

An Empathic Avatar in a Computer-Aided Learning Program to Encourage and Persuade Learners

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(Submitted July 23, 2009; Revised January 26, 2011; Accepted March 31, 2011)

ABSTRACT

Animated pedagogical agents with characteristics such as facial expressions, gestures, and human emotions, under an interactive user interface are attractive to students and have high potential to promote students' learning. This study proposes a convenient method to add an embodied empathic avatar into a computer-aided learning program; learners express their emotions by mouse-clicking while reading, and the avatar motivates them accordingly. This study designs empathic responses for avatars to encourage and persuade learners to make greater reading effort. This experiment examines emotional recognition, empathy transformation, and the effect of virtual human encouragement and persuasion. Subjects identify facial expressions of the avatar, especially those expressing positive facial emotions. Compared to the contrast group, the empathic avatar increases learners' willingness to continue reading and complete exercises.

Keywords

Animated pedagogical agent, Computer-aided learning, Encourage, Persuade, Empathy

Introduction

Animated pedagogical agents (APAs), with characteristics such as facial expressions, gestures, human emotions, and an interactive user interface, are attractive to students. Many studies posit that social agencies with social cues in multimedia messages encourage learners to interpret human-computer interactions as a parallel to human-to-human conversation. These agents provide students with more lifelike interactions that could increase the communication capacity of learning systems and the ability of these systems to engage and motivate students. Many learning environments have been integrating APAs since their conception to encourage and motivate students to make greater learning effort.

Lester, Converse, Kahler, Barlow, Stone, & Bhogal (1997a) and Lester, Converse, Stone, Kahler, & Barlow (1997b) developed an interactive learning system with a lifelike agent in his laboratory by a large, multidisciplinary team of computer scientists, graphic designers, and animators. The lifelike agent provides students with customized advice in response to their problem-solving activities and plays a critical motivational role as it interacts with students by giving principle-based animated advice to challenge the student, or employs task-specific advice if the student is having difficulty. Experimental results revealed that students perceive the agents as being helpful, credible, and entertaining. Emotions in the agent design reinforce its expression of social cues and satisfy learners' emotional needs. Picard (1997), in the book *Affective Computing*, indicates that emotions play an essential role in decision making, perception, learning, and more—they influence the very mechanisms of rational thinking. Lester, Towns, & FitzGerald (1999) used lifelike pedagogical agents with visual emotive communication (including facial expression, full-body behaviors, arm movements, and hand gestures that visually augment verbal problem-solving advice and encouragement) to encourage and motivate students. D'Mello et al. (2008) revealed an affect-sensitive Intelligent Tutoring System, which detects learner emotions by monitoring conversational cues, gross body language, and facial features by hardware. Their research considered learners' affective and cognitive states in selecting pedagogical and motivational dialogue moves, and responding through an embodied pedagogical agent with animated facial expressions and modulated speech. McQuiggan, Rowe, Lee, & Lester (2008) showed a narrative-centered learning

environment and evaluated its affective transitions. Jaques, Lehmann, & Pesty (2009) created an emotional pedagogical agent with affective tactics that predicts students' emotions according to the psychological model OCC (see Ortony & Collins, 1988). Though the prediction rate of specific emotions can reach a certain high percentage, improper emotional responses based on the fault of automatic emotion prediction hypothesis might provoke negative feelings in users.

Many studies have mixed multimedia materials with APAs for increasing students' motivation and learning effect. System development requires a large, multidisciplinary team of domain experts, computer scientists, graphic designers, and animators (Lester et al., 1997a). Johnson, Rickel, & Lester (2000) listed eight types of human-APA interactions that could benefit learning environments, including interactive demonstrations, navigational guidance, gaze and gesture as attentive guides, nonverbal feedback, conversational signals, conveying and eliciting emotion, virtual teammates, and adaptive pedagogical interactions. Many researchers have created animated pedagogical agents who convey emotional responses to the tutorial situation to increase the learning environment by engaging and motivating students. These studies necessitate dedicated and complicated detectors and calculating formulas to work together with learning systems for active and precise detection of users' emotions by facial expressions, full-body behaviors, arm movements, or hand gestures (D'Mello et al., 2008). These requirements hinder the materialization in general subjects and practice. To reduce the complexity of detecting users' emotions, some systems inferred their emotions according to the psychological model (Jaques, Lehmann, & Pesty, 2009).

