Towards a Model of Technology and Literacy Development: Story Listening Systems

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Abstract: This article lays out a program of research designed to address one specific need of young children – to learn how to write – based on one specific ability of young children – the ability to tell stories. I outline a model that accounts for how non-screen-and-keyboard based technologies that *listen* to children can be used in such a way as to support their emergent literacy behaviors and have an effect on their subsequent writing skills. The model comprises four components: the importance of *emergent literacy behaviors*, which are features of literate language that are demonstrated in children's oral language, the critical role played by a *socially-situated peer*, the design of *non-keyboard-based computational technologies*, and the potential of information technologies that encourage *construction* rather than *consumption*. I describe one kind of technology that fits the model -- the *story listening system (SLS)* – and describe a number of implemented story listening systems and evaluation of their use by children.

"Narrative ability is the single most important language ability for success in school" (Feagans and Appelbaum, 1986: 359)

1. Introduction

The discussion of the role of computational technology in children's development has become increasingly polarized over the last year or so. On the one hand we find a frantic push to place computers and internet access into all U.S. schools (Committee on Information Technology Literacy, 1999), and on the other hand, a frantic *push-back* to place a "moratorium" (Cordes, 2000) on children's access to computers. Clearly the answer lies at neither end of this long spectrum, and a careful review of existent studies shows a number of benefits, a palmful of harmful effects, and a plethora of unknowns (Wartella, O'Keefe et al., 2000). Our own response is that the answer lies in responsible and developmentally informed design and evaluation of technology that specifically targets the needs *and unique abilities* of young children. Computers will not go away, nor should they, as they provide benefits to children that are either unavailable elsewhere, or too resource-intensive otherwise to be practical. History also teaches us that whereas initial fears about movies or radio or television concern the very presence of the medium, it is the content of the medium – the message – that must be evaluated and improved (Bickham, Wright et al., 2001; Wartella and Jennings, 2001). "Computer technology" need not be incompatible with play-based learning, physical activity, active engagement, and social interaction, those features of childhood whose loss computer phobists decry.

This article describes a program of research designed to address one specific need of young children – to learn how to write – based on one specific ability of young children – the ability to tell stories. I lay out a model of how to support children learning how to write through the use of *story listening systems (SLS)*. *(SLS)*. The model depends on four components: the importance of *emergent literacy behaviors*, which are features of literate language that are demonstrated in children's oral language, the critical role played by a socially-situated peer, the design of non-keyboard-based computational technologies, and the potential of information technologies that encourage *construction* rather than *consumption*.

While multiple, and technological, literacies have become the topic of considerable research, reading and writing literacy remain the basis of education, and the prerequisites to science, mathematics, and technology fluency. Effective writing skills are important in all stages of life, from early education to future employment. Nevertheless, many children in the United States lack even basic writing skills. In its *1998 Condition of Education*, the United States Department of Education's National Assessment of Educational Progress found that only 31% of 11th graders (17 year olds) were generally able to write complete, sufficient responses to questions, while only 2% were capable of providing effective, coherent responses (Snyder and Wirt, 1998). Reading and writing skills are not learned only in school, however. Children prepare themselves for later literacy in many important ways long before first grade (Heath, 1983). And preparation for writing literacy consists of more than knowing how to form letters with a pencil. It includes: (1) treating language as an object (metalinguistic awareness (Cazden, 1976)); (2) maintaining cohesion and reference in oral language (to introduce a new character by saying "The man wearing blue" as opposed to "he" . . . but to refer back later by saying "he"); and (3) making one's communicative intentions known (for example, "I'm going to tell you about my day").

Many of these *emergent literacy* (Teale and Sulzby, 1986) skills are first acquired in language play and in storytelling. Many of them are acquired in the context of children's interactions with peers, in early play contexts. Peers push one another to make communicative intentions known clearly (Goncu, 1993) and play a critical role in the acquisition of storytelling skills. For example, Preece (1992) found that children's interaction with each other contributed to the modification, expansion, increased coherence, and complexity of their anecdotes and stories. Preece's study revealed that children are active, alert, engaged, and even aggressive listeners. Educators have begun to recognize the importance of the peer context, and address it through classroom activities such as sharing time (Gee, 1986; Michaels, 1986; Gallas, 1992), round-robin storytelling, and the editor's corner.

Parents also play a role in emergent literacy activities, scaffolding early reading activities by asking questions, expanding children's utterances, and focusing on books with children (Whitehurst, Falco et al., 1988). Only certain cultural contexts (primarily white mainstream/middle class families), however, privilege early literacy connections (Heath, 1986). And teachers often have difficulty accommodating the discourse styles of children whose backgrounds are different from their own (Michaels, 1986). In view of this problem, programs have been started to train parents to support early pre-literacy activities, and these programs have demonstrated successful results (Hinkle, 2000; Singer, 2001), including gains in vocabulary acquisition and the use of decontextualized language when parents are trained to elicit children's narratives. But programs such as these are resource-intensive. In addition, in part because we do not yet know exactly what activities lead to literacy, intervention programs are not as effective as they might be. Knowledge about the bridge between emergent and actual literacy is still partial, particularly where *writing* literacy is concerned. What features of oral language are precursors to what features of written language? In what contexts are these features of oral literacy found? And, how do we design interventions to lead to better writing literacy?

I believe that technology, and particularly tangible non-screen-and-keyboard based technology, can play a unique role in supporting emergent writing literacy activities. In the remainder of this article, I propose a model of technology for literacy, whereby four essential traits allow technology to effectively scaffold literacy. Those four traits are embodied in a suite of technologies that I have developed, called Story Listening Systems, which I then describe. The four traits are to (a) depend on children's oral storytelling skills to bootstrap literacy, (b) introduce peers as playmates **in** the system or with the system, (c) invite the kind of embodied play away from the desktop that is most comfortable for young children, (d) allow children to construct their own personally meaningful content. In order to evaluate the effectiveness of these systems, I rely on three crucial predictors of literacy: (i) using decontextualized language (language removed from its original context, and reworked for a new audience), (ii) gaining metalinguistic awareness, (iii) collaborating with peers to make meaning. In addition to having an effect on these three

predictors, Story Listening Systems can also, I believe, impact children's learning of literacy skills in a fourth way, and that is by participating in a broader definition of emergent literacy in such a way as to successfully scaffold literacy for children whose pre-literacy behaviors don't fit the mainstream model.

2. Background

Wells (1981) describes three broad phases of language development. The first involves the discovery that language is a pattern of sounds that takes on meaning and purpose. In the second phase children come to understand the social aspects of language, that assumptions and values are encoded in particular linguistic representations and that these values are specific to a particular community (e.g., the style of language used on the playground is different from the style of language used at school). These first two phases involve a close link between speaking and doing. Wells describes a third stage of development that involves the creation and manipulation of language designed for an audience that is spatially or temporally separated from the author. Wells calls this stage "literacy," and defines it as the ability to communicate with an audience not in the immediate physical or temporal context.

2.1. Decontextualized Language

Literacy, then, is the ability to make meaning for others across space and time. Only in this stage does language have permanence. It can be use for reflection, memory and sharing meaning with others not currently present. Children's use of literate language occurs, in a sense, the first time *meaning* is separated from *context*. It is in this way that language becomes "decontextualized," or removed from its original context, and reworked for a new audience. Literacy as "decontextualized" language use is a central aspect of the literacy definition used in the current proposal.

Another way of thinking about the aspects of literacy that will concern us here has to do with the distinction between "inside-out literacy skills" and "outside-in" literacy skills (Whitehurst and Lonigan, 1998). The former consists of skills on which are based the actual act of writing: such as phonological awareness, knowledge of how to form letters, and the kinds of punctuation involved in writing. The latter consists of skills which relate to the function and features of writing in the world, and it is those skills that will concern us here. Children's readiness for the outside-in aspects of writing literacy begins in play and storytelling activities that don't explicitly involve the decoding or creation of text. One of the most important outside-in writing literacy skills is the ability to deal with decontextualized language (Snow, 1983). Decontextualization includes the ability to maintain cohesion and reference (Gee, 1985; Michaels, 1986; Peterson, Jesso et al., 1999) through manipulating linguistic devices such as (1) tense and temporal adverbs (e.g., *when, after*), (2) connectives (*but, and, so*), and (3) referring expressions (*she, one*) (Nelson, 1996). In fact, these markers are precisely what teachers look for in school-based discourse (Michaels, 1986). Storytelling is a perfect place for children to practice talk about the "then-and-there" (Scarlett and Wolf, 1979) as they learn to distance objects, actions, and feelings both in thought and in language (Nicolopoulou, 1996). And structuring experience as stories ("narrative thought"), and telling those stories are skills that come naturally to children, who have "an abundant and early armament of narrative tools" (Bruner, 1990: 79).

