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Title: Designing Tools that Care: The Affective Qualities of Virtual Peers, Robots, and Videos.

A Running Title: DESIGNING TOOLS THAT CARE.

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Summary:

This chapter is concerned with the use of advanced learning technologies in order to facilitate a learner's positive affect and, thereby, increase engagement and learning. The chapter introduces three tools that we have used to promote positive affect in groups of learners ranging from preschoolers to college students: *virtual peers* (animated, on-screen characters), *humanoid robots*, and *online videos*. The chapter starts with a brief discussion of the integral relationship between affect and cognition to emphasize the importance of learner affect as a catalyst for successful learning. The following sections discuss how each of the three technologies has been used to support positive affect in students who face various challenges in their learning. The chapter ends with concluding thoughts and recommendations for future research.

Key Words: Learner affect, Advanced technology for learning, Computer-assisted learning, Virtual peer, Embodied conversational agent, pedagogical agent, Humanoid robot, Educational robotics, Online video, Affective computing.

Designing Tools that Care: The Affective Qualities of Virtual Peers, Robots, and Videos

The Integral Nature of Affect and Cognition

The evidence for the integral relationship between affect and cognition has been accumulated over the last three decades, especially with the advance of research in neuroscience (Damasio, 1994). Currently it is widely believed that affect influences social thinking and memory and facilitates effective decision-making. Also positive affect reduces cognitive and judgmental errors. Materials associated with a user's current emotional state are more likely to be activated, recalled and used in constructive cognitive tasks (Bower & Forgas, 2001). People process affect-congruent materials more deeply, elaborate information from the materials more effectively, and learn from these materials more fluidly than they do with affect-incongruent materials (Bower, 1981). Moreover, our cognitive processes are responsive to environments signaled by our feelings. That is, affect signals influence the spontaneous choice of a processing style compatible with an individual's goals and task demands. Sad individuals are likely to spontaneously adopt a systematic, detail-oriented, and bottom-up strategy; happy individuals may prefer simple heuristics, explore new procedures and possibilities, and adopt an unusual, creative, top-down strategy (Schwarz, 2002). In general, learners with a positive affect spend longer in the task and learn more, compared to learners with a negative affect.

Affect is a context specific entity and closely aligned with social contexts (Saarni, 2001). It seems natural that the social context of learning plays a significant role in shaping students' motivation, learning behaviors, and academic outcomes in classrooms. In classrooms, the affective states of teachers, peers, and others, function as social contexts and influence learners' affective characteristics, such as emotions, self-conception, and motivation (Sutton & Wheatley, 2003). Recently, achievement gaps in challenging subject matters (e.g., mathematics and science) among different groups of students in public schools are often attributed to a less supportive learning context and undesirable social influences (e.g., stereotyping). Some groups of low-achieving students in conventional settings lack the instructional support that might motivate them to sustain and succeed in those areas.

Although three components of scaffolding (perceptual, cognitive, and affective) are necessary for effective learning and motivation (Stone, 1998), many conventional computer-based tutoring environments have focused primarily on assisting learners in the cognitive processes of learning. They have often neglected to implement the perceptual and affective aspects of scaffolding. A recent study reports that individuals with low self-esteem are less receptive to personal support, compared to those with high self-esteem; the low self-esteem individuals become more receptive when the support validates their negative feelings (Marigold, Cavallo, Holmes, & Wood, 2014). The authors believe that minimizing a learner's negative feelings and supporting positive affect is crucial for cognitive engagement. We have investigated various ways to create an affective learning context in technologically enhanced environments. Our experience suggests that designing tools to afford a caring context could help boost learners' positive affect and also close the achievement gap of diverse groups of students in public education (Kim & Lim, 2013). With this goal in mind, we have used three tools: *virtual peers* (animated, on-screen characters), *humanoid robots*, and *online videos* to promote positive affect of learners ranging from preschoolers to college students. We have paid special attention to traditionally marginalized groups of students in conventional classrooms and observed how those technologies helped address their unique needs.