To present APAs, some research has adopted 2D or 3D animation approaches. Okonkwo & Vassileva (2001) designed an emotional pedagogical agent with simplified facial expressions that motivates students by convincing them it really cares about their performance and progress throughout the training. Kim, Baylor, & Shen (2007) created portrait-sized pedagogical agents as learning companions, developed using a 3D-animation-design tool to provide context-specific information and helpful messages at learners' request. Experimental results showed that APA's empathetic responses had a positive impact on learner interest and self-efficacy. The social agency delivering the verbal and visual social cues, such as facial expressions, gestures, head and body movements of the animated agent, in computer-based environments, fosters the development of a partnership by encouraging learners to consider their interaction with the computer to be similar to that of a human-to-human conversation (Mayer, Sobko, & Mautone, 2003; Moreno, Mayer, Spires, & Lester, 2001). Although many studies have investigated APA approaches, it is still worth investigating in how APAs affect students' emotions and behaviors in different learning activities.

This research evaluates how emotional avatars in different learning activities affect students' e-learning behavior. We added an embodied empathic avatar into a computer-aided learning program; learners express their emotions by mouse clicking while learning, and an avatar cares about and motivates them accordingly by its coherent voice and upper-body motions. Emotional buttons set beside the e-learning system screen passively read users' emotions after they press the emotional buttons. Empathic responses from avatars encourage and persuade learners to increase effort. The results of this study may support existing pedagogical theory and help utilize technique strategies in promoting an e-learning system with APAs.

The organization of the paper is as follows: Section 2 describes the empathic avatar design and learning system; Section 3 shows experiments and results; Section 4 and 5 present discussion and conclusions.

Empathic avatar design

Avatars should be polite (Wang, Johnson, Mayer, Rizzo, Shaw, & Collins, 2008) and emotionally positive (Kim, Baylor, & Shen, 2007), possess a real voice with full social cues (Atkinson, Mayer, & Merrill, 2005), and demonstrate proper hand gestures for indications that might impact on learners (Baylor & Kim, 2009). This research considers trust relationship between agents and learners as one of the factors influencing motivation (Fogg, 2003). An emotional-interactive system design should also consider instructions. This study focuses on how to add an empathic avatar to an existing learning system to promote students' learning, and uses textbooks in the system as learning materials. The avatar plays the role of a learning companion who encourages and persuades students to make more effort in learning. The user interface of the system allocates the main area on the computer screen for students' learning and reserves the right column for human-computer interaction, including emotional expressions and animated tutor reactions. Figure 1 shows the system's user interface. Students read and do exercises on the left side. They can also switch learning activities anytime. Predicting the emotions of students from various backgrounds

and diverse cognitional and emotional statuses is difficult. A blank area allows learners to express their emotions at any time, and an animated avatar appearing in the video display area responds to assist in their learning (see the upper-right area in Fig. 1). Learners express their emotions by clicking one of the four-pair emotional buttons (see the bottom-right area in Fig. 1). Four pairs of basic negative-positive emotions occurring during interaction with the educational system (Tzvetanova & Tang, 2005) include the emotions of distress-joy, fear-confidence, boredom-fascination, and unsatisfied-satisfied. Choosing the emotion set simplifies students' choice of emotional expressions and covers most emotions while learning. The middle-right area of Figure 1 is the record of the student-avatar dialog.



Figure 1. Interface of the system

The following three sessions describe how to create the virtual human and how the virtual human interacts with students.

Creating the avatar

According to the social agency experiment, APAs might imitate human interactions as much as possible to enhance the sensation by delivering large numbers of social cues (Mayer et al., 2003; Moreno et al., 2001). Nguyen & Canny (2009) have also shown that upper-body video framing, which conveys subtle cues, might be more effective than face-to-face interaction regarding empathy effects. However, mimicking real humans requires that professionals spend much time on designing a vivid, detailed virtual human. This research chose 3D animation software to create the virtual human and its performance, while considering the appeal of 3D roles with various built-in emotional expressions. Development of the virtual-human animation focuses on behaviors and voices. A class of 52 college students elected built-in 3D roles as their favorite, and selected a female-embodied virtual human named Maggie. Poser 6, a 3D animator, was used to create the actor-empathic performance. After the animations were created, they were converted to MPEG4 (AVI-Format) films for integrating into the learning system.

