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Animated Pedagogical Agents: Face-to-Face Interaction in Interactive Learning Environments

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ABSTRACT
Recent years have witnessed the birth of a new paradigm for learning environments: animated pedagogical agents. These lifelike autonomous characters cohabit learning environments with students to create rich, face-to-face learning interactions. This opens up exciting new possibilities; for example, agents can demonstrate complex tasks, employ locomotion and gesture to focus students' attention on the most salient aspect of the task at hand, and convey emotional responses to the tutorial situation. Animated pedagogical agents offer great promise for broadening the bandwidth of tutorial communication and increasing learning environments' ability to engage and motivate students. This article sets forth the motivations behind animated pedagogical agents, describes the key capabilities they offer, and discusses the technical issues they raise. The discussion is illustrated with descriptions of a number of animated agents that represent the current state of the art. Abstract The potential of emotional interaction between human and computer has recently interested researchers in human–computer interaction. The instructional impact of this interaction in learning environments has not been established, however. This study examined the impact of emotion and gender of a pedagogical agent as a learning companion (PAL) on social judgments, interest, self-efficacy, and learning.
KEYWORDS: Educational applications, intelligent systems, children, agents, empirical studies.

INTRODUCTION

The social context of cognition and its applications to learning and instruction has received increasing attention from theorists and researchers.Teaching and learning are highly social activities. Interaction with teachers, peers,and instructional materials is a major influence for cognitive and affective gains.From the very earliest interactions between parent and child to the more advancedrelationships between graduate student and advisor, much of our learning takesplace by way of social interaction. Thus, social interaction among participants in the learning contexts is seen as the primary source of cognitive and social development (John-Steiner, 1996; John-Steiner & Mahn, 2003; Lea & Nicoll, 2002; Matusov & Hayes, 2000; L. Piaget, 1995; Reynolds, William, & Miller, 2003; Rogoff, 1995). Seminal psychologists, such as Piaget, Vygotsky, and Bandura, have already acknowledged the impact of social contexts and social interaction on learning and development. According to Piaget (1995), "social life transforms the very nature of the individual" (p. 210), and reasoning is processed by way of social mechanisms. Social interaction with equally able peers fosters cognitive restructuring and becomes an impetus to cognitive growth. Social interaction with more knowledgeable peers or adults could also advance learners in the zone of proximal development. In Vygotsky's theory (1978), higher-level development that forms intellectual and mental functions originates from socio-cultural contexts; intellectual development occurs while individuals work with other participants who are more experienced in the society. Similarly, Bandura (2001) argues that, in many areas of social life, people cannot directly control social systems and practices, so they have to get resources or expertise of others to accomplish what they desire. According to Bandura, learning occurs through not only learners' active participation but also their observation of modeled attainments. The social presence of others as models plays a meaningful role for learning and self-efficacy beliefs. Affect as an integral part of social cognition influences our rational thinking, decision-making, social memory, and learning. People's memory, judgment, and the content of thinking are coordinated by an integrated system of affect and cognition. More specifically, our momentary moods influence daily social interactions and hence information processing and retrieval. Our affect conveys information about the interface between us and our environment, so we regularly use feelings to make judgments and decisions. Also, cognitive processes are responsive and tuned to meet the situational requirements signaled by feelings and guide us to choosing an appropriate processing strategy (e.g., topdown or bottom-up). Therefore, educational interventions might be able to successfully reach their goals when they include the social cognitive dimension of learning and development. Traditionally, computer-based learning has been used to support individualized learning, tailored to meet individual students' needs, and to provide immediate feedback, leading each learner to the achievement of mastery learning (J. R. Anderson, Corbett, Koedinger, & Pelletier, 1995). The recent perspective of social cognition necessitates reframing the way we used educational technology and suggest a new metaphor of employing computers as social cognitive tools. In particular, pedagogical agents refer to an educational use of an anthropomorphized interface that renders personas to computers and emphasize social relations between agent and learner. Pedagogical agents as9297 learning companions (PALs) are a unique use of pedagogical agents. PALs adopt a peer metaphor to simulate peer interaction and to take advantage of the cognitive and affective gains of human

