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Digital Peers to Help Children's Text Comprehension and Perceptions

ABSTRACT

Affable Reading Tutor (ART) is an online reading lesson designed for children who start reading to comprehend. A digital, human-like character (virtual peer) in ART serves as a peer model that demonstrates the use of the reading comprehension strategy *questioning* to help improve the learners' comprehension of expository texts. This study, with 141 boys and girls in the fourth and fifth grades in the United States, examined the effects of virtual-peer presence (presence vs. absence vs. control) on learners' text comprehension and also the effects of learner gender and virtual-peer attributes (human-like male vs. human-like female vs. robot still image) on learners' perceptions of their peer and on their text comprehension. The results revealed that the virtual-peer presence group outperformed both the absence group and the control group in the immediate and delayed posttests text comprehension. There were mixed results in the impacts of learner gender and virtual-peer attributes on text comprehension. The learners' perceptions of their agent were not differentiated by neither learner gender nor virtual-peer attributes. The findings are discussed with virtual-peer design implications.

Keywords

Interactive learning environment, Virtual peers, Pedagogical agents, Computer-assisted language learning, Reading strategy instruction

Introduction

Researchers in literacy education argue that social interaction fosters the comprehension of texts while reading. That is, personal connection with peers and teachers enhances students' curiosity towards reading, their engagement in reading, and their preference for reading challenge (Guthrie, 2002). At the same time, the National Reading Panel in the United States (National Reading Panel, 2000) has issued a strong recommendation that young readers be directly taught reading strategies to increase their comprehension of expository texts. Children at the early stages of reading to comprehend seem to need more direct individualized instruction and guidance through supportive relationships. This type of individual support, however, has been a big challenge in a conventional classroom setting that typically has one teacher and tens of children. As an alternative, computer-assisted language learning (CALL) might be explored as a way to provide young learners with direct and self-paced strategy instruction. With recent advances in interface technology, in particular, it is possible to simulate social and affective interactions in CALL, through animated digital peers or tutors (Kim & Wei, 2011; McQuiggan, Robinson, & Lester, 2010). The author has developed *Affable Reading Tutor (*ART*)*, a CALL environment embedded with a digital peer, to help elementary-school students learn questioning strategy to comprehend cause-and-effect relationships in expository texts. This paper presents a classroom-based experiment that has examined the effectiveness of peer presence on learners' text comprehension and their perceptions of their peer in ART.

Theoretical Backgrounds

Effective Reading Comprehension Instruction

Social interaction is considered critical in learning and intellectual development. In particular, reading researchers have established that social interactions with peers and teachers can foster motivation to read and enhance text comprehension (Palinscar & Brown, 1984; Gambrell, 2001; Guthrie, 2002). Guthrie (2002) argues that situational interest is easily aroused in a shared reading context where individuals naturally expand themselves through interaction with their peers and teachers. Traditionally, well-known reading-comprehension instruction approaches like reciprocal teaching (Spörera, Brunsteina, & Kieschkeb, 2009), interactive read-aloud (Barrentine, 1996), dialogical-thinking reading lessons (Commeyras, 1993), guided reading (Pinnell, 2002) are all interactive in nature and emphasize the provision of social context for enhanced engagement in reading and comprehension.

In addition, children who start reading to comprehend expository texts are very likely to benefit from direct, self-paced strategy instruction that helps them grapple with new texts (Almasi, Garas-York, & Shanahan, 2006; Guthrie et al., 2004; Leopold & Leutner, 2012; Pressley, 2002). For many young readers, reading comprehension strategies are not acquired naturally; rather, strategy use is a specific and learned procedure that promotes active and intentional reading (Trabasso & Bouchard, 2002). Readers who are not explicitly taught this cognitive procedure are less likely to learn, develop, or use the strategies spontaneously (Andreassena & Bråtenb, 2011; Wharton-McDonald, Pressley, & Hampston, 1998). Reading comprehension strategy, hence, must be taught by way of direct instruction that utilizes explicit and repeated demonstration and modeling of strategy use (National Reading Panel, 2000). Moreover, it seems that a young reader benefits from individualized guidance, where he/she can learn at his/her own pace to build the habit of strategy use gradually. One challenge is that this kind of individualized and direct strategy instruction is not always offered in conventional classrooms due to limited resources (i.e., a single teacher with a multitude of children) (Pearson & Dole, 1987). One promising area to explore could be work done in computer-assisted language learning.

