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Children's storytelling technologies:
Differences in elaboration and recall

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Abstract

This study examined the elaboration and recall of children's stories through an analysis of the content and structure of children's retelling of a wordless picture book. The book was presented to 72 children (ages 6-7) in England and Sweden. Using a between subjects design, each child was presented with either a paper version of the picture book, a computer presentation with traditional hyperlinks, or a computer presentation with panning and zooming. The technology that was used was KidPad, a children's spatial storytelling application (Druin et al., 1997). Results revealed that the computer presentation with panning and zooming offered benefits in elaboration and recall by means of more complex story structure and a greater understanding of initiating events and goals.

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Storytelling has been a subject of inquiry by researchers from many disciplines, including education, history, anthropology, sociology, psychoanalysis, psychology, linguistics, management science, and religion (McCabe & Peterson, 1991). In the areas of children's cognitive, social, and emotional development, research on storytelling and narrative enjoys a long, rich tradition. Developmental psychologists have used narratives to study children's emergent literacy and early language socialization and discourse ability (Bamberg, 1997; Budwig, 2001).

Narratives are important in the development of literacy (DeHirsch et al., 1966; Meek, 1982). Storytelling has been shown to support the development of children's writing, reading, vocabulary, listening skills and other language abilities (e.g., Baker & Greene, 1977; Cass, 1967; Ellis & Brewster, 1991; Grugeon & Gardner, 2000; Malkina, 1995; Wright, 1995). Children's participation in storytelling facilitates the recall of content and facts (George & Schaer, 1986), assists in comprehension (Malkina, 1995), and contributes to listening and concentration skills (Baker & Greene, 1977; Ellis & Brewster, 1991). Storytelling offers an opportunity for creative and artistic expression (Ellis & Brewster, 1991; Sawyer, 1962), the development of a sense of self and well-being (Bettelheim, 1976; Campbell, 1988; Erikson, 1950; Wigren, 1994), and exposure to ethical value systems (Scott, 1971).

In the area of children's technologies, researchers in academia and industry are currently developing tools that support children's storytelling. Technology is becoming increasingly significant in the life of a child. More than ever, teachers and parents are looking to computer

technologies to support learning activities for their students and children. In the United States, public schools have spent more than $27 billion on computer technology and related expenses in the last five years alone (QED, 2000). Between 1990 and 1998, the ratio of computers in K-12 schools dropped from one for every twenty students to one for every six students (U.S. Department of Education, 1999). While much is known about the nature of children's storytelling with traditional tools, little is known about the ways in which new computer technologies support storytelling.

Many educational organizations are calling for educators to critically examine the impact of technology on children and to use technology to benefit children in very specific ways (Alliance for Childhood, 2000). Further, educators are encouraged to endorse the development of technologies that accommodate the needs of learners with different abilities. Thus, there is a need to understand how children use technology as a way of enhancing children's narrative abilities.

The purpose of the current study was to understand how different storytelling media might support young children in their ability to comprehend and orally re-tell stories. Our goal in exploring this area of storytelling was not to illustrate that any one particular media was better than another. Instead, our focus was to systematically and empirically determine the ways in which different forms of media affect children's ability to understand a story's content and structure.

Within this study, we defined storytelling as the oral process of conveying meaning regarding temporally sequenced events. Aspects of this definition are commonplace in research into storytelling (e.g. Labov, 1972; Engel, 1999; McCabe & Peterson, 1991). Labov (1972) defines a minimal narrative as "a sequence of clauses… containing a single temporal juncture" (p. 360-361). McCabe and Peterson (1991) describe narrative as "the oral sequencing of temporarily

successive events, real or imaginary" (p. ix.). Engel (1999) defines narrative as "an account of experiences or events that are temporally sequenced and convey some meaning…can be of an imagined or a lived everyday event" (p. 19). Common themes include the concepts of a sequence of events involving the passage of time and the conveying of meaning. In addition, we will be considering both the structure and content of children's stories. Although researchers typically focus on either structure, content, or process (Engel, 1999), our approach represents an effort to be more inclusive.

In the current study, KidPad, a spatial storytelling tool for children (Benford et al., 2000), was used to better understand the nature of children's storytelling. KidPad is a zooming storytelling tool that enables children to individually or collaboratively create stories (Druin et al., 1997). The KidPad software is not limited to a "page at a time" storytelling experience, but rather, it enables young children to zoom and pan through a story, making visual connections between characters, objects, places, and events in a narrative. We have been interested in how the unique spatial features of the KidPad software might compare with more traditional storytelling technologies, such as turning pages in a book or navigating hyperlinks on the web.