Virtual Peers

Virtual peers are animated peer-like characters. Human/computer interaction research argues that computer users tend to expect computers to be like social entities and build humanlike relationships with an animated character (Nass & Moon, 2000). This trend has stimulated the popular use of virtual peers in computing environments for educational and commercial purposes. The provision of simulated social presence and peer interaction may make virtual peers distinct from traditional computer-assisted tutoring, seemingly offering a unique instructional opportunity. Although the theoretical frameworks for virtual peer technology and its educational effectiveness vary, it is clear that a virtual peer plays a distinct social (even persuasive) role for learners across age groups. For example, kindergarten children listen to their virtual peer's stories very carefully and, afterward, mimic the peer's linguistic styles (Ryokai, Vaucelle, & Cassell, 2003). Secondary school students prefer a virtual peer that looks similar to them over a dissimilar peer (Kim & Wei, 2011). College students expect their virtual peer to have a nice and friendly persona (Kim, 2007). As aforementioned, our affect influences our thinking processes, and we can respond more adaptively to our environments when feelings signal our cognitive processes. Therefore, a virtual peer could be designed to promote learner confidence and engage the learner effectively in challenging learning tasks. Also, the peer's affect might be adjusted to the nature of the learning challenges and designed in the way to stimulates a learners' positive affect that signals the appropriate processing strategy for the task.

Virtual Peer Affect

In general, affective computing refers to a computer's capabilities to recognize a user's emotional states, to express its own emotions, and to respond to the user's emotions (Picard, 1997). Each capability requires different kinds of technologies and resources to implement; hence, investigating each capability separately might provide more accurate information on their individual effectiveness in achieving intended goals. Given that affect recognition is engineered with auxiliary hardware, we focused on a virtual peer's emotional expressions and empathetic responses to help achieve desired instructional outcomes. In our study, we examined the effectiveness of a virtual peer's emotional expressions and the effectiveness of its empathetic responses separately in two experiments (Kim, et al., 2006). In the first experiment on peer emotional expressions, 142 college students in a computer-literacy course voluntarily participated in a web-based e-Learning module taught by a virtual peer for one class hour. During the instruction, the peer tutor demonstrated positive or negative emotions or no emotions at all, through its facial and verbal expressions. After working at the module, the college students rated the peer that showed constant positive emotion as significantly more engaging and facilitating to their learning. In the second experiment on the peer's empathetic responses, fifty-six college students in a required course participated in a web-based lesson taught by a virtual peer as a mandatory class activity. The learning task was an essential part of the curriculum the students had to master, so the students were expected to engage in the task seriously. This situation might have instigated increased emotional arousal in the students. During the lesson, they were asked to express their current emotional states by clicking emoticons at the bottom of the screen. The virtual peer either presented empathetic messages responding to their emotional states or did not respond at all. The results showed that the students who received the virtual peer's empathetic responses rated the peer as significantly more engaging and facilitating to their learning. Also, with the empathetic peer, the students showed significantly higher self-efficacy in the learning task than those with the non-responsive peer.

Affective Role Models

Another perspective we have taken is the use of virtual peers as role models. Grounded in the classical theories of social modeling and attribute similarities, we have designed a virtual peer to serve as coping models or role models. That is, the peer responds sympathetically to the challenges the learner faces and/or demonstrates desirable behaviors that will lead to successful learning outcomes. According to social modeling theory (Bandura, 1997), attribute similarities (the similarities of personal characteristics between a social model and a learner such as age and gender) are considered a determinant of successful modeling. The more similar a model is to a learner, the greater the probability that the learner will repeat the model's actions. Likewise, similarity-attraction theory indicates that people are more attracted to a person who is similar to themselves (Berscheid & Walster, 1969). This attraction influences both their interpersonal relations and behaviors. More recent research also reports similarity attraction between learners and a virtual peer. High school boys and girls preferentially chose a same-gender peer and a same-ethnicity peer as their tutor in online mathematics-learning (Kim & Wei, 2011); college students of color chose same-ethnicity peers significantly more (Moreno & Flowerday, 2006) and also evaluated similar peers significantly more positively than dissimilar ones (Baylor & Kim, 2004).