This description counters the view that the fundamental differences between speaking and writing mean that their acquisition is quite separate. Sulzby (1996) shows that children do not acquire oral and written language in a linear sequence but instead that the two are intertwined. Her model of emergent literacy describes children's language acquisition as the result of co-occurring competency with both oral and written media and the contexts in which they are used. For young children, then, encouragement to both produce oral language for an audience that requires sophisticated use of decontextualized linguistic devices, and to begin to write, may be the most successful approach to integrating the insights of emergent literacy into the classroom.

2.2. The Role of Peers

The "somebody" for whom language is produced is often peers. Although parents certainly introduce the importance and possibilities of writing to children (through writing thank-you notes to relatives, grocery lists, and so forth (Hall, 2000)), it is through interaction with peers that the conception of the other as audience, with its attendant demands for decentered and decontextualized language, matures. In emergent literacy both the cognitive and the social roles played by peers are vital (Damon and Phelps, 1989). The inter-dependence between peers is unique in how it pushes children to take the perspective of the other and to function at a higher level than otherwise. In fact, when two peers collaborate, the simple juxtaposition of their actions appears to allow the peers to modify their understanding of their own actions, through appropriating the perspective of the other peer (Rogoff, 1991). That is, to apply Rogoff's notion to emergent literacy, the very fact of telling a piece of a story that follows after the piece told by one's peer, allows both peers to gain a new understanding of the meaning of their words in the context of the story (Doise, 1990: 46). But peers also serve quite explicit instructional roles with one another in literacy contexts. Neuman and Roskos (1992) observed children engaged in instructional conversation with their peer, negotiating, and coaching each other's literacy activities. Unlike in adult-child instructional conversations, children instructing one another often reversed roles and attributed the role of the more capable peer according to the purpose of the play at hand. Similarly, Stone and Christie (1996) observed children helping each other by modeling, assisting, directing, tutoring, negotiating, affirming, and contradicting each other in literacy activities. In fact, these functions serve a concrete role for both parties: Engaging in peer talk that served a wide range of social functions (from asking questions and initiating text sequences to playing) was positively correlated with the change toward writing in the third person (Daiute, Campbell et al., 1993).

2.3. Metalanguage

Finally, essential for writing literacy is awareness not just of language but also of *metalanguage*. Metalinguistic awareness is the ability to attend to and reflect on the nature, structure and function of language. Even very young children who are just learning to speak demonstrate a kind of metalinguistic awareness when they play with the sounds of language. By the time they are two years old, children begin to play with the words that make up language, often in "conversations" with themselves, when they are alone (Nelson, 1989). Slightly older children engage in similar behavior, but in collaboration with others. Children of this age derive tremendous pleasure from rhyming words ("you silly," "no, you pilly") or words that sound similar (adult: "Indians lived in a teepee"; child: "pee-pee!"). Slightly more complex kinds of metalanguage that imply actual reflection on language, such as the use of puns, which demonstrate a metalinguistic awareness of the multiple meanings of words, have been shown to be important for reading and for written language development (Hiebert and Raphael, 1998). Around the age of four, children begin to acquire metalinguistic awareness of pragmatics – knowledge of different communicative contexts, and the ability to describe language (Shatz and Gelman, 1973; Gombert, 1992). Children of this age begin to mimic accents and different speech styles. In fact, traditional 'reading readiness' measures predict reading ability less well than children's use of more explicit metalinguistic terms such as *say*, *write*¸and *talk* during their spontaneous pre-school play (Pellegrini and Galda, 1993). Three- and four-year old children's use of narrative perspective in "reading" a storybook has been correlated with later academic competence in math (O'Neill and Pearce, in preparation). These terms, and others that introduce reported speech, or bracket instances of embedded language of one kind or another, are important in part because they demonstrate a growing ability to conceive of language as something that is produced by somebody for somebody.

2.4. Broadening the Definition of Emergent Literacy

However, the particular features of narrative most often prized by teachers (e.g., explicit use of linguistic markers and logical sequences) are encouraged primarily in mainstream culture (Gee, 1985; Heath, 1986; Michaels, 1986). For example, traditional African-American oral narrative does not depend on the restricted temporal and causal chain ordering conventions of "school-literate" narrative (Michaels, 1986).

And yet genres of language play and of storytelling exist in all cultural contexts. Despite descriptions of the multicultural aspects of storytelling activities, and some descriptions of their link to children's literacy and other aspects of development (Labov, 1972; Lee, 1992; Miller and Hoogstra, 1992), virtually no attempt has been made to integrate their benefits into the classroom (see (Pinkard, in press), described below, for a notable exception). Indeed, the specific kinds of language play demonstrated by African-American children is sometimes devalued and belittled to such an extent that African-American children lose their desire to participate in the classroom (Michaels, 1981). This is the more the pity since, as Heath (1986) explains, an exposure to many different speech genres is essential for all children. Heath points out that none is inherently more elementary than another, and all students could benefit from having exposure to many types of language activities and genres. And when teachers respect the different discourse and literacy practices in the home, children can be highly successful in school-defined literacy acquisition (Katsarou, 1992).

Many of the activities that we have described as contexts in which literacy emerges are play among children. Play among children of this age group involves the whole body, and yet when literacy-supporting technology is found in the classroom, it typically resides in a desktop computer where an individual child is placed in front of a computer monitor and a keyboard. This makes it difficult both for children to collaborate, and for them to involve their bodies in play. We believe non-screen-and-keyboard technology is important in scaffolding collaboration, and in encouraging verbal, non-verbal and embodied aspects of children's language play. Research in educational technology has not, however, tended to look at the speaking-writing continuum, nor the benefits of storytelling. In the next section we describe research that has come close to the goals laid out in the current proposal.

2.5. Relevant Previous Technological Research

Some other research has addressed technology for literacy, although more previous work has concentrated on technology that supports children's reading rather than their writing. For example, Project LISTEN (Mostow, Aist et al., in press) has demonstrated impressive results with an automated (non-embodied) Reading Tutor that displays stories on a computer screen, and listens to children read aloud. Mostow found that over a period of 4 months, children using the Reading Tutor gained significantly more in passage reading comprehension than children using commercial reading software, or engaging in classroom reading activities. A number of companies (for example, LeapFrog and Scholastic) have also targeted reading literacy, although for the most part their products have addressed the "inside-out" skills of phonetic and graphemic awareness.

As described above, oral storytelling takes place in households of many different cultural backgrounds, but teachers are often unable to use emergent literacy activities that differ from their own to scaffold children's classroom skills. Pinkard introduced the Lyric Reader software (Pinkard, in press) built upon the experiences and background of low-income African-American children. Two Lyric Reader applications, Rappin' Reader and Say Say Oh Playmate provide "contextualized reading instruction" with reading material drawn from children's prior knowledge of song lyrics. After children used these technologies for two sessions, Pinkard found that while European-American children's pre- and post-test raw scores in vocabulary tests were greater than African-American children, at all grade levels, African-American children demonstrated a greater percentage word gain than European-American children. Like

the Reading Tutor, Pinkard's work depends on a traditional screen-and-keyboard computer that resides in a classroom.

A number of technologies to support children's storytelling have been developed. For example, Druin and her colleagues have designed a number of interfaces for and with children focused on supporting children's storytelling play (Druin, Stewart et al., 1997; Benford, Bederson et al., 2000). Druin's work is strong in its attention to collaboration among children and argues that by including children in the design process, technologists can create storytelling applications that are more representative of the authorship issues children find salient. Hayes-Roth's Improvisational Puppets System (Hayes-Roth and Gent, 1997) provided an environment where children can act out plays. MOOSE Crossing (Bruckman, 1995) encouraged children to construct a virtual environment, using narrative descriptions, in which they could interact with one another. Graphic StoryWriter (Steiner and Moher, 1992) let children manipulate multimedia objects as a way of supporting storytelling. Another multimedia authoring tool encouraged children to treat videos, photos, drawings, texts, sounds and cartoons as "electronic building blocks" that represent segments of time in a story (Kim, 1995). Druin's newer work has begun to embed storytelling technologies into everyday objects; otherwise, her older systems and the other systems described here, reside in desktop computers. And, in none of these systems is the link between storytelling and literacy addressed.

