Scaffolding Learner Motivation through a Virtual Peer

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Abstract: It is well-documented that advanced technology can scaffold learning and cognitive development and also that human-peer models in classrooms positively influence learner motivation, in particular, self-efficacy in specific tasks. This paper describes three exploratory studies that investigated the potential of *virtual peers* (VP, animated digital characters designed as peer-like) to scaffold college students' motivation towards lesson-planning tasks. The studies examined how differing characteristics of the VPs motivated learners, as measured by learners' task-related self-efficacy beliefs and learner interest in the task and in working with the VPs. Study 1 examined the competency and interaction type of a VP; Study 2 examined the gender and emotional expression of VPs; and Study 3 examined the gender and emotional response of VPs. Results indicated the close relationships between learner motivation and VP characteristics. These findings support for the instructional utility of the virtual peers as motivational scaffolds.

Introduction

In the community of learning sciences, computers have been acknowledged and applied as cognitive tools to scaffold learners' cognitive attainments, i.e., complex problem solving and cognitive-skill acquisition (Pea, 2004). *Scaffolding* in this paper has a global definition: with appropriate assistance, or scaffolding, a learner attains an intended goal, otherwise not possible (Davis & Miyake, 2004). Referring to Wood, Bruner, & Ross's work (1976) Stone (1998) identified the three components of scaffolding: perceptual, cognitive, and affective. This study highlights the affective component of scaffolding, commonly neglected in the design of technology-based environments. In the use of scaffolding in general, a learner's shared interest and/or goal orientation is assumed as requisite to success, Such an assumption might not be warranted in every classroom setting – i.e., many learners may not demonstrate the desired level of interest or engagement. This study inquires into the possibility of using a digital virtual peer to advance a learner's positive affect and motivation to learn beyond the current level.

Social interaction among participants in learning contexts is coming to be seen as the primary source of cognitive and social development (John-Steiner, 1996). It is also widely accepted among motivation researchers that learners' beliefs and attitudes, primarily formed in social contexts, greatly impact their motivation to learn (Mclnerney & Van Etten, 2000). In particular, learners' self-efficacy beliefs, regarded as a critical predictor of academic achievement, constitute their judgments of their capability to perform academic tasks (Bandura, 1997). In general, the stronger the sense of self-efficacy, the more likely learners are to select challenging tasks, invest more effort, persist at the task in the face of difficulties, and perform the task successfully (Zeldin & Pajares, 2000). Hence, enhancing a learner's self-efficacy beliefs in the task should be a primary step to engage the learner in the task (Dietz *et al.*, 2002).

Human/computer interaction is similar in many ways to human-to-human interaction (Reeves & Nass, 1996). People frequently develop a personal sense of connection, affinity, and involvement with figures in the media, such as media celebrities or television characters (Burgoon et al., 2000). Similarly, people respond to computers in fundamentally social ways. People, young or old and educated or not, often apply the same social expectations and rules to computers as they do to humans in the real world. For instance, gender differences in the real world are projected to computing environments (Kim, 2005; Lee, 2003). Educated computer users apply politeness norms, notions of "self" and "other," and gender stereotypes when interacting with computers (Reeves & Nass, 1996). These findings, which may suggest that computer-based learning should be designed to afford social contexts, enable the authors to propose a new metaphor of computers as *social cognitive tools* for learning.

The immediate tool is the virtual peer. A virtual peer (VP) here refers to animated peer-like characters designed to simulate a human peer in computer-based learning. Given the positive impact of a peer model on a learner's self-efficacy beliefs in traditional classrooms tasks (Schunk, 1987), it seems natural to expect that a simulated peer model integrated in computer-based learning environments might play a role for learner motivation and/or learning. Virtual peer technology, however, is just now emerging and needs empirical evidence of its instructional potential, prior to broader use. This paper describes three exploratory experimental studies that investigated the instructional potential of a VP as a peer model for college students' enhanced motivation, by examining differing characteristics of the VP. Study 1 examined the competency and interaction type of a VP; Study 2 examined the gender and emotional expression of a VP; and Study 3 examined the gender and emotional response of a VP.

