Emotional Math Tutors: Applying Emotional Virtual Agent in Education

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Abstract
This undergraduate research project focuses on employing emotional virtual agents in a teaching and learning environment to promote students' interest in learning and assist teachers in teaching and tutoring. In the recent years, the idea of using computers in the teaching learning environment has been accepted. The challenge has been in developing software that are appropriate as well as emotionally engaging for the teaching and learning environment. The idea of introducing emotions in educational software creates a sense of human to human interaction when interacting with a computer. Emotions give life to software agents, making them believable in a virtual learning environment. In this research, we use the psychoanalytic theory (“Freudian” theory) of transference of emotions in developing emotional virtual agents that can act as math tutors using Scratch programming language. The major components of the tutorial program include animations, sound and icons that will help the young children understand the tutorials. The designed tutorial program is highly interactive, user friendly, and also encourages the students as well as the teachers to participate in an amusing virtual learning environment. It also serves as a preliminary research to introduce intelligent emotional virtual agents to K-12 education and to design them for educational purposes.

1. INTRODUCTION
Until recently, computers were hardly used in teaching subjects other than computer related subjects. As more developments in technology occur, the idea of using technology in the learning teaching environment has been accepted. Educational software has been developed for teaching purpose but it seems to have become mere educational tool that teachers use. Knowledge in developments in affective computing and mainly human-computer intelligent interaction (HCI) seem to have a solution for transforming education software from mere education tool to software agents that can replace the teacher in the classical human-human interaction and still maintain the basic human-human issues. [1] [2].

In a classroom scenario where you have a computer math tutor and a student tackling some math questions, the student is bound to get frustrated after giving a few incorrect answers and is likely to quit if not encouraged to continue. In order to encourage the student, the computer math tutor needs to express positive emotions. The computer math tutor needs to have the intelligence to recognize a series of events and actions and as a result express the expected emotional reaction that a human math tutor would express. Affective computing: a developing area in human-computer interaction is satisfying most of the computer user needs related to emotions and interaction [3].

With current research on the area of affective computing, computer applications that can detect the emotional state of user are developing [4]. Bos states that computers are now successful in classifying facial expressions with 80%-90% accuracy. Great strides have been made in affective computing to enable computers to recognize user’s emotions but users require complete human-computer interaction where the computer is able to react to human emotions. In the teaching learning environment in order for students to be entirely engaged in a tutorial session where the tutor is a computer and also for such a tutorial session to be successful, emotional software agents need to express emotions that are similar to that of a human teacher. For this reason we further our research in this field.

2. RESEARCH BACKGROUND
Emotional agents have been used in Artificial Intelligence specifically in affective computing, which deals with the design of systems and devices that can recognize, interpret, and process human emotions [5]. Currently emotional agents are used in form of video games, animated movies and robotics. Emotional agents are narrowing the gap between humans and the machine [6] this can be seen in development of technologies used in neuropsychological assessment [7] and behavioral treatment of a variety of phobias [8]. Emotional agents stimulate emotional behavior and instigate tendencies to act. In the research area, Machine Affect Expression, of affective Human-Computer Interaction (HCI) [6] emotional agents behave in a way that appears to reflect a particular emotion or may induce emotional reactions in the human user.

Understanding how emotions are expressed in humans enables researchers to develop emotional agents that can exhibit similar expressions. Moldt and Scheve [9], state that emotions help to convey intentionality which influence
user’s decisions and serve to establish social relationships. Although most research focus on user’s emotion recognition in the interaction between the user (human) and the computer more research should be carried out to establish the response of the computer to the user’s emotional state. Although the reaction may vary according to the expected outcome of the interaction but, it is important that the emotional agents express emotions that are recognizable to the user irrespective of the user knowledge of the agent. Thus knowledge on human emotion expression is required in developing emotional agents.

After understanding how emotions are expressed by human beings then how can these emotions be expressed by emotional agents? Since in our research we focus on developing emotional software agents that exhibit expressions similar to that of a person in the user’s life we focus on the Sigmund Freud psychoanalytic theory of transference of emotions. When emotional agents express emotions that are similar to a person in the user’s life it is expected that the user will respond in a way similar to how they would respond to the person.