Computer-Assisted Language Learning (CALL)

In recent decades, CALL researchers have explored a range of technologies and pedagogical approaches -- such as interface design and authoring, data management and access, intelligent tutoring systems, speech recognition technologies, and natural language -- processing to varied topic areas in language learning and teaching (Stockwell, 2007). The areas most extensively studied in CALL research over time include grammar, vocabularies, speaking, and writing. Also, CALL has been applied and studied more actively in the context of second language learning than first language learning. For example, in a study with 122 Korean tenth-grade EFL[1] learners, Yun and colleagues (2008) found that constructed-response (fill-in-the-blank) questions with explicit feedback in CALL were effective for improving the learners' recall of vocabulary and transfer. Chen and Wang (2008) tested several of Ellis' language learning principles in collaborative cyber-community-based learning, with seven Chinese EFL learners at Griffith University and found that the use of text chat and joint web browsing helped foster communicative language skills in synchronous online classes.

In contrast to the growing amount of CALL research, the use of CALL to teach reading has been relatively limited and even has shown a consistently decreasing trend over the last decade (Stockwell, 2007). Furthermore, among the existent CALL applications for reading, the majority deals with discrete skills development like vocabulary building and word recognition. A meta-analysis of CALL research in reading indicates that most research has focused on developing phonemic awareness, letter identification, word identification, and speed and fluency in reading words (Blok, Oostdam, Otter, & Overmaat, 2002). There has been a dearth of CALL research to examine the effectiveness of CALL for reading comprehension instruction. Reading comprehension could be better taught in social and interactive contexts, as recommended by many reading researchers. Although CALL applications afford individualized instruction conventionally, they often fall short of integrating social interaction. Hence, the author explored animated, digital peer technology to see if the technology would expand the capacity of CALL by rendering a social context, which might benefit young readers.

Virtual Peer

A virtual peer refers to an animated, digital character, a subset of a more broadly used term *pedagogical agents* (animated life-like characters embedded in educational applications). It is well acknowledged that people,

[1] EFL: English as a foreign language.

consciously or unconsciously, tend to ascribe mental states to computers and interact with computers socially (Kim, 2007; Reeves & Nass, 1996). Virtual peer technology seems to broaden the communication bandwidth between a learner and a computer. It has been used to render social presence and enrich learning experiences in computer-based learning (Gulz, 2005; Iacobelli & Cassell, 2007; Johnson, Rickel, & Lester, 2000). A number of researchers in pedagogical agents support consistently that the social presence produces positive gains in learner affect and engagement (Atkinson, 2002; Dempsey & van Eck, 2003; Gulz, 2004; Johnson, et al., 2000; Kim & Wei, 2011; Mayer, Johnson, Shaw, & Sandhu, 2006; Moreno & Mayer, 2000; Plant, Baylor, Doerr, & Rosenberg-Kima, 2009). Moreover, some studies argue for the modeling effect (Kim & Baylor, 2007; Ryokai, Vaucelle, & Cassell, 2003). Kim and Baylor (2007) claimed that the use of virtual peers as role models for learners could be viable for enhanced motivation and learning, in that a virtual peer playing as a coping or mastery model could motivate the learner toward challenging and less popular domains of learning.