The Cognition and Technology group at Vanderbilt University, has targeted reading, writing, and storytelling in an innovative literacy series that has had considerable success in the classroom. Children in primary grades first listen to and watch an "anchor" story presented in a video format, fostering oral comprehension skills. The stories end with a challenge to the children that makes it important for the children to write a book about the story they have just seen and heard. They then use specially designed "book making" software to produce a reconstruction of the story that they can print out in book form and "read" to their peers and family. Comprehension is supported by having the students use storyboarding technology to decide on the temporal and causal sequence of events in the book. The story reconstruction is done orally by having children record what they want to say as well as in written form by typing in the words for each page. Children can also create their own stories in the book making software. Note taker technology helps them write stories or nonfiction reports from scratch. The project has demonstrated gains on reading comprehension and in various measures of written story production (e.g., word fluency, sentence fluency and story complexity) among high-risk low-SES first-grade children (Cognition and Technology Group at Vanderbilt, 1998).

Some Intelligent Tutoring Systems (ITS) have examined the role of peers or partners in learning. For example, Chan and Baskin (1988) proposed the notion of a "learning companion system." The learning companion was an artificial student who interacted with the real student while both learned under the guidance of an intelligent tutoring system. The learning companion was designed to be at about the same level as the real (college) student, and both the student and the companion exchanged ideas while being taught by the computer teacher. The relationship between the two students was designed to include cooperation, competition, modeling, co-teaching, and observing. By having the two tasks – learning by being tutored and tutoring, learning companion systems offer a learning protocol that is similar to "reciprocal teaching" (Palincsar and Brown, 1984) where children take both the teacher's and learner's role. While their preliminary results did not show significant improvements on problem solving tests, Chan and Baskin's interviews revealed that the students enjoyed teaching an agent over a real student because they felt it was like a game. It is possible that a more complete model of peer relations would maximize the effects of this kind of ITS. In the Teachable Agent project (Brophy, Biswas et al., 1999), children learned ecology by teaching an (non-embodied) agent about the subject. Brophy et al. found that children who studied in order to teach the agent did better on the post-test than control children who studied just for the test, as the students who prepared to teach spent time trying to understand "the why" of what they were learning. Animated Pedagogical Agents (Johnson, Rickel et al., 2000) are intelligent

tutoring systems that have been given an embodied representation, which allows them to demonstrate visually how to perform tasks, and communicate using language, hand gestures, and facial expressions. Empirical evaluations of these systems have yielded mixed results. For the most part, subjects (the vast majority have been college students) report enjoying the learning experience more, but comprehension and recall have not been improved by the presence of a visual interface, or image of the agent (Dehn and Mulken, 1999; Moreno, Mayer et al., 2000). In these systems, however, it is unclear whether the contribution of embodiment has yet been capitalized upon. That is, although these pedagogical agents can demonstrate behaviors by pointing and demonstrate enthusiasm by facial expressions, they do not yet distribute functionality to language and to embodied behaviors in maximally human-like ways

Although certainly not a new technology, a particularly intriguing result from a study looking at contextual effects on the production of narrative language demonstrated that stories children told over the phone were longer, more detailed, and more vivid than those told face-to-face (Cameron and Wang, 1999). Cameron and Wang suggest that the mediation of the telephone encourages children to not decontextualize, but – more intentionally – *recontextualize* their language for an audience. Note that, as Naigle reports (Singer, 2001), and despite popular claims to the contrary, television was never shown to have a positive effect on language learning (meaning, the development of grammar, and not just vocabulary). Television viewing is more active than many people might suppose (Bickham, Wright et al., 2001), but televisions simply do not reply to children. Unlike television, however, new technologies can encourage active construction of language, and their mediating properties, I believe, can be used to encourage metalinguistic reflection. It is for this reason that I believe that Story Listening Technologies can encourage children to make gains in language skills. I believe that story listening systems will encourage children to recontextualize their language for an interlocutor, in a similar way to that demonstrated by Cameron and Wang – whether that interlocutor be co-present or temporally/spatially distal, real or imagined.

In sum, narrative is of paramount importance to literacy. In order to support emergent literacy, children need to author their own personally and culturally meaningful content in a way that is representative of the oral-written emergent literacy continuum, but that focuses them on key aspects of decontextualized language use. These goals can be achieved through storytelling and story writing, activities that are also important in children's broader cognitive, communicative, and linguistic development. Many schools are beginning to recognize the creation and manipulation of oral and written text as key aspects of literacy education. In parallel, teachers are being encouraged to incorporate technology into classroom activities. Technology, and particularly tangible non-screen-and-keyboard based technology that can support children's language play involving the whole body, may play a unique role in supporting emergent writing literacy and otherwise making a bridge between oral and written language, both in the classroom and outside.

3. A Model for Technology and Literacy Development: Story Listening Systems

With the exception of the work of Goldman and colleagues, previous work on literacy technologies has for the most part eschewed writing in favor of reading. And, even within reading, most of these technologies approach literacy from the inside out – graphemes, phonics, and punctuation – rather than the more social and functional approach. Technologies for literacy and for storytelling have been approached separately, and thus the personal and epistemological connections that can arise from constructing one's own language have been ignored (Resnick, Bruckman et al., 1996), as has the possibility of using technology to bootstrap academic competence off of a skill that the child is already good at. Finally, technology to support the collaborative social and peer context of emergent literacy, such as pretend play or oral storytelling in pre- or non-school contexts, has not been explored. Technology of this sort would have to move away from the desktop screen-keyboard interface, since young children primarily engage in collaborative oral storytelling and fantasy play using their whole

bodies, and may be utterly slowed down by the constraints of a keyboard and mouse. Overall, then, with rare exceptions, it appears as if technological innovation has not kept up with innovation in literacy learning theory, and that the four key features of the literacy development model named above and underlined as important by researchers in (non-technological) approaches, have not found their way into technologies for literacy development.

What is needed to support the outside-in components of literacy is a social context – a feeling of being understood, and having an authentic environment in which to pursue one's communicative goals. Of course, technology will never replace a genuine social context – peers and adults who care. I seek to improve on current technology for literacy by extracting those aspects of the social context of peer interaction and of adult interaction that facilitate literacy learning, and use enabling technologies to perform them. Thus, the SLS model relies on two features of childhood and two features of new technology: children's inherent ability and desire to tell stories which may contain within them the skills required for writing; the fact that the support children provide to one another in the narrative play arena may be as good as, or even superior to that provided by adults; new technology's ability to be removed from the old screen-and-desktop context; and its capacity to support children as producers as well as consumers of content. I believe that, by proceeding along these four axes, based on essential properties of childhood and possibilities of new technology, we will create an effective context for the acquisition of literacy skills. Story Listening Systems share these four essential traits. (a) They evoke storytelling from children, and use children's oral storytelling skills to bootstrap literacy, (b) they encourage peer play, and sometimes even embody peers as playmates **in** the system, (c) they do not require children to learn desktop screen-keyboard-and-mouse interfaces or to sit at a desk before they can engage in normal children's behavior; instead they are built into children's toys, and thus invite the kind of embodied play that young children engage in, (d) rather than constraining the kind of stories that children can tell or listen to, they ask children to construct their own personally meaningful content. I predict that systems possessing these four characteristics can allow children to succeed at three crucial predictors of literacy: (i) using decontextualized language, (ii) gaining metalinguistic awareness, (iii) collaborating with peers to make meaning. They can also, I predict, succeed at (iv) broadening the definition of emergent literacy in such a way as to successfully scaffold literacy for children whose pre-literacy behaviors don't fit the mainstream model.

One of the benefits of the approach is that the SLS allow abundant access to the child's process of storytelling – they allow, therefore, for study of the learning mechanism that underlies the SLS. Each stage in the child's interaction with the object is saved for analysis. As a result, comparison of children's uses of different SLS, and of SLS with other kinds of literacy instruction can be compared to evaluate each of the features that makes up the model, and thus evaluate the design features for literacy technologies.

4. Six Story Listening Systems

In what follows, I first describe three early "story listening systems" (Renga, Rosebud, SAGE) designed to look at the general role of technology in children's storytelling, and that we have evaluated through informal, ethnographic, and quasi-experimental means. Next, I turn to three story listening systems (TellTale, StoryMat, Sam) that have explicitly addressed the value of "toys that listen" for fostering children's emergent literacy skills. These latter three systems target those aspects of language interaction that are a source of literacy-relevant and literacy-necessary skills. Finally, I will describe future work that supports children in an explicit transition from oral language to writing.