2.1. Expressing Emotions

In his diverse study on expression of emotions, Charles Darwin [11] concluded that emotions are universal. In furthering Darwin’s research Ekman [10] carried out a cross cultural research on facial expression of emotion. In his research on the Fore tribesmen of Papua New Guinea, he observed that members of this tribe could identify the expressions of emotion in photographs of people from cultures with which they had not interacted. From this research he concluded that the expressions of some emotions were basic and universal to all humans. Research on emotions has led to the categorization of emotions to basic and secondary emotions. Different researchers and scholars have different basis of classifications of emotions, they differ in their conclusions on which emotions are basic [12]. Ekman’s first list of basic emotions included anger, disgust, fear, happiness, sadness and surprise [10]. He later on added to this list, but for our research will consider the first list of basic emotion based on his cross cultural research that led to the conclusion that they are universal. This means that regardless of the person’s culture most people will identify these emotions.

Emotions are expressed by humans through the voice, face, body movements and gestures. They can also be expressed through music and art. Facial expression has been the main study in the field of emotions. The research on facial expression began with Darwin’s study on the expression of emotions in man and animals [14]. In the study of Facial expression two major developments led to further studies in this research area. The first was the study on cross-cultural interpretation of emotions conducted by Ekman. This led to the conclusion that all cultures interpretation of facial expression is the same [15]. The second development was the objective measure of facial expression. Researchers in this area measured facial activity directly rather than drawing their conclusion on the judgment of an observer [15]. These two developments have led to extended research in the study on emotions.

As opposed to facial expression, there is no evidence for universal emotional expressions in human voice. Various researches have been done on emotional voice recognition and recently some research show good results in the possibility of using emotional voice recognition in emotion research studies [2]. For example research carried out by Kwon and colleagues [16] which used pitch, log energy, formant, Mel-band energies, and Mel frequency cepstral coefficients (MFCCs). This research yielded results that led to the conclusion that pitch and energy play an important part in emotion recognition. Other studies on emotion recognition have been done and some of them include more than one modal- multimodal emotion recognition [2]. Examples include De Silva and colleagues [17] who propose a rule based method for joining vocal and visual information and the Humaine project by Kollias and Amir [18] which combines features from visual and vocal data, gesture recognition and bio signals to develop a system for emotion analysis.

A lot of research has been done on human emotion recognition but in order for human computer interaction to be effective more research need focus on computer emotional stimulation and expression. This is important in enabling emotional agents to interact with human user using social protocol understood by humans [2]. In this research we look at achieving this. We focus on the expression of emotions by software agents in order to communicate effectively with the user.
2.2. Psychoanalytic Theory of Transference of Emotion

Sigmund Freud developed the idea of psychoanalytic therapy and his first form of psychoanalytic therapy focused on emotionally traumatic events of patient’s earlier life [19]. In his therapy he helped his patients to recall the traumatic moments in their lives enabling them to become conscious, thus freeing the patient from the trauma’s harmful effects. In this form of therapy Freud discovered a distinctive feature, the transference of the client to the therapist. In the case of Ida Bauer, “Dora” Freud realized that after sometime in the therapy session Dora started treating Freud with distrust as she did with her father. This led to Dora abandoning therapy after three months just as she had emotionally detached herself from her father [19].

Oatley and colleagues [19] describe transference as “the manifestation of emotion schemas, mental models that embody ways of relating to others that have become habitual” (p. 390). Experiments on transference have been carried out by other researchers such as Berk and Anderson [20]. In their experiment, 120 participants (called perceivers) were asked to write descriptions of significant other and two weeks later they returned to the lab where they were given information about another person (the target) who was described to have traits similar to their significant other. They were asked to talk for eight minutes with the target in order to provide a balanced assessment. When the targets trait marched the positive traits of the perceiver’s significant other, the target seem to exhibit positive emotion in the conversation over the intercom. This experiment concluded that when positive transference was received from the perceiver, it made the target happier that when negative transference was received [19].

