocabulary, but the real benefit comes from using a narrative to launch a multi-faceted understanding. Sometimes decoding the parts only makes sense if one knows that a larger picture exists. McCloud writes “I had been trying to [understand] egyptian paintings for years when I began this book and was ready to call it quits—until I discovered that the books I had been using as reference had only been showing part of the picture!” Once he was able to see the complete depiction of the story he was able to “read” the scenes [McCloud 2008, p.14]. This analogy is similar to trying to learn to read from flash cards compared to reading a book. The book provides different clues, such as spatial arrangement and repetition of elements, that may help cue the reader on how more general words apply to a specific scenes. For example, “She found the right one,” might mean she found what she was looking for at a particular location, or she was able to match her ideal.

TinkRBook provides narrative choices.

TinkRBook provides readers with choices, so that readers can have control over some story elements. These choices are designed to help storytellers demonstrate the meaning of words by allowing readers to observe the Principle of Contrast. A TinkRBook exposes the thought process of how someone chooses to tell a story. Good storytellers have a choice of words to select from their internal repertoire of words. They understand how the effect of different words can vary the perception of the story.

By exposing the idea that story elements are alterable during story sharing, the connection between words and representation becomes a teaching tool for emergent literacy. TinkRBook is like a shared worksheet allowing the choices a storyteller makes to be instantly observable by both the parent and the child. It explicitly demonstrates that words are *chosen*. By realizing that words are deliberate choices made by an author, readers can start to think critically about the meaning of words. The end effect of this addresses a simple yet relevant question: do TinkRBooks replace regular books? The answer to this is no, in fact *a TinkRBook can potentially enhance a parent’s performance of static books, expanding them in multifaceted ways.*

Active exploration of narrative by the child

Children above a certain age naturally ask questions, specifically, “Why?”, or “What would happen if...?” [Dwyer 2008] There are no explicit answers to these in static books, yet there is certainly room for exploration, given a strong communicative basis between parent and child. TinkRbooks develop this basis, by illustrating which consequences, cause/effect relationships or conclusions are satisfying to a child, and how deep curiosity lies. They provide an explicit answer to queries. Thus, while static books can never provide such a reward, development of a strong performer-child rapport provides stylistic, content-based and emotional cues by which the parent can explore other stories. For example if a child were adamant that Baby

Duck SHOULD be clean, and anything else were unacceptable, *this would allow a parent to explore the possibilities within a static book using a philosophies and strategies that enhance the child's curiosity and reception.* .

In addition, some changes are simply not as important to others in an absolute sense. For example in the Baby Duck Takes A Bath story, seeing colors change might be enjoyable for a time, but has no effect on plot (this is not to completely discount the possibility that a child may become fixated on this change to the expense of all other changes, but the notion here is apparent). Changing character agency, in contrast, affects the frustration, repetition and length of the story. In another story, changing colors might be important to the narrative (e.g., a chameleon story where the animal has to blend in to the surroundings).

The social benefits of TinkRBook

Parents tend to appreciate traditional storybooks as visual and mental interfaces shared with their children, and they were encouraged by the TinkRBook's expansion of this shared interface. Explicit demonstration of semantic highlighting and alterable story elements allow them to communicate about the story even more, on a fundamental level. These features were believed to be most useful for facilitating communication about the concept of print between parent and child. The expressive typography drew attention so that readers could discuss it. Finally, parents were also interested in what a TinkRBook could tell them about their child's development. In this respect, they wanted it to help them gauge their child's interests, rather than judge any sort of success or failure.

Externalizing a child's interests: Interactivity can be used to provide an indication of a child's attention, particularly in very young children who are developing oral language. The act of selecting story elements reflects the child's curiosity, and results in simple yet personalized stories that are more interesting to each child. In the ideal teaching setting, the parent is attuned to the child's interest and can help guide the child to understand new ideas. Story interfaces that reflect the child's individual preferences can help them sustain interest in reading activities. Also, if different children have personalized stories reflecting individual preferences, children will have words to communicate with for relating the differences between stories. This can be a fun way to foster conversation between children during dramatic play.