Embedded in computer-based reading instruction, a virtual peer could be designed to explicitly demonstrate reading strategy use and encourage a young reader to use the strategy. Through the peer's modeling (Bandura, 2001; Schunk & Hanson, 1989), the learner might vicariously learn the strategy use and improve their text comprehension. Further, the peer's visual and verbal demonstration is likely to lessen young readers' burden to read through explanations in text or graphics (i.e., reducing cognitive load) and, thereby, improve the efficacy of strategy instruction. Ryokai and colleagues' study (2003) hinted this modeling effect. In their study, children who played with the virtual peer *Sam* listened to Sam's stories carefully and mimicked Sam's linguistic styles in their speech. It seemed that Sam played a social role for the children. The children might feel affiliated with Sam, which, presumably, induced their behavioral changes. A similar modeling impact was implied in an online tutoring game teaching phonemic decoding skills, where children's skills increased only when the program included a digital tutor that gave oral feedback to the children (Kegel & Bus, 2012).

Given the lack of computer-based reading-comprehension instruction, the author developed a reading lesson, *Affable Reading Tutor* (*ART)* to model the use of comprehension strategy for children who just started reading to comprehend. In the lesson, the children studied finding cause-and-effect relationship in expository texts, observing a virtual peer's strategy use. The young readers might be able to develop social relations and interact socially with the peer, which would be beneficial for their motivation and text comprehension. The author investigated the impact of the peer serving as a peer model that demonstrated strategy use to increase the learners' text comprehension.

This study was focused on how effectively a virtual peer's modeling of reading strategy use would improve children's text comprehension, compared to the strategy instruction without virtual-peer presence. The primary research question asked 1) *Will the presence of a virtual peer influence learners' text comprehension?* Also, referring to the current literature in virtual peers (or pedagogical agents), two additional questions were asked. The second question was about learner gender because learner gender was often a factor determining the effectiveness of agent presence (Baylor & Kim, 2005; Kim, Baylor, & Shen, 2007). The second question asked 2) *Will learner gender and virtual-peer presence interact to influence text comprehension?* The third question was about learners' perceptions of virtual-peer attributes. Researchers in agent technology emphasize a learner's building social relations with their agent in order to maximize its instructional effectiveness (Dautenhahn, Bond, Canamero, & Edmonds, 2002). How a learner would perceive their virtual peer seems to be a meaningful factor for the efficacy of the learning environment. At the same time, much of agent research indicates learners' sensitive reactions to agent attributes, such as gender and appearance (Baylor & Plant, 2005; Haake & Gulz, 2008; Kim, Wei, Xu, & Ko, 2007). In particular, Haake and Gulz (2008) argue that an agent's visual appearance carries social baggage that could activate a learner's expectations of the agent. The third question asked 3) *Will learner gender and virtual-peer attributes interact to influence learners' perceptions of a virtual peer?*

Method

Participants

Participants were 141 children in the fourth and fifth grades (68 boys and 73 girls) in an elementary school located in a mountain-west state in the United States. Access to the participants was achieved by collaborating with classroom teachers who volunteered to use the intervention environment in their classes. The study was implemented as a mandatory class activity. The participants were randomly assigned to experimental conditions by the system programming.

Learning Environment

Curriculum Content

The intervention was an online strategy lesson named *Affable Reading Tutor (ART)* delivered via web browsers. The curriculum was reading comprehension of science texts, combining language arts and science education in keeping with the Benchmarks for Science Literacy by the American Association for the Advancement of Science (http://www.aaas.org) in the USA. Comprehending expository texts is known to be challenging because of their abstract nature and complicated and varied sentence structures (Gersten, Fuchs, Williams, & Baker, 2001). It is particularly difficult to young learners whose limited background knowledge inhibits their ability to inferentially connect ideas into a coherent mental representation of the texts (Cote, 1998; McNamara, 1996). Reading strategy instruction should be necessary to assist those learners. The specific content was identifying cause-and-effect relationships using questioning strategy. Questioning strategy was chosen because it was the one recommended most broadly in the literature in reading strategy instruction (Cerdána, Vidal-Abarcab, Martínezb, Gilabertb, & Gilb, 2009; Rosenshine, 1986; Spörera, et al., 2009). The National Institute for Literacy (2007) highlights questioning strategy as a way to support struggling readers in the publication *What Content-Area Teachers Should Know About Adolescent Literacy*. To deal with expository texts, readers should "generate questions before, during, and after reading… (p. 20)." Questioning thoughtfully while reading helps a reader to gain more information from unfamiliar texts.