It is known broadly that many adolescent females are less willing to participate in mathematics and science learning, compared to their male counterparts. This is often attributed to the social influence of family, friends, and teachers that might impose gender-related social stereotypes and expectations on the girls (Clewell & Campbell, 2002). These girls lack instructional support and encouragement for their intellectual pursuit in mathematics and science classrooms. Feminist scholars argue that many females are better motivated when the learning environment affords social relations and collaborative interactions (Boaler, 1997, 2002). The provision of supportive relationships should be critical for many females' intellectual pursuit of challenging topics and perseverance in these topics (Crosnoe, Riegle-Crumb, Field, Frank, & Muller, 2008).

Given this educational challenge, we have developed an algebra-learning environment called *MathGirls*, in which a virtual peer provides middle-grade girls with verbal encouragement and persuasion to counteract unconstructive social influence. Research has indicated that a humanlike agent's presence primes human-to-human social interactions and motivates learners to converse with the agent and build interpersonal relations with it (Moreno et al., 2001). So, it was expected that the girls in the study would build social relations with the peer and thereby enhance their positive affect and sustained engagement in learning. We questioned whether virtual peer presence would influence middle-grade girls more positively than boys. One hundred and twenty 9^{th} grade boys and girls took virtual-peer-based algebra lessons daily for one week. The peer presented personalized instructions and social and empathetic messages during the instruction. The results supported the expectation (Kim & Lim, 2013). Virtual peer presence had a significantly more positive influence on girls' affect than it did on boys'. More specifically, the girls in the study evaluated the virtual peer significantly more positively than the boys did, with the most positive evaluations from minority girls (here, Latinas). The girls showed significantly more positive attitudes toward learning with the peer than did the boys. Girls significantly increased their self-efficacy in learning algebra concepts after working on the peer-based lessons, whereas males did not show an increase. Follow-up interviews confirmed that girls built more developed social relationships with their virtual peer in the learning process. Another encouraging result was that both boys and girls increased their learning significantly after working in this socialized learning environment.

Humanoid Robots

Robots have been common in industrial settings for years, but during the last decade, their popularity as an educational resource has risen dramatically (Johnson, 2003). In the early

1990's LEGO Mindstorms (http://mindstorms.lego.com) became a frontrunner in the effort to improve engagement and mastery of STEM topics for elementary, middle school, and high school students. While some educational programs still focus primarily on "robots *in* education" (i.e., robots as tools for learning robotics), recently more and more educators and researchers have become interested in "robots *for* education" (i.e., robots as mediators of learning in any area) (Shin & Kim, 2007, p. 1040). Nowadays, trends in educational robotics include a wide range of robot applications in a variety of different subject matters (Rusk, Resnick, Berg, & Pezalla-Granlund, 2008). One subject where robots have become especially important is English as a Second/Foreign Language (ESL/EFL). In Japan, Korea, China, and other countries pursuing innovations in educational technology, EFL learning is the domain that has most actively used robot assistants. Due to a growing understanding of the social nature of acquiring language, robots' involvement in language learning has sparked many questions about the ability of machines to replicate not only human speech and gestures but also human affect. There is a growing need for research that examines the value of robots as learning partners and helps developers design robots that accurately and effectively portray human affect.

Robots and Affect

When discussing robots, it is important to differentiate between robots as learning *tools* and robots as *partners* that can cooperate with, teach, and even build relationships of trust with users (Kidd & Breazeal, 2004). While humans expect to use tools, they do not expect to use partners, and this difference in expectations leads to different kinds of interaction. One major component of human-to-human interaction is affect, and many researchers have demonstrated that a robot's display of affect can have a significant impact on the way the robot is perceived and on the robot's ability to guide, engage, and help humans (Leite et al., 2012; Hudlicka et al., 2009). Affect is especially important in robots that serve as partners or tutors because humans recognize their physical presence as evidence that robots are *real*, and as a result, users are more likely to perceive them as human than they would an animated or virtual character on a screen (Kidd & Breazeal, 2004).