Study I: Competency and Interaction Type of VP

This experiment examined whether the competency and interaction type of VPs would affect learner self-efficacy beliefs in performing a task. VP competency (high vs. low) was examined, in that the competency of a human social model often influences learners' self-efficacy and achievements (Schunk, 1987). Also, the initiation of VP-learner interaction (proactive VP vs. responsive VP) was examined, given that, according to Bandura (1997), the exercise of control over one's environment is a determinant of one's self-efficacy beliefs. Participants were 72 undergraduates (29% male and 71% female) in a computer literacy course in a large public university located in the southeast of the United States. The average age of the participants was 20.48 (SD=1.64). The participants were randomly assigned to one of the four experimental conditions.

The material was a web-based instructional design module, where the participants wrote instructional plans to teach 6th graders the economic concepts of 'supply' and 'demand'. In the module, a VP named Mike constantly stayed on the screen and served as a collaborating partner, providing information or suggestions to help learners perform the task. Because Mike was the only information source, the learners relied on Mike's comments to make a progress in the task. Given that both male and female college students prefer to interact with male partners in online discussions , the male gender was adopted (Jeong & Davidson-Shivers, 2003). The learning task took approximately 30 minutes, with individual variations. Figure 1 shows an example screen with Mike.

Figure 1. A Example Screen with Mike.

Independent Variables: VP Competency and Interaction Type

Competency, i.e., how knowledgeable a VP was in the domain of instructional planning, had two levels (high vs. low), determined by the scripts of the VP. In the high condition, the VP simulated an advanced peer and provided accurate information about instructional planning. In the low condition, the VP simulated a regular peer and suggested his own ideas, not necessarily accurate.

Interaction type, a question of who, the learner or the VP, would initiate their interactions, also had two levels (proactive vs. responsive). In the proactive condition, the VP initiated interactions to proactively provide information or ideas without the learner's request. In the responsive condition, the VP remained quiet and provided information or ideas only in response to the learner's request.

Dependent Variable: Learner Self-Efficacy Beliefs in the Task

Learners' self-efficacy beliefs about the learning tasks were measured with a one-item question, developed according to the guideline of Bandura and Schunk (1981) for specificity. The guideline emphasizes that self-efficacy is the degree to which one feels capable of performing a particular task at certain designated levels. Before and after the intervention, participants answered the question "How sure are you that you can write a lesson plan?" on a scale ranging from 1 (*Not at all sure*) to 5 (*Extremely su*re).

Results

The study employed a 2 × 2 factorial design, in which the variables included competency (Low vs. High) and interaction type (Proactive vs. Responsive). ANCOVA with prior self-efficacy as a covariate was conducted. The significance level was set at $\alpha = .05$.

There was a significant main effect for competency on self-efficacy, $F(1, 64) = 4.08$, $p < .05$. Students who worked with the low-competent VP ($M = 3.00$, $SD = 1.18$) showed significantly higher self-efficacy regarding the task than did students with the high-competent VP ($M = 2.47$, $SD = 0.98$). The standardized effect size for this difference was Cohen's $d = 0.49$, which indicated a medium effect according to Cohen's guidelines. There were no significant main effect for interaction type and no significant interaction effect.

Study II: Emotional Expression and Gender of VP

This experiment examined whether the emotional expression and gender of a VP would influence learners' self-efficacy beliefs and their interest in the task and in working with the VP. In classrooms, the emotional expressions of other participants (teacher and peers) significantly influenced a learner's affective and cognitive characteristics, e.g., the learner's emotions, self-conception, and motivation (Sutton & Wheatley, 2003). Likewise, VP's affective states might be transferred to learners (Picard, 1997) to influence their affective states in learning within a computing environment. Also, gender difference manifested in academic interest and cognitive styles influences affective experiences (Brody, 1999).

Participants (142 undergraduates in a computer literacy course in the same university as in Study 1) were randomly assigned to the experimental conditions. The material was similar to Experiment 1, developing an instructional plan, except for the subject matter. The students' task was to write their ideas for designing a class to teach freshmen to be more efficient in time management. The functions of male and female VPs, both named Chris, were consistent with Study 1. The VPs, constantly on the screen, provided the learners with information in each stage of instructional planning. The session took approximately 30 minutes.