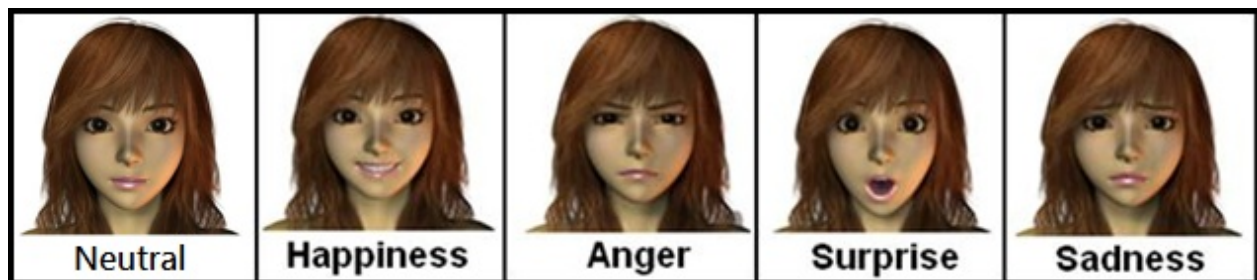


Figure 2. Examples of the avatar's facial emotions

Adding empathic characteristics to the virtual human involves adding facial expressions, hand gestures, body movements, and voices. Ekman & Friesen (1978) interpreted that each emotion puts unique signals in the face, so facial expressions are more reliable indicators of a person's emotional state than is body language. This study adopted Ekman's facial action coding system in the design. The basic six emotions include happiness, anger, surprise, sadness, disgust, and fear. To feed the needs of e-learning, two emotions (worry and neutral) were also included. Figure 2 shows five of the avatar's facial emotions.

This work referred to studies on human affective gestures (Givens, 2002) for hand gestures and body movements to make the avatar's nonverbal behaviors consistent with its empathic expressions. Figure 3 shows two poses of the design. This project recorded the avatar voices from a dub actor.

Interaction design of the avatar

The purpose of the student-avatar interaction is to encourage and persuade users to increase engagement and learning effect. Greetings and self-introduction in the beginning serve as orientation; caring, and empathic responses are designed in the passive mode, which are awakened after students trigger the emotional expression or after an examination; and a farewell greeting and well wishes end the session.

The avatar is designed as a friend to listen to students, to care for and encourage them. Parallel-empathic responding strategy is used for caring and encouragement. The designed conversation scenarios are as listed below.

Greetings: When a student logs into the system, the avatar appears in the interaction area and welcomes the user with a smile.

Empathic responses: Emotional buttons beside the e-learning screen obtain users' emotions after they press the emotional buttons. The avatar always wears a smile. After students express their emotions by pushing one of the buttons, the avatar uses empathy to encourage and persuade them into persistent learning. Besides these empathic reactions, the avatar persuades students to keep learning when they want to break from learning activities. The next session describes the details.

Farewell: When students want to leave, the avatar waves and says, "Goodbye, take care, and hope we can meet again."

Table 1. Empathic responses of the avatar

Negative emotions	Positive emotions
(Status: Distress) Voice: I feel sad when I hear that you are distressed. Cheer up, never give up. Facial emotion: from Sadness to Neutral	(Status: Joy) Voice: I am glad to see you so happy. I am very happy. Facial emotion: from Surprise to Happiness
(Status: Fear) Voice: I feel sad to see that you have fear. But don't worry too much. Remember to keep learning. Facial emotion: from Sadness to Fear, and then Neutral	(Status: Confidence) Voice: You are great. I am glad to see you so confident. Facial emotion: from Surprise to Happiness
(Status: Boredom) Voice: Do the learning activities make you feel bored? Sometimes we need to persist to the end to gain knowledge. Facial emotion: from Worry to Neutral	(Status: Fascination) Voice: I am moved to see you so fascinated. I hope I can be like you. Facial emotion: from Surprise to Happiness
(Status: Unsatisfied) Voice: I am sad to see you dissatisfied. No matter what has happened, never mind. Facial emotion: from Sadness to Neutral	(Status: Satisfied) Voice: Thank you and I am glad to see you satisfied. Facial emotion: Happiness

Encourage and persuade students with empathy into persistent learning

To design avatars to encourage and persuade students to continue learning, maintaining the relationship between avatars and students is necessary. Besides greetings, encouragement, and saying goodbye, we considered empathic reactions in designing avatars. “Empathy is the process of putting oneself in the place of another person, seeing matters from the other’s perspective, perceiving the other’s feelings and thoughts, and conveying this awareness to that person” (Davis, 1996). McQuiggan & Lester (2007) also described the processes of empathy as follows. First, the antecedent consists of the empathizer’s consideration of herself, the target’s intent and affective state, and the situation at hand. Second, assessment consists of evaluating the antecedent. Third, empathic outcomes, for example, behaviors express concern. Table 1 shows one set of avatar empathic responses when students signal their emotions.

