Literacy Learning by Storytelling with a Virtual Peer

Kimiko Ryokai Catherine Vaucelle Justine Cassell

MIT Media Laboratory

[kimiko, cati, justine]@media.mit.edu

ABSTRACT

In this paper, we present Sam, an embodied conversational storyteller who tells stories interactively with children. Sam was designed to appear as a peer to preschool children, but to tell stories in a developmentally advanced way in order to model narrative skills important for literacy. Literacy learning - learning how to read and write, begins long before children enter school. One of the key skills to reading and writing is the ability to represent thoughts symbolically and share them in language with an audience who does not share the same background. Children learn and practice such important language skills in the informal setting of everyday storytelling with their peers and adults available around them. In particular, storytelling in a context of peer collaboration provides a perfect place where children not only learn language skills important for literacy, but also learn to be critical listeners of others' stories. Preliminary evaluation showed that by interacting with Sam, 5-year-old children's stories more closely resembled Sam's linguistically advanced stories with more quoted speech and temporal and spatial expressions. In addition, the children listened to Sam's stories carefully, assisting her and giving suggestions on how to improve them. With Sam, children not only learned new linguistic behaviors that are important for literacy, but also to become critical listeners of other's stories.

Keywords

Literacy learning, storytelling, peer collaboration, virtual peer

INTRODUCTION

While new technologies have been introduced into classrooms to prepare children for computer literacy, traditional literacy skills – the ability to read and write – remain critical for children's academic success and may also be aided by advances in technology and research. The acquisition and practice of skills leading to literacy begin in informal settings of everyday interactions with adults and peers, and are not isolated to formal, academic environments. In this paper, we address the specific discourse genre of *storytelling* as a bridge to literacy. Storytelling occurs in the context of peer play and while a fun activity for children, also involves emergent literacy activities that can bridge children's competence and knowledge of oral language with that of written language. We present and discuss a novel approach in supporting children's literacy learning, where technology is a listener of children's stories and can provide opportunities for children to practice and acquire linguistic expressions in oral mode that are useful for their later literacy skills. First, we provide background for the link between storytelling and literacy, and the importance of social interactions in literacy learning as children learn new linguistic skills in interaction with both adults and peers. We will then introduce Sam, an embodied conversational storyteller who can act as a peer to children in storytelling play, and discuss our preliminary findings with children.

Oral Storytelling and Literacy

Our research is based on the theory of emergent literacy. Emergent literacy theorists view children as "active hypothesis testers of their language who are in the process of becoming literate" (Teal & Sulzby, 1986). According to this view, literacy learning does not happen only in formal classroom settings, but also in informal settings, in both oral and written modes, and in collaboration and interaction with others.

Whitehurst and Lonigan (1998) distinguish between the "inside-out" and "outside-in" skills of literacy. Inside-out skills are concerned with children's phonological and syntactic awareness, and grapheme-phoneme correspondence, thus facilitating children's ability to decode information within a sentence. Outside-in skills are concerned with children's ability to take the meaning of a sentence from the context in which the sentence is placed. Therefore, children must bring in their knowledge about the world and apply that to the text. Children need both inside-out and outside-in skills for successful literacy learning. However, with development, the outside-in skills become increasingly important to children, as literacy learning is concerned more with comprehending text, and not just the decoding of letters in the text (Snow, 1983; Whitehurst & Lonigan, 1998).

Successful storytelling not only requires children to use decontextualized language, the language that is not bound to the concrete here and now (Snow, 1983), but it also requires them to "recontexualize" (Cameron & Wang, 1998). In

Cameron and Wang's terms, children must be able to hold the audience's perspective in mind in order to reconstruct the context of a story in a way that is understandable for the audience. This ability to adopt an audience's perspective in recounting an event is crucial to literacy (Snow, 1983; Cameron & Wang, 1998). Storytelling, then offers a perfect place for children to practice such outside-in skills of literacy. Children learn these skills through interaction with both adults and peers.

Literacy Learning with Adults

Vygotsky defined the zone of proximal development as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p.86). According to this theory, a child performs at a higher developmental level of abstraction and performance with a knowledgeable and skilled partner than he would achieve individually.

Adults act as the competent partner in emergent literacy activities to support children's literacy learning. With parents and teachers, children engage in many different kinds of conversations together: exchanging information, disciplining and socializing, and showing feelings. Within those various types of conversations, children are given opportunities for conversations that require syntactic planning, careful lexical selection, making explicit cross-utterance relationships, and integrating successive utterances into a particular structure (Nelson, 1996). For example, the use of rare words during parent-child book reading is correlated with children's vocabulary acquisition (Snow, 1993). Dickinson, Cote, and Smith (1993) found that preschool teachers' use of rare words during meal time and in free-play settings were positively correlated with story understanding and definitional quality (such as a cat is a kind of animal) in addition to vocabulary growth. Therefore, adults' conversations serve as a model for children in learning new ways of using language to express their thoughts and feelings.