In KidPad, the narrative structure of a story is defined by creating spatial hyperlinks between objects on the canvas. Through these hyperlinks, a child is able to move quickly, or "zoom", from one object to another (see Figures 2 and 3). Zooming from one story object to the next "makes visually explicit where children are going and where they have been" (Druin, 1999, p. 598). In contrasting traditional web links and KidPad hyperlinks, children have said that with KidPad "you clos[e] your eyes and when you open them you're in a new place. Zooming lets you keep your eyes open" (Druin, 1999, p. 598). The zooming function "invites travelling into the drawing, thus creating an invitation for narrative elaboration" (Harvard, 2000, ¶18). In talking

about such non-linear applications, the Cognition and Technology Group at Vanderbilt (1996) claims that nonlinear formats "enable students to engage in different kinds of knowledge construction activities than would be possible with strictly linear applications" (p. 821).

In the KidPad environment, users explore a space where images and movement are used to draw attention to the relationship among concepts. The KidPad environment organizes visual information in such a way that makes relationships among images and concepts salient. Benford et al., (2000) assert that KidPad enables the creation "of links and zooming between pictures and scenes or zooming deeper into scenes. These story representations might make salient the links between scenes and the overall structure of the story" (p. 557).

An illustration of KidPad's spatial hyperlinks and "zooming" is provided by the sequence of images presented in Figure 1, 2 and 3. In Figure 1, the KidPad canvas with local tools and a hyperlink, which rests on an opened book, is illustrated. In Figure 2, the endpoint of the hyperlink or the "zoomed in" version of the book is shown. In Figure 3, another hyperlink takes the user from a picture on the book's page into the image.

Various theories of learning lend support to the relevance of spatial storytelling technologies. In schema theory, our cognitive structures enable us to process new information, to understand, and to learn. Cognitive structures provide meaning to experiences. Rumelhart & Ortony (1977) define schemata as "data structures for representing the generic concepts stored in memory. They exist for generalized concepts underlying objects, situations, events, sequences of events, actions, and sequences of actions" (p. 101). Further, Rumelhart (1980) states that schemata "represent all levels of our experience, at all levels of abstraction" (p. 41). Spatial environments, such as KidPad, may enable users to build schema, by exploring spaces where images and movement draw attention to the relationship among concepts.

Mental models provide another view on learning in the cognitive tradition with potential application to this technology. A mental model is a representation of a specific idea based on existing knowledge of something physical or a semantic version shown in a text. Johnson-Laird (1983) asserts that a mental model "represents a state of affairs and accordingly its structure is not arbitrary like that of a prepositional representation, but plays a direct representational or analogical role. Its structure mirrors the relevant aspects of the corresponding state of affairs in the world" (Johnson-Laird, 1983, p. 98).

We proposed that the spatial capabilities of KidPad would enable children to create more complex story structure and encode an increased level of story content. Further, KidPad's spatial environment and features would enable users to build a mental model of stories by organizing visual information in such a way that makes relationships among images and concepts salient. One possible reason for differences lies in the zooming feature and the spatial environment, as a new opportunity to navigate through story information. Therefore, we expected to see structure and content differences in story re-telling due to the spatial or non-spatial capabilities of the story technology.

We also predicted that KidPad's unique 2 1/2D spatial environment would provide an opportunity for both genders to perform in an equal manner. Previous research on children's spatial skills has shown that gender differences between boys and girls in spatial relations is strong, with boys outperforming girls. Adolescence was considered to be the time at which boys began performing better than girls in spatial skills (Peterson, 1976; Waber, 1976). Although gender differences may be declining (Linn & Peterson, 1985), a recent study suggests that gender differences in spatial skills begin as early as preschool. In this study, boys and girls between four and seven years of age were given the task to mentally rearrange pictures of simple shapes,

and by 4 ½ years of age, boys were more accurate and efficient in their responses than girls (Dodge, 1999). Based on previous research, one might expect boys to outperform girls in this study's storytelling tasks. However, we hypothesized that KidPad's spatial environment would not require the same level of cognitive effort that is required of typical three-dimensional environments and tools, thereby providing strong storytelling opportunities for both genders. In addition, since the participants in our study are monolingual and bilingual, we conducted an exploratory look at the differences in storytelling in relation to the variable of language.

Method

Participants

The children in this study were evenly divided between the two participating schools located in Sweden and England, respectively. Within the schools, participants were randomly assigned to one of three conditions. The participants were from a larger project involving two participating schools.

There were a total of 72 children (ages 6-7), with 36 in both locations. In England, the age range was 6.4 to 7.3 with a median of 6.7. In Sweden, the age range was 6.0 to 7.9 with a median of 7.1. Participants were fairly evenly divided between genders, with 37 boys and 35 girls represented in the study. The sample consisted of children with little or no previous exposure to KidPad, the technology being utilized in this study.

Many of the participants in this study were bilingual. Twenty-five of the 36 Swedish participants spoke first languages other than Swedish, while in England one of the 36 participants was bilingual.

Design and Procedure

A between subjects design was employed for this study. Each participant was provided with one of three versions of a wordless picture book: (a) a paper version of the picture book, (b) a computer presentation of the book with traditional hyperlinks—Non-Spatial KidPad, or (c) a computer presentation of the book with panning and zooming between pictures—Spatial KidPad.