The affect displayed by a robot is a major factor in its ability to elicit positive perceptions and engage users (Kanda et al., 2012; Leite et al., 2012). Robots that can display emotion are more likely to motivate learners (Shin & Kim, 2007) and socially supportive behavior from robots has resulted in improved performance in children learning a new language (Saerbeck et al., 2010). All of these advantages make affect in robots more than just a nice feature; rather, it seems that affective affordances may be some of the most essential features a robot can possess.

The Robot Friend *Skusie*

The authors use the humanoid robot *Skusie* in an on-going project on educational robotics (http://www.create.usu.edu/projects.html). Skusie's purpose is to help ELs (English Learners) to learn English in their first few years of preschool and elementary school. The robot system is equipped with three types of sensors (optic, touch, and proximity) and movements controlled by Android smart-phone apps via Bluetooth technology. A phone is cradled on the robot's head implying the robot's visible brain. The integration of smartphone and humanoid hardware systems places Skusie in an affordable range and thus solves the problem of cost that can often be a roadblock in robot development and broad use.

A sociable robot like Skusie is especially valuable to ELs for several reasons. First, all learners are more likely to engage in the learning tasks and perform at a high quality when they are given appropriate resources, opportunities, and environmental conditions (Brophy, Biswas, Katzlberger, Bransford, & Schwartz, 1999). Instruction that attends to learners' needs is more likely to enhance their engagement that leads to the achievement of goals (Ryan & Deci, 2000). In previous studies, students engaged more with robots that could actively interact with them and display emotions (Kanda et al., 2012). Feeling a lack of instructional support in classrooms, ethnically diverse students seem especially prone to building more developed social relationships with artificial beings (Kim & Lim, 2013). The ability of minority students to develop social skills through technology deserves special consideration since EL children often struggle to fit in with native English speaking peers. In our project, during the design process for Skusie's educational app, we have tried to focus on filling the affective needs of EL students, especially the need to feel motivated and included in learning. Social robots can provide a valuable mediator between isolation and full human-to-human contact, and during user testing we found Skusie capable of providing interaction in both one-on-one and small group situations (Kim, et al., 2014). Furthermore, when using Skusie, children are placed at the center of play; the robot pays full attention to them, and, as other studies have demonstrated, the relationship built between the robot and child can positively contribute to the children's learning engagement, motivation, and performance (Shin & Kim, 2007; Saerbeck et al., 2010).

At first glance, Skusie might not seem capable of demonstrating very much emotion. The robot cannot change its facial expression but instead relies on LED blinking to signal shifts in emotion, and its movement is limited to its feet and hips. During user testing, it only communicated through recorded speech, noises, and flashing lights. However, research suggests that robots actually need to do very little to be perceived as social agents (Kozima, et al., 2009). Toddlers perceive a robot called Keepon as a social being even though it is limited to communicating through rudimentary movements and flashing lights (Kozima et al., 2009). Anyone who has seen the movie *Star Wars* and is familiar with the character R2-D2 has also seen evidence of this. Although R2-D2 is bulky and can only produce beeps and flashes of lights, this robot is one of the most beloved characters in the popular movie series (Davis & Pakowski 2013). Additionally, Leite et al. (2012) point out that if a robot can verbalize (but not recognize human speech), this does not hinder its ability to interact verbally with users. The real key to successful verbal interaction seems to be creating robots that can respond reliably to both the requirements of the task and the expectations of the user.

Designing for Children: Interplay Between Designers and Children

That was also the case with Skusie. None of the children who worked with Skusie seemed to notice that the robot was unaware of what they were saying because all of the robots' verbalizations fit the activities and matched the child's performance. In fact, during the process of Skusie's design and development, we found the Wizard of Oz method of user testing to be invaluable in creating believable affective speech (Riek, 2012). Through role-playing in the position of the robot, our designers were able to have a much clearer idea of what the robot should say, when the robot should say it, and how the robot should say it. For example, during a session of user testing, the tester noticed that when she tried to elicit a response from a child, she would typically repeat the target word three times and use different variations in her voice (high and low tones, different emphasis on syllables, silly voices, etc.) to encourage the child to respond. She reported this to the team and they implemented this same pattern of repetition and variation to the robot's dialogue. For example, after singing a song about a triangle, the robot would say: "You say it! (pause) triangle (pause) triangle (pause) triangle (pause)." This relatively simple addition made a huge difference not only in each child's willingness to respond but it also added more fun to the activity as children tried mimicking the playful tones of the robot's speech. Again, the issue was not so much how much the robot could say or understand, but how accurately it could respond in an engaging, credible, and appropriate way to the user.