Literacy Learning with Peers

While parents and teachers may not always be available to listen to children's everyday stories, peers are available and can also offer scaffolding to their co-equal status partners. Neuman and Roskos (1991) investigated how children provide the kind of expert-to-novice scaffolding adults may provide in literacy activities. Neuman and Roskos observed children engaged in instructional conversation with their peers – designating, negotiating, and coaching each others' literacy activities. Unlike in an adult-child relationship, children often took turns being the more capable peer according to the purpose of the play. Similarly, Stone and Christie (1996) found that children engaged in collaborative behaviors to help each other in literacy activities. In their mixed-age, K-2 classroom, they observed children collaboratively helping each other by modeling, inviting, assisting, directing, tutoring, negotiating, affirming, and contradicting to each other in literacy activities. Results from these studies suggest that the combination of literacy-enriched play environments and literacy-rich older primary-grade children in a mixed age play setting stimulates literacy behaviors. In addition, Christie and Stone (1999) with their studies of multi-age classrooms have shown that even younger children (supposedly less capable ones) could offer assistance to older and more capable ones. Therefore, peer interaction involves not just one-way transmission of knowledge from an expert to a novice, but more "multi-directional" interactions (Christie & Stone, 1999).

It is through dialogue with others in peer collaboration that children come to realize the unique functional potential of the various symbol systems in their society, including reading and writing (Vygotsky, 1978). In a comparison of collaborative teacher-child writing with collaborative child-child writing, Daiute et al. (1993) found that generally, teacher-child collaboration produced more elaborated classic narrative structure than peer collaboration. However, one pattern of teacher talk that was controlling was negatively correlated with more elaborative narrative. Peer collaboration did not produce a more classic narrative structure than teacher-child collaboration, but did produce elaborated narrative texts. Moreover, engaging in highly interactive peer conversation was positively correlated with the change toward writing in the third person. Daiute et al. concluded that the nature of social interaction around literacy may be more important than the absolute expertise of any partner.

RELATED SYSTEMS

Significant improvements in oral reading fluency and other literacy skills have been found with new developments in technology. Mostow et al. (1994) focused on inside-out skills of literacy and developed a reading tutor that gave appropriate feedback for children reading storybooks out loud. The reading tutor was found to increase oral reading fluency in children significantly. In contrast to Mostow's intelligent tutor approach, the Cognition and Technology Group at Vanderbilt used a situated learning approach in developing their Young Children's Literacy series (The

Cognition and Technology Group at Vanderbilt, 1996). In it, anchored video stories challenged children to write a story to save the animals they saw in the video. Interaction with others was key to literacy learning as the teacher modeled the story writing activity for the children, and children worked together as a group. The series has produced significant improvements in children's word and sentence fluency and story complexity.

Our previous story listening system, StoryMat (Ryokai & Cassell, 1999) was a technologically enhanced play mat that recorded children's oral stories and movements of stuffed animals made on the mat, and played those stories as animations on the mat when the same or another child told a story at the same place. Through listening to peer stories on StoryMat, children told more imaginative and structurally advanced stories. Therefore, peer stories became models and through an opportunity to listen to peer stories, children told more sophisticated stories than they did alone. Our previous story listening system TellTale (Ananny & Cassell, 2001) recorded pieces of children's stories into the body parts of a plastic caterpillar. Through deciding how to arrange and segment story sequences, children's use of discourse connectives and story event language improved. These systems led us to questions about the potentially encouraging role of a partner's feedback on children's stories; for instance, could we foster children's storytelling skills in a way more specifically helpful for literacy by incorporating a kind of virtual companion who could be a listener of children's stories?

Chan and Baskin (1988) proposed "learning companion systems" which employed both an intelligent tutor and an artificial student that were both designed to be at about the same level as the student (both were non-embodied agents). The idea was that a student would learn from an intelligent tutor (in regards to programming LISP), but then was asked to teach the artificial student (learning companion) what he learned. 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 & 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, their interviews revealed that the students enjoyed teaching an agent over a real student because they felt it was like a game.

In the Teachable Agent project (Brophy et al., 1999) children learn ecology by teaching an 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 subject test, as the students who prepared to teach spent time trying to understand "the why" of the studies.

As evident from this literature review, there seems to be an advantage in making technology play a more social role in supporting children's learning. In literacy learning, such social interactions are important as they serve as opportunities for children to gain new knowledge about language and communication, and also to test their knowledge about language and how such knowledge becomes useful.