For the Non-Spatial KidPad condition, a special version of KidPad was developed that did not take advantage of the spatial zooming/panning capabilities. Instead, the story jumped instantaneously from image to image with participant input. For the Spatial KidPad condition, the full set of KidPad features was utilized. In this condition, the zooming, panning, and fading features were used to appropriately fit the narrative content of the scene.

The picture book that was utilized in this study was *Frog, Where Are You?* (Mayer, 1969). This children's book has been used in many previous international studies (e.g., Bamberg, 1987; Berman, 1987, 1988; Cameron & Wang, 1999; Trabasso et al., 1992).

To get a sense of the overall way the images looked in the physical book and on the computer, refer to Figures 4, 5, and 6. Figure 4 is a scanned image of scene 9 of the physical book, where the boy is looking at a hole. Figure 5 illustrates the corresponding image in KidPad, which is considered the "content equivalent" of this particular scene. Figure 6 is the zoomed image.

After looking at the wordless story, each participant was asked to perform an elaboration task and a recall task. In the elaboration task, participants were asked to tell the story, going a "page" at a time for the physical book condition or an "image" at a time for the KidPad conditions. For this task, the participants had the book pages or the computer images in front of them during the entirety of their narration, and they looked at the pictures as they told the story. This enabled us

to see children's elaborations upon the picture book, their language choices as they interacted with the page in the "here and now". This procedure is typical of previous research studies of this type (Berman, 1988; Trabasso et al., 1992). Meanwhile, in the recall task, participants were asked to tell the story without the book or computer in front of them. This offered us a window onto children's recall of the contents of the pictures from memory.

It should be noted that the story images were exactly the same for the Non-Spatial KidPad condition and the Spatial KidPad condition. In addition, in recreating these images in KidPad, every effort was made so that the scenes from the technology versions would be as identical as possible to the paper version of the book. This was aided by the scanning of images directly from the physical book into the computer.

The data were collected by three adults in the school settings. In all cases, the child participant was unfamiliar with the adult. The individuals who collected the children's stories were fluent in the particular culture's native language. In Sweden, the participants told stories in Swedish and the story collector was a native Swedish speaker. In England, the participants told stories in English and the story collector was a native English speaker.

The participants' stories in Sweden were translated to English prior to analysis. Since the analysis did not occur in the native language, it is possible that some nuances of the stories were lost. Every effort was made to ensure that the translations were accurate and details through the employment of a translator who was highly fluent in both Swedish and English.

Measures

Children's story elaboration and recall were coded using two previously developed instruments (Berman, 1988; Trabasso et al., 1992). Assessments were conducted on the resulting narratives to determine their level of story structure and content. All narratives were coded and

analyzed by this paper's first author. An interrater agreement was established for each of the two coding schemes used in this study. Four coders analyzed four stories each to create a total of 16 coded stories, which represents 22% of the total number of stories gathered in this study. The structural coding scheme received an interrater agreement of 91% and the content coding scheme received an interrater agreement of 89%.

Narrative structure. To understand narrative structure, Berman's coding scheme (1988) was used to investigate how children of various ages talk about events that form part of an ongoing narrative. In Berman's study, the *Frog Where Are You?* picture book (Mayer, 1969) was used to perform a plot component analysis of children's narratives. Evidence for overall narrative organization was provided by the following measurements categories: text length, number of references to plot advancing events, number of references to plot summations, types of connectivity markers, and use of verb tense. Text length was determined by the number of clauses per narrative, where a clause referred to "any unit that contain[ed] a unified predicate… (that is) a predicate that expresse[d] a single situation (activity, event state)" (Berman, Slobin, et al., 1986, p. 37).

Plot advancing events were measured by specific mention of three important parts of the story. The first component referred to the initial event chain or the onset of the problem. The second component referred to the search motif or the goal. Lastly, the third component referred to the resolution of the problem. Each participant was given a score depending upon how many of these corresponding elements were mentioned explicitly.

Plot summations were indicated by three orientations toward a search motif, namely, search initiation, sustained search, and encapsulation. Search initiation was indicated by the number of explicit references to the fact that when the boy and his dog walked out into the forest, they

began a search. Expression of a sustained search required explicit, repeated mention of a search. Lastly, encapsulation involved summarizing formulations.

Connectivity markers involved the use of linguistic forms that marked the shift from one situation to another in the continuing narrative. The three kinds of clause initial markers are deictics, sequentials, and subordinates. Deictics were words which express the time or place, such as "here" and "now". Sequentials were words that expressed movement or transition in the story, such as "then" and "suddenly". Lastly, subordinates reflected temporal and logical statements, such as "when", "while", "because", and "so". Verb tense was measured by the "dominant tense" in each narrative, "defined as 75% or more incidences of either present or past tense verb forms out of all the verbs in the narration, not counting infinitives, imperatives, or future tense forms" (Berman, 1988, p. 484).