4.1. Renga

In Renga (Cassell, 1995) we examined the collaborative and community-building aspect of storytelling. Our objective was simply to experiment with the technical capabilities of the web as support for the social activity of storytelling. On the basis of the kind of round-robin storytelling that children often engage in in first grade classrooms, Renga (from the Japanese word meaning, "linked poem" or "linked image") encouraged children to add a sentence to an ongoing story on the web, and in doing so to become a part of a storytelling community. In our initial introduction of Renga, we invited the participation of every school in the world that had web presence (214 schools, in October, 1995!). Children from fourteen schools in eleven countries accepted our invitation and used Renga to collaboratively tell stories during one 24-hour period in October 1995. Our experiences with Renga during that 24-hour period, and children's subsequent reactions during later informal use of the system, led us to realize that the nature of storytelling collaboration among children requires a social as well as task-oriented component. Several children explicitly asked us how to find out who else was "there." Our interpretation of this reaction was that it is not enough to collaborate on a task; the collaborators' *social presence* (Short, Williams et al., 1976) must somehow be felt. To this end, we added a function so that when children clicked on any sentence in the story, they were able to see information about the author -- name, country of origin, hobbies – and at any time the names of the 5 most recent collaborators were listed in the storytelling "room." Renga continued to be used over a year or two period, however, after that point scalability became an issue due to the increasing numbers of children on the web.

Renga succeeded in supporting a kind of collaborative storytelling among children across distance, and succeeded in focusing children on the task of constructing local linguistic links between the sentences that they wrote, and the previous sentence on the page. But the nature of the collaboration was not inspired by any particular topic – the story could be about anything – nor did it have any overarching structure and so it typically devolved into rather unrelated sentences 100 or so lines down. In addition, there was no facility for rewriting, editing, reflecting on one's own language or the language of one's peers, nor was there any audience – notion of who the story was written *for*. To address these limitations, we designed Rosebud.

4.2. Rosebud

The Rosebud system (Glos and Cassell, 1997) was designed to support collaboration between multiple children, and between a child and his/her stuffed animal; also to encourage writing, and reflecting on writing. In Rosebud the computer, in the form of a screen-based storybook, recognizes children's stuffed animals (via an infrared transmitter in the toy, and receiver in the computer) and invites the child to type a story about the stuffed animal into a magical storybook. With each play session, the child accumulates more stories about the stuffed animals in the personalized storybook. Once a story has been written, the child is encouraged to "tell more," to revise, and to expand. Rosebud supports storytelling not only by one child and one stuffed animal, but also by multiple children each with his/her own stuffed animal, working together. Rosebud allows collaboration by allowing

multiple-toy use and multiple-author storybooks, so that several children could write a story together about all of their stuffed animals. We instrumented a menagerie of stuffed animals, including highly "mediatized" figures such as Winnie the Pooh, and anonymous figures such as an elephant. Use of the system by 7 to 9 year old children demonstrated that, regardless of the identity of the stuffed animal, highly personal stories were likely to be told, as we can see in the following story told by one 9 year old girl playing with a Pooh Bear and Eeyore animal:

> Once upon a time a very long time ago there were two friends named pooh bear and eeyore. They liked each other very much and let nothing get in there way. One day eeyore felt sad because his mother passed away. So he went to his good friend pooh bear to ask for advice. Eeyore asked pooh bear and pooh bear said to take it easy and relax. Eeyore said ok I will.

Children's most frequent request was to allow them to record their story into the stuffed animal so they could take the animal with them, and share their stories with their friends. We implemented this function, but their use of the system made clear to us the importance of moving the interaction away from the desktop computer. In addition, despite the edit and revision features of the software, children were not particularly interested in rewriting – there seemed to be no reason intrinsic to the system for them to reflect on what they had written, and to rework it. To address these limitations, we designed the SAGE system, where the structures of discourse were explicit in such a way as to encourage children to be reflective about language use.

4.3. SAGE

The goal of SAGE (Bers and Cassell, 1998) was to invite children to design their own ideal listeners, and in doing so to reflect on the speaker and audience aspect of storytelling. The SAGE (Storyteller Agent Generation Environment) story listening system encouraged children to tell personal stories by giving them a library of computer-based wise old sage storytellers to choose from, each of whom listened and then responded with a relevant tale of his/her own. Children could choose to speak to a rabbi, who responded to children's stories by saying "what, you think you're maybe the first person this happened to? Let me tell you a tale" and then chose a relevant story from a database of Hasidic tales; a Buddhist scholar who always had a relevant Tao proverb; or a French grandmother who replied with one of the fables from La Fontaine. Older children (we tested the system with ten and eleven years old) could also create their own sage storytellers and to design storytelling interactions for their peers.

In order to support children as constructors as well as consumers of the storytellers, we implemented a visual programming language that allowed children to design and program: (1) the scripts used by the storyteller to respond to users, (2) the conversational structure or flow of the interaction, (3) the database of stories offered in response by the storyteller. We saw children, over the course of a weekend workshop become able to observe and repair breakdowns in conversational interaction. For example, one child built a "wise old person" based on Shaquille O'Neal, the basketball player. In a demonstration of the system, when Shaq asked the child's father, "I guess you are around 11, am I right?" and the response was, "No, I am 45," Shaq crashed. The child quickly realized that he hadn't programmed a branching node to allow the possibility of a "no." He went back to the authoring mode and added the branching to the conversational structure. This process appeared to engage children in the exploration of notions of communicative decentering. As one eleven year old told us in the post-workshop interview, "First I learned how to put myself in another place and pretend I am someone else,

and I learned how hard it is [. . .] But really I talked to myself and I learned more about myself [. . .] My stories are sad, but if you wante to hear a funny story you can play with Waloompa the alien. When you have a problem it is sad and that is why my stories are sad." The SAGE system has been given a web interface so that children may design story listeners for children around the world.

SAGE was quite successful in encouraging metalinguistic awareness, and also reflection on the activity of storytelling – its structure and function. In order to be engaged in this reflection, on language and on storytelling, however, children needed to master a programming language that was more difficult than we expected. Even the eleven year old children we worked with had difficulty with the task, and children of this age group are less in need of scaffolding for metalinguistic awareness than are much younger children. Our experiences with the SAGE system led us to turn our attention to much younger children, systems that are simpler to use, and more explicit scaffolding of pre-literacy behaviors.

4.4. TellTale

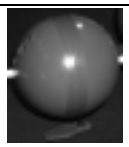
TellTale (Ananny and Cassell, 2001) was the first SLS designed explicitly to engage children in the kind of discourse that is needed for writing literacy. TellTale illustrates by its form an important concept of writing: units of discourse must hang together somehow, and then be connected to other units, and there must be a beginning and an end. In this sense TellTale resembles the manipulatives (Resnick, Martin et al., 1998) used to support children's exploration of math and physics. TellTale is a caterpillar-like toy with five modular body pieces and a head. Children can press a button on each of the five body pieces to record 20 seconds of audio. The child can then press a button on that body piece to play back the audio. The body pieces detach from one another and children can arrange and rearrange them in any order. At any point the child can attach the toy's head to the body to hear the entire audio story played in sequence. Any body piece can be re-recorded, or re-arranged.

4.3.1. *Metalanguage.* Initial informal observations of children playing with TellTale revealed that the artifact appeared to affect how children reflected on their story language and how they experimented with story structure. Four stories recorded one after another by one 6-year old illustrate this pattern and are shown in the table below. The first story this 6-year-old girl recorded is a complete and coherent narrative. She only used two of the five body pieces, saying she "didn't need the other ones." In this first story, then, the form of the caterpillar played no role in the form of her story. In her next story she used all five body pieces by putting shorter story segments in each, which involved at least some advanced planning about the structure of the story. The third and fourth stories were recorded in response to a question the experimenter posed about why she liked or disliked TellTale. She responded that she liked "TellTale a lot because you can split things up in different ways – see?" and then proceeded with the third story – in which she predominately recorded a single word into each body piece – and the fourth story – in which she recorded a single clause into each body piece. Note that the fourth story is based on the third but conveys more information. The third and fourth story demonstrate this child's ability to reflect on the structure or segmentation of the story, and how to map it to the structure of TellTale. Thus this child is engaging in metalinguistic awareness of discourse segmentation.