External legibility: With a TinkRBook, users can equally observe and control the interface. Simple and obvious controls for active exploration allow children to drive the learning process. With the TinkRBook, parents can let their child lead the reading process. By observing how their child actively explores conceptual links, parents get an indication of which concepts are troubling or hard to understand. As the child proceeds in active exploration, their interactions reveal their internal inquiry. Parents can see the physical representation of the child's curiosity, and become more effective teachers by commenting or tailoring their discussion guided by the child's interaction.

Treating children as peers in the reading process: In some respects, the open access of tinkerability and external legibility of a TinkRBook allows for children to become more active in the reading process. Their ability to contribute to the joint traversal of the narrative allows them to take on more responsibility in their

own reading instruction. TinkRooks allows children to act more like reading peers than with conventional books. Although they might not be able to externalize their thoughts or ask proper questions, they can demonstrate their knowledge and inquiry. They can imitate the gesture their parents make to demonstrate some reciprocal communication to signal they recognize the communication. This ability to act literate gives them a new way to close the feedback loop in communication with the parent. As children get older and master oral language skills, they of course will be able to contribute to the discussion as peers. In the studies, some parents seemed to treat their children as peers in the reading process, allowing their children to demonstrate mastery and comprehension of concepts in conversation, allowing a greater depth of social interaction and communication.

Matching the interface to the audience

Several limitations of the TinkRBook still exist. Although reading is a conceptual process, the physical form of traditional storybooks provides tactile interaction that is easily accessible for young children. A touchscreen interface is not the same as a physical storybook, and the tactile manipulations of a physical storybook are missed. Rather than try to imitate all the physical affordances of a storybook, we have adapted some of the tactile manipulation techniques such as page navigation and underlining. It is our hope that the conceptual benefits of the TinkRBook will mitigate these tactile losses, although a more tactile solution would be an interesting design problem.

The young ages of the target audience raises concerns as to whether such young children can understand what is happening in the interface. However, the children in my study exhibited no emotional difficulties or frustration that would indicate such a misunderstanding. iPhones and iPads have been reported to be 'OK' with young children. Nevertheless, useability must be determined by target and intent. That is to say, as TinkRBook is developed, potential avenues and caps for learning potential will be better understood, and interfaces can be tailored for appropriate age groups.

Cost

Another main limitation of the technology is the cost involved at all levels of involvement. It costs more resources to produce a TinkRBook than a regular book. Story element assets (such as graphics, animations and sound effects) must be made to support multiple storylines and alternatives. One solution is to generate a wide range of animations cheaply using the Open Mind commonsense database [Singh 2002]. A base set of animations (such as standing, running, and jumping) could be adapted to different motion profiles by querying the commonsense database with a set of gesture profiles for motions. Additionally, story creators can construct gesture templates using programming by demonstration [Lieberman 1993]. Other creative solutions might use computer algorithms to generate new stories [Schank 1977].

Although the wireless tablets for implementing tinkerability are expensive, note that this thesis is not about any one hardware platform. The *concept of tinkerability* is the contribution of this thesis. Tinkerability could be ubiquitously implemented on many different platforms (e.g., computers, mobile phones, or table-top computers).

The elusive 'A-HA moment

Each child reaches the AHA moment at different times. This is an elusive moment to catch, especially if children were exposed to tinkrability for a short period for this study. It is hard to know what is the exact catalyst for the AHA moment. Once the child reaches the AHA moment however, they may still find TinkRBook useful as their vocabulary learning accelerates. For this discussion we may also pose the question as to what the 'A-ha' moment truly is. At this stage, it does not seem immediately feasible to expand simple, illustrative and linear narratives to full-scale short stories or books, but is perhaps not a necessary exercise. What if the 'A-ha' moment means children are ready to devour and enjoy the vast literature that already exists? Can TinkRBooks accelerate childrens' graduation to books? This would be a tremendous contribution if so.

