Virtual Peers for Literacy Learning

Justine Cassell, Andrea Tartaro, Yolanda Rankin, Vani Oza, Candice Tse

The ArticuLab
Northwestern University

Submitted to Educational Technology, special issue on Pedagogical Agents

Correspondence regarding this manuscript:
Justine Cassell (justine@northwestern.edu)
Frances Searle 2-148
Northwestern University
2240 Campus Drive
Evanston, IL 60660

Acknowledgments
The research reported in this article is based upon work supported by Grant No. 0400457 from the National Science Foundation to Justine Cassell and Susan R. Goldman, and by a School of Communication Innovations grant to Justine Cassell and Andrea Tartaro. Any opinions, findings, conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the funding agencies. We gratefully acknowledge the contribution of Austin Wang, alumnus of the research projects reported here, and the collaboration of Susan Goldman and her colleagues at UIC. We also express our deepest appreciation to all of the teachers and students, parents and children, who have participated in the studies we describe.
1 Introduction

From mathematics word problems to great literature to science texts, being able to read and write is of paramount importance to academic success. And yet, literacy remains a critical unsolved issue in our educational system. In fact, paradoxically, some of the newer approaches to literacy are turning out to result in a “fourth grade slump” for the most economically disadvantaged, where children who may appear to have acquired literacy skills when they are tested in first grade, still may not know how to “read to learn” when they reach the fourth grade (such as: Chall & Jacobs, 2003). Problems with literacy education are exacerbated for non-white children (e.g. African Americans, Hispanics) who still score below their Caucasian counterparts (Donahue, Daane, & Grigg, 2003). In fact, on national standardized reading assessment, only 39% of African American children in the fourth grade scored at or above basic reading level (2004).

We believe that pedagogical agents can play a unique role in supporting literacy development. In this article we discuss one kind of pedagogical agent that we believe is particularly suited to helping children acquire literacy skills, and that is a virtual peer – a computer-generated cartoon child on a screen that is capable of interacting with children and engaging in collaborative storytelling. In what follows we first outline some of the challenges that children face in learning how to read and write, and the role that real-life peers play in literacy learning. Then we turn to the notion of a virtual peer. We describe the research that goes into implementing this technology, how it can be used in both formal and informal learning contexts, and the results of our evaluations on the effects of virtual peers on young children’s emergent literacy skills.

2 Background

Emergent Literacy

According to Wells (1981), the third stage of language development involves the creation and manipulation of language designed for an audience that is not present while the language was created. Wells calls this stage “literacy.” Looked at in this way, children prepare themselves for learning literacy skills long before first grade (S. B. Heath, 1983) in a process that has come to be known as emergent literacy (Teale & Sulzby, 1986). So, for example, learning how to write includes: (1) metalinguistic awareness (Cazden, 1976), which is the ability to reflect on the form of language, such as being able to count syllables in a word; (2) using decontextualized language (Snow, 1983), which is the ability to use language to express things in a way that is clear for listeners who don’t share exactly the same context; and (3) making one’s communicative intentions known (for example, “I’m going to tell you about my day”).

Because the listener plays such an essential role in emergent literacy, these skills are often first acquired in social contexts such as language play and storytelling, and many of them are acquired in the context of interactions with peers. For example, Preece (1992) found that children are engaged, and even aggressive listeners for one another, and that this active listening contributes to the modification, expansion, increased coherence, and complexity of their stories. A study of the effects of these peer relationships on kindergarten children discovered that
friendship plays a role in acquiring cognitively complex interactions such as emergent literacy skills (Pellegrini, Galda, Bartini, & Charak, 1998). On the basis of studies such as these, many educators have begun to recognize the importance of the peer context, and to address it through classroom activities such as sharing time (Gallas, 1992; Gee, 1986; Michaels, 1986) round-robin storytelling, and the editor’s corner. But peers can also disrupt and be disengaged, and they don’t have the language skills that the child is trying to acquire. What would be ideal is to have as a teacher someone who looks and acts like a peer, but who has the capabilities of an adult and is therefore able to scaffold children’s learning.