	Body Piece	Audio recorded into body piece
1st recorded story	1	Once upon a time there was a little boy who was sleeping. The next morning he lost his pet frog. Then he went looking and … [with rising intonation]
	2	He looked in a hole and the dog looked in the beehive. He looked I think under a rock and an owl flew over. And then he was calling his frog's name. He fell into the river. He was looking and he said "shhh". Then he found his frog. The end.
	3	*Did not use*
	4	*Did not use*
	5	*Did not use*
2nd story	1	Once upon a time there was a unicorn. And he was so pretty.
	2	And when he touched its horn a jewel came. And he touched anything and a jewel came
	3	And then it lay and it wanted me to get on its back.
	4	Then I rode to its castle.
	5	And saw a real live princess. The end.
3rd story	1	Once
	2	Upon
	3	A
	4	Time
	5	There was a unicorn.
4th story	1	Once upon a time
	2	There was a unicorn
	3	Named Crystal
	4	And she liked to play hide and go seek with people. And she was a good person.
	5	The end

These first informal observations led us to design a study to look more explicitly at the development of an awareness of narrative segmentation and structural language, as embodied in TellTale's segmented form.

4.4.2. *Decontextualized Language*. We constructed a control condition TellTale where only one piece recorded audio, and it contained 100 seconds of audio (the same amount as the entire original TellTale). 14 children playing alone with the unified unit (UTT) or segmented unit (STT) TellTales were invited to record stories (in a room with no adult present). We examined the use of connectives and other kinds of macrostructure markers at the boundaries between body parts. Connective use by children can be divided into local chaining and macrostructure markers (Peterson and McCabe, 1991).

Segmented TellTale **(Child aged 6 years, 11 months)** 	**Unified TellTale** **(Child aged 6 years, 7 months)** 
BP#1: "Once upon a time there was a unicorn. And he was so pretty." **BP#2:** "And when he touched its horn a jewel came. And he touched anything and a jewel came." **BP#3:** "And then it lay and it wanted me to get on its back." **BP#4:** "Then I rode it to its castle." **BP#5:** "And saw a real live princess. The end."	"The caterpillar had just got home. He didn't know where he was. He asked the horse where his mother was. The horse said …said he was … she was … at … the … leaves she … it … she said …"

Stories told with STT were longer than those told with UTT: STT stories were an average of 72 words per story and 40.5 seconds per story whereas UTT stories were an average of 42.1 words per story and 34.2 seconds per story (N was too small in this study to report inferential statistics). Stories told with *Segmented TellTale* (STT) had fewer false starts than those told with *Unified TellTale* (UTT) indicating

that the segmented body pieces may allow children to plan their utterances off-line. Stories told with STT also had contained more conjunctive phrases (and, then, however, when, while, after, later, so, therefore, one day) per word (.1 conjunctions/word) than those told with UTT (.06 conjunctions/word). And when conjunctive phrases did occur in STT, they tended to occur at body piece boundaries, indicating that children treated body pieces as story units, linking them with connectives.

In both UTT and STT conditions children tended to tell stories with classic beginnings (e.g., "once upon a time") but only in the STT condition did children also consistently finish their stories with classic endings (e.g., "the end"). Stories told with UTT tended to end in either false starts or long pauses indicating that children may have been having difficulty planning the next utterance.

TellTale's segmented interface, then, seems to help children tell stories that are longer, more cohesive (containing fewer disfluencies and more conjunctions) and with more traditional beginnings and ends. The skills children practiced while playing with the segmented version of TellTale (planning, chunking, revising) are very similar to those that are required for written literacy. These findings suggest that, with respect to segmentation, TellTale encourages children to tell oral stories in ways that are similar to how they will eventually construct written texts.

4.4.3. *Multiple Discourse types.* TellTale does not restrict in any way (other than length) the kind of discourse that can be recorded. We carried out an evaluation in two schools in Dublin, Ireland to examine how TellTale may support the language play of children from different socio-economic strata (SES). Specifically, this evaluation investigated whether children of high- versus low-SES establish cohesion within oral narratives using different strategies. A total of 22 children participated: 5 low-SES dyads (10 children) and 6 high-SES dyads (12 children). All children were invited to "tell stories with this storytelling toy."

Despite the explicit instructions, in general we found that children in the low-SES condition used TellTale in unanticipated ways: they were less likely to tell complete stories, and more likely to record song fragments, dialogues and rhyming sequences into the body pieces, or record an amusing quotation into each body piece. Children from both high- and low-SES groups consistently recorded utterances that contained story events (in both conditions, approximately 75% of all children's recordings contained at least one event). Children from both high- and low-SES groups also used connectives at TellTale body piece boundaries but children from high-SES consistently used more connectives. In terms of the process of telling stories, interestingly, both high- and low-SES children incorporated both narrative (characters, places, actions) and syntactic (exact word phrases) aspects of their partner's utterance into their own. But low-SES children tended to make incorporations simultaneously (i.e., during co-occurring recordings) whereas high-SES children tended to incorporate each other's content across consecutive recordings. *C*hildren from both high- and low-SES engaged in cohesion with the previous child's segment through paralinguistic means (e.g., rising and falling intonation) and non-verbal means (e.g., gestures and eye-gaze). But children from the low-SES group were less likely to use cohesive devices at all, or they used only paralinguistic and non-verbal strategies, rather than explicit connective chaining with the previous child's segment.

Overall, children from different socio-economic strata tended to engage in slightly different behaviors during collaborative storytelling. Specifically, an initial analysis may interpret low-SES children's high percentage of co-occurring utterances and low percentage of syntactic connectives as an indication that they are less able to engage in good turn-taking behavior and be aware of their co-participant. However, this may not be the case for two reasons: children from the low-SES group appear to be using non-syntactic, paralinguistic and non-verbal strategies to indicate cohesive chaining during story construction. Also, despite the high percentage of co-occurring utterances in low-SES children's recordings, these children consistently incorporated elements of their partner's utterances simultaneously. Children from high-SES tended to establish coherence using syntactic connectives between consecutive recordings.

4.5. StoryMat

StoryMat (Cassell and Ryokai, 2001) was designed to encourage exactly the aspects of 4 to 6 year old's collaborative reciprocal storytelling that have been shown to be related to later literacy (Dickinson and Tabors, 1991). In StoryMat the voices of previous children who have played with the toy serve as peer collaborators, egging children on to continue producing narrative language, and providing a kind of virtual audience for the children's words. We hypothesized that even so thin a representation of a peer as a disembodied voice would, as described by Dyson (1993) imbue the child's symbolic acts with social meaning in such a way as to drive the acquisition of those acts of symbolicization.

StoryMat was entirely removed from the desktop, and provided children with (virtual) peer collaborators. The implementation of StoryMat was a soft cloth quilt with appliquéd figures on it – a familiar toy for young children, one that evokes narrative and whole-body play. Squeezing one of the small stuffed animals provided with the quilt triggered the system to start recording the child's narrating voice and the two-dimensional coordinates of the stuffed animal. When the child let go of the stuffed animal, the coordinates and the voice were combined into a movie file and saved in the computer to be played at the appropriate location on the mat. When new input was subsequently encountered at the same place on the mat, the movie file was then automatically triggered and played back via a projector mounted above the mat, and heard through a pair of speakers next to it. The current child could then tell her next story. Sometimes she might come up with a continuation of the story she just heard. Or she might continue telling her own story, incorporating some story elements from the story she just heard. In this sense, StoryMat is a kind of imaginary playmate (Taylor, 1999), but who also mediates collaborative storytelling between a child and her peer group.

Our evaluation of the StoryMat system concentrated on three kinds of emergent literacy activities among early school-age children. First symbolic transformations of real objects into fantasy story objects, important because of the link between symbolic transformations and later writing literacy (Pellegrini & Galda, 1993). Second, incorporations of story elements from the story of a collaborating peer, important because of the increased complexity found when children incorporate aspects of each other's stories (Corsaro, 1992), and the role played by peers in encouraging more sophisticated linguistic devices (Bokus, 1992; Preece, 1992). Third, the use of different narrative voices, because of the essential role of perspective taking in the development from oral to written literacy (Peterson and McCabe, 1983), and the specific role of narrative voice in acquiring more sophisticated kinds of story structures (Auwarter, 1986). These decontextualized language measures were taken from previous work cited above, and were therefore well validated. 36 children between the age of 5 and 8 participated in the evaluation study. Children were randomly assigned into one of two groups: 1) a StoryMat group, who played on StoryMat and 2) a control group, who played on an identical mat, without the responsiveness (the "passive mat"). In each group, 6 subjects played alone and 12 subjects played with another playmate, resulting in 6 dyads and 6 singles in each group. In all conditions, the experimenter's instructions were fundamentally the same: "let's pretend that we are living in this world. Will you tell me stories that happen in this world? First I'll play with you some. But I'm going to leave the room in a little while so that you can be alone to tell your stories on the mat." Children on the StoryMat condition were given one additional instruction: "Do you see a button here? (Show the button on the stuffed rabbit) You have to hold down the button while you tell your story so that the mat knows you are telling your story. And you let the button go when you are done so that the mat knows you are done with your story." The experimenter always told the first story, and in the StoryMat condition the experimenter then sat and listened to the story that the mat gave back in reply. In all conditions the child was then invited to tell a story, and then the

experimenter left the room. Thus, in all conditions children heard an equal number of practice stories before the actual session began. No additional instructions were given as to the functioning of the system, nor what was expected of the child. The experimenter was absent for the entire play session, as many studies have shown that children interact less with one another when they are in the presence of adult observers.