In the lesson (ART), children read a story about a boy named *Ian* who set up a weekly training schedule to condition himself to run a marathon. The virtual peer *Chris* demonstrated the questioning strategy and encouraged the learners to use the strategy. Before the learners started reading, Chris explained what a cause and an effect were and how to use the questioning strategy to find the cause-and-effect relationship in sentences. During the reading, Chris demonstrated using the strategy by asking the learners questions about what they have read and also presented verbal encouragement for the learners to build a habit of questioning while reading. The learners practiced identifying causes and effects, guided by Chris' questioning. The practice problems were presented in different formats, e.g., multiple-choice, short-answer, and open-ended.

Based on the literature (Guthrie, Wigfield, & Humenick, 2006; van Keer & Verhaeghe, 2005), the author developed Chris' questions in seven categories: 1) Questions to activate students' prior knowledge: e.g., *Do you like sports? What's your favorite sport?* 2) Summarizing questions: e.g., *If you were to summarize the first paragraph to one or two sentences, what information would you include in the sentence(s)?* 3) Direct questions: e.g., *Why does Ian need regularly scheduled days of rest? What will happen if Ian doesn't rest his muscles and joints?* 4) Questions to guide writing: e.g., *If you could exercise regularly, what kind of exercise would you like to do? And why?* 5) Comprehension questions: e.g., *If you can make a title for the story, what would you choose for the title?* 6) Inference questions: e.g., *What would happen if Ian doesn't practice running when he runs a marathon?* 7) Inferential-comprehension questions: e.g., *What is this passage mainly about?* Figure 1 presents example screens of the ART environment, with two variations of Chris (male Chris and female Chris) and without Chris (a still image of a robot as a space filler).

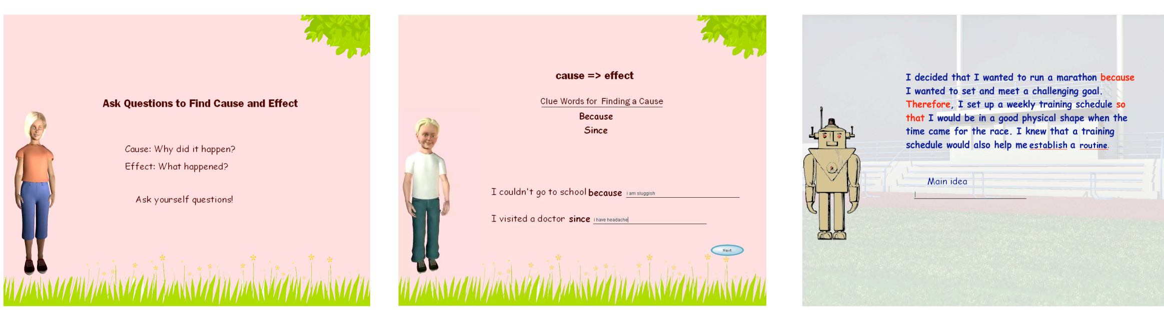

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Figure 1. Virtual peer variations in ART

Virtual Peer Design

Male and female peer images were designed using Curious Labs' Poser as seen in Figure 1. Voices of a similar-age boy and a girl were recorded and synchronized with the images. To stimulate a learner's sense of being related to the virtual peer, the talking style was matched with the target learner group's style. Facial expressions, blinking, and pointing gestures were added to make Chris look believable and natural.