Independent Variables: VP Emotional Expression and Gender

Emotional expression was achieved through verbal and facial expressions, voices, and head movements, as supported by human emotion research indicating that people express and perceive emotions mostly through facial expressions, acoustic sounds, and body movements, together with verbal manifestations. VP emotional expression was one of three conditions: positive, negative, and neutral. In the positive condition, a VP expressed positive emotions with a happy, smiling face, an engaging posture, and eye contact. In the negative condition, a VP expressed negative emotions with a somber and frowning face and an aloof posture, with evasive eye gaze. In the neutral condition, a VP did not express emotions.

Either a male or female version of Chris, the VP, was included according to experimental conditions. The two were identical in all other aspects (e.g., comments and emotional expressions), differing only by image and voice. Figure 2 presents the male and female versions of Chris expressing positive and negative emotions.

Dependent Variable: Learner Self-Efficacy and Interest

Regarding learner self-efficacy in the task, the one-item measure in Study 1 was found to be too limiting. Hence, a questionnaire with five items was developed according to the guidelines from previous research indicating that the direction of self-efficacy is best captured by "*I can* vs. *I can't*" (Weiner, 1992) or "*How sure are you ?*" (Bandura & Schunk, 1981; Pajares, 1996). The five items, scaled from 1 (*Strongly disagree*) through 5 (*Strongly agree*), asked for a response to 1) *How well can you write a lesson plan for E-learning?* 2) *How sure are you that you can design a quality lesson plan for E-learning?* 3) *I can write a lesson planning for E-learning.* 4) *I am confident in learning how to design an E-learning lesson plan.* 5) *I am competent in designing a lesson plan.* Item reliability was evaluated as coefficient $\alpha = .95$. Learners' self-efficacy beliefs were measured before and after the intervention.

Learner interest referred to learners' disposition toward working with the VP and toward the task of instructional planning. Anderson and Bourke (2000) suggested that the range of interest is best expressed on the scale of "interested/disinterested." In response to the suggestion, a questionnaire consisting of five items was developed, with a scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*): 1) *How much are you interested in designing a lesson plan for E-learning?* 2) *How much are you interested in learning about designing a lesson plan for E-learning?* 3) *I was attentive while doing the task.* 4) *I was interested while working with Chris.* 5) *I was attentive while working with Chris.* Item reliability was assessed as coefficient $\alpha = .87$. Interest was measured before and after the intervention.

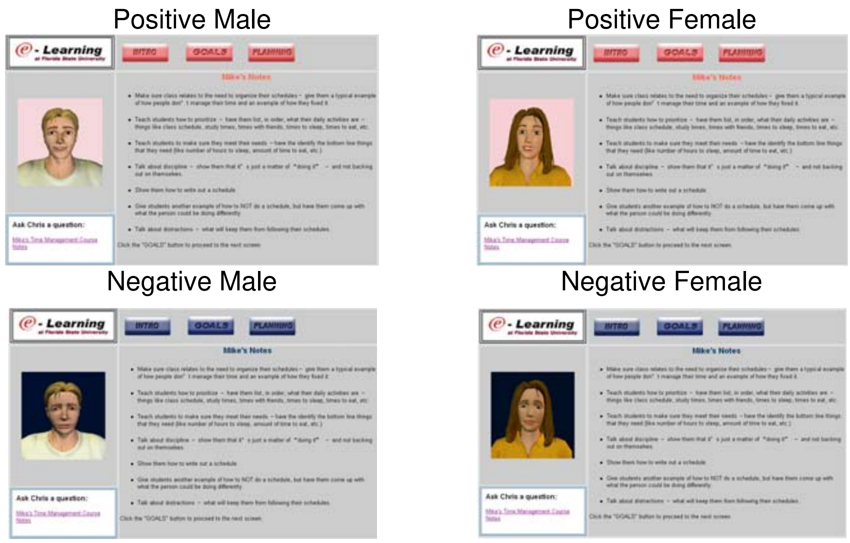

Figure 2. The varying versions of a virtual peer Chris.