Results demonstrated that StoryMat encouraged more symbolic transformations in the children's stories than the control condition for both children who played on the mat alone and with a co-present peer ($F(3,20)=9.7$, $p<.01$). Children playing on StoryMat also incorporated story elements from the stories offered by StoryMat in the similar way as they did from real life peers ($F(3,20)=3.49$, $p < .05$). Finally, children playing alone on StoryMat more often took the more narratively advanced role of narrator role (72%) than of character (28%), while the control group of children playing alone acted in character role (95%) much more frequently than in narrator role (5%). Some of the advantages that accrue to children playing with peers, then, seem to accrue to those children playing with the StoryMat system.

4.6. Sam the Castlemate

The Story Listening Systems described above incorporate some implicit aspects of peer support for narrative performance. However they contain no embodied representation of the other (virtual) children with whom the child is playing. Embodied Conversational Agents (ECAs) can serve this role. ECAs are life-size human-like graphical computer characters projected on a screen that are able to engage in face-to-face dialogue with a user, using not only speech but also nonverbal modalities such as gesture, gaze, intonation and posture (Cassell, Sullivan et al., 2000). We have constructed several such systems that use machine vision and speech recognition to sense the user's speech, gesture, body posture and intonation, and use models of the relationship between verbal and nonverbal behavior to make the animated computer character respond appropriately. Our research on ECAs has begun to serve the goals of our research on story listening systems as we have developed the notion of *shared reality* to describe systems in which virtual collaborators can share real objects with their human users. This is the case for MACK, an animated embodied robot in a kiosk who can share a real map with users, and for two recent story listening systems that we have built:

- GrandChair, a virtual grandchild who elicits life stories from seniors; speech recognition and sensors in a rocking chair that the user sits in allow the virtual grandchild to give appropriate feedback, while the system videotapes the stories for later viewing by the senior and his/her family (Smith, 2000).
- Sam, a virtual peer designed to engage in particular kinds of storytelling play with children, described further below.

Sam the Castlemate (Cassell, Ananny et al., 2000) was designed to encourage children to produce decontextualized language and metacognitive reflection in the context of peer storytelling, by modeling and scaffolding the child in those activities, and inviting the child to scaffold and coach in return. Sam is a virtual child who invites children to participate in collaborative and conversational storytelling play with real toys. The Sam system has two components: an embodied conversational agent – a life-size gender-non-specific child named Sam – and a toy castle with several plastic figurines. Sensors, audio threshold, and floor mats allow Sam to recognize when the child is speaking, what room the child is currently playing in, and which figurine the child is using. Sam is projected on a screen behind the castle, and can both tell stories, using a recorded child's voice, and listen to the real child's stories, responding with appropriate feedback (such as "cool,"

"then what happened?" and short comments (such as "I'll put the toy in the magic tower so you can take a turn"). The physical toy castle that Sam and the real child share extends into the virtual world. The figurines can exist in either the physical world or on the screen, but never both, and Sam and the child can pass them back and forth between their worlds by way of the magic tower. Sam has a database of rather short stories that involve one or two characters played out by the figurines, and involve several locations, which Sam illustrates by moving the figurines among the different rooms of the castle. All of the stories are told in the first person, begin with the introduction of a scene, and involve complicating actions (e.g., losing a horse) and resolution (e.g., found the horse), as well as appropriate introduction of referents, and use of cohesive devices. The stories were written by several members of the Sam research team, and then re-written for us by a local nine year old who then recorded the stories in her own voice (and with her own sound effects). In a newer version of Sam (post- the evaluation reported below), all stories also demonstrate third person narrative voice and embedded reported speech ("character voice").

A recent empirical study examines the effect of Sam on collaborative peer-like and metalinguistic behavior, and use of decontextualized language. This study employed a 2x2 design, comparing (a) single children to pairs of children, and (b) interacting with Sam vs. interacting with the castle but without Sam. The single child vs. dyad condition allows us to examine the effect of Sam on collaborative behaviors among real peers, as well as to get a baseline of peer-peer collaborative storytelling play. All children came from a mixed ethnicity, mixed socio-economic status public school in one of the towns surrounding Boston. Only girls participated in this particular study, as the version of Sam that they played with employed a pink castle, and some boys refused to participate for that reason (our current version of Sam plays with a wooden castle, and this problem has been alleviated). All children were aged between 4 years 6 months and 5 years 6 months. 31 children have been videotaped interacting with the castle, in pairs and alone, with and without the Sam virtual peer. Experimental procedure was identical for all conditions: the castle and figurines, whether or not Sam was present, were introduced in the following way: "This toy is good for telling stories. See the castle? And the little toy? You can use these to tell stories. Ok, do you want me to show you? I'll tell a story with the toy, and then you can tell a story." In the Sam condition, the experimenter added "That's Sam. Sam likes to tell stories and listen to your stories. Sam knows that it is my turn to tell the story because I will take the toy from the magic tower." The experimenter finishes the instructions by saying, "Tell as many stories as you like [in Sam condition: "with Sam"] and then come and get me." For the remainder of the session, the experimenter remained outside the room, while a video camera recorded the child.

Sam involves all four traits of the model described above: it (i) engages children's oral storytelling skills, (ii) involves peers as playmates both in the system and with the system, (iii) invites whole-body play with familiar toys, and (iv) allows children to produce their own personally meaningful content. For this reason, I spend some time below analyzing children's use of the Sam system. In what follows, I first describe some general characteristics of children's play with the system, and then use transcripts of children's interaction with Sam to give examples of children's performance on the literacy predictors outlined above.

Children's play with Sam is striking in its naturalness. The children enjoy playing with Sam, and appear to enter into the game of playing with a virtual peer, perhaps from previous play with puppets, or from experiences with imaginary playmates. The children do know that Sam is a toy; as one child remarked:

"[Sam's] more complicated because like you have toys that like do only like one thing -- Sam does a lot of things. He tells different stories -- not that many. It's way complicated".

On the other hand, they are still concerned that Sam listen to them, as demonstrated in the following interaction between a child and the experimenter. In this instance the system incorrectly sensed that the child had left, and so Sam went through the farewell part of the interaction, which led the child to fetch the experimenter from her observation post outside the experimental room:

CHILD: Sam said bye. He said bye to me and left.
ADULT: Uh oh. I wonder what that means.
CHILD: Sam's gone
ADULT: Sam's gone. Let me see if I can fix it. That's what happens with computers. Sometimes things break.
CHILD: But, he wasn't listening? Was Sam listening?

The children who played with Sam, either by themselves, or with another child, told a number of complete and fairly long stories. This is in contrast to children playing by themselves in the absence of the Sam virtual peer, who may very well be telling themselves silent stories, but who do not vocalize those stories. These children become bored quite quickly, and start to take the castle apart (also a problem when two children played with each other, without Sam, as can be seen below).

But a complicated, even an open-ended, toy does not suffice in literacy development. And, if children playing alone don't engage in literacy practice, then one might ask: why not simply provide children with peers, since peers have been demonstrated to be important in emergent literacy? As a baseline story between peers, and in partial response to that question, below is an example of two children playing with the castle (and without Sam).

CHILD #1: It hangs there --
CHILD #2: Do you want me to do it?
CHILD #1: No, I can.
CHILD #2: She said nothing's going to move for it.
CHILD #1: But I'm just scared,
CHILD #2: I am, too. Let's turn on the lights. Now you won't be scared.
CHILD #1: Because ghosts do not like light, right?
CHILD #2: No.
CHILD #1: You broke this after I had fixed it.
CHILD #2: Not me.
CHILD #1: It's probably the ghost.
CHILD #2: There's no such thing as monsters. Did that door just open, or was it just my imagination?
CHILD #1: It was just your imagination.
CHILD #2: No. I think it was just the wind. I'm having nightmares.
CHILD #1: Me, too.
CHILD #2: I want to sleep. I want to sleep. I hope I am.