SAM

Sam is an attempt to have technology play a social role in supporting young children's literacy learning (Cassell, 2001). The Sam system has two components: Sam, an embodied conversational agent (who is designed to look like a child around age 6), and a toy castle with a figurine. Sam is projected on a screen behind the castle, and can both listen to a child's stories and tell her own. The figurine can exist in either the physical world or on the screen, so that Sam and the child can pass it back and forth between their worlds (Cassell et al., 2000). When a child arrives in front of the toy castle, Sam looks at the child and says, "Hi, I'm Sam!" After the child greets Sam, Sam tells a story as she moves the figurine around the castle, occasionally looking up to draw the child in to the story. When Sam finishes her story, she then says, "I'll put the toy in the magic tower so you can tell a story," and places the figurine inside the tower. When the child opens the door, she finds the figurine Sam had been playing with and tells her story. While the child does so, Sam watches the child (following where the child is moving the figurine with head and eye movements), nodding, smiling, and prompting, "What happens next?" When the child is done, the child gives the figurine back to Sam and the interaction continues.

Figure 1. Sam with her toy castle

As discussed earlier, children model literacy skills from a competent partner. Sam acts as that partner as she tells stories using more advanced forms of linguistic expressions (quoted speech, and temporal and spatial information to give enough information for the audience to reconstruct the event). In interacting with precocious Sam who tells stories in developmentally more advanced forms than the child, the child may enter his/her "zone of proximal development" (Vygotsky, 1978). In Vygotsky's term, children develop through their participation in activities that are slightly beyond their competence, with the assistance of adults or more skilled children. In a way, Sam acts as that more skilled peer who can push the ability of the child a little further along. Our hypothesis is that by interacting with precocious Sam and listening to Sam's developmentally advanced stories, children model Sam's linguistic behavior and therefore, perform their storytelling task in a more developmentally advanced form themselves. Yet, because of Sam's peer-like appearance and the playful environment with the toy castle, Sam may offer both playful and collaborative activities, more than what an adult may offer. Our intention is for Sam to provide just the right amount of challenge. Sam's storytelling is more advanced than the child's, but not too advanced, as he is a partner who is just a head taller than the child.

Technical Implementation

Sam detects a child's presence through a microphone, and a motion detector sensor in front of the castle. When the child is playing with the toys and narrating, the system uses audio threshold detection to determine when to give feedback (backchannels such as "uh-huh" nods, and explicit prompts such as "and then what happened next?"). Swatch RFID tag readers are embedded inside of every room in the castle. The tag attached to the figurine tells the system which room in the castle the figurine is at. A switch in the door tells the system whether the figurine is inside of the magic tower and when the magic tower door is opened, so that the child will never see the physical and virtual instantiations of the toy simultaneously (when the door is opened and Sam has the figurine, it disappears instantly and Sam expresses surprise). In order to make Sam's character believable, Sam's stories and other utterances were recorded from a real child, as the quality of children's synthesized voices is still poor. The software is written in Java and C++ and can run on a single PC with a graphics acceleration card. The animation is displayed on a back-projection screen behind the castle.

SAM STUDY

To investigate Sam's role as a competent peer who tells stories using oral language important for literacy, we observed how children interacted with Sam and how her presence affected a child's use of decontextualized language, compared to children who played with a human peer partner.

The study was done in a "Wizard of Oz" setting where Sam's response was controlled by a researcher behind the screen. Thirty-one children volunteered for the study. All children were female and aged 5. Nine children played alone with a castle without Sam, 10 children played alone with a castle with Sam, 6 children played with a co-present playmate with a castle but without Sam, and 6 children played with co-present playmate with a castle and with Sam. All children played for approximately 15 minutes: 5 minutes introduction with an experimenter, and 10 minutes play session on their own. All the children's 10-minute play sessions were transcribed.

Sam as a Storytelling Partner

Sam's presence as a partner who told stories and invited children to tell their stories engaged both children who played alone and children who played with a co-present playmate. In taking turns with Sam and listening to Sam's stories, children seemed to use and explore linguistic expressions important for literacy learning. The following is an example of a child interacting with Sam:

Ann (age 5) is telling stories with Sam by herself

SAM: OK. Let me start. Today I'm going to ride horses in the meadow. My parents said I could ride the big horse named Star. Oh, no. Star has been stolen. I better go tell the sheriff. "Oh, sheriff, my favorite horse Star has been stolen and I don't know where she is." "Oh, no. No need to worry. A kind old lady from the other side of the forest has found her, and she is just coming back home." "Yippee! Thanks. Come on, Star."

SAM: I'll put the toy in the magic tower so you can tell a story.