Independent Variables

Virtual-Peer Presence

Virtual-peer presence had three levels of Presence versus Absence versus Control. In Presence, a peer (either male or female, randomly assigned) was present. In Absence, students worked in ART without a peer. Instead, a still image of a robot filled the space, and a computer-generated voice-over presented instructional messages. The control group did not take ART and performed the learning task individually with a paper-based material. This material presented exactly the same strategy instruction in text and graphics, without a virtual peer image. Except for the described differences, all three conditions presented the identical instructional content.

Learner Gender

Based on the previous agent studies and the preliminary interviews with boys and girls from the target group, learner gender (Male versus Female) was included as a variable to understand if there would be gender differences in text comprehension and their perceptions of a virtual peer (the research questions 2 and 3).

Virtual Peer Attributes

Virtual-peer attributes had three levels of Human-like male versus Human-like female versus Robot image.

Dependent Measures

Text Comprehension

To measure the students' text comprehension, paper-based pre- and posttests were administered. The pretest included six short-answer-type questions about a passage on Ian's sunburn after swimming at the beach, e.g., *What caused Ian's sunburn? What was the effect of sunburn?* The test was administered the day before the intervention and later used as a covariate to control for learners' prior comprehension skills. Two posttests were implemented, one the day after the intervention (immediate-posttest) and the other one week after the intervention (delayed-posttest). In a short-answer format, each test asked two recall questions on the information presented in the intervention and eight comprehension questions (four questions per passage). Two recall questions asked 1) *What key words help you identify a cause?* 2) *What key words help you identify an effect?* Each was awarded three points. The comprehension questions were similar to the pretest, e.g., about the passage on rainbows, *Let's find the effect, what happens after rainbows occur? What causes the colors to arc across the sky?* The maximum possible score in a posttest was fourteen.

Perceptions of a Virtual Peer

Learners' perceptions of a virtual peer were measured with a questionnaire with fourteen items, modified from Agent Affability Measures (Kim, Baylor, et al., 2007; Kim, Wei, et al., 2007). At the end of the lesson, the learners were asked to express the degree of agreements to each item on a scale from 1 (*Not At All*) to 7 (*Very Much*): 1) Chris *was friendly*, 2) *Chris was smart*, 3) *Chris was interesting*, 4) *Chris made me feel comfortable*, 5) *Chris was dependable*, 6) *Chris was intelligent*, 7) *Chris was easy to understand*, 8) *Chris was approachable*, 9) *Chris cared about my learning*, 10) *Chris made the lesson interesting*, 11) *Chris made me excited about reading*, 12) *Chris helped me understand better*, 13) *I felt like Chris understood me*, and 14) *I'd like to learn reading skills from Chris again*. Inter-item reliability, evaluated as Coefficient α, was .95.

Procedures

The researcher implemented the ART lesson, assisted by the teachers, to control for implementer variations. Both computer- and paper-based (control group) lessons were entirely self-contained. The learners completed all the tasks individually, depending solely on the information presented in the material. The overall procedures were as follows:

1) The children took a paper-based pretest a day prior to the intervention;
2) On the intervention day, they were randomly assigned to the groups and briefly introduced to the materials;
3) They performed the learning task for a one-class period; and
4) They took a paper-based posttest the next day after the lesson and another posttest a week after the intervention.

Design and Analysis

For the research question 1, the independent variable was virtual peer presence (agent presence vs. absence vs. control), and the dependent variable was text comprehension. This question was answered using one-way ANCOVA's, with a pretest text comprehension set as a covariate, respectively for the immediate posttest and for the delayed posttest. For the question 2, the independent variables were virtual-peer presence and learner gender (male vs. female), and the dependent variable was text comprehension. The question 2 was answered using two-way ANCOVA's, with a pretest set as a covariate, respectively for the immediate posttest and for the delayed posttest. For the question 3, the independent variables were virtual-peer attributes (Human-like male vs. Human-like female vs. robot image) and learner gender (male vs. female), and the dependent variable was learners' perceptions of their peer. The question 3 was answered using a two-way ANOVA. For all the analyses, the significance level was set at $\alpha < .05$.