In this interaction there is a seamless transition between off-topic talk (as the children broke, and attempted to fix, the chandelier in the toy castle) and first-person narrative talk as the two children played at being friends in a haunted house. Knowing which segment of talk fulfills which function requires access to the physical context, as the children are not using explicit contextualizing cues. This kind of conversation is not a bad thing, as it's perfectly comprehensible to all participants. On the other hand, it isn't demonstrating the kinds of decontextualizing storytelling behaviors that we know are correlated with literacy skills. We can compare the previous interaction to the following instance of one child playing with Sam:

SAM: Today, I'm gonna ride horses in the meadow! My dad, the king, said I can ride the, my big horse named Star. Oh no! Star has been stolen.

I'd better go tell the sheriff. Oh, sheriff, my favorite horse Star has been stolen, I don't know where she is. Oh, no. No need to worry. The kind old lady from the other side of the forest has brought her back. And she's just coming back now. Whoopie! Thanks. Come on Star!

CHILD: Once there was a little prince. His mom and dad were really, really rich. That's what made them the king and the queen. He liked his life so much. He got a really fancy bedroom with a big window that was so high up he could see the whole entire land. One day he really wanted to do something. He went downstairs so he could ask his mother what there was to do. He said, Mom, what can I do? Then his father came into the room and they had a big surprise for him. Well, dear, we got more money so that means you can do whatever you want to do. Do you have any ideas of what you want to do today? Well, I want, I've always wanted to have, I've always wanted to have very, I've always wanted to have a crown. Cause. Well, we can get you one. Do you have anything else that's so much fun? Well, I want, today I want to learn how to do Irish step dancing. Cause St. Patrick's Day is coming up and I want to do some of that to entertain you. Well, OK. They got him a crown, then they went to a class where he could learn how to do Irish step dancing. And he learned everything. And on St. Patrick's Day when he woke up he not walked down the stairs like you usually do to be careful, he ran, ran and then he tripped and then he fell and then he started crying. Then his mom and his dad took him to the hospital and the doctor said he broke his leg. That meant he had to stay in his bed and he couldn't do Irish step dancing. So he was really sad. But then he got an idea. Probably he could show his mom and dad how to do Irish step dancing. Like draw all the steps and how he did it. Because he had a magic potion, so he put spells on his pictures and the pictures showed his mom and dad how to do Irish step dancing. Then he went upstairs and went into bed and closed the door. The End.

Note that this child's story continues Sam's theme of a king and his child, but then launches into topics that clearly come from the child's own life or imagination (Irish step dancing). Many of the children who worked with Sam continued themes from the Sam story that they heard. In addition, this child's story is well constructed, uses third person narrator voice and embedded reported speech for several different characters, and includes evaluative comments ("so he was really sad"). In fact, the majority of children playing with Sam told stories in the third person (despite the fact that Sam didn't model that), while the majority of children playing with another child, without Sam, told stories in the first person, reflecting our earlier findings with the StoryMat system. And, those children who did tell first person stories in the single-child-Sam condition appeared to be explicitly continuing one of Sam's stories, as in the following example:

SAM: OK, my turn. I'm going to have a party and I'm going to invite whoever I want. My mom, the queen said I could. Oh look! Here Chris comes. I'm going downstairs to meet him. "Hi Chris, you're the first one here. What do you want to do?" "Well, we can go ask the mirror, who is going to come to your party?" "Oh yeah. Oh, mirror, who is going to come to my party?" "Oh, people from all the way over the land." "Oh yeah. Here, I see Cheryl, Brad, and Sean. Oh, this is going to be a great party." I'll put the toy in the magic tower so you can tell a story.

CHILD: La, la, la, la. Oh, it's my birthday today, and mommy and daddy are going to be out. I better get setted up. Da, da, da, da, da. Dee, dee, dee, dee. Uh oh.

SAM: And then what happened?

CHILD: I see my friends coming. I need to set up the party still. Oh no. Hi friends. Where's the party. Oh, I haven't set it up yet. Would you help me? Sure. I'll watch. Now tell me, my friends are

they coming or not. Da, da, da, da. The yummy dessert is on the table. Where's my [XXX]. OK. Coming up. See any friends yet? Yup. I see Carla, Meg and Sheg. That's everyone I invited and you. Oh. This is going to be a great party. What's with the present? Oh no. I forgot it. I can run home and get it. I'll let the others in. Oh hi, friends. Yeah, I know I'm late. Where's the [. . .]

Continuing themes from Sam's story is not the only kind of collaboration that was apparent in the interactions. Single children seem to engage in peer-like collaborative interaction with Sam, talking as they might with another child, in particular as they might with a slightly younger child:

CHILD: You done, Sam? OK.
SAM: I'll put the toy in the magic tower so you can tell a story.
CHILD: What should I tell, Sam? Do you have an idea? Hmmmm.
SAM: tell me a story
CHILD: Oh, the girl was happy. She came back from- her husband was there, she was very happy. Everyone, I mean everyone knew she was a good girl. She always had fun playing with her sisters.
CHILD: You're silly, Sam!
SAM: I'll put the toy in the magic tower and you can tell a story.
CHILD: Hey Sam, want to talk about like where are we from? OK? Sam, I'll tell a story that's really cool, about where I'm from.
SAM: Cool.
CHILD: Once there was a girl, her name was Simone. That's me. She went to the house, she loved it, and then she married a boy named Sam. Oh, sorry Sam, I messed up.

In fact, children ask Sam to continue their stories, and even coach Sam in storytelling, much as if they were engaging in reciprocal instruction (Palincsar and Brown, 1984), and in line with Stone and Christie's description of peer interaction around literacy activities (Stone and Christie, 1996).

SAM: Cool. OK, my turn. One day me and my friend were playing around and we heard this loud cry [. . .] I'll put the toy in the magic tower so you can tell a story.

CHILD: [talking to Sam] Try to make a longer story next time. It's like this. The little boy was outside. He flipped all around and he went inside, he did a flip [. . .]

Children's behavior in the dyad-with Sam condition allows us to examine the effect of Sam on children's prosocial collaborative behaviors with one another. And, in fact, we do see more prosocial behavior than when two children play without Sam, and we find more instances of explicit storytelling. Both effects are illustrated in the following example:

CHILD #1: Once upon a time there was a girl named --
CHILD #2: What about Anna?
CHILD #1: And the mom and dad went to a store. She could do whatever she wanted. So, she built everything. She went down the stairs, and then she broke the lamp. And then she messed everything up. And she jumped and jumped all over the place. And then she looked in the magic mirror and said, when is my mother and father coming home? And the magic mirror said, they're coming home right now. And she ran upstairs.
CHILD #2: Wait a minute,
CHILD #1. We can go upstairs.
CHILD #1: And she ran upstairs. And she ran upstairs again. So, they didn't find her. And then they were surprised that it was all messed up. And they didn't even know who it was from. So, then, she came back down. And they said, Annabelle. Did you do this? And she said, no. And she was lying.
CHILD #2: So, her nose went big?
CHILD #1: So, then, the mother and father put her bed.

CHILD #2: Because she lied?
CHILD #1: Because she lied, and because she wasn't supposed to do that.
CHILD #2: OK. My turn.
CHILD #1: Sammy - I want Sammy to do it. I'll put it back. (CHILD #1 puts the toy in the magic tower for Sam to take her turn)

In sum, children modeled their stories after Sam's, but also told stories as explicit models for Sam to follow. In doing so, children engaged in decontextualized language use, and metalinguistic comments about storytelling. Children engaged in prosocial constructive collaboration with Sam, and more often engaged in those types of behaviors with other children when in Sam's presence. In this sense, Sam is acting much like the Vygotskian more capable peer (Vygotsky, 1978), seeming to push children to act at the top of their individual abilities, or in their zone of proximal development, through the nature of their social interactions. It is not coincidental, of course, that social interaction be so important to the acquisition of literacy. As discussed above, in Cameron and Wang's terms, the outside-in component of literacy requires "recontextualizing" one's thoughts so that they make sense to another (Cameron and Wang, 1999). Talking to Sam, like talking to a slightly older child, or a stranger, appears to require more top-down structure and reflection, and to push children to use grounding devices (devices to ensure and establish common ground) in their talk. Children's interaction with Sam demonstrates that social interaction, even with a virtual peer, can support individual development in the domain of language use and collaborative behavior.