7 Future Directions

Multisensory avenues to tinkerability

'Puppeteering' a story character is the preferred solution for tinkering with words. However other ways to alter story elements in a diegetic manner also provide a promising avenue for research. A young child may lack manual dexterity, so interaction choices should allow generous time and size to accommodate small hands and slow response times. Large buttons, in the guise of story elements, are one solution. Another method is to embed tinkerable choices in the words directly. The system would outline an alterable word differently to cue the reader that it can be changed. When the reader touches and briefly lingers on the special word, a graphic or textual pop-up menu might appear. These options will remain visible until explicitly dismissed. The reader can touch any of the choices to make that change, or touch outside the choices to make the menu disappear.

Control options other than menus should also be explored, as there are still many potential ways to create alterable story elements. A reader might change story elements using a combination of touch and speech. For example, the reader touches the word or element he wishes to change. Then, that element will visibly respond if it is indeed alterable. The reader then speaks the new option aloud. Assuming the spoken word is accepted as a valid replacement, both text and illustration change to suit. For example, audio and touch could combine to change the weather. The reader can touch either the word "sunny" or the sun itself, and say "rainy" to cause clouds to roll in and rain to start falling. This scheme limits voice-recognition errors, as the touch greatly constrains the list of possible spoken words, making disambiguation simpler.

Encouraging Audio Expression

Early on, one feature I tried was allowing the microphone input to control the size of a story element. This created a fun and enjoyable storytelling experience. The variations in audio expression at each reading provided a playful performance aspect. Unfortunately, this feature was hard to calibrate and inconsistently supported on different tablet platforms. In addition, audio echo and feedback were annoying problems, sometimes requiring muting of the device. Currently, I have no solution for the echo problem with audio in the vocal control loop. Thus verbal interaction, though positively reviewed by users, has not been a focus of development. Users seem able to perform their storytelling behaviors with the current implementations, however, the dynamic expressivity of vocal control was considered to be very fun and usable for young

children. However, this carries with it a further risk, in that if a child discovers he can make it rain by saying "rain," he may avoid reading/touching the written word altogether.

More explicit vocal limitations on the animation control could address the above risk and enhance the performance aspect, so that graphic movements responding to sound are related to a word *only when touched*. This would allow multiple animations to be controlled through directing the vocal energy at particular words. Voice recognition is a further avenue to further exploration, perhaps using phrase spotting technology. Phrase spotting techniques scan for specific, user-defined words which might be ideal. By restricting recognition to a small word list, perhaps voice recognition system can run faster than with traditional voice recognition methods. Voice recognition that I have tried (the Sphinx speech recognizer) in the past has been error prone, slow, hard to train, and incompatible with a noisy, multi-speaker environment.

Foreign language learning

TinkRBook is a natural candidate for foreign language learning. Already, development has begun for a French version, where people can use the principle of contrast to toggle a story between French and English. This work is being performed jointly with undergraduate researcher Tom Roberts. One area where TinkRBooks can help is with learning phrasal verbs, for example when subtle differences between "give out," "give up," and "give in," among many others. TinkRBook may be able to help map gestural interactions to these parts of speech.