Results

The study employed a 3 × 2 factorial design. Given the multiple items in each measure, two MANCOVA's were conducted with prior self-efficacy and interest as a covariate each. The significance level was set at $\alpha = .05$. For learner self-efficacy, there was no significant main effect for VP emotional expressions and no interaction effect of emotional expressions and gender. For learner interest, the overall MANCOVA indicated a significant interaction effect between emotional expressions and gender, Roy's Largest Root = 1.0, F (5, 128) = 2.51, $p < .05$, partial $\eta^2 = .11$. The univariate analysis did not show the significance of this interaction effect; however, a visual inspection suggested that students' interest in the male VP conditions was differentiated according to the types of VP emotional expressions. Simple Trend Analysis indicated a significant linear relationship of VP gender only in the positive emotions conditions, F (1, 136) = 5.21, $p < .05$. When the VPs expressed positive emotions, students who worked with the male VP tended to show higher interest than did those with the female VP. Also, the overall MANCOVA revealed a significant main effect for VP gender on learner interest, Wilks' Lambda = .893, F (5, 127) = 3.05, $p < .05$, partial $\eta^2 = .11$. Students who worked with the male VP showed significantly higher interest in the task and working the VP than did students with the female VP.

Study III: Empathetic Response and Gender of VP

This experiment investigated the impact of VP's empathetic response to learners' affective states and VP gender. Participants were 56 pre-service teachers enrolled in an introductory educational-technology class in the same university as the two previous studies. About 80% of the participants were female, 20% male.

As in the first two studies, the learning task involved instructional planning. The intervention took about an hour. Instructional planning processed in four main stages (Case study, Blueprints, Planning, and Assessment), in which a VP as an information provider helped a learner perform the task. In between the stages, learners expressed their affective states at the moment by clicking an emoticon (i.e., icons expressing emotions). A panel of six emoticons appeared when the learners initiated a move to the next stage. When the learners expressed their affect, the VP responded to it or not according to experimental conditions. The emoticons included six affective states that commonly occurred in learning situations, derived from the Affective Model suggested by Kort and colleagues (2001): Interest, Boredom, Confidence, Anxiety, Satisfaction, and Frustration.

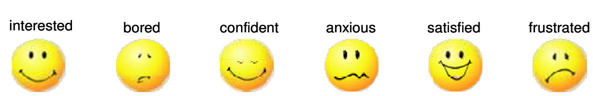

Figure 3. The emoticons.

Independent Variables: VP Empathetic Response and Gender

Empathetic response, i.e., a VP's verbal responses to a learner's expressions of their affect, had two levels: responsive vs. non-responsive. In the responsive condition, the VP immediately responded to the learner's signaled affect with empathy. The responses were brief and did not affect the overall instruction time. In the non-responsive condition, the VP did not respond to the learner's signaled affect. In both conditions, the amount of information provided by the VP was identical. As in Study II, either a male or female VP, (both named Chris), was used depending on experimental conditions.

Dependent Variable: Learner Self-Efficacy Beliefs in the Task

The same self-efficacy and interest measures in Study II were used consistently.

Results

The study employed a 2 × 2 factorial design. As in Study II, two MANCOVA's were conducted. The significant level was set at $\alpha = .05$. For learner self-efficacy, the results yielded a significant main effect for VPs' empathetic response: Wilks' Lambda = .71, F (3, 31) = 4.29, $p < .01$, partial $\eta^2 = .29$. Students who worked with the responsive VP showed significantly higher self-efficacy than did students who worked with the non-responsive VP. For learner interest, the overall MANCOVA revealed a significant main effect for VP affective response, Wilks' Lambda = .53, F (5, 20) = 3.54, $p < .05$, partial $\eta^2 = .47$. Students who worked with the responsive VP showed significantly higher interest in the task and the VP than did students with the non-responsive VP.

Discussion

The ideal form of instruction might well be one-on-one human tutoring (Bloom, 1984), where a learner can benefit from individualized cognitive guidance through dynamic social interaction. Given the challenges of providing such an ideal environment of one-on-one human tutoring, however, computer-based instruction has attempted to afford individualized cognitive guidance. Some of those systems reported their success stories (Koedinger & Anderson, 1997), but their impact was—as is to be expected--far weaker than that of human tutoring. Initially, the explanation has been sought in the limited adaptability of the technology to a learner's needs, but also it seems natural to inquire about what has been missed in conventional computer-based tutoring environments, compared to human tutoring. Such a new focus may lead us to ask how we can make a difference in utilizing technology for learning and motivation. The recent emphasis on social cognition seems to suggest the need to include social context in computer-based environments.