peer-mediated learning. To build social relations with learners, PALs should be believable so that learners can perceive them as realistic virtual peers (Dautenhahn, Bond, Canamero, & Edmonds, 2002). At the center of believability is PALs' ability to demonstrate affect (Bates, 1992; Dautenhahn, 1998; Lester & Stone, 1997; Lester, Voerman, Towns, & Callaway, 1999; Nijholt, 2001; Ortony, 2002). Affect is an essential part of social cognition to allow us to successfully function in daily social and intellectual life. Thus, the affective capability of PALs might be critical to be human-like and believable. The affect of PALs might have unique importance in investigating and designing socially intelligent PALs. The emerging concept of social intelligence seems to refer to the more comprehensive human capability to function naturally and rationally in the social context of everyday life. Human intelligence without the inclusion of affective ability might indicate nothing but an "idiot savant". This significance of human social intelligence can be applied to the design of anthropomorphized pedagogical agents. Moreover, the development of social understanding is differentiated by the nature of the social relationship – with parents, teachers, siblings, and friends. Thus, the affect of PALs might have different implications from that of pedagogical agents in general. Further, gender difference manifests not only for academic interest and cognitive styles but also in affective experiences, such as emotional expression, empathic accuracy, and emotional behavior (Adler, Kless, & Adler, 1992; Brody, 1999; Zillmann, Weaver, Mundorf, & Aust, 1986). Women consistently report that they express a wider range of feelings and more intense positive and negative emotions than men. Will this gender difference in human affect be consistent in PAL affect? It is unknown whether gender and affect of PALs will influence learners' affective and cognitive characteristics as in human relationships. Nass and colleagues (Nass, Fogg, & Moon, 1995, 1996; Nass & Moon, 2000; Nass & Steuer, 1993a, 1993b; Nass, Steuer, & Tauber, 1994; Nass & Sundar, 1995) indicate, in a number of studies on human-computer interaction, that people's reactions to computers are social and natural and that people expect computers to conform to social rules as in the real world. These studies reveal that the role expectations and social stereotypes in the real world are projected consistently to human-computer interaction. Thus, it is highly plausible that the affect and gender of PALs influence learners' expectations and perceptions of PALs. In this regard, very few studies have been done. Since the findings of human emotion research spurred researchers to accommodate affect in human computer interaction, some studies have showed the positive impact of agent affect (Klein, Moon, & Picard, 2002; Scheirer, Fernandez, Klein, & Picard, 2002). However, these studies were implemented in game environments with incentives (e.g, one hundred dollar award for the best player). The implications of these studies might not be necessarily generalizable to learning environments. It needs to be rigorously investigated how PALs' affect together with PALs' gender effect motivation and learning in computer-based environments.

Purpose of the Study

The purpose of this study was to examine the impact of PAL affect and gender on learning, interest, self-efficacy, and agent persona in computer-based environments. In general, agent affect is defined in terms of the capabilities of recognizing, expressing, and responding to affect (Hudlicka, 2003; Picard, 1997). Emotion recognition is mainly engineered with hardware technology (Hudlicka, 2003; Partala & Surakka, 2003). Thus, this study focused on the latter two aspects. PALs' affect was investigated in terms of affective expression and response. For PALs' gender, the impact of male and female PALs was investigated. Data were gathered in two phases with two controlled experiments. Experiment I examined the effects of PALs' affective expression, which included three levels (positive vs. negative vs. neutral). Experiment II examined the effects of PALs' affective responses to learners' affect, which included two levels (responsive vs. non-responsive). Also, both experiments examined the effect of PAL gender by including male and female PALs. Outcome measures included learning, interest, self-efficacy, and agent persona