ANN: Once upon a time there was a little girl and she went downstairs. She looked in the magic mirror. She went downstairs and looked in the mirror. And turned on the lights, and then went back up the stairs. And she looked at her magic, and she looked in the magic mirror, then went back downstairs, and there was her mom and dad. The end. Your turn to tell the story.

SAM: Cool! OK, let me start. 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.

ANN: Once upon a time, there was a little girl who wanted her mommy and poppy, but she didn't have one so she could do anything she wanted. She hopped downstairs and then she saw the, she went upstairs and told the magic mirror that she wanted a mama and papa. The magic mirror told her that she couldn't get one. So she went back downstairs and she saw a monster. She went back upstairs to the magic mirror and said, "Magic mirror, why there's a monster?" and she went back downstairs and there wasn't a monster anymore. The end!

In the example above, Ann took turns with Sam, listened to Sam's stories, and in that process, her stories seemed to become more sophisticated. In her first turn, Ann's sentences involved very little complexity. Her speech was almost an eventcast (i.e. the form of "then she did this, and then she did that...") rather than a story with a causal connection between clauses (Labov, 1972).

Figure 2. A child telling stories with Sam

Sam's stories were created to involve complicating actions (e.g. losing a horse) and resolution of stories (e.g. finding the horse). They also modeled advanced language, such as relative clauses (e.g. the big horse named Star), quoted speech (e.g. "Oh, sheriff..."), temporal expressions (e.g. *today* I'm going to...), and spatial expressions (e.g. a kind old lady from *the other side of the forest*). After hearing Sam's stories, Ann used more literate expressions, such as relative clauses (e.g. "a little girl who wanted her mommy and poppy") and quoted speech (e.g. "she said, 'Magic mirror...'").

Two researchers coded together the occurrence of spatial expressions, temporal expressions, and quoted speech in the children's stories. Following Peterson, Jesso, and McCabe (1999), spatial expression was coded as definite information about *where* the event took place (e.g. "then the boy went to the *kitchen*") and temporal expression as explicit information about *when* the event took place (e.g. "he went downstairs *when he heard the noise*"). For the quoted speech, we coded for both direct speech with a framing clause (e.g. then she said, "Oh no!") and indirect speech such as "he said that he wasn't hungry" (Hickmann, 1993). The occurrences were tallied, and the numbers were then analyzed with respect to the time each child had to tell her story.

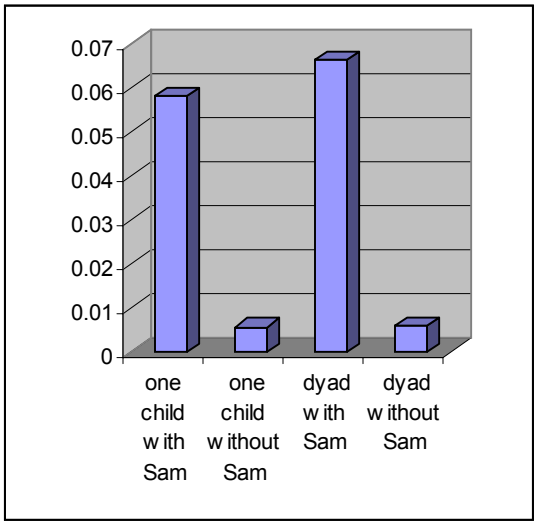

Figure 3. Mean frequency (tally of occurrences / total time) of spatial information

The presence of Sam dramatically increased the frequency with which children used quoted speech and temporal and spatial expressions. Figure 3 shows the mean frequency (tally of occurrences of expressions by each child / total time that child spent speaking) of spatial expression across the four conditions. Thus, for the dyads, the bar represents the mean frequency for each of the children in dyads. A full-factorial ANOVA revealed a main effect due to the presence or absence of Sam, $F(3, 24) = 68.04$, $p<.01$. There was no main effect for number of children (the one child vs. the dyad condition), nor were there any interactions. Children used significantly more spatial expressions when playing with Sam than they did alone, or with another child. Findings were equally significant for quoted speech ($F(3, 24)=10.58$, $p<.01$) and temporal expressions ($F(3, 24) = 30.52$, $p<.01$). The children in the "dyad with Sam" condition had equally high frequencies of quoted speech and temporal and spatial expressions as in the "one child with Sam" condition. This suggests that Sam succeeds in evoking literate behaviors even in the presence of a real flesh-and-blood playmate.