For example, when a student tells the system that he is distressed, the avatar responds, “I feel sad when I hear that you are distressed,” with a sad face and two arms crossed in front of her chest. The avatar continues saying, “Cheer up. Never give up,” in a confirming intonation accompanied by a neutral facial expression, arms bent at the elbow and raised, and hands in a fist (see the left part and the right part in Figure 3).



Figure 3. Nonverbal expressions of the avatar

Besides these empathic reactions, the avatar persuades students to keep learning when they want to break from learning activities. When students indicate that they want to stop reading by pressing the upper-middle button labeled Stop Learning, the avatar will say, “You are great. You have learned so much, but do you really want to leave? Don’t you want to learn more?” When students want to quit doing exercises, the avatar says, “You are great. You have done so many exercises, but do you really want to quit? Don’t you want to do more exercises?”

Experiment

To examine the avatar effect, this study first examined whether students could recognize the avatar’s facial emotion in Experiment 1. In Experiment 2, we examined whether students could tell how the avatar felt, based on its upper-body performance, and whether or not students could feel empathy from the virtual human. This work also examined whether encouragement and persuasion help students put more effort into learning activities.

Experiment 1

The purpose of the experiment was to determine whether users could recognize the emotions behind the agent’s facial expressions. The results of this experiment designed to elicit feedback from users were used to improve the quality of our emotional agent design.

The subjects were 52 college students from the department of computer sciences at National Central University. They were freshmen and had been using computers for five years on average, and only a few of them had ever interacted with avatars. The eight facial expressions of the avatar were shown separately, and the subjects were asked to rate their perception level of the eight emotions expressed on five-point scales. For example, the first question assessed the user’s perception level: “Do you agree that the facial emotion of the virtual human is anger?” Choices

ranged from 1 (strongly disagree) to 5 (strongly agree). Besides rating emotions, subjects were encouraged to give their opinions about the design.

Table 2 shows subjects' perception rate of the avatar's eight facial expressions. Five of the eight emotions (anger, sadness, surprise, happiness, and neutral) received higher scores. The remaining three facial designs of the avatar's emotions were revised according to feedback from the subjects. Interviews were conducted to gain their opinions. Seventeen subjects found it difficult to distinguish worry from sadness. In the fear countenance, 23 subjects thought the mouth opened too wide to be natural. Eight subjects thought the avatar should narrow its eyes or frown a little more when disgusted. The results were shown to our artist to improve the design of the avatar's facial expression. Experiment 2 evaluated the perception of the avatar's empathy where the avatar expressed empathy by her voice and upper-body performance, including facial expressions, gestures, and body movements.

Table 2. Mean score on subjects' perception of the virtual human's eight expressions

Anger		Sadness		Surprise		Worry	
<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
3.87	0.84	3.88	0.78	4.02	0.94	3.62	0.87
Happiness		Disgust		Fear		Neutral	
<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
4.10	0.77	3.31	1.05	3.54	0.94	3.87	0.84

(1 = strongly disagree; 2 = disagree; 3 = no comment; 4 = agree; 5 = strongly agree)

Experiment 2

To investigate students' perception of the avatar and its effect on students' learning behavior, we exposed students to agents in controlled learning experiences to obtain students' assessment of the avatars by questionnaires. To investigate the effects caused by the avatar, we analyzed their (1) amount of learning time, (2) willingness to continue learning, and (3) emotions in reading activities and doing exercises.

To study how different agent settings influence students' perception and learning, we developed three settings of agents and introduced each one into a copy of the learning environment. The first setting includes the empathic avatar, which responds to participants with empathic facial expressions, voices, gestures, and body movements. The second setting is almost the same as the first setting, with only the empathic design removed from the avatar. In the third setting, the avatar performance was replaced by text. Despite the difference, the settings were identical in all other respects.