Narrative content. To investigate narrative content, Trabasso et al.'s coding scheme (1992) was used in the present study of children's narrations. In this analysis of content, the *Frog, Where Are You?* picture book (Mayer, 1969) was used to examine children's ability to create a coherent narrative around a hierarchical goal plan. This understanding of goals was built around five events. First, the protagonist had a relationship to an object, state, or activity. For example, the protagonist possessed a valued object. Second, the protagonist underwent an undesirable state change, relative to the valued object, state or activity, which initiated a goal and goal plan. In particular, the protagonist lost the valued object. Next, the protagonist carried out actions relevant to the goal of altering the undesirable state change. For example, the protagonist tried to repossess the lost object through carrying out a plan to search for it. After this, the protagonist continued attempts to attain the goal in the face of failure. In particular, the protagonist made multiple failed search attempts. Lastly, the protagonist's attempts finally resulted in the

successful attainment of the goal. For example, the protagonist found and repossessed the lost object (from Trabasso et al., 1992, p.139).

Results

Narrative structure and content were analyzed through multivariate analysis of variance. A series of 2 X 2 X 3 (Language X Gender X Media type) MANOVAs were run to determine any significant effects on children's storytelling structures and content. We first report the results by coding area, specifically elaboration and recall measures, and then we discuss the results by effect area, namely media type, gender, and location.

Coding Area

Elaboration-structure. Analysis of children's narrative structure for the elaboration task revealed significant main effects for Media Type, $\underline{F}(14, 108) = 2.54$, $\underline{p} < .01$ and Language, $\underline{F}(7,54) = 3.25$, $\underline{p} < .01$. The multivariate and univariate statistics from these analyses are presented in Tables 1 and 2. Table 1 reveals significant outcomes in Media Type for clauses, references to plot advancing events, sequentials, and subordinates. For Language, there was a significant outcome in the category of sequentials.

As shown in Table 2, the corresponding means indicate that participants who used Spatial KidPad ($\underline{M} = 77.38$) scored significantly higher than those using the physical book ($\underline{M} = 39.25$) in clauses. In addition, participants who used Spatial KidPad ($\underline{M} = 5.00$) and those using Non-spatial KidPad ($\underline{M} = 4.88$) scored significantly higher than those using the physical Book ($\underline{M} = 3.71$) in references to plot advancing events. Lastly, with regards to subordinates, participants using Spatial KidPad ($\underline{M} = 5.92$) scored significantly higher than those using Non-Spatial KidPad ($\underline{M} = 2.08$) and those using the physical book ($\underline{M} = 1.50$). For Language, bilingual

participants (M = 16.80) scored significantly higher than monolingual participants in the category of sequentials (M = 9.62).

Multivariate tests on elaboration-structure illustrated no significant overall effects on Gender, F(7,54) = 1.30, p> .05. In addition, there were no significant interactions. Meanwhile, in terms verb tense variable, participants narrated more frequently in present tense while using Spatial KidPad (46%) and the physical book (58%), while those using Non-Spatial KidPad utilized past tense most often (54%).

Elaboration-content. Analysis of children's narrative content for the elaboration task revealed a significant main effect for Media Type, F(8,114) = 2.25, p< .05. The multivariate and univariate statistics from these analyses are presented in Tables 3 and 4. As illustrated by Table 3, results reveal a significant outcome in the area of initiating events. Table 4 presents means indicating that participants who used Spatial KidPad (M = 4.25) scored significantly higher than those using the physical book (M = 3.08).

In regards to Language, multivariate tests reveal no significant overall effect on the measures, F(4,57) = .83. p > .05. In addition, there were no differences in Gender, F(4,57) = 1.80, p > .05. There were no significant interactions.

All participants who used Spatial KidPad and the physical book mentioned the frog at the start of narration, while one participant using Non-Spatial KidPad did not. Meanwhile, 21% of participants using Spatial KidPad, 33% of participants using Non-Spatial KidPad, and 29% of the participants using the physical book mentioned the boy's possession of the frog at the start of narration.

When considering the subordinate goal, 79% of participants using Spatial KidPad encoded this information, as opposed to 75% for Non-Spatial KidPad and 21% for the physical book. On the other hand, for the superordinate goal, 71% of participants using Spatial KidPad encoded this information, as opposed to 67% for Non-Spatial KidPad and 33% for the physical book.

Recall-structure. Analysis of children's narrative structure for the recall task revealed significant main effects for Media Type, $\underline{F}(14, 108) = 2.29$, $\underline{p} < .01$ and Language, $\underline{F}(7, 54) = 3.17$, $\underline{p} < .01$. The multivariate and univariate statistics from these analyses are presented in Tables 5 and 6. As illustrated by the data presented in Table 5, there were significant outcomes in clauses, references to plot advancing events, sequentials, and subordinates for Media Type. In Language, significant outcomes occurred in deictics and sequentials.