Was children's use of literate expressions attributable to the fact that Sam modeled these behaviors? In order to examine this question, we looked at whether the literate expressions increased over the course of the interaction with Sam. Remember that as the children took turns with Sam, every one of their stories was preceded and followed by a story by Sam. Figure 4 illustrates the mean number of spatial expressions per story produced by the children in the "one child with Sam" condition. The figure illustrates the increased amount of spatial expressions as the children tell their stories with Sam: the first story contained a relatively low number of spatial expressions, yet the number doubles and triples over the course of a child's interactions with Sam. The Pearson product-moment correlation test revealed a significant positive correlation between the chronology of stories and occurrence of spatial expression, r=.35, p<.05, and of quoted speech (r=.27, p<.06). No significant correlation was found for temporal expressions (r=.065). Interestingly, however, if one looks only at the first three stories, the use of temporal expressions does increase significantly over the stories. This suggests that children may have become tired after the third interaction, and no longer were able to push their linguistic behavior to its limits. Of course, a future study will investigate children's interaction with Sam over a longer term, as observation of stable linguistic improvements may require more than a few storytelling turns with Sam.

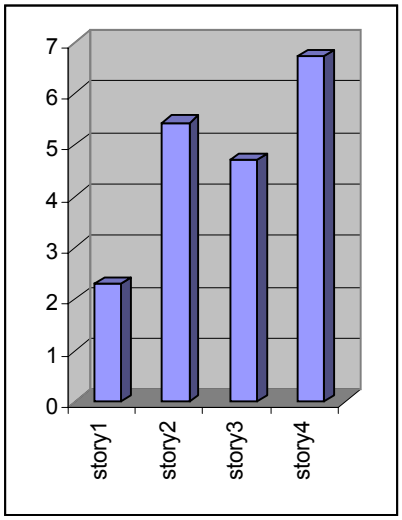

Figure 4. Mean number of spatial expressions per story

Unlike the children who played with Sam, children who played with another child without Sam treated each other as conversational partners rather than taking turns being the storyteller and the story listener. In the example below, the two children engage in fantasy/pretend play (i.e. the two children seem to be pretending to be at a house with a ghost) and talk to each other as a character in their play. As the two children are engaging in a conversation, rather than storytelling, their speech is more dependent upon contextual cues. For example, the child did not introduce or explain what "this" was in the utterance "You broke this..." because the referred item was immediately shared with her partner and in their conversation:

Wendy and Sarah (both age 5) are playing without Sam

Wendy: You broke this after I had fixed it.
Sarah: Not me.
Wendy: It's probably the ghost.
Sarah: There's no such thing as monsters. Did that door just open, or was it just my imagination?
Wendy: It was just your imagination.
Sarah: No. I think it was just the wind. I'm having nightmares.
Wendy: Me, too.
Sarah: I want to sleep. I want to sleep. I hope I am.

The children who played with Sam also shared the physical context with Sam (e.g. sharing the castle). However, Sam explicitly invited the children to tell stories and modeled decontextualized storytelling behavior. Further, because Sam's method of narration did not rely on contextual cues, the children's narration also became less context-dependent. In a way, the children and Sam shared the same invisible audience. Therefore, Sam's presence as a partner who took turns with children and told stories using diverse linguistic expressions appears to have been important in making the stories more sophisticated, fostering children's use of linguistic expressions in storytelling.

Sam as a Peer

Children seemed to perceive Sam as a co-storyteller and collaborator, as demonstrated below:

Ann (age 5) is playing alone with Sam. Sam finishes her story and gives the turn to Ann.

SAM: I'll put the toy in the magic tower so you can tell a story.
ANN: Once upon a time there was a little girl and she went downstairs. [eye gaze at the toy she is telling her story with] She looked in the magic mirror. She went downstairs and looked in the mirror. And turned on the lights, and then went back up the stairs. And she looked at her magic. And she looked in the magic mirror, then went back downstairs, and there was her mom and dad. The end. Your turn to tell the story. [gaze back at Sam]

Once Ann finished her story, she acknowledged Sam's turn by looking at Sam and saying, "Your turn to tell the story." Then Ann put the toy back to the magic tower for Sam to take it away. Many children acknowledged Sam's turn by giving similar "Your turn!" acknowledgement. When things were not clear, as in the following example, children seemed to "ask" Sam questions as if to check if Sam was OK:

Simone (age 5) *is playing alone with Sam.*

SAM: Cool! OK, my turn. Today I'm going to ride horses in the meadow. [...] She is just coming back now. Whee! Thanks. Come on, Star. [pause]
SIMONE: You done, Sam? OK.
SAM: I'll put the toy in the magic tower so you can tell a story.
SIMONE: What should I tell, Sam? Do you have an idea? [gaze Sam] Hmmmm.[gaze away]
SAM: Tell me what happens next.
SIMONE: Oh, the girl was happy.[...]