First setting: empathic avatar with empathic facial expressions, voices, gestures, and body movements.

Second setting: avatar without empathic responses and with neutral facial emotion.

Third setting: empathic responses in text without the avatar.

Participants and setting

Thirty college freshmen (24 males; 6 females) majoring in computer science participated in the evaluation. Most had been using computers for five years on average, and only a few of them had ever interacted with avatars. Students were randomly assigned to one of the three groups. Students in different groups experienced all three settings of the learning system in different order. Students in the first group used the first, second, and third setting of the system sequence. Students in the second group used the second, third, and first setting of the system sequence. Students in the third group used the third, first, and second setting of the system sequence.

The study was conducted in a meeting room. The program was installed on laptops, each with 80GB hard disc, a two-button mouse, and a 14-inch color display that ran Microsoft Windows XP operating system. The screen resolution was 1024 pixels x 768 pixels.

Materials and procedure

Each student was placed in a learning system setting with a laptop for 30 minutes on average. During this time, students read, performed exercises, interacted with an avatar, and completed a questionnaire. The avatar introduced students to the experiment and the learning system. Then students spent 5 to 15 minutes reading the e-textbook and simultaneously interacting with the avatar. Students could stop reading at any time and the amount of reading time was recorded, shown in Table 4. After reading, students entered the exercise phase. The exercise contained 40 yes/no questions. When students wanted to quit the exercise activities, the avatar persuaded them to complete the remaining questions. The number of completed questions was recorded to show differences between the three settings. After exercising, the agent encouraged students to read the e-textbook again, and their willingness in the three experimental settings was recorded for further analysis. At the end of the experiment, five-point Likert scale questionnaires and interviews were conducted.

Data analysis and results

To verify students' perceptions of the avatar and the learning system, Table 3 lists the questionnaire results. The top lines of Table 3 present the means and standard deviations for the three settings on each of these questions. Results in question 1 showed that the empathic avatar and the empathic text on average obtained empathy transmission from the subjects, and that the former group gained higher scores than the latter one. The examination shows that students in the empathic avatar setting rate significantly higher than students in the avatar without empathy group, based on a two-tailed t test, $t(28) = 3.08, p = 0.005$. Students in the empathic text setting also rated significantly higher than students in the avatar without empathy group, based on a two-tailed t test, $t(28) = 2.63, p = 0.014$. But students in the empathic avatar setting did not rate significantly higher than students in the text-agent group, based on a two-tailed t test. Compared to the non-empathic avatar, results in question 2 showed that the empathy expressed by the avatar or in the form of text increased users' interests. Subjective feelings also compared to their usage of the system. In question 2, the empathic avatar setting obtained the same scores as the empathic text setting, with similar results to the experiment results of the study (Moreno et al., 2001), saying that a pedagogical agent's image in a multimedia lesson does not hurt, nor does it provide any cognitive or motivational advantage for students' learning. Similarly, compared to the other two control groups, results in question 3 showed that the system with the empathic avatar merely had higher potential for students to use again; two-tailed t tests in question 3 showed that students in the different settings did not have significant rates.

Table 3. Results of empathic reactions by questionnaires

	First setting: Empathic avatar	Second setting: Avatar without empathy	Third setting: Empathic text
	<i>M, SD</i>	<i>M, SD</i>	<i>M, SD</i>
Q1: Did you sense empathy from the agent?	<i>M</i> = 3.73, <i>SD</i> = 0.80	<i>M</i> = 2.86, <i>SD</i> = 0.74	<i>M</i> = 3.53, <i>SD</i> = 0.64
Q2: Do you like the learning activities more when learning interactively with the agent?	<i>M</i> = 3.60, <i>SD</i> = 0.83	<i>M</i> = 3.27, <i>SD</i> = 0.80	<i>M</i> = 3.60, <i>SD</i> = 0.83
Q3: Are you willing to learn with the agent again?	<i>M</i> = 3.80, <i>SD</i> = 0.86	<i>M</i> = 3.4, <i>SD</i> = 0.83	<i>M</i> = 3.47, <i>SD</i> = 0.74

(1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree)