Remote Story Interaction

Another direction is remote storytelling. In terms of story sharing, the ability to couple reading with demonstration of meaning could provide a new way of communicating ideas between people. The idea is that two people can hear each other and control the same scenes in the story. In this way, they collaboratively read the book. What is interesting about the scenario is that new interaction techniques need to be invented to allow for simultaneous multiple traversals through narrative. In particular, how do they jointly decide on a story branch? What happens when two people touch the same animation? Can they collaboratively create new traversals and demonstrate activities that are hard to demonstrate with current remote technology? For example, over NetMeeting or whiteboard applications, one person takes control and the other person is passive. It would be interesting to create an interface where both people can control different parts of the story at the same time. For instance, both people create a color for their character together, or cause a character to move faster because more people are reading together. Another interesting part about remote story sharing is understanding what type of stories are better to share remotely. People already share stories about alternate destinations (e.g. trips, happenings in their town). Perhaps these types of stories can make people more aware of the sociocultural values from another area. In some cultures, there is emphasis on mentioning the weather at the beginning of a meeting so that people understand what conditions exist in the remote place. A remote story sharing application could increase this remote awareness and make people more curious about cultural interaction and sharing across cultures.

Revisiting the parallels between speech and print

There are certainly parallels between learning to speak and learning to read. Centrally, speech and text are similar encodings. Both are symbols to ideas in our heads. Speech lends itself to performance, and even before the encoded meaning of the speech is apparent, one can convey emotion and suggest intent. Although it is customary to teach children to read from books (cards, signs and television), modern technology allows us to experiment with trying to make teaching to read as natural as teaching to speak. Thus, giving parents the familiarity of control and taking advantage of their natural abilities to perform. Certainly, there are other aspects of this parallel that merit exploration. Can we generate text as ubiquitously, as portably, and as variably as the mouth generates words? Can we do so unobtrusively, in a way that leaves both hands free to act? Can we all have comical speech bubbles? To some extent, Sesame Street delivers this in packaged quantities in skits where animated text, music and speech combine. Some instructors label every item in the classroom, to provide students with a benevolent flood of written words with everything they see and touch. Finally, speech is *motivated* by a need to convey desires. Can we find a similar motivation for reading?

“Where TinkRBook is more clearly innovating: text that changes (at all), text that changes in response to parent/kid interaction, loose/dynamic narrative.

I also genuinely believe that most commercial reading experiences (my own included) do not have anywhere the pedagogical thinking that Tinkrbook has. I do think you'd be able to find non-story learning applications that DO have solid research behind them (I'm thinking about learning games, etc).

Another thought: TinkRBook takes advantage of the tablet form to create a collaborative learning experience between parent and child, by design -- this isn't the kind of app that you just hand off to your kids while you make dinner. For what is worth, this potential to engage both parent and child TOGETHER is what excites me most about TinkRBook.”

- email from educational media developer well versed in the current state of the art of interactive storybook media for children [Nunez 2011]

Interaction design for active exploration of narratives

Challenges and best practices arising during the design of TinkRBooks highlighted the need to develop new interaction paradigms better suited to narrative exploration. Most modern interface design philosophies address *information access* and *manipulation of discrete data* [Schneiderman 1981]. In contrast, narratives consist of interwoven networks of causal relationships. We have proposed a series of interaction techniques for selecting and navigating through numerous causal relationships between text and imagery. Within the context of shared reading, another challenge is to identify which designs are usable by both parents and children. Finally, we anticipate that novel feedback mechanisms will need to be designed to provide appropriate and obvious response to narrative changes. As we observe users with the interface, it will be clear that certain interactions are better suited for active exploration of narratives.

Additional Evaluations

From my evaluation, it seems clear that tinkerability facilitates positive emergent literacy behaviors in parents and children. What is not clear is how tinkerability compares to other types of media in this respect, in particular the many current interactive ebooks targeted at children. Prior research has reported varying effects with educational media and interactive storybooks [Calvert 2005; Cordes 2000; Children Now 2005; Fisch 2004; Labbo 2000; Lewin 2000; Zimmerman 2007; Zipes 2009]. In some cases, ebooks work very well, particularly in small group settings where there is an adult reading to the child. In other cases, as discussed in the background section, this type of interactivity has had negative effects on children's comprehension. I did get an assessment from someone who has worked on developing many interactive ebooks who considers TinkRBook's interactivity to be unique (see insert, previous page).