Simone seemed to regard Sam as a storytelling partner. So, when Sam finished her story, and did not immediately give up her turn, Simone asked Sam, "You done, Sam?" before she took her turn. Simone also seemed to consider Sam as a fellow collaborator. When Simone was thinking about what to tell, she looked at Sam and asked, "What should I tell, Sam? Do you have an idea?" Then, she gazed away while she thought about what to tell, a behavior one might observe from two real peers. Although we did not quantify eye gaze patterns used by children in the study, our observation leads us to believe that children looked back-and-forth from Sam to the castle in similar ways as they did when they were playing with another child. And, in fact, even with a co-present playmate, children seemed to take Sam into account. The following is an example from two children playing with Sam:

Amy and Beth (both age 5) are playing together with Sam. Beth has already told her story. Now Amy is telling her story.

AMY: 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.
BETH: So, her nose went big?
AMY: So, then, the mother and father put her bed.
BETH: Because she lied?
AMY: Because she lied, and because she wasn't supposed to do that.
BETH: OK. My turn.
AMY: Sammy. I want Sammy to do it. I'll put it back. [Amy puts the toy in the magic tower for Sam to take her turn]

The two children seemed to collaboratively tell a story. While Amy is the main storyteller, Beth scaffolded Amy by giving some ideas (e.g. "What about Anna?" "Because she lied?"). When Amy finished, Beth tried to take the turn. However, Amy turned things over to Sam.. Thus, even with a co-present playmate, the children seemed to take Sam into account. In everyday storytelling, children become collaborators and facilitators of peer narrations (Preece, 1992). Thinking about Sam's turn and acknowledging Sam's role as a fellow collaborator is similar to what children go through with peers in everyday collaborative storytelling. Literacy learning is more profound in situations where children assist each other or collaboratively engage in activities than it is in parallel or solitary behaviors (Stone & Christie, 1996). In our experiments, Sam seemed to play the role of an engaging peer, and was thus able to elicit linguistic behaviors predictive of future literacy.

Children Coaching Sam

Children not only seemed to regard Sam as a storytelling partner to model, but also as a peer to coach. We did not design Sam to be a character that explicitly elicited help from children. However, in interaction with Sam, children spontaneously helped Sam. The following is an example of a child "coaching" Sam:

Jane (age 5) *is playing alone with Sam.*

SAM: Now what happens?
CHILD: It's like this. Now it's a girl. Hi. [...] The End. Now it's your turn.
SAM: Cool. OK, my turn. One day me and my friend[...] I'll put the toy in the magic tower so you can tell a story.
JANE: [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, [...] He went to sleep. That's the end!

Jane told a long story before Sam took her turn. After listening to Sam's story, Jane went on to model what she was looking for. "It's like this," she told Sam and then told her own, longer story, thereby coaching and modeling for Sam how to be a better storyteller.

The following is another example of a child correcting Sam:

Ann (age 5) is playing alone with Sam. Sam tells a story which Ann has heard before. Ann interrupts Sam and comments that Sam has already told that story before.

```
SAM:   OK.  My turn.  I love dancing with the music. [...] They said that the lady from
       the other side of the forest was going to come, but she didn't show up.
ANN:   You already told that story!
SAM:   So, many people until my parents said I have to go to bed.
ANN:   Sam!
SAM:   I could have danced all night.  When I grow up, I'm going
ANN:   Sam, you already told that story.  You can still tell it though.  Go ahead.
       [pause]
SAM:   I'll put the toy in the magic tower so you can tell a story.
ANN:   OK.  Let's see.  [pause]
SAM:   Why don't you tell me a story?
ANN:   Just a minute, Sam.
```

Ann listened carefully to Sam's story and commented that Sam had already told the story before. Ann was acting as a corrector of Sam's storytelling, but did so politely, allowing Sam to finish her story. In everyday storytelling, children become not only collaborators and facilitators, but also active critics and correctors of peer stories (Preece, 1992). Accordingly, Jane and Ann became critics and correctors of Sam's storytelling. Sam seemed to act as a co-storyteller, but also a peer the children felt responsible to critic and coach. By coaching, peers provide substantive input to one another's learning (Cazden, 1988; Rogoff, 1990; Neuman & Roskos, 1991). Therefore, children's interaction with Sam both as co-storyteller and as critic may contribute to them becoming critical thinkers who could evaluate and challenge others' linguistic behaviors.

Limitations

Sam's current response behavior is fairly limited. Sam was able to elicit collaborative behaviors from children, but could not follow up on the children's collaborative behaviors. For example, Sam did respond to a child's story by saying "Cool!" However, Sam was not able to give any specific feedback that related to the child's story. Somewhat surprisingly, given Sam's quite limited collaborative behavior, children still took Sam as a peer and continued to engage in collaborative behavior with Sam. We are currently investigating how Sam could relate to and incorporate children's story elements into her own stories through the use of keyword recognition techniques.