REVIEW OF LITERATURE

Cognitive psychology has evolved away from "purely cognitive" variables of memory and thought to valuing learners' motivational and belief systems formed in social contexts (Bruning, Schraw, Norby, & Ronning, 2004). This evolution has also led to another important understanding – the role of social interaction and socio-cultural influences in fostering cognitive development. In particular, from the perspective of distributed cognition, human cognition does not reside only inside one's mind; instead, is distributed across tools, symbols, and participants in socio-cultural environments (Salomon, 2001). Environments are integral parts of a whole system of cognition. When individuals perform cognitive activities, tools, symbols, and contexts dynamically interact and build intellectual partnership with the individual and help expand one's cognitive capabilities to improve performance. Seminal developmental psychologists, such as Vygotsky and Piaget, presume that learning and intellectual development are social processes by nature and cannot be fully attained without social interaction within the context. The role of these participants differs for each theorist, however. Vygotsky (1978) emphasizes guidance and support from more capable others, such as teachers or competent peers, who advance the knowledge of learners in the zone of proximal development. In Piaget's theory, the role of peer partners is preferred. Here, learners need instigating partners, who cause cognitive conflicts by providing not necessarily correct answers or by suggesting new perspectives and thus promote reflection and coordination of learners' actions and perspectives. Equal power relations between learners and partners is important in Piaget's conception of social interaction (Tudge & Winterhoff, 1993). That is, interaction with less-capable partners is often preferable to that with adults or advanced partners (Matusov & Hayes, 2000). In the similar context, Bandura (1997) emphasizes attribute similarity between social models and learners for successful modeling effects. People's self-efficacy beliefs are enhanced when the personal characteristics of the models, such as age, competency, or gender, are similar to their own. This is because, when people appraise their competency, they compare it with the competency of those who look similar to themselves more frequently than to those who are dissimilar. The positive impact of peer models over adult models on learning and self-efficacy is supported empirically (Schunk, 1987; Schunk & Hanson, 1985, 1989; Schunk, Hanson, & Cox, 1987). From the earlier years, educators observed the benefits of peer interaction that mediate effective learning

and motivation. Since Bell and Lancaster initiated the systematic implementation of peer-mediated learning in late 18th century (Chiplin-Williams, 1997), a number of peer-mediated interventions have been implemented in small or large scale around the world. Recently, pedagogical agent technology with an anthropomorphized interface affords a new opportunity to simulate peer interaction in computer-based learning. Pedagogical agents can also address some limitations of human peer-mediated interventions. More specifically, pedagogical agents as learning companions (PALs) serve as simulated peers in computer-based learning environments. The design of effective PALs can be guided by the implications of human emotion research. Affect plays a significant role in social interaction. Our memory of daily social interactions can be reconstructed as a collection of social episodes. The mental representations of the social episodes are dominated and reorganized by momentary feelings (Forgas, 1979, 1981; Niedenthal & Halberstadt, 2000; Pervin, 1976). In classrooms, the affective states of teachers and peers function as social contexts to influence learners' self-efficacy, motivation, cognitive gains, and behaviors. Also, affective experience is differentiated by gender. Gender difference is manifested in affective expressions, empathetic accuracy, and affective behavior. This affect-gender interaction becomes more salient in peer relationships. Given these implications, PALs can be designed as socially intelligent – that is, equipped with affective capabilities – and can build social empathetic relations to learners, which would in turn facilitate social interaction. However, it is unknown whether the impact of affect and gender in human relationships will be consistent in the PAL-learner relationship. In this chapter, first, social cognitive theories are reviewed as the theoretical framework for PALs. Following that, the early works of human peer-mediated learning are overviewed; some limitations of the human peer mediated learning are discussed; and the potential benefits of using agent technology for peer mediation are suggested. Next, pedagogical agents as learning companions are characterized; the current status of research is reviewed; and, the potential for socially intelligent PALs is discussed. After that, the implications of human emotion research for designing affective PALs are reviewed. Lastly, based on the review of literature, the research problems and hypothesis of the current study are presented.