2.1 Background: Virtual Peers

Enter the virtual peer. Virtual peers are a unique kind of pedagogical agent that my students and I have been developing since 2000. Whereas the vast majority of pedagogical agent research is modeled after teachers or tutors (Lester, Voerman, Towns, & Callaway, 1997), virtual peers exist as playmate and learning companion, in line with the literature on children’s development in a peer context. Virtual peers are a kind of embodied conversational agent (Cassell, Sullivan, Prevost, & Churchill, 2000), which means that they can have conversations with real people, using language but also hand gestures, facial expressions, eye gaze, and other kinds of “body language.” Virtual peers are designed using a unique methodology (see Figure 1) that relies on data about children’s natural development to build technologies that can play the role of a friend or playmate.

![Figure 1: Virtual Peer Methodology](image)

In the remainder of this article, we will describe this methodology with respect to 3 case studies; in each case looking at how we learn about natural storytelling among children, how we build virtual peers, and how we test their educational effectiveness.

3. Case Studies
   Case 1: Sam
Our interest is in how natural storytelling behaviors among peers can help children acquire literacy skills. On the basis of the literature reviewed above, we knew that children’s storytelling sometimes contained instances of decontextualized language, metalinguistic reflection, and making one’s communicative intentions known – oral precursors to reading and writing. And we knew that these behaviors were more likely to occur spontaneously in peer play. So, in a study of children’s storytelling (with no adults in the room), we looked at the cues that children gave one another to indicate that they wanted to play and that they were engaged. Sam was designed after this period of observation, and was based on how children used their bodies – how they touched one another, gestured with toys, and made facial expressions – as well as the kinds of stories they told.

Sam (Cassell et al., 2000; Ryokai, Vaucelle, & Cassell, 2002) looks like a child who is sitting behind a toy castle and waiting for a playmate to tell stories with. To this end, the Sam system has two components: an embodied conversational agent – a life-sized child named Sam – and a toy castle with several plastic figurines. 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 and short comments (See Figure 2).

The house is a two-story playhouse, with a virtual counterpart that is displayed in front of Sam, creating an illusion that the physical house extends into Sam’s space. In addition, figurines are tagged with radio frequency badges that allow the system to know what toy the child is playing with. A small compartment in the attic is accessed via a small swinging door. Children can “share” toys with Sam by placing them in the attic. Sam then seems to pick up those same toys and play with them. Sam has a database of short stories that involve one or two characters, played out by the figurines. The stories were taken from actual children’s stories that we observed, but were adapted to demonstrate third person narrative voice, reported speech (“character voice”), appropriate introduction of new characters, and appropriate use of cohesive devices.

After having built Sam, we brought it into schools to see first whether children would want to play with Sam, and second whether there would be a positive effect on emergent literacy
skills. We discovered that children were very willing to play with Sam as they would with another child. They clamored to be the next in line, and asked their teachers when Sam would be back. When playing, they asked Sam questions (“are you a boy or a girl”), tried to help Sam (“tell a longer story next time, Sam. They like it when you tell long stories”), and asked questions of the experimenters that demonstrated that although they did not think Sam was a real child, they thought Sam was a good playmate: “[Sam’s] more complicated because like you have toys that like do only one thing -- Sam does a lot of things.”

In our analysis of the effect of Sam on emergent literacy, we looked at those behaviors which have been found to predict later literacy: metalinguistic behavior, and use of decontextualized language. 31 children aged five years were videotaped interacting with the castle, in pairs and alone, with and without the Sam virtual peer. The children’s stories were analyzed for the occurrence of explicit spatial expressions (e.g. “then the boy went to the kitchen”), temporal expressions (e.g. “he went downstairs when he heard the noise”), and quoted speech with an introductory verb (e.g. “then she said, “Oh no!”” or “he said that he wasn’t hungry”). Results demonstrated that the presence of Sam significantly increased the frequency with which children used quoted speech \( F(3, 24)=10.58, p<.01 \), temporal expressions \( F(3, 24) = 30.52, p<.01 \), and spatial expressions \( F(3, 24) = 68.04, p<.01 \). No effect was found for number of children. This suggests that Sam is equally successful in evoking literate behaviors when working with a single child as when working with two children. Results also demonstrated that with each subsequent story that children told with Sam, children in the “one child with Sam” condition used more decontextualized language and metalinguistic expressions: for spatial expression \( r=.35, p<.05 \), for quoted speech \( r=.27, p<.06 \), and for temporal expressions \( r=.363, p<.041 \). Finally, when children played with Sam for 30 minutes once per week over a period of a month, we found a significant increase of 5% in their composite literacy scores (Spoken Language Quotient) on the TELD (Test of Early Language Development), indicating that interaction with Sam is predictive of increased performance of exactly the sort schools hope when they use the TELD to measure literacy skills in young children.