Results

Table 1 presents the descriptive statistics of three text-comprehension tests. The pretest was analyzed using a one-way ANOVA, which revealed no statistically significant difference among the groups.

Table 1. Means and standard deviations of text comprehension tests

Tests	Peer presence	Peer absence	Control
Pretest	2.85 (1.12)	2.85 (1.35)	2.18 (1.18)
Immediate posttest	7.86 (.36)	6.36 (.62)	6.46 (.60)
Delayed posttest	8.65 (.23)	8.16 (.38)	7.26 (.35)

Research Question 1: The Effect of Virtual Peer Presence on Text Comprehension

For the immediate posttest, the one-way ANCOVA revealed a significant main effect for virtual-peer presence, F (2, 98) = 3.36, $p < .05$, $\eta^2 = .06$ (a medium effect according to Cohen's guidelines) (Cohen, 1988). The virtual-peer presence group outperformed the absence group and also the control group.

For the delayed posttest, the one-way ANCOVA revealed a significant main effect for virtual-peer presence, F (2, 87) = 5.53, $p < .01$. The effect size of this difference was evaluated as $\eta^2 = .11$, indicating a medium effect. The Bonferroni post hoc revealed that virtual-peer presence group significantly outperformed the control group. In conclusion, both immediate and delayed posttests results supported the effectiveness of virtual-peer presence on learners' text comprehension.

Research Question 2: The Interaction Effect of Learner Gender and Peer Presence on Text Comprehension

The two-way ANCOVA revealed neither statistically significant interaction of learner gender and virtual-peer presence nor main effect of learner gender on text comprehension in immediate and delayed posttests. However, as shown in Figure 2, a visual representation suggested an interaction trend that separated boys' and girls' text comprehension by virtual-peer conditions in the two tests. That is, girls' text comprehension was ranked in the order of virtual peer presence highest, robot image next, and control least whereas boys' text comprehension in the order of virtual peer highest, control next, and robot image least.

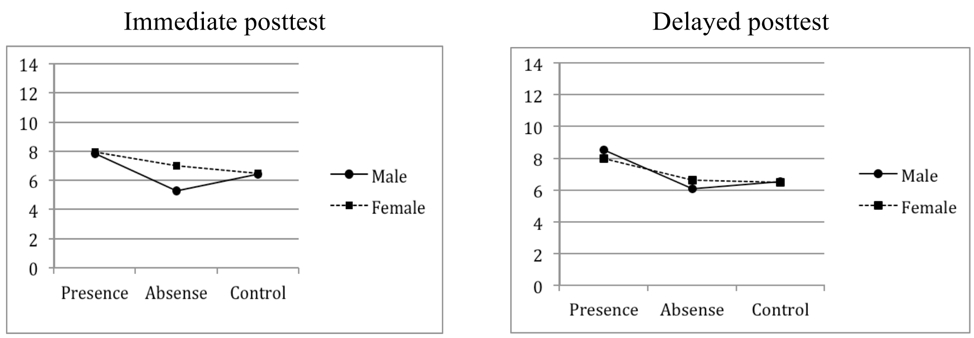

Figure 2. Text comprehension in the immediate posttest

Therefore, one-way ANCOVA's with boys and with girls separately were further conducted to examine statistical differences in each group's text comprehension by virtual-peer presence. The results revealed a significant difference only in the girls' text comprehension in the delayed posttest, F (2, 46) = 3.62, $p < .05$. The Bonferroni post hoc revealed that the girls in virtual-peer presence significantly outperformed the control group. The effect size of this difference was evaluated as η2 = .14, indicating a medium effect.