The means in Table 6 indicate that participants who used Spatial KidPad and those using Non-Spatial KidPad scored significantly higher than those using the physical book in clauses ($\underline{M} = 39.79$, $\underline{M} = 40.54$, and $\underline{M} = 16.71$, respectively), references to plot advancing events ($\underline{M} = 4.54$, $\underline{M} = 4.42$, $\underline{M} = 2.75$, respectively), and sequentials ($\underline{M} = 12.38$, $\underline{M} = 12.38$, $\underline{M} = 4.96$, respectively). In addition, participants who used Spatial KidPad ($\underline{M} = 2.96$) scored significantly higher than those using the physical book ($\underline{M} = .92$) in subordinates.

Bilingual participants scored significantly higher than monolingual participants in the areas of deictics ($\underline{M} = .28$, $\underline{M} = .00$, respectively) and sequentials ($\underline{M} = 13.00$, $\underline{M} = 8.26$, respectively). Tests revealed no significant overall effects upon Gender, $\underline{F}(7,54) = .78$, $\underline{p} > .05$. There were no significant interactions.

Recall-content. Analysis of children's narrative content for the recall task revealed a significant main effect for Media Type, $\underline{F}(8, 114) = 2.96$, $\underline{p} < .01$. The multivariate and univariate statistics from these analyses are presented in Tables 7 and 8. Table 7 shows significant

outcomes for initiating events and failures. The means in Table 8 indicate that participants who used Spatial KidPad and those who used Non-Spatial KidPad scored significantly higher than those who used the physical book in initiating events ($\underline{M}$ = 3.38, $\underline{M}$ = 3.25, and $\underline{M}$ = 1.83, respectively) and failures ($\underline{M}$ = 3.79, $\underline{M}$ = 3.50, and $\underline{M}$ = 1.92, respectively).

There were no significant overall effects on Language, $\underline{F}(4,57) = .59$, $\underline{p} > .05$ or Gender, $\underline{F}(4,57) = .75$, $\underline{p} > .05$. There were no significant interactions. In addition, all participants who used Spatial KidPad and Non-Spatial KidPad mentioned the frog at the start of narration, while all but two participants who used the physical book did the same. Meanwhile, 38% of participants who used Spatial KidPad mentioned the boy's possession of the frog, as compared to 58% of Non-Spatial KidPad participants and 38% of physical book participants.

When looking at the subordinate goal, 75% of participants who used Spatial KidPad encoded this information, as opposed to 63% for Non-Spatial KidPad and 42% for the physical book. With regards to the superordinate goal, 42% of participants who used Spatial KidPad encoded this information, in contrast to 58% of the Non-Spatial KidPad participants and 29% of the physical book participants.

Effect Area

Media type. Media type had a significant effect on all four categories of measures: elaboration-structure, elaboration-content, recall-structure, and recall-content. In this study, the computer conditions led in all categories of measures where there were significant differences. Participants who used the physical book did not score significantly higher than those who used Spatial (KidPad with panning and zooming) or Non-Spatial KidPad (KidPad without panning and zooming).

In what categories did the technology, in general, make a difference? Participants who used Spatial or Non-Spatial KidPad scored better than the physical book in a number of areas, particularly in the structure measures. In elaboration, participants who used Spatial and Non-Spatial KidPad scored significantly higher in one of the seven structure measures, namely, references to plot advancing events. Meanwhile, in recall, participants who used Spatial and Non-Spatial KidPad scored significantly higher in three of the seven structure measures, particularly, clauses, references to plot advancing events, and sequentials. These participants also scored significantly higher in two of the four measures, namely, initiating events and failures. These benefits are not a commentary on the spatial environment of KidPad or on its animation features. Since these benefits were present in both KidPad conditions, we may, be witnessing children who are enthusiastic with using technology.

Research has shown that technology appears to have an intrinsic appeal to children. Interestingly, Cameron and Wang (1999), who used *Frog Where are you?* to examine the differences in telling a narrative over the telephone and face-to-face, also showed media to have a significant overall effect, while gender had no significant effect. It may be that children approach technology, even an ordinary telephone, with a level of interest that is not always the case with traditional print-based media.

In what areas was Spatial KidPad particularly advantageous? Results reveal that the spatial environment of KidPad may have assisted in building story structure and in understanding goals, predominantly in elaboration tasks. In elaboration, participants using Spatial KidPad performed well in the structure areas of clauses and subordinates, and in the content areas of initiating events, subordinate goal, and superordinate goal. In recall, these participants performed well, again, in the structure area, subordinates and, again, in the content area, subordinate goal.

KidPad seems to have provided an opportunity to build more complex structures and to better understand the goals and some of the events in the story.

What these results lead us to believe is that the zooming, panning, and fading features of KidPad may enable children to develop a more complex story schema and encourage increased story content by providing a spatial awareness of the narrative's features. By not limiting the narrative to a "page at a time" experience and by presenting the pictures in a non-sequential format, children may make increased connections between characters, objects, places, and events in the story, resulting in the increased building of story structure and increased encoding of story content. Learning theories, which might explain these possible differences, are schema theories (Rumelhart & Ortony, 1977; Rumelhart, 1980) and mental model theories (Johnson-Laird, 1983).

Gender. In regards to gender, there were no significant differences in any measures.