Despite the incredible ability of robots to elicit or stimulate learners' affective reactions with limited mobility and expression, our team discovered that robots have an even greater (and previously untapped) social ability: helping learners collaborate with other learners (Kim, et al., 2014). One of the final sessions of field-testing with Skusie occurred in the media center of a public elementary school, where students spoke both English and Spanish in all of their classes. Several classes came in and out of the media center while individual children worked through a series of activities with the robot. The team was about to wrap up for the day when two seven-year-olds from another class approached the team leader and asked if they could play with the robot. This led to the discovery of the potential for small group interaction instead of only one-on-one interaction with the robot. As the team watched, the two children voluntarily took turns solving the tasks presented in the robot application. Rather than trying to beat one another, the boy and girl collaborated to score points in the games and find the robot's secret passcode in the book. As the design team watched them interact with each other and the robot, they became more and more excited about the ways the robot became a tool to support English language learning and, more importantly, a venue for children to collaborate and socialize, which serves as a building block for language learning. In other words, though it will take time before robots can mimic the full range of adult human social interaction, if a robot can help humans to interact with their peers—particularly those who struggle to interact because of language or other barriers—then the positive effects of social learning can be accessed both through the robot itself and through activities mediated by the robot and others.

Online Videos

Instructor-Learner Interaction in Online Learning

In higher education, online learning has been growing rapidly in recent years due to ease of access and scheduling flexibility (Kim, 2012; Robinson & Hullinger, 2008). One popular technology that is increasingly used to deliver learning content is online instructional videos, which are videos prerecorded by the instructor and placed online for convenient access by the learners. Online instructional videos might be a potentially powerful medium due to instructors' visibility that adds a sense of social presence to, otherwise, socially bleak environments filled with text and graphical information. Social presence in online learning seems to be crucial because low completion rates in online learning are often attributed to the lack of affective support and interpersonal relationships between the instructor and the learner (Kim, 2012).

Affective experience of the learners is a valuable and vital part of the learning process (Micari & Pazos, 2012; Sakiz, 2012; Xiao, 2012). A lack of interaction between learners and instructors has a negative impact on the learner's affective experience and can interfere with the success of online learning (Kim, 2012). Likewise, interaction with the instructor is one factor that significantly influences students' satisfaction and perceived learning gains (Swan, 2001). Although they are limited to one-way interaction, online videos may have an advantage over the aforementioned tools (virtual peers or humanoid robots). That is, the instructor is actual human who can present all the affective cues that humans do. With virtual peers or humanoid robots, these affective cues (such as facial expressions, tone of voice, etc.) have to be artificially defined. Adult learners might discriminate between a genuinely human presentation and an artificially programmed one. While it is clear that humans can and do attribute affective qualities to machine entities, it is also clear that no amount of clever programming can completely recreate the genuineness of a human face and voice, and all of the emotional qualities that they convey. For this reason, online videos may be used for college students as a way to support their learning processes while preserving the *human* element of instruction.

Compensatory Strategies

Indeed, there may be compensatory strategies available to help increase positive learner affect while learners are attending to online video instruction. Developing a strong relational rapport between the learners and the instructor can increase positive student affect and decrease negative student affect (Angelaki & Mavroidis, 2013; Sakiz, 2012). This relational rapport can be built as the instructor demonstrates that he or she cares about the students (Teven, 2007), praises their efforts and achievements (Arghode, 2012; Komarraju, Musulkin, & Bhattacharya, 2010; Marchant & Anderson, 2012; Xiao, 2012), and presents him or herself in an approachable way (Micari & Pazos, 2012). In particular, Micari and Pazos (2012) discovered that three variables were correlated with the rapport between the learner and the instruction: viewing the instructor as a role model, the approachability of the instructor, and the respect that the instructor shows for his or her learners.