Of course, 4 sessions over a month is still a controlled situation, and does not constitute a proof of Sam’s ability to be integrated into a classroom. Thus, Goldman, Kehoe, et al., (this issue) have studied how engagement with Sam can be sustained over the long term, and how Sam can be made a part of the school context. In our own work, we have turned to further investigations of the linguistic and social context of virtual peers. That is, how can virtual peers be more useful to linguistic development, and for particular populations

**Case 2: Collaborative Sam**

The findings described above demonstrate that a virtual peer can successfully elicit emergent literacy skills. However, comparing Sam’s play to that of real children led us to realize that we had omitted one very important skill ... and that was to somewhat rudely interrupt the other child, to criticize, jump in, and more interactively construct a joint story. Sam, on the other hand, always told a whole story before turning over the floor, and waited for the child to tell a whole story before taking the floor. Children’s seemingly rude interaction has in fact strong benefits for children’s use of language. We therefore went back to observing real children’s play to refine our model of storytelling.

Preece (1992) divided children’s narratives into two categories, according to participants’ specific roles: (i) Critics & Author where the listening child acts as critic by suggesting &
correcting while the author narrates, and (ii) Facilitator & Collaborators where the “lead child” coordinates stories by assigning character roles & plotting stories. In our study, we found that children also sometimes competed to be the primary author, or became co-authors in the story. We therefore added a third category: (iii) Co-authors where participants share the floor in either organized (role-play), or unorganized fashion (simultaneous turns).

But, how do children recognize which category of play to engage in? We watched children’s play and found that each category of collaborative storytelling was distinguished by different kinds of speech and different kinds of nonverbal behaviors, as shown in Table 1 (taken from (Wang & Cassell, 2003)).

**Table 1 – Taxonomy of children’s collaborative speech acts**

<table>
<thead>
<tr>
<th>Roles</th>
<th>Speech act</th>
<th>Speaker</th>
<th>Function</th>
<th>Turn-taking behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critics and authors</td>
<td>Suggest</td>
<td>Critic</td>
<td>Suggest an event or idea</td>
<td>Critic eye gaze towards author, author uses paralanguage drawls and socio-centric sequences</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Both</td>
<td>Seek clarification or missing information</td>
<td>Eye gaze towards other, lack of backchannel feedback like head nods, increased body motion, author stops gesturing</td>
</tr>
<tr>
<td>Facilitator and collaborator</td>
<td>Acknowledge</td>
<td>Collaborator</td>
<td>Acknowledge a role designation or storyline suggestion</td>
<td>Eye gaze towards facilitator, backchannel feedback like head nods, both stop gesturing</td>
</tr>
<tr>
<td></td>
<td>Role-play</td>
<td>Both</td>
<td>Play the role of characters in the story</td>
<td>Eye gaze towards action, prosody of character, gesture with toy</td>
</tr>
<tr>
<td>Co-authors</td>
<td>Simultaneous turns</td>
<td>Both</td>
<td>Compete for turn</td>
<td>Both sets of hands in play space, eye gaze towards action</td>
</tr>
</tbody>
</table>

We then implemented into Sam a subset of speech acts and corresponding turn-taking behaviors, according to the model described in Table 1. Sam was extensively modified: new non-linear stories were added (each with multiple paths and endings), along with collaborative turn-taking strategies. Considerable effort was taken to constrain the themes of the interaction such that it would be manageable by an autonomous agent.