Language. In elaboration, language was significant in one of the seven structure measures, sequentials. In recall, language was significant in two of the seven structure measures, specifically, deictics and sequentials. Language was not significant in any of the content measures.

Since there were no significant interaction effects, we cannot say that these differences in language were associated with the use of one specific media type- KidPad or the physical book. However, the results show that bilingual participants performed better in all of the measures where significant differences were seen. These areas measured the complexity of connectivity markers, namely deictics, sequentials, subordinates.

Bilingual participants may have been "freed" by the lack of text in the picture book story. Without text, participants did not need to translate "in their heads" from their native language to

their second language, prior to telling their narratives. Instead, the wordless picture book may have been a somewhat less complex, demanding task, thereby offering opportunities to build more complex story structure.

Some of the language differences witnessed here may be the result of environmental factors across these institutions. The two schools in this study represent two unique environments set in different cultural contexts. Additional study to identify the impact of KidPad upon children with varying levels of language acquisition would be needed to further understand these differences.

Discussion

This study was conducted to understand how different story media might support children's story construction. This research reflects the growing need for increased evaluation of children's storytelling technologies. As designers and educators, we need to know our technologies well and be able to identify the specific skills that are supported. We should not assume that a particular technology is effective for teaching in all contexts or with all skills. In this particular study, KidPad supported specific skill areas with more benefits apparent in elaboration than in recall. As evidenced by this study, different types of media support different kinds of storytelling tasks. This needs to be kept in mind when we select technologies for the teaching of storytelling and for the broader field of literacy instruction.

Based on our experiences with this study, the use of animation in many storytelling media, such as television, may not aid in our recall of the information that is presented. However, if the technology is to be used as a presentation tool for storytelling elaboration, then spatial storytelling may be quite effective. Interestingly, our understanding of children's abilities in narrative structure is to date very much based on research using traditional print books. Little is

known about how spatial storytelling technologies affect the construction of narratives. As children are becoming more immersed more spatial technologies, research in this area is vital.

When it comes to storytelling, the use of technology appears to have an inherent appeal for children. Since the physical book did not outperform the technology in any measures, we see a picture of children who are eager to engage in technology. This is an important finding, since many educators are currently questioning the role and benefits of technology for young children.

The lack of gender differences in this study adds to the growing body of research in the area of children's spatial skills (Hyde, 1981; Linn & Peterson, 1985; Peterson, 1976; Waber, 1976). If gender differences in spatial skills begin as early as four years of age, then why were these differences not observed in the six and seven-year old participants in the present study? The particular study tasks or measures may not have brought to the surface potential gender differences. Recent evidence suggests that gender differences occur before adolescence for only certain kinds of spatial tasks and that gender differences in spatial ability are dependent upon the nature of the measure (Linn & Peterson, 1985). Gender differences in spatial ability which favor males "are large for mental rotation; they are medium for spatial perception and small for spatial visualization" (Eisenberg et al., 1996, p. 370).

Another possibility for the lack of gender differences may rest in the precise nature of KidPad's spatial environment. Although previous research (Dodge, 1999) might suggest the potential presence of gender differences related to the use of KidPad, the lack of gender differences in this study may be an indication that KidPad's spatial environment demands less cognitive effort that is required with typical three-dimensional environments or tools. KidPad is a 2 ½ D environment, which may be an easier place to build structure and encode information. As a result, KidPad's unique environment may put both genders on equal footing.

Although the present study did not formally investigate motivation, it may also be a factor. Storytelling with the use of computer technology may actually generate high interest and engagement, regardless of gender. Perhaps, this appeal that bridges the gap between genders. Further research is needed to identify and understand gender effects related to the use of KidPad.

In terms of the study's limitations, there were some challenges in adapting the *Frog, Where Are You?* picture book to a computer environment. Transporting a linear story to a spatial environment required some tradeoffs. Although every effort was made to duplicate the images from the picture book to the computer file, there were instances where some context was lost or gained. The images in KidPad were in color, whereas the images in the physical book were monochromatic. In addition, some of the transitions and animations were not as smooth as desired. This certainly did not work in favor of the spatial file, so any benefits may be that much more evident. Improvements in the software were suggested as a result of re-creating this story in KidPad's environment. This study enabled us to learn more about KidPad from a technical development standpoint, as well.

Many opportunities exist for extensions of this research. The impact of KidPad with different age groups and different kinds of storytelling tasks are an important area for future study. Research with KidPad might ask participants to create the KidPad stories, rather than merely retell them. As stated by Engel (1999), "when children tell stories with the only goal to fulfill the request of an experimenter or teacher, conventional story characteristics are salient. When children tell stories they are eager to tell, that are about content that matters to them, they may use conventions to help shape the story, but they are also more likely to depart from convention in order to get across their particular fantasy or fiction" (p. 110).

The issue of children's control of the storytelling content and situation may have particular application in regards to spatial environments. Adult-controlled spatial experiences have been shown to hinder the development of spatial understanding, but children's opportunity for the investigation of space under their own command has been found to encourage spatial knowledge (Poag et al., 1983).