While each of these approaches to improving instructor-learning rapport is most effectively done in in-person settings, it may be possible to cultivate this rapport and improve student affect in online instructional videos (Velasquez, et al., 2013). It is unknown yet how the learner-instructor relationship could be developed and promoted in online video-based learning (Angelaki & Mavroidis, 2013), but some attempts have been made to investigate the issue.

The authors have recently studied whether the relationship-building strategies that are effective in in-person contexts are also effective in an online context, when used in an online video (Kim, Thayne, & Burdo, forthcoming). If so, then these relationship-building strategies may serve as compensatory measures that could help alleviate some of negative aspects that result from the static nature of the video presentation. In the study, we developed two versions of a four-lesson, college-level statistics module. In one version of the instruction, the instructor used relationship-building strategies in the design and presentation, including building up the instructor as a role model, being approachable, and showing that the instructor respects the learners (Micari & Pazos, 2012; Young, 2006). The instructor used a friendly and warm tone of voice and included colloquialisms, provided anecdotes about his own experience with statistics, including stories of how he struggled with certain concepts and how he still continued to use the information, and used encouraging language towards learners. In the other version, the instructor used none of these strategies, but simply presented the curricular material in a straightforward manner.

Study participants were college students who enrolled in a required introductory statistics course offered for general education credits. The four online video lessons replaced one week of statistics classroom lectures in the middle of the semester. The results showed a statistically significant effect on the students' attitude towards the instructor and the learning material. The attitudes of the students in both groups towards the material and the instructor decreased over the period of time while they were learning the material using online videos, rather than in person. However, those who watched the videos using the relationship-building strategies experienced a significantly *less* decrease in their attitudes towards the material and the instructor. If we assume that attitude is closely related to (and mediated by) learner affect, we can conclude that these strategies may have positively influenced the affect of the students. From the study, we conclude that while robust interaction between the learner and the instructor should always be encouraged, online videos that do not allow for this interaction can be enhanced — and perhaps deliberately designed to positively influence student affect — by incorporating sound relationship-building strategies into the design and presentation of the video.

Conclusion

Emotion research suggests that, to help learners with various challenges, making efforts to build learners' positive affect should be an essential, preliminary step to any type of instructional support. The tools like virtual peers and humanoid robots are relatively free from the biases in the real world, so they might provide a safer learning environment for students who can be marginalized in regular education classrooms for various reasons. Also, just by adding some pedagogical strategies, a relatively simple tool like instructional videos can be utilized to enhance social and affective qualities in online learning.

Virtual peers, robots, and videos could be effective and affective tools only when they are designed right. When creating programs with virtual peers, designers may keep in mind the power of a peer to positively engage learners and enhance learning experiences. When designing applications for educational robots, there are several exciting opportunities for further exploration and innovation. It seems that affect is more related to the robot's capacity to replicate human behavior than a robot's capacity to replicate a human's physical abilities. The "Wizard of Oz" method may be especially helpful in identifying which instructional behaviors are most relevant to their particular learning outcomes. It can be easy to overlook the simplest kinds of human interaction (like repeating words or changing our tone of voice), but including these relatively small details into robot applications can lead to a much more authentic and effective learning experience. Last, but not least, when incorporating videos into online learning, instructors could first be aware of the affordance and limitation of the medium, as well as of the research in this area. Unless instructors take care to ensure that students are engaged on an affective level, instructors who use online videos may see their students' positive attitudes decrease. It should be further explored how online videos can be deliberately designed to increase positive student affect. The case for doing so is strong, but the research on precisely *how* to do so is still weak. As our study finds, the use of relationship-building strategies may help.

Overall, it is clear that rendering social and relational learning contexts to educational tools is feasible and crucial to success in learning. Building off of our initial findings, subsequent research needs to be done on how those technologies can mediate and encourage positive learning experiences in both one-on-one and group settings.

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