In our research, we look at how transference of emotions can be used in teaching learning environment. We look at how a student would respond to an emotional software agent that exhibits traits that resemble the teacher.

3. DEVELOPMENT OF EMOTIONAL VIRTUAL AGENTS FOR EFFECTIVE LEARNING ENVIRONMENT.

Emotions play a big part in our decision making and when it comes to education it is emotions that influence us to like or dislike a subject. Students have different reasons for their preference to one subject and not the other. A teacher can play a big role in this preference. Some students like a particular subject simply because they relate well with the subjects instructor. They feel that the instructor understands them and also motivates them to do well in the subject. The ability of a student to understand a particular concept of a subject is dependent on how the concept is explained by the instructor.

Other researches show that motivation and believability play a big role in education [21][22][23]. Motivation and believability is dependent on emotion. Research also shows that emotions have an impact on memory and information processing style [21]. Virtual agents that stimulate emotions are better than virtual agents without emotions. Emotional virtual tutors are most appropriate in the learning environment.

An instructor or a teacher plays a big role in the learning ability of a student, especially to a kindergarten student. Kindergarten school is where a child starts learning various concepts of different subject and what the teacher says is always right. If you ask a kindergarten student why they say a ball is circular most probably their answer will be because my teacher says so. For this reasons it is important that a virtual emotional agent that is used in the teaching learning environment exhibits traits that a human teacher would. The most important trait is the expression of certain emotions in response to a particular event or activity.

Research on transference of emotions shows that when positive transference is received, positive results are expected [20]. In this research it is assumed that the teacher is a significant person to a student, and the student’s attitude towards learning is dependent on how the student relates with the teacher. For a virtual learning environment to be successful, a student needs to have positive emotions toward the human teacher or tutor. By creating a virtual math tutor that exhibits traits that the human tutor possess, positive transference is received. Positive transference result into positive attitude towards the tutorial. In our tutorial program we mainly employ two traits of the human teacher, the voice and face.

3.1. Developing Simple Emotional Virtual Agents

In our introduction, we gave a scenario of a computer math tutor and a student. Using scratch programming language [24] we create this scenario. We use scratch programming language in our research because it does not require a lot of programming knowledge. It also provides a tutorial on how to use it and it enables the user to import images into the program. This makes it appropriate since teachers and parents can easily use it to create tutorials for their students or children. With scratch programming, the teacher can be able to personalize a tutorial to focus on a specific need of a student.

Using scratch we create a virtual emotional math tutor who is to help a student learn different shapes. In the first program we employ the voice of the human tutor by recording the voice in the program. In this program it is assumed that the student always follows the human tutor’s instruction and if the virtual agent has the human tutor’s voice then the student is expected to follow the virtual tutor’s instructions. As seen from other research [2] emotions are expressed through the voice. By using the
In the first program we use an animated character that has the human tutor’s voice. We used an animated character for the basic reason that children responded positively to such characters. In the program the virtual tutor first explains to the student what to expect in the lesson and what to do. The virtual tutor asks the student to name a shape and if the student names the shape correctly the virtual tutor expresses a positive remark. If the student names the shape wrongly the virtual tutor expresses a negative emotion and then tells the student the correct answer. If the student gives wrong answers to consecutive questions the virtual tutor expresses emotions to encourage the student to continue.

In the second program we use a character that looks like the human tutor. It is expected that if the virtual tutor resembles the human tutor the student unconsciously transfers his emotions to the virtual tutor. As a result the student’s reaction towards the virtual tutor is similar to his reaction towards the human tutor. By combining the two human tutor traits, that is the voice and facial features, we make the virtual tutor more believable. As a result the student feels like he is interacting with the real tutor.
In both programs positive and negative emotions are expressed. The virtual tutor smiles in response to a correct answer (positive emotion) and the tutor also frowns in response to an incorrect answer (negative emotion). The expression of emotions by emotional virtual agents helps the student to relate to the virtual tutor and as other research has shown that this may help in improving the students learning and motivation and also in reducing math anxiety [21].