Another important area for future research involves looking at collaborative storytelling. Studies that investigate the "co-present collaboration" features of KidPad (Benford et al., 2000), where multiple children are able to simultaneously create stories, may contribute to our understanding of children's collaborative processes. Although a rich body of literature exists regarding children's collaborations with their peers, including the nature of children's friendship processes and peer group acceptance (Rubin et al., 1998), little of this research has been applied to the world of children's collaborative storytelling with or without technology.

In addition, future study into the effects of KidPad with children with varying levels of Kidpad experience would be beneficial. The stories of children who use spatial storytelling technologies after they have engaged frequently in this environment may be very different than those of novice users. It's important to discover if frequent use of spatial storytelling technologies effects the ways in which children create and share stories by means of other storytelling media and in other environments.

Finally, further evaluation could be considered to identify the underlying learning processes at play and to study the learning theories that are at the heart of KidPad's design. As Wood (1988) states, "any limitations of the theory will be inherited by the system" (p. 295). Further, "if we are to be intelligent users of such systems in education, and not simply dupes of a hard sales pitch, then we must measure their promise against our general knowledge of how children think

and learn" (p. 295). We need to continue to evaluate storytelling technologies and to make efforts to incorporate established principles of learning and instruction from many domains into the development process.

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Table 1

Analysis of Variance for Elaboration-Structure

		F						
Effect	df	CL	PAE	SI	SS	DE	SE	SU
				Between subjects				
Media (M)	2	4.57*	7.49**	0.43	2.04	0.24	3.48*	4.65*
Language (L)	1	1.02	3.89	1.17	0.42	0.25	5.91*	0.74
Gender (G)	1	2.78	0.16	1.00	2.56	0.76	3.53	0.12
M*L	2	0.07	0.54	0.49	0.04	0.18	2.05	0.31
M*G	2	0.15	1.03	1.43	3.69	0.08	1.12	0.19
M*L*G	2	0.05	1.23	0.23	0.33	0.83	0.06	0.21
L*G	1	1.14	0.19	3.38	0.53	1.31	0.10	1.54
Error	60	(1623.61)	(1.53)	(0.32)	(3.71)	(8.91)	(156.79)	(26.73)

Note. CL = clauses; PAE = plot advancing events; SI = search initiation; SS = sustained search DE = deictics; SE= sequentials, SU= subordinates. Values enclosed in parentheses represent mean square error. Wilks' Lambda was utilized.

*p < .05. **p < .01.

Table 2

Means and Standard Deviations for Elaboration-Structure

	Media Type					
	Spatial KidPad		Non-Spatial KidPad		Physical Book	
	M	*SD*	*M*	*SD*	*M*	*SD*
Clauses	77.38	60.22	63.88	28.17	39.25	18.37
Plot Advancing Events	05.00	01.25	04.88	01.12	03.71	01.40
Search Initiation	00.54	00.66	00.46	00.51	00.54	00.51
Sustained Search	01.63	02.90	00.79	01.38	00.63	00.97
Deictics	01.63	03.19	01.38	03.23	01.00	02.21
Sequentials	13.63	17.39	15.17	12.73	07.54	06.61
Subordinates	05.92	07.98	02.08	02.69	01.50	01.59

Note. N=72

Table 3

Analysis of Variance for Elaboration-Content

		F			
Effect	df	IE	AT	PAT	FA
			Between subjects		
Media (M)	2	4.02*	3.35*	2.92	2.48
Language (L)	1	2.14	0.10	0.19	0.79
Gender (G)	1	1.02	0.56	5.10	2.86
M*L	2	0.48	2.49	0.22	1.72
M*G	2	1.45	0.16	0.98	0.30
M*L*G	2	0.26	1.55	0.54	0.71
L*G	1	0.34	1.06	1.81	0.19
Error	60	(1.90)	(7.60)	(11.33)	(2.86)

Note. IE = initiating events; AT = attempts, PAT = purposeful attempts; FA = failures. Values enclosed in parentheses represent mean square error. Wilks' Lambda was utilized.

* $p < .05$. ** $p < .01$.

Table 4

Means and Standard Deviations for Elaboration-Content

	Media Type					
	Spatial KidPad		Non-Spatial KidPad		Physical Book	
	M	*SD*	*M*	*SD*	*M*	*SD*
Initiating Events	4.25	1.36	3.38	1.31	3.08	1.41
Attempts	4.54	3.09	5.42	2.99	3.67	2.24
Purposeful Attempts	4.38	4.97	2.88	2.25	2.08	1.95
Failures	5.38	1.71	5.13	1.42	4.54	1.89