Despite these positive, and literacy-supporting, aspects of children's collaboration with Sam, there are still serious limitations to the system, and many puzzles. Sam currently carries out no natural language understanding and thus does not *really* understand what the child is saying. This leads to occasional failures in communication as children begin stories and expect Sam to continue them, or as children ask Sam explicit questions and receive no response. For this reason we are in the process of investigating options for keyword spotting – understanding single words in the stream of the child's speech – so that Sam will have a better idea of what the child is talking about. In terms of tantalizing puzzles, although the children appear to attend to Sam's stories – continue the themes, ask for Sam's advice, coach Sam – some features of their interaction are peculiarly un-peerlike. For example, many of the children do not look at Sam when telling their story, or give feedback while Sam is speaking. Finally, a number of the children who interact with Sam tell stories that are clearly based on interaction with objects in the castle rather than any top-down story structure ("he went up the stairs, then he swung from the chandelier, then he went down the stairs, then he went through the door . . ."). These features are all the more fascinating for being not quite peer-like responses. They are leading us to new experiments where we vary some aspects of Sam's performance – embodied or verbal feedback, kinds of story structure, and so forth.

5. Future Work

The burgeoning field of emergent literacy has acknowledged the role of peers, of play, and of narrative in later academic competence. When technologies have been designed to support literacy, however, these findings have not been incorporated. The work presented here demonstrates that, first of all, these findings **can** be incorporated into technology, and second, when they are incorporated, that children perform well on tasks that are good predictors of later literacy.

In the research reported here, some striking correlations have turned up between the use of the Story Listening Systems and three crucial predictors of literacy. Children using SLS were shown to use more metalinguistic terms, more decontextualized language, and to engage in more pro-social collaboration with peers. This research has not targeted, however, correlations between the use of SLS and actual writing literacy. Nor has the work reported here targeted in any systematic way the issue of broadening the definition of emergent literacy. Both of these issues constitute the goals of my future work. In order

to analyze the effects of SLS on actual writing literacy, and to examine use of SLS by children engaging in a broader spectrum of pre-school language behaviors, we have implemented another Story Listening System, and are preparing to employ a different methodology, suited to more longitudinal, and more school-based studies.

5.1. Animal Blocks

Animal Blocks explores an explicit connection between children's oral storytelling play with physical toys and their writing. Animal Blocks resembles an empty storybook, with a set of small wooden animal figurines lying next to it and a set of landscape props (a meadow, a lake, a forest). When a single child or several children choose from the collection of small wooden animal blocks and landscape objects to play with on the special platform, a colorful projection of the toys they have chosen migrates up onto the blank page of the storybook sitting next to the blocks. The child's choice determines which beginning of a written story is projected onto the left-hand side of the white pages. The right-hand side is blank, except for the words "and then." A voice prompt (in the voice of a child), invites the child to tell a story. After the child responds, the voice prompt gives the child the choice of listening to his/her story, looking at other children's stories, or typing in a continuation of the story on the page. The child can continue the story by continuing to play with the physical animal blocks, and by entering text onto each page (by voice-recording or by using a keyboard, although the rest of the interface in no way resembles a computer). If the child pages backwards in the storybook s/he finds stories by other children who have used the interface. As the child pages forward, the current child's entire story is regrouped on the left-hand side of the page, while the right-hand side displays a prompt to continue. In a sense, Animal Blocks is an extension of TellTale into the written mode, because the prompting and the page structure during the child's storytelling mirrors the segmentation of a story. The hypothesis is that this configuration will allow children to use decontextualized language even in the presence of the toys they are speaking of, and that the page structure of the book will encourage overall structure to be applied to the story.

5.2. Researching School-based Literacy

In the school-based context, and even with respect to actual writing activities, I am still interested in the same characteristics of language, and behavior around language, only as manifested in writing, and behavior around writing. Thus: (i) decontextualized language including appropriate use of pronouns vs. full noun phrases, narrative perspective (as in the StoryMat study, first vs. third person narrating of a character's words), and telling of stories with an overarching structure vs. associations of disconnected events; (ii) metalinguistic reflection including explicit talk about storytelling, such as found in the example above where a child told Sam how to tell a good story, as well as children's use of different narrative voices; (iii) prosocial constructive collaboration, such as that demonstrated above where children integrate words and themes from the SLS stories into their own, and also those instances where dyads of children playing with the SLS engage in turn-taking with one another (as opposed to trying to take the toy away from one another, or independent parallel play); and finally (iv) broadened definitions of emergent literacy, which in this instance means looking at the relationship between different kinds of discourse behaviors and later writing by building a database of stories for Sam and for Animal Blocks that includes different kinds of starter stories, such as topic-associating narratives (Gee, 1985; Heath, 1986), rapping stories (Pinkard, in press), and others, and looking at whether children who come from the cultures where these story types originate are more influenced in later writing literacy **and** whether children from other cultures broaden the kinds of stories they are able to tell, and whether this has a positive influence on their writing skills.

This research requires quite a different methodology than the non-school, play-based environments, and relatively ethnographic approach used previously. Particularly appropriate is the design experiment (Brown, 1992) or design study (Linn and Hsi, 2000) approach to testing the impact of the technologies on children's literacy development. This methodology emphasizes careful observation of learning in a particular (designed) testing environment for the purposes of redesigning it to improve learning processes and outcomes. Thus, for example, I plan to set up Sam and Animal Blocks and a paper-and-pencil writing exercise at three different "activity centers" in classrooms, and allow children to choose to play with whichever system tempts them most. After a certain period of time (for instance, 8 or 10 weeks), learning outcomes are examined, and changes are made to the technologies. In this work the focus will continue to be the 4 to 8 age group (pre-school, kindergarten, first, second grade). Recent discussions pertaining to predictors of children's school success and readiness have highlighted the need to begin intervention *before school age* (Powell, 1985; O'Neill and Pearce, in preparation), and it is therefore important to collect before and after statistics from the age group during which the most change is occurring.

Of course, in school-based studies such as these, children's initial developmental level is key – that is, where do the children start before they begin to use the technology? Important to this kind of assessment is a test that has been standardized on children of the right age group, and that demonstrates good reliability and internal consistency (such as the Test of Early Language Development – 2nd Edition (Hresko, Reid et al., 1991). And assessing children's subsequent level – after the SLS intervention – is equally important – and not self-evident. Some have used achievement tests, such as the written expression subtest of the Peabody Individualized Achievement Test – Revised (PIAT-R (Markwardt, 1998)). But researchers in the field of emergent literacy have stressed the need to also examine less quantifiable features, such as metalinguistic reflection, and expressions that have to do with narrative expression per se. And, pro-social behaviors can't be measured from text at all, and instead come from analyses of children writing stories together, or from assessing children's knowledge of positive interaction strategies by having them judge those behaviors when acted out by puppets.

6. Implications and Conclusion

The kinds of learning environments enabled by Story Listening Systems provide opportunities for children to bridge informal and formal contexts by sanctioning and encouraging modes of play as avenues for the development of "school" language. But as well as informing the design of contemporary learning environments, the research reported here also impacts the fields of language acquisition, cognitive development, and early education. In fact, a recent study has shown that children's ability to take multiple perspectives in storytelling is positively correlated with their mathematical skills (O'Neill and Pearce, in preparation), meaning that development in metalinguistic awareness may have an effect beyond writing literacy. Intelligent Tutoring Systems might also profit from integrating models of peer relations of the kinds described here. Tutoring systems that could engage in fluid negotiation of roles – sometimes the more capable partner, sometimes needing some coaching or scaffolding of its own – would undoubtedly be engaging to children, but might also lead to strong learning results.

More generally, the systems described here demonstrate a model of collaboration between human and technology that is quite different than that found in most educational technology. Story Listening Systems exhibit a kind of collaboration that resembles that found among peers more than the collaboration (or cooperation) between an expert and a novice. However, unlike the cognitive dimensions of peer learning companion systems, SLS demonstrate the importance of the social context of peer collaboration, its playful, spontaneous, personally meaningful dimensions, its ability to evoke a desire to make oneself understood. All of these dimensions enter into the socio-cultural understanding of learning, whereby the very fact of monitoring mutual understanding, of watching for how another understands what one has just said, changes one's understanding of one's own words or actions. For

literacy learning, this process of appropriation (Rogoff, 1991) is key. Literacy is all about making meaning for others – about participating in a community of meaning-makers.

Finally, the field of Children's Media has been concerned with the kinds of media designed for children and youth. Young audiences have always appropriated content in innovative and provocative ways. But as makers of new technology, we have the chance to provide children with media that encourage them to make, to produce, to construct. All of which leads us back to the policy arena and the debate regarding the pros and cons of technology for children. In the context of this unnecessarily polarized, and often heated, debate, the proposed research attempts to provide a knowledge base to inform the two sides. In particular, the current research builds on the assumption that there is no inherent conflict between technology and physical exploration, play, and the joy of active discovery. Rather, technological tools can be designed to incorporate the powerful, positive aspects of play and active learning at the same time as they scaffold and empower more formal language, cognitive and social development.

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