Besides subjective questionnaires, this research considered quantitative measures to examine the effect of encouragement and persuasion, (1) time spent on e-textbook reading and willingness to reread; (2) the completion rate of exercises and willingness to do more exercises. This study did not count time spent on interaction between the avatar and students as reading time. The e-learning system consisted of 40 exercises, and Table 4 shows the results. The empathic avatar can impel subjects to express their willingness to read more, but this does not affect their reading behavior actually. Subjects in the third setting (empathic text) spent 747.2 seconds on average in reading activity. However, in the first setting and second setting, the average number of seconds subjects spent in reading was 689.4 and 611.93, respectively. Subjects in the empathic text setting spent significantly more time reading than did students in the non-empathic avatar group, based on a two-tailed t test, $t(28) = 3.201, p=0.003$. However, subjects in the empathic avatar setting did not spend significantly more time reading than did subjects in the non-empathic setting. This study expected that subjects would spend much time reading, following the empathic avatar's

persuasion. Subjects showed highest agreement to read again in the first (empathic avatar) setting. However, subjects in this setting did not spend as much time as those in the third (empathic text) setting. Subjects might have only given positive opinions in the questionnaire to satisfy the avatar's or system developer's expectations. The longest reading time occurring in the empathic text setting seemingly resulted from giving subjects a quiet learning environment, which helped them concentrate on what they really wanted to read. The results are similar to many studies; virtual humans might distract students and disturb their learning. The empathic avatar seemed to affect student-learning behaviors by increasing the number of exercises they did. The students in the empathic setting did not differ significantly in the number of completed exercises from students in the non-empathic setting. The results are similar to Okonkwo & Vassileva's (2001) experimental results that students felt a need to do well to avoid disappointing or hurting the social agent's feelings. In this study, many of them attempted to satisfy the agent's expectations. The results support the observation that ordinary computer-literate individuals can be induced to use social rules toward computer agents and behave as if computers were human (Nass, Steuer, & Tauber, 1994).

Table 4. Encouragement and persuasion results

		Empathic avatar	Avatar without empathy	Empathic text
Activity 1: Reading e-textbook				
Amount of the reading time (seconds)	<i>M</i>	689.40	611.93	747.20
	<i>SD</i>	110.13	116.57	114.89
Willingness to read again (Percentage of participants)		53.33%	33.33%	40%
Activity 2: Doing exercises				
Number of answered questions	<i>M</i>	32.20	26.53	28.33
	<i>SD</i>	8.10	8.25	7.92
Willing to do more exercises (Percentage of participants)		66.67%	33.33%	60.00%

In addition to the questionnaire and behavioral results, this experiment classified subjects' emotions while the students read the e-textbook and did exercises in the three different settings. Figure 4 shows their emotions in different learning activities. The upper part of Figure 4 shows that most subjects felt interested and happy while reading. Subjects working with the empathic avatar obviously expressed their worries. To examine whether subjects in the three settings experienced different learning emotions while reading, a chi-square test was used, and results indicated that subjects' emotions in the three settings were significantly different ($\chi^2_{(1)} = 22.536, p = 0.032$). Subjects in the three settings were all told that their reading performance involved participating in the reading activity and doing exercises. Pressure causes worry, but only subjects in the first setting (empathic avatar) felt worry while reading. The avatar's emotional responses and persuasion seemingly raised the participants' feeling of worry.