Research Question 3: The Effect of Learner Gender and Peer Attributes on Perceptions of the Peer

The two-way ANOVA revealed neither statistically significant interaction effects nor main effects of learner gender and virtual-peer attributes on learners' perceptions of their peer. However, a visual representation of the data suggested an interaction trend, as shown in Figure 3. Boys tended to perceive the robot image most favorably whereas girls perceived it least favorably. Therefore, one-way ANOVA's with boys and with girls separately were further conducted to examine statistical differences in each group's perception of their peer by virtual-peer attributes. The results did not reveal statistical significance of virtual-peer attributes on the boys' perceptions of the agent nor the girls' perceptions.

Incidentally, the author tested boys' and girls' text comprehension by virtual-peer attributes. The results revealed a significant difference on the boys' text comprehension in the immediate posttest, F (2, 35) = 8.65, $p < .001$. The effect size of this difference was evaluated as $\eta^2 = .33$, indicating a strong effect. The boys in the male-peer condition outperformed the female-peer group ($p < .001$) and also the robot image group ($p < .01$). This difference was not observed among the girls.

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Virtual peer attributes by learner gender

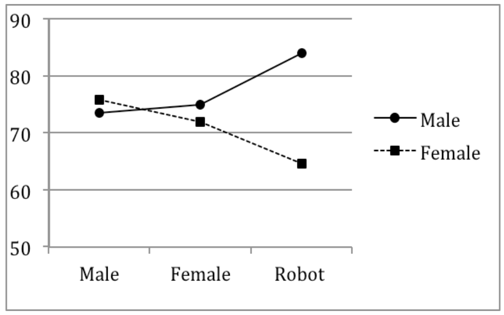

Figure 3. Learner perceptions of the virtual peer

Discussion

This study explored if a virtual peer would be able to simulate the role of a peer model in conventional settings so as to effect computer-based reading-strategy instruction. Although direct and individualized reading strategy instruction is essential for children who start reading to comprehend, reading strategy instruction has not been actively applied in CALL. Also, some conventional reading programs present the concepts, examples, and strategies in text or at best in images. This manner of information presentation seems untenable, particularly for young readers who start reading to comprehend. First, children might be less engaged in learning reading strategies because of the impersonal nature of written texts presented on the screen. Text may not be sufficiently motivating to promote strategy use. Second, the learners will need constant reminders and encouragement to use the learned strategy. The author examined the use of the social and affective affordance of virtual-peer technology to provide more engaging strategy instruction for young children. The results of the study, in general, supported the benefit of virtual peer technology as a viable tool to offer effective strategy instruction in CALL.

First, regarding the effectiveness of virtual-peer presence on text comprehension, the results supported the effectiveness of virtual-peer technology on learning. This study, implemented in natural classrooms, added evidence for the positive impact on learning gains that have been inconclusive in the virtual-peer (or pedagogical-agent) literature. A number of empirical studies in agent technology conducted over the last decade have supported its effectiveness on learner affect including interest, motivation, attitudes, or engagement, with different age groups. There is a consensus among the researchers on the effectiveness of agent presence on learner affect and motivation. However, only a few studies have shown the effectiveness on learning gains (Atkinson, 2002; Graesser, Moreno, & Marineau, 2003; Moreno, Mayer, Spires, & Lester, 2001). In this study, the fourth and fifth-grade boys and girls more effectively increased their comprehension of expository texts after working with a human-like virtual peer, compared to the peer absence groups. As a reason, the virtual peer might play a social role as a peer model to motivate the learners to engage. More important, the peer was equipped with solid pedagogy for strategy instruction recommended by the reading research community. Designers often seem to focus on maximizing the affordance of a technology and overlook the importance of content pedagogy. To be effective, however, technological affordance should be orchestrated integrally with subject-matter pedagogy. This might be analogous to a capable human teacher or peer in classroom. Teacher presence alone might not be sufficient to produce increased learning. The teacher must be well versed in the content and pedagogical approaches to foster successful learning. Also, the social and affective dynamic seems to play a pivotal role in reading instruction for a learner's willingness to try. Just as the virtual peer's supportive demeanor might facilitate the learners' engagement, so do the supportive relationships with the teacher or peer help aspire a learner to read in a classroom.