3.2. Impact of Emotional Virtual Agents on Learning

Campos, Frankel and Camaras [25] define emotion as a rapid appraisal of significance of the situation which prepares you for action. This definition encompasses other theorists’ take on the functional approach of emotion which states that your emotional reaction in turn affects your desire and tendency to repeat an experience. Based on this approach, it is important to know what impact the emotional virtual tutor has on the student. In developing emotional virtual agents we considered the impact of each emotion on the decision making process.

Different emotions have different effects on the decision making process. In developing the virtual learning environment, we look at creating virtual tutors that focus on improving performance. Using the voice to express these emotions was more successful than using facial expression. In a real classroom situation when a student gives a wrong answer, in order to encourage the student to continue participating, the teacher would express a negative emotion followed by a positive one. Similarly in developing an emotional virtual tutor we use this order of expressing emotion. Research has shown that emotions are interwoven with cognitive processing, influencing mastery and serving as the force for continued involvement and learning [26].

Negative emotions can trigger two different types of emotions: the sad expression by the virtual math tutor can motivate the student to react in a way that changes the sad emotion to a happy one. In this case, the student would proceed to the next question and try his best to get a correct answer. Expression of sadness may cause withdrawal by the student.

In developing a virtual math tutor that exhibits both the negative and positive emotions of the human tutors, we look at ensuring that the negative emotions do not cause withdrawal, but instead a motivation to proceed. The emotional virtual math tutor expresses a positive emotion following a negative emotion and this is mainly expressed in the voice. We also consider the role that self-conscious emotions play in cognitive processing. Self-conscious emotions include embarrassment, envy, and pride. If a human tutor expresses emotion that may stimulate embarrassment of the student, this may cause the student to retreat from an action. In contrast, if the tutor expresses emotions that stimulate pride that reflect the students achievements, the student will be motivated to take on further challenges. In exhibiting human tutor’s emotions, the virtual tutor is selective in the emotions that we borrow from the human tutor. We concentrate on emotions that will encourage and stimulate pride but not stimulate embarrassment.

Emotions also have an impact on memory. Previous research [26] has shown that positive emotions leads to gist-based or heuristic processing, whereas negative emotions lead to more detailed processing. In a virtual learning program, the student is more likely to remember the name of the shape that he got wrong, and negative emotion was stimulated by a sad face.

Although these two tutorial programs have not been practically tested on kindergarteners, it is expected that they will yield similar results. The first program may be more entertaining to young kids since the virtual tutor used is a cartoon character, but the second program is more likely to stimulate student’s emotions since the virtual tutor resembles the human tutor and thus more like to cause transference of emotions.

Since this model is dependent on transference of emotions on the virtual math tutor, it may not be entirely successful if the student has negative feelings towards the human tutor; for instance, if the student dislikes the human tutor, creating a virtual tutor that resembles the human tutor may discourage the student from actively and positively participating in the tutorial.

Using scratch programming in creating a virtual learning environment was not entirely successful: The facial emotional expression of emotion was limited comparing to voice emotional expression. Facial expression could not entirely capture the intensity of emotions. So far, the facial
expression was mainly successful in exhibiting happy and sad emotions.

4. CONCLUSION

The goal of this research was developing a way of employing emotional virtual agents in education. We have looked at expression of emotions in human beings and explored the possibility of expression of emotions by virtual agents in a similar manner. We propose to rely on the theory of transference of emotions in developing emotional virtual agents that can be used in the teaching learning environment. By developing virtual agents that possess human traits, then there is a possibility of transference of user to emotional virtual agents. The transference of student to emotional virtual agents is dependent on the believability of the emotional agents. Thus we propose that the emotional virtual agents retain certain human tutor’s aspects such as the voice. In this research, we use scratch programming language to develop simple emotional virtual agent that acts as a math tutor. Further research is needed to improve the believability of virtual agent’s emotions.

References
http://info.scratch.mit.edu/