I have not tested TinkRBook against ebooks to determine how it compares in effectiveness in engaging parents and children in the reading process. This would be useful.

Other populations to study

My thesis examined how 'good' reading instructors behave in order to design a system to support and encourage positive emergent literacy behaviors. It remains to be seen how different populations might use TinkRBooks, and whether the system encourages positive emergent literacy behaviors in these other populations. The 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 TinkRBook to be useful. Parents who are slow readers themselves may progress differently, as may children who read to other children, as seen in the Africa project. The immediate feedback provided by tinkerability is itself an educational tool that could be used to practice whole language reading.

Groups of children with parents. In my study, I was able to film some scenarios of parents with multiple children. Sugatra Mitra notes that children working in groups will figure things out faster. In my own ethnography I observed children helping each other to understand the TinkRBook. This might be where the social qualities of interactive narrative apply. Children will see the TinkRBook as a shared puzzle that encourages the most knowledgeable ones to assist their peers.

Longer term evaluation - Finally, this study only evaluated a short-term usage of TinkRBooks. A longer term evaluation will be useful to determine if children actually do reach the AHA moment faster. Significant gains in interactive and performance quality indicate a strong probability that this would be the case.

8 Conclusion

Towards an educationally evolving narrative

In Stephenson's *The Diamond Age* [Stephenson 1995], an orphan girl uses an intelligent book, called the illustrated primer and learns from the stories it tells her as she grows. This vision of an educational adaptive narrative is interesting because it provides a platform for long-term personalized education. Stephenson's vision is realizable today using current technology. This thesis has taken the first steps toward the vision of an educationally evolving narrative. We must be cautious, however, in that key learning and communication points for a pre-literate child can be vastly different than that of a beginning reader, or a mature thinker. It would be interesting to see which design concepts persist positively. The concept of *adult literacy* was not explored in this thesis, but as those individuals may be more self-motivated, a similar set of design principles could be envisaged using this technical framework.

The first steps in implement an educationally adaptive narrative have been realized. Using tinkerability, a story can be modified by presenting narrative choices to the user. Over time, the story can adapt to the increasing advancement of the child's language development. As the current implementations show, TinkRBooks allows readers to make a narrative path through educational concepts.

Unlike Stephenson's vision, however, TinkRBook technology is not a replacement for parents. In this thesis, technology is an enhancement of behaviors people already perform. Interactivity is an elaboration prompt to encourage parents to express themselves during storytelling. At the same time, this interactivity encourages children to test the relationships between words and meaning, making them active participants in the learning process. Tinkerability is designed to promote parent-child discussion. In particular, tinkerability promotes literacy behaviors by prompting discussion and demonstrative storytelling behaviors. In short, Stephenson replaces parents with magic books. *TinkRbooks provide a set of 'training wheels' to parents and children alike, to accelerate and enhance their journey from purely oral and gestural interpersonal communication, to a new avenue of interplay via the written word, robust and naturally personalized best practices for assisted reading, to the moment where children can demonstrate independence by reading books to their parents.* This reinforces my decision to quantify results based on interactive experiences and communication key points, rather than reading assessment tests.

Contributions

The conceptual focus of this thesis is an idea called textual tinkerability, a new tool for teaching reading. Tinkerability is the ability to test and manipulate the text-concept relationship while reading. With tinkerability, the fact that there is a relationship between text and concept is shown, but the nature of the relationship still requires insight. Tinkerability allows parents to demonstrate how words, gestures, and images connect to a concept. This gives control of the story plot to parents and children, and makes story telling more fun. Tinkerability also educates children in reading by allowing them to actively explore the concepts of text more obviously.

Conceptual contribution:

Textual tinkerability links text with dynamic representations that:

- exposes the text-concept relationship actively
- allows pre-literate children to grab images and words
- allows gestures to change the narrative while reading
- allows readers to explore concepts in text more obviously
- enables readers to take some control of the plot during reading
- enables readers to perform the words during story reading
- enables reading to be taught in a new way.