Sam was modified to assume three of the six collaborative roles: author, facilitator, co-author. When assuming these roles, and using the appropriate speech and nonverbal behavior for each role, Sam is inviting the child to take on the three corresponding roles (critic, collaborator, co-author). To perform the various turn-taking cues described above, Sam uses eye-gaze, body and head posture, hand gestures, and speech to negotiate turns. And in each role, Sam says just a part of a story, rather than a whole story. Thus, when being a facilitator, Sam says “you be the princess and I’ll be the prince, ok”. When being a co-author, Sam starts a story, and then begins to hesitate, saying “umm umm” while looking at the real child.
Strikingly, these tactics work! When Sam is the facilitator, children take on the part they have been given. When Sam is a co-author children do jump in and take over the story when Sam hesitates. Children are once again very willing to suspend disbelief, and to engage in collaboration with a virtual peer. We are currently evaluating Collaborative Sam for its ability to keep children engaged, and to get children to use more decontextualized language. In addition, we are looking at whether Collaborative Sam encourages children to use more complete narrative structures, because the structure of the story is scaffolded by the interaction.

**Case 3: Alex**

Storytelling enables children to practice emergent literacy skills but storytelling practices differ according to cultural background (Champion, 1998; Shirley Brice Heath, 1986; Smitherman, 1999). If only one kind of story is used to bootstrap literacy in school, children from other cultural backgrounds may have trouble making a bridge from home to school language (Gutierrez & Rogoff, 2003).

The community of interest to us is African American children who speak African American Vernacular English (AAVE), a group that has traditionally not fared well in the transition from home to school language (Michaels, 1981; Watson, 2001), although their language skills may be highly developed according to the community’s own linguistic norms (Goodwin, 1990; Lee, 1997). Lee (1997) proposes that rather than requiring students to divorce themselves from these cultural practices in order to acquire the appropriate literacy skills of the mainstream, that we should provide a “cultural modeling framework” that leverages those cultural practices constructed from home and community experience as stepping stones for building and honing students’ literacy skills.

In concrete terms, we have relied on this theoretical position to build a virtual peer, Alex, who can serve as a learning partner to African American children. Preschool children assess race based skin color, hair, attire and speech (Hirschfeld, 1996; Holmes, 1995). In most previous research on race and ethnicity in pedagogical agents, however, only the external features have been varied. Alex models oral traditions and narrative modes, verbal and non-verbal narrative features, and interactional styles as a bridge to learning.

As with all of our work, the methodology is three-fold. (1) First we studied the actual storytelling practices of children, in this instance, speaking African American Vernacular English. (2) After long study of the syntactic, phonological, oral delivery, narrative, and nonverbal features of language that index a speaker as African American, we then created a virtual peer that *looks* race neutral, but can model African American cultural storytelling and behavior. We chose to make the virtual peer race neutral in appearance for two reasons: (1) to avoid stereotyping features that may be offensive to particular segments of our target population, (2) to be able to evaluate whether verbal and nonverbal features alone are effective in helping children make a bridge to literacy when working with virtual peers.
Now that we have implemented a virtual peer capable of speaking African American English (shown in Figure 4), and we have assessed whether children consider the virtual peer to be like them, we test the effectiveness of this virtual peer in helping children acquire literacy skills. We will soon be carrying out an evaluation that looks to see which kind of peer is more effective in helping AAVE speakers: a virtual peer that speaks Standard English, or a virtual peer that speaks AAVE. However, some literature suggests that for all children being exposed to different ways of speaking is helpful to learning literacy skills. That is because metalinguistic reflection – the ability to think about language – is increased with exposure to different languages. For this reason, we are also testing the AAVE-speaking peer with white children speaking Standard American English.

4. Conclusions

In each of these case studies, we base our virtual peer on spontaneous storytelling among children. We try to tease out the parts of children’s own natural language use that can help them develop school-based literacy skills, and we use virtual peers to help children concentrate on those particular language practices. One case study has been completed from start to finish, and we have been able to demonstrate that Sam, the storytelling virtual peer, does encourage children to use emergent literacy devices. A second case study, Collaborative Sam, has been built based on the lessons from Sam, and we have shown that children are willing to interrupt, criticize and otherwise tightly engage with a virtual peer. Currently we are analyzing the results from a study of Collaborative Sam’s educational effectiveness. Finally, a third case study, the African American Vernacular English-speaking virtual peer Alex, has been implemented on the basis of a careful study of AAVE storytelling, and we have demonstrated that children recognize Alex as an AAVE speaker. Now we are ready to conduct a study of whether Alex can help AAVE and Standard American English speakers develop literacy skills in the classroom. We hope that the paradigm of virtual peers will come to be developed for other domains as well – for science and math, for social skills and children with atypical development. For in all of these domains, children case serve as powerful companions in learning.