The scope of the study was limited in that it included only 5-year-old girls. Would interactions with Sam and her toy castle be engaging for both girls and boys? To children of what age range could this type of storytelling play be engaging and effective? We are designing Sam and her toys and stories to appeal to both girls and boys for our future study, as well as the age range appropriate for such an interface.

Finally, the children in the study played only once with Sam. However, in order to establish a longitudinal study, Sam's interaction with children needs to evolve over time. For example, Sam cannot simply greet "Hi, I'm Sam!" every time a child plays with her. How could Sam establish a long term relationship? Can Sam be a friend to a child? A study has shown that friends, compared to non-friends, resolved more conflicts and performed better at emergent literacy activities during pretend play (Pellegrini et al., 1998). We plan to investigate the kind of interactions and relationships Sam could have with children over a longer term.

FUTURE WORK

We are currently developing Sam in two directions: 1) designing Sam's stories with more precise features of outside-in literacy skills and 2) enhancing Sam's interactivity.

In order to more precisely model outside-in literacy skills, Sam's new stories will involve more decontextualized language (e.g. spatial and temporal information of stories), and perspective taking. A recent study has shown that children's ability to take multiple perspectives in storytelling is positively correlated with their mathematical skills (O'Neill & Pearce, 2001). We believe Sam could model such perspective taking by introducing and maintaining different characters in her stories. To encourage such perspective taking, we have also incorporated multiple figurines so that Sam and children can tell stories with multiple perspectives using the figurines.

In order to increase Sam's interactivity, we are investigating keyword spotting speech recognition technology. In addition to speech input, Sam's toy castle is being enhanced with more sensors to follow movements children make while they are narrating. For example, movement of furniture in the castle while children tell their story will be cues for Sam to give feedback to their actions. Finally, in order for Sam to produce the positive effect of multi-age collaboration where children learn by both modeling and coaching their peer (Christie & Stone, 1999), we need to have a more explicit model of a peer who could both teach and be criticized. Currently, we are investigating behavioral features of Sam that invite constructive criticism. With a more explicit model of Sam as a peer, we plan to further investigate children's literacy learning with Sam.

DISCUSSION

In summary, Sam became a partner for children to model their own stories after, as well as a peer in need of didactic coaching. The role of the "more capable partner" in the Vygotskian sense, changed fluidly between Sam and her human playmate, just like it does between real peers. This type of role change resembles a reciprocal model of peer assistance where children take both the teacher's and student's roles (Palincsar & Brown, 1984; Cazden, 1988), beneficial for collaborative learning in general.

Most importantly, Sam was able to model linguistic behaviors crucial for literacy. By taking turns with Sam and by listening to Sam's stories, the children's stories became more sophisticated and explicit through the use of quoted speech and spatial and temporal expressions. As such, children learned and practiced ways to gear their text more sensitively to an audience, which is one of keys to literacy learning.

By listening to Sam's stories and having Sam as their listener, children became both active learners and critics of others' stories. Unlike in traditional CSCL, where computers are enlisted to support learning between a teacher and pupils or to support collaborative learning between pupils, this work explored the role of computers as participants in collaborative learning. This work contributes to the field of CSCL as it illustrates how computers could play a more social role in supporting young children's literacy learning in familiar environments.

ACKNOWLEDGMENTS

We thank all the children who participated in the study, Thompson School, Vicky Rose, Linda Lin, Elisabeth Sylvan, Dona Tversky, Stefan Marti, Ian Gouldstone, Schuyler Horton, and the members of the Gesture and Narrative Language group at the MIT Media Lab.

REFERENCES

Ananny, M. and J. Cassell (2001). Telling Tales: A new toy for encouraging written literacy through oral storytelling. *Society for Research in Child Development biennial meeting*, Minneapolis, MN.

Brophy, S., Biswas, G., Katzlberger, T., Bransford, J. & Schwartz, D. (1999). Teachable Agents: Combining Insights from Learning Theory and Computer Science. In S. P. Lajoie and M. Vivet (Eds.), *Artificial Intelligence in Education.* vol. 50, pp. 21-28. Amsterdam: IOS Press.

Cameron, C. & Wang, M. (1999). Frog, Where Are You? Children's narrative expression over the telephone. *Discourse Processes*, 28, 217-236.

Cassell, J (2001). "Towards a Model of Technology and Literacy Development: Story Listening Systems." Tech Report ML-GNL-01-1.

Cassell, J., M. Ananny, Basu, A., Bickmore, T., Chong, P., Mellis, D., Ryokai, K., Smith, J., Vilhjálmsson, H., & Yan, H. (2000). Shared Reality: Physical Collaboration with a Virtual Peer. In *Proceedings of CHI 2000*.