Note. N=72

Table 5

Analysis of Variance for Recall-Structure

		F						
Effect	df	CL	PAE	SI	SS	DE	SE	SU
				Between subjects				
Media (M)	2	09.78**	08.36**	00.08	01.09	00.51	06.84**	04.19*
Language (L)	1	00.01	00.08	00.06	00.01	09.04**	05.09*	00.76
Gender (G)	1	00.05	00.03	00.08	00.16	00.10	00.63	02.62
M*L	2	00.20	00.26	01.26	00.46	01.25	01.13	00.17
M*G	2	00.25	01.22	00.24	00.53	00.87	00.23	02.73
M*L*G	2	00.73	01.96	05.00	01.63	01.96	00.35	01.08
L*G	1	00.80	00.01	00.21	02.66	00.06	00.02	03.33
Error	60	(411.62)	(2.22)	(0.25)	(2.27)	(0.12)	(71.79)	(4.77)

Note. CL = clauses; PAE = plot advancing events; SI = search initiation; SS = sustained search DE = deictics; SE= sequentials, SU= subordinates. Values enclosed in parentheses represent mean square error. Wilks' Lambda was utilized.

* $p < .05$. ** $p < .01$.

Table 6

Means and Standard Deviations for Recall-Structure

	Media Type					
	Spatial KidPad		Non-Spatial KidPad		Physical Book	
	M	*SD*	*M*	*SD*	*M*	*SD*
Clauses	39.79	25.93	40.54	17.67	16.71	12.23
Plot Advancing Events	04.54	01.25	04.42	01.38	02.75	01.78
Search Initiation	00.33	00.56	00.42	00.50	00.38	00.49
Sustained Search	00.79	02.34	00.54	01.14	00.17	00.38
Deictics	00.17	00.28	00.17	00.48	00.15	00.28
Sequentials	12.38	10.81	12.38	08.88	04.96	04.32
Subordinates	02.96	02.90	02.13	02.29	00.92	01.28

Note. N=72

Table 7

Analysis of Variance Recall-Content

		F			
Effect	df	IE	AT	PAT	FA
		Between subjects			
Media (M)	2	9.47**	3.13	1.87	7.78**
Language (L)	1	0.45	0.61	0.64	0.39
Gender (G)	1	0.00	2.45	0.02	1.46
M*L	2	1.40	1.76	0.12	0.81
M*G	2	0.88	1.78	1.22	1.54
M*L*G	2	1.83	0.36	1.49	3.02
L*G	1	1.42	2.14	1.23	0.17
Error	60	(1.87)	(4.03)	(4.28)	(2.96)

Note. IE = initiating events; AT = attempts, PAT = purposeful attempts; FA = failures. Values enclosed in parentheses represent mean square error. Wilks' Lambda was utilized.

* $p < .05$. ** $p < .01$.

Table 8

Means and Standard Deviations for Recall-Content

	Media Type					
	Spatial KidPad		Non-Spatial KidPad		Physical Book	
	M	*SD*	*M*	*SD*	*M*	*SD*
Initiating Events	3.38	1.44	3.25	1.29	1.83	1.43
Attempts	2.25	1.92	2.63	2.52	1.38	1.66
Purposeful Attempts	1.33	1.88	1.96	1.99	1.13	1.23
Failures	3.79	1.96	3.50	1.72	1.92	1.69

Note. N=72

Figure Captions

Figure 1. KidPad screen, with local tools and hyperlink.

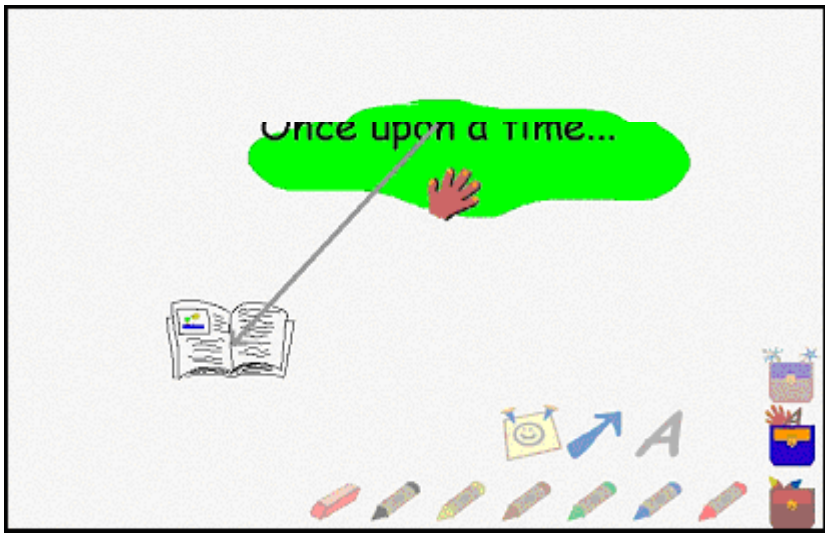
Figure 2. KidPad screen, end location of hyperlink.

Figure 3. KidPad screen, next screen in sequence.

Figure 4. Scanned image of scene 9 from paper book, *Frog, Where Are You?* (Mayer, 1969).

Figure 5. Content equivalent of scene 9 in KidPad computer files.

Figure 6. Zoomed image of scene 9 in Spatial KidPad file.


Once upon a Time...