Technical contributions:

CodeBase: Dynamic text-representation connections are actively triggered.

Design principles for developing tinkerable stories

Evaluation Method and Report of performative reading instruction behaviors

Proof that Tinkerability results in positive reading behaviors, including:

- active exploration of text by children
- performative storytelling by parents

Application contributions:

2 TinkRBooks:

- TinkRBook Interactive Narrative
- TinkRBook Pedagogy Showcase

Figure 8-1. Summarized Contributions

My technical contribution is a framework for creating interactive stories that allows the text-concept link to be tested. The underlying codebase maps how text (from letters to phrases) can link to representations in response to user input. This framework demonstrates how tinkerability can be used to change people's behaviors during reading instruction. The result is an increase in positive emergent literacy behaviors, and increased communication between people as they read. I also demonstrate how tinkerability can be integrated with existing educational paradigms outside of reading to foster discussions about text.

Accordingly, I have created a set of design principles describing how to create these experiences. These design principles have been implemented in two TinkRBooks, and are the result of extensive conversations and iterative testing with experts and target users. The evaluations and presentation of findings in this thesis are also novel, as a way of understanding how performative reading interactions foster positive emergent literacy.

The *application contributions* are two TinkRBook stories demonstrating the use of tinkerability. These stories allowed me to study how tinkerability promotes positive reading instruction behaviors by nature of its design. Over repeated interactions, TinkRBooks allow for personalization and customization of story elements, a first step in realizing the vision and testing the potential of an educationally adaptive narrative. Beyond this, they provide a first step into the literary world that exists, and provide a means for vastly improved parent-child communication.

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Appendix A: List of Experts

The following is a list acknowledges the educators, researchers, storytellers, and media technologists with whom I consulted in the course of this study. This thesis is the result of extensive conversations with many of the following experts:

Edith Ackerman, Honorary Professor of Developmental Psychology at Univ. of Aix-Marseille, France
Mirit Barzillai, Center for Reading and Language Research, Tufts University
Marina Bers, Adjunct Associate Professor of Child Development, Tufts University
Tim Bickmore, Associate Professor of Computer and Information Science, Northeastern University
Erik Blankinship, Education Technologist at Media Mods
Cynthia Breazeal, Associate Professor of Media Arts & Sciences, MIT
Kevin Brooks, Storyteller
Glorianna Davenport, Documentary Filmmaker, MIT
Jonah Elgart, Animator, and Game Developer at JonahElgart.com
Fardad Faridi, Animator, and Developer
Sylvia Feinburg, Former Professor, Department of Child Development Tufts University
Clara Fernández-Vara, Singapore-MIT Gambit Game Lab, MIT
Stephanie Gottwald, Research Coordinator, Center for Reading and Language Research, Tufts University
Ian Gouldstone, Animator and Filmmaker
James Gouldstone, Illustrator, Author, and Developer
Fox Harrell, Associate Professor of Digital Media, MIT
Nicollette Nordin Heavey, Storyteller
Elizabeth Kazakoff, Department of Child Development, Tufts University
Eric Klopfer, Associate Professor of Science Education, MIT
Henry Lieberman, Narrative Commonsense, MIT
Nick Montfort, Associate Professor of Digital Media, MIT
David Nunez, Game Developer, Creative Technologist and Designer at DavidNunez.com
Laura Packer, Storyteller & Writer at laurapacker.com
Keith Peters, Author, and Game Developer of Bit-101.com
Mitch Resnick, LEGO Papert Professor of Learning Research, MIT
Audrey Schulman, Author
David Gove Surman, Artist, Animator, Game Developer, and Film Maker
Elisabeth Sylvan, Education Technologist at TERC
MaryAnne Wolf, Director of the Center for Reading and Language Research, Tufts University