Second, regarding the impact of learner gender, this study resulted in somewhat mixed findings. When both learner gender and virtual-peer presence were included in the analysis, there was no statistically significant gender difference. However, when the impact of peer presence was examined with boys-only and with girls-only, the results revealed different patterns of gender difference in text comprehension. The girls' text comprehension in the delayed posttest was significantly higher in the virtual-peer presence condition, compared to the peer-absence group who used ART without a peer and also to the control group who used a paper-based material. The boys' text comprehension was significantly higher in the immediate posttest in the male-peer condition than the female-peer condition and the robot-image condition. These findings seem to be in line with agent literature. First, female students show more positive attitudes toward agent presence and perform better after working with an agent or at computing applications supporting social interactions (Cooper & Weaver, 2003; Hakkarainen & Palonen, 2003; Kim, et al., 2007; Passig & Levin, 2000; Weber & Custer, 2005). Second, studies revealed the superior effectiveness of a male agent to that of a female agent, regardless of learner gender (Baylor & Kim, 2004; Kim, Baylor, et al., 2007). The authors in these studies attributed the differential effectiveness to the influence of gender-related social biases (Carli, 1999, 2001). The current study revealed a similar pattern in learner and agent gender, but less strongly. This could be due to the developmental stage of the boys and girls. Literature in social psychology indicates that post-13-aged students are considered typically imbued with gender-related stereotypes (Dunham, 1990). The learners in this study did not seem to possess established gender-based biases for their learning, or perhaps these biases still remained at a subliminal level. Debriefing with the learners also revealed a consistent pattern. The author asked the learners about their preferences for virtual-peer gender in future applications. Although several boys and girls articulated their preferences, the majority looked uninterested in the issue. This might also explain why the learners' perceptions of their peer were not differentiated by virtual-peer attributes, in contrast to previous agent studies with adolescents and college students.

Third, regarding the impact of virtual-peer attributes, the study did not produce sufficient evidence for the boys' and girls' differential reactions to virtual-peer attributes. This result might be related to the second point. The learners did not seem to have developed stereotypic expectations for agent appearance – i.e., visual stereotypes (Haake & Gulz, 2008). This age group might be at the stage when we can effectively intervene to prevent from undesirable gender- or race-related stereotypes, using agent technology. As Haake and Gulz suggested, virtual peers could be flexibly designed to have a range of identities and styles for educational purposes and counter negative social influences in the real world.

One thing to note is a trend that girls' perceptions of their virtual peer were ranked consistently with their learning gains. They perceived a human-like virtual peer -- regardless of its gender-- most favorably and comprehended text highest in the peer condition. On the other hand, boys' perceptions of the peer were ranked opposite to their learning gains. The boys perceived a robot image with synthetic voice-over most favorably, but performed poorest in that condition. Perhaps, the boys perceived the robot as fun, which, in turn, triggered a play mood and made the boys less serious about the learning task. Learners' readiness must be a consideration in the design of virtual-peer attributes. Careful analysis of learners, immediate and long-term learning goals, and learning contexts should be warranted prior to launching the design.

A few recommendations are made to expand and confirm the findings. First, subsequent research should examine learners' strategy use itself. The frequency of their strategy use in the following reading task will better inform us of the effectiveness of virtual peer modeling and the relational bond between a learner and the peer. Second, it would be worth examining the relationship between fun learning experience and actual learning gains in technology-based learning (e.g., virtual-peer, simulations and games). Third, the findings provide only initial evidence for the potential of a virtual peer for effective strategy instruction and should be generalized judiciously. Virtual-peer technology was new to the learners; we cannot exclude the possibility of the novelty effect. Future research should confirm the finding in a long term.

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