The study attempted to expand the instructional functionality of computers, traditionally acknowledged as cognitive tools, and to define the potential use of computers as social-cognitive tools. The major concern was whether a simulated peer can scaffold a learner's affective characteristics. Research on social modeling and human emotion guided the three experiments, which examined the potential of virtual peers to simulate the role of a peer capable of increasing learner motivation in computer-based environments. In the current studies the VPs' characteristics seemed to consistently exert influence on learner self-efficacy and learner interest in computer-based learning. Most notably, the low competency of a VP increased learner self-efficacy beliefs in the task, as did the empathetic response of a VP. Observing the poor performance of a low-competent VP, the novices in the task might evaluate their competency relatively high and thus feel more confident. The low-competency VP may have served as a "coping model" (Schunk et al., 1987) throughout the program, modeling for the learners how to cope with the novel situation as a novice, which in turn might have provided them with new possible strategies to replicate or ignore. According to Bandura (1986), the most functional efficacy judgments tend slightly to exceed what one can actually accomplish, and this overestimation serves to increase effort and persistence. It is open to question, however, to what degree students benefit from high perceptions of academic capability in the face of low achievements. Efforts to decrease students' relatively high self-appraisals should be discouraged. When students accurately understand what they know and do not know, however, they might be able effectively to deploy appropriate cognitive strategies while engaging in an academic task (Britner & Pajares, 2001). Potential subsequent research might explore whether task achievement is comparable when improved self-efficacy perceptions are attained with virtual-peer models. As regards the emotional expressions of the VP, Study II indicated that a "happy talking face" was not sufficient to influence a learner's self-efficacy beliefs; rather, a VP should be responsive to a learner's affective states, as indicated in Study III.

For learner interest, the results of Study II supported the positive impact of the male VP: students who worked with the male VP showed significantly higher interest in the task and in working with the VP. Although the results with the small effect sizes should be carefully generalized, the superior impact of the male agents to the female counterparts has been replicated in previous studies. This phenomenon might indicate that gender-related social stereotypes in the real world (Carli, 2001) were consistently applied to an agent/learner relationship. Future research is invited to investigate the adroit design of a VP-based environment to reduce such stereotypes. Also, when the VP responded with empathy to the learners' affect, students showed higher interest both in the task and in working with the VP, reflecting previous findings in classroom environments, where students' motivation and self-concept were increased when students understood that their teachers cared about them (Wentzel, 1996). Likewise, when a VP showed that he/she cared about a learner's affect by verbally responding to it with empathy, the learner's interest and self-efficacy in the task were enhanced.

These findings suggest another important research question: whether the increased interest will engender enhanced learning and also greater persistence in complex problem solving tasks. This study seeks to contribute to a knowledge base about VP deployment; further research that documents varied effects of VPs in comparison to humans or on a full range of cognitive and affective variables will be required to expand that knowledge base before VPs can be widely used in classroom settings. Finally, it should be noted that this study was limited to highlighting one key notion of scaffolding: "guided by another." Characteristics of scaffolding are multifarious, most notably including a process of careful diagnosis and gradual removal (Pea, 2004). Scaffolding in this study dealt with only two aspects of affective support and modeling from the original conceptualization by Wood, et al. (1976). Given the challenges for successful scaffolding even with human adults and knowledgeable peers, it is assumed that many challenges remain in VP-based affective scaffolding with the current status of technology. It must be understood that anthropomorphic characteristics of a VP in a given study are always a function of the computational and graphical capabilities available at the time of the study. As those capabilities improve, it is reasonable to expect that interfaces may change sufficiently to require re-examination of questions addressed by studies with earlier or less sophisticated interfaces. Nevertheless, these results show that the potential exists to structure learning environments of the future to include social-cognitive tools like VPs that effectively and affectively resonate with learners. The role of VPs in such future learning environments is presently difficult to foresee. Stepwise design research that engineers and implements VP capabilities in alignment with the increasing knowledge base in learning sciences will provide the essential foundation for translating findings such as those reported here into more effective learning.

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