Limitations and Recommendations

There were some limitations in the study. First, affective experience is a feeling state known only to the individual; thus, the best way to really measure experience is to ask people to think about their feeling states (Brody, 1999). However, Brody also points out that people may not want to articulate socially unacceptable feelings to others. The measurement of interest and self-efficacy in the current study was somewhat limited because it relied solely on the participants' self-reports. Second, the number of participants in Experiment II was limited due to low course enrollment. This resulted in low statistical power, which was sensitive only to large mean differences across the conditions. Third, students' answers to the application question in Experiment II were not included for analysis due to the large number of missing data, which was problematic. Fourth, the study was conducted by two one-time implementations taking about 30 minutes and one hour each. Continuous implementations and longer durations may or may not produce consistent results. Given the findings and limitations, future research is invited to replicate the current study. First, the study was grounded on social intereactions, which might need mutual engagement of PALs and learners. Learner characteristics, such as age, gender, or academic ability, may or may not interact with PAL affect and gender. Especially, it would be interesting to see whether the advantage of male PALs shows up with younger learners. Thus, it might be worthwhile re-examining the variables of the current study together with varying learner characteristics. Second, studies that indicated the motivational impact of pedagogical agents tended to be conducted on a short-term basis; however, it is open to question whether the impact of PALs on motivation would sustain in the long term. Lastly, PALs can be a test-bed to examine the ways to crack stereotypic expectations associated with gender. Compared to humans, PALs are easy to be manipulated according to research constructs of interest. The findings of research on PALs can provide implications for studies on human relations.

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FUTURE SCOPE

PALs as significantly more facilitating to their learning and more engaging than students who worked with the PALs that expressed negative affect. Overall, these results are supported by a previous study (R. Lewis, 2001). In classrooms, teachers' expressions of negative emotions were less favorable and associated with learners' negative affect. Similarly, in the current study, PALs' negative affect was perceived less favorably than positive and neutral affect. However, PALs' affective expression did not influence learning, interest, and self-efficacy. The author speculated that the lack of variations in PALs' emotional expressions might be a reason. In the current study, the PALs expressed one constant type of affect throughout the instruction - - all happy, all sad, or nothing. The learners who were randomly assigned to one affect condition might be less aware of PALs' emotional states, at least not enough to change their affective and cognitive characteristics. This speculation seems to be plausible when we consider the results for perceived agent persona. The impact of positive and neutral PALs was not distinctive, rather both were perceived favorably. Also, previous studies reporting the motivational impact of agent emotions implemented a full range of emotional variations. For instance, learners showed their preferences for and higher interest in an emotional agent expressing 26 emotional variations (Lester et al., 2000). However, even with the emotional variations, the agent's emotions did not influence learning. Also, Baylor and students compared an agent who demonstrated positive emotions with an agent who demonstrated evasive emotions in computer-based math instruction for GED students (Baylor, Shen, & Warren, 2004). Their study did not support any impact of agent emotions on learning and motivation. This lack of evidences for the impact of agent affective expression might lead to questioning the value of the implementation of agent affective expression for learning and motivation. In particular, thinking of cost-effectiveness, more rigorous evaluations might be needed as regards to implementing emotional agents for instructional applications. Future research is invited to validate this skepticism.

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CONCLUSION

As a result of rapid advances in animated agent technology, the prospect of deploying animated pedagogical agents on a broad scale is quickly becoming a reality. Because these agents can provide students with customized advice in response to their problem-solving activities, their potential to increase learning effectiveness is significant. In addition, however, these agents can also play a critical motivational role as they interact with students. As a result, students may choose to use interactive learning environments frequently and for longer periods of time. To investigate the affective impact of animated pedagogical agents on students' perception of their learning experiences, we undertook an empirical study with 100 middle school students. The study revealed that well crafted lifelike agents have an exceptionally positive impact on students. Students perceived the agents as being very helpful, credible, and entertaining.

This persona effect held strong even for an agent whose communicative behaviors were muted. The study also found that combinations of types of advice can (1) increase students' positive perception of the agent and (2) increase learning performance. This work represents a promising first step toward developing an understanding of the impact that animated pedagogical agents can have on children's learning experiences. Perhaps the greatest challenge lies in determining precisely which characteristics of these agents are most effective for particular age groups, domains, and learning contexts. We will be investigating these factors in our future research.

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