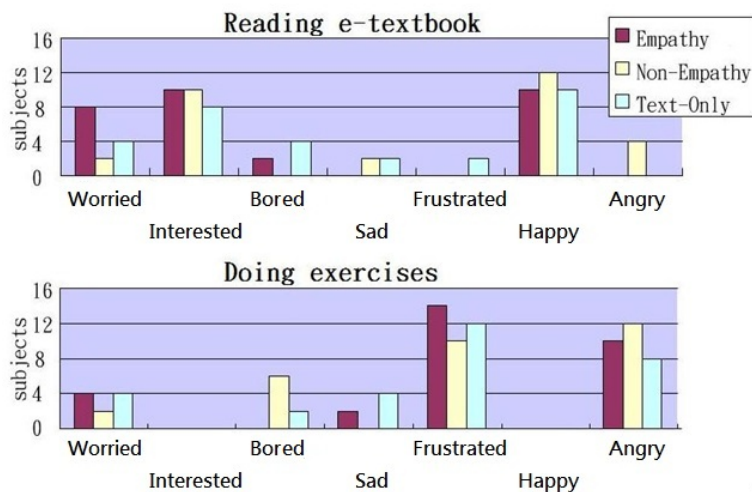


Figure 4. Subjects' emotions while reading and doing exercises

The lower part of Figure 4 shows students' emotions while doing exercises. The students mainly felt frustrated and angry while doing exercises (answering yes/no questions) compared to when they were reading. While doing the exercises, six subjects expressed boredom in the non-empathic setting, while no one expressed boredom in the empathic setting. Compared to students in the non-empathic setting, students in the empathic-avatar setting felt worried, sad and frustrated. Students in neutral setting experienced more anger than did the students in the other two groups. To examine whether subjects in the three settings had different learning emotions while exercising, a chi-square test was used, but there were no significant differences. The result that differs from previous one might be caused by an exercise that greatly affected students' emotions. Some participants expressed that the time constraint for answering each question caused their anger, and their ignorance during the previous reading activity caused their frustration. Far more research is needed on how students' emotions change while learning and interacting with an avatar. Moreover, a chi-square test was used to examine whether participants have different learning emotions in reading and exercising activities. Results were statistically significant ($\chi^2_{(1)} = 111.656, p < 0.001$).

Discussion and design implications

This study designed avatars as companions that empathetically responded to users for the purposes of encouragement and persuasion. The experiment results show that an avatar who delivers empathy might affect users' perceptions, emotions, and behavior. Compared to the non-empathic one, the empathic avatar attracts users and increases their interest, which might cause students to work harder (Harp & Mayer, 1998). Results in question 3 of Experiment 2 show that a system with an empathic avatar has higher potential for future use by students. Nevertheless, avatars might also distract students and the effect revealed in this study shows that students in the empathic-avatar group did not spend more time on reading than students in the empathic-text group. Therefore, a compromised design might be that the avatar will appear only when students need it.

The experimental results show that users felt a need to do well to satisfy the agent's expectation in the subjective questionnaire and in actual learning behavior. Compared to the two learning activities, rereading is unspecific and intangible compared to doing more exercises, causing inconvenience for students. Persuasion seemed effective in tangible learning activities. After persuasion, subjects tended to do five to six exercises on average, compared to subjects in the non-empathic group. The willingness percentage to do more exercises in the questionnaire increased from 33.33 percent to 66.67 percent. Applying the avatar to encourage or persuade students might be more useful with concrete instructions on tangible activities. Participants felt much more frustration and anger during the second activity, when they worked more exercises according to the avatar's persuasion.

This experiment is limited by the nature of the learning materials and few participants. Different subjects with various learning materials might determine students' perception of the system and agent, and their learning behavior. Having participants not divided by their gender, experiences, and proficiency might affect perceptions and behavior. Exercises with different difficulty might also provoke different emotional responses. This is worth considering while designing this type of empathetic avatar in learning system.

Conclusions

This study proposes a methodology to create an avatar that empathically encourages and persuades students while they use e-learning systems. Students can read, do exercises, and empathically interact with an avatar at the same time. An animator created upper-body performance of the avatar to react with learners in empathic ways, trying to encourage and persuade them into persistent learning.

Results show that participants in general recognize the avatar's emotions through facial expressions and sense empathic reactions from the avatar. Animators creating coherent voices and upper-body behavior, including facial expressions, gestures, and head and body movements of the avatar, can promote students to satisfy the avatar's expectation, and persuade them to put forth more effort on quantitative and specific learning activities. The experiment shows that well-designed and interesting avatars can positively change learning attitudes and behaviors. The avatar's emotional responses and persuasion might foster user's feelings of worry, which could be utilized in an e-learning system design to enhance student's learning performance. Moreover, different learning activities, like reading or exercising, might affect students' emotions differently. As a result, learning activities should be

considered on a case-by-case basis while providing empathic avatars as their learning assistants. These experiments and findings could have many important implications for educational software design.

Future research could develop sophisticated avatars that clearly engage with students' cognition and emotion. Automatic detection of emotions and cognition could also enhance functionality. The proposed methodology needs long-term examination and a large number of subjects to examine the design.

Acknowledgments

We would like to thank the researchers, teachers and students who participate in the system design, implementation and experiment. We are also grateful for the support of the National Science Council, Taiwan, under NSC 99-2631-S-008-004 and 99-2631-S-008-006-CC3. We would also like to thank the support from Research Center for Science and Technology for Learning, National Central University, Taiwan.

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