Cazden, C. (1988). *Classroom discourse*. Portsmouth: Heinemann.

Chan, T-W & Baskin, A. (1988). Studying with the Prince: The Computer as a Learning Companion, *Int'l Conference on ITS*.

Christie, J. & Stone, S. (1999). Collaborative literacy activity in print-enriched play centers: Exploring the "zone" in same-age and multi-age groupings. *Journal of Literacy Research*, 31, 2, 109-131.

The Cognition and Technology Group at Vanderbilt. (1996). A multimedia literacy series that celebrates authorship and books. *Communications of the Association for Computing Machinery (ACM) on Learner-Centered Design,* 39 (8), 106-109.

Daiute, C., Campbell, C.H., Griffin, T.M., Reddy, M. & Tivnan, T. (1993). Young authors' interactions with peers and a teacher: Toward a developmentally sensitive sociaocultural literacy theory. In Daiute (Ed.) *The development of literacy through social interaction.* San Francisco: Jossey-Bass Publishers.

Dickinson, D.K., Cote, L.R. & Smith, M.W. (1993). Learning vocabulary in preschool: Social and discourse contexts affecting vocabulary growth. In W. Damon (Series Ed.) & C. Daiute (Vol. Ed.), *New directions in child development: Vol. 61. The development of literacy through social interaction* (pp. 67-78). San Francisco, CA: Jossey-Bass.

Hickmann, M. (1993). The boundaries of reported speech in narrative discourse: some developmental aspects. In John-Arthur, L. (Ed.) *Reflexive language: Reported speech and metapragmatics*, New York, NY: Cambridge University Press, pp.63-90.

Labov, W. (1972). The logic of non-standard English, *Language in the Inner City: Studies in the Black English Vernacular* (pp.201-240). Philadelphia, PA: University of Pennsylvania Press.

Mostow, J., Roth, S., Hauptmann, A.G. & Kane, M. (1994). A prototype reading coach that listens, *Proceeding of the Twelfth National Conference on Artificial Intelligence,* August 1994 (pp.785-792), Seattle, WA: American Association for Artificial Intelligence.

Nelson, K. (1996). *Language in Cognitive Development*. New York: Cambridge University Press.

Neuman & Roskos (1991). Peers as literacy informants: A description of young children's literacy conversations in play. *Early childhood research quarterly*, 6, 233-248.

O'Neill, D. & Pearce, M. (2001). A new perspective on the predictive relation between narrative perspective-taking ability in preschoolers and academic competence, (under review).

Palincsar, A.S. & Brown, A.L. (1984). Reciprocal teaching of comprehension-fostering and comprehension monitoring activities. *Cognition and Instruction*, 1, 117-175.

Pellegrini, A.D., Galda, L., Bartini, M. & Charak, D. (1998). Oral language and literacy learning in context: The role of social relationships. *Merrill-Palmer Quarterly*, 44, 1, 38-54.

Preece, A. (1992). Collaborators and Critics: The nature and effects of peer interaction on children's conversational narratives. *Journal of Narrative and Life History*, 2, 3, 277-292.

Ryokai, K. & Cassell, J. (1999). Computer support for children's collaborative fantasy play and storytelling. In *Proceedings of Computer Support for Collaborative Learning*, 1999, pp.510-517.

Rogoff, B. (1990). *Apprenticeship in Thinking: Cognitive development in social context.* New York: Oxford University Press.

Snow, C.E. (1983). Literacy and Language: Relationships during the Preschool Years, *Harvard Educational Review*, 53, 2, 165-189.

Snow, C.E. (1993). Families as social contexts for literacy development. In Daiute (Ed.) *The development of literacy through social interaction.* San Francisco: Jossey-Bass Publishers.

Snow, C.E., Tabors, P.O., Nicholson, P.A. & Kurland, B.F. (1995). SHELL: Oral language and early literacy skills in kindergarten and first-grade children. *Journal of Research in Childhood Education*, 10, 1, 37-48.

Stone, S.J. & Christie, J.F. (1996). Collaborative literacy learning during sociodramatic play in a multiage (K-2) primary classroom. *Journal of Research in Childhood Education*, 10, 2, 123-133.

Teale, W.H. & Sulzby, E. (1986). *Emergent Literacy: Writing and reading*. Norwood, NJ: Ablex.

Vygotsky, L.S. (1978). *Mind in society: The development of psychological processes*. Cambridge, MA: Harvard University Press.

Whitehurst, G.J. & Longian, C.J. (1998). Child development and emergent literacy. *Child Development*, 69, 848-872.