Modeling an Affectionate Virtual Teacher for e-Learning underpinning 3-Dimensional Emotion Model

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Abstract

"E-learning could become the major form of training and development in organizations as technologies will improve to create a fully interactive and humanized learning environment" [18]. With a notion to acknowledge the above statement, this paper explains an affective role model of a virtual teacher intertwined with emotional states of e-learners to facilitate interactive and successful learning. The paper first presents the relationships between emotion and learning from different literatures and surveys. Then model of an affectionate virtual teacher is explained with the help of a three-dimensional emotion model. Laboratory experiments to interrelate learners' emotional state to the behavioral dynamics of virtual teacher's are then discussed. The paper concludes with the notion of future research.

Keywords: Affective Model for e-Learning, Emotion and e-Learning, Virtual Teacher, Affective Computing, E-learning, Affection in Pedagogy

I. INTRODUCTION

Web-based courses, often called e-Learning, are characterized by a predominance of asynchronous activities that replace those typically found in a face-to-face (F-to-F) classroom: presentation of information and interaction between the students, instructor and content [12]. The pedagogy of on-line learning is still in it innovations, but it is already a useful tool and, if used well, can increase the range and excitement of learning. The differences between F-to-F and purely web-based courses are rapidly disappearing. In the future, the term e-Learning may be obsolete because technology will appear invisible to both the learner and instructor because the technology-rich environment will fill the gap the necessity of the real class-room environment. Hence research on manifold issues is needed. One of the scopes could be that e-Learning technologies will allow for a humanized learning environment [20] and so this paper tends to characterize such humanized agent called Virtual Teacher.

II. LEARNING AND EMOTION: ARE THEY INTERTWINED?

There has been little exploration of the extent whether emotion is associated with learning online. Martin and Briggs [10] almost twenty years ago now, proposed the integration of the two domains, affective and cognitive, into a more holistic and realistic framework for instructional design. The proposal was not popularized for the continuing separation of emotion and cognition with the difficulty in defining perspectives and a multitude of definitions of emotions [10, 13, 30]. These various constructions of emotion each provide particular insights into what is a complex phenomenon. In this context let's figure out the definitions of emotion, affect, and cognition.

Emotion can be regarded as some combination (with various emphases and sequences) of physiological, psychological and psychomotor components. Early promoter of this general approach defined emotion in terms of the feeling of the 'bodily expressions' which follow the perception of an 'exciting fact'. Other variations identify 'affective' and 'somatic' dimensions of emotion, 'experiential, behavioral and physiological' aspects, or 'corporeal' and 'cognitive' dimensions. However, a clear, agreed upon definition seems to be not easily arrived. As LeDoux [18 p.23] said "everyone knows what [emotion] is until they are asked to define it." To the question what are emotions, LeDoux responds "there are many answers and many of these are surprisingly unclear and ill-defined". The picture of emotions that emerges is diverse and multifaceted. This complexity makes the task of exploring the relationship between emotions and learning a difficult one, even though several attempts are obvious in [4]. O'Regan [4] conducted a survey with the online course- taking students. All the participants spoke of a range of emotions both positive and negative which had been associated with, and had impacted on, their learning.

Affect is influenced by or resulting from the emotions [9]. Affective includes aspects such as passion, frustration, satisfaction, distress, joy, fulfillment, gratitude, comfort, arrogance, or disinterest. Cognition can be defined as the mental process of knowing or acquiring to know [9]. Cognition describes how people become aware of, gain, manage, and build new knowledge about the world. This term includes aspects such as awareness, creativity, perception, reasoning, comprehension, analysis, synthesis, evaluation, application, judgment, concept learning, memory, problem solving, task sequencing, goal setting, and progress monitoring.

According to Margaret [9], a more pragmatic, comprehensive view of learning considers the differing influence and complex relationships between conative, affective, cognitive, social, and other relevant learning-

related factors recognize dominant psychological factors, other than just cognitive aspects, that influence learning. McLeod's [11] review of research into emotion and learning in mathematics, which identifies separate cognitive and affective domains. Shelton [15], too, writing of the importance of emotion in learning addresses the need to develop certain 'emotional competencies' before learning can proceed satisfactorily. Similarly, other researchers describe of the importance of 'emotional competence' in relation to learning. In his terms, learning can be inhibited by emotional incompetence. He draws on Heron's model of multi-modal learning in which action, conceptual and imaginable learning all depend on the capacity to learn at an emotional level. So, with this approach, emotion is relevant to learning in that it provides a base or substrate out of which healthy cognitive functioning can occur. This has led to a growing awareness and researchers have started to admit that emotion and learning have inextricable juxtapositions. We can say, cognition is not as logical as it was once thought and emotions are not as illogical. Stock [16] acknowledges that 'all sensory input is processed through our emotional center first…before it is sent to be processed in our rational mind'. The centrality of emotion in many cognitive processes is now being acknowledged.

Students who are anxious, angry, or depressed don't learn; people who are caught in these states do not take in information efficiently or deal with it well." [11, pp. 78]. It is therefore imperative that the interaction with the ''machine'' be as ''un-traumatic'' as possible. In e-learning, ignoring the emotional factors that come into play may lead to total failure [20]. The impact of emotions and intentions on learning, in the real world, are an integral part of learning and cannot be separated from learning and thinking ability, that is, we cannot consider one without considering the other [9].

III. MODELING AFFECTIONATE VIRTUAL TEACHER

The affective role involves the personal motivation and satisfaction of the learner. Affective behavior has a direct positive impact on cognitive learning [3]. Lepper and Chabay [8] note that "motivational components of tutoring strategies are as important as cognitive components, and more generally, that truly personalized instruction must be individualized along motivational as well as cognitive dimensions" (p. 243). Duchastel [3] similarly stresses the need for the affective role in his discussion of study guides for correspondence courses. A number of roles played by instructors are identified by Coppola, et al, [1]. According to them three particularly crucial ones are the cognitive, affective, and managerial roles. The cognitive role determines the actual interplay of learning/teaching. How we present content, provide interaction, and reinforce learning is the subject of this role. The affective role involves motivation and satisfaction.

The agent metaphor provides a way to function and simulate the "human" aspect of instruction in a more cost-effectively, valid way than other controlled computer-based methods. Picard, et al, [6] thus assume that computers will, much sooner than later, be more capable of recognizing human behaviors that lead to strong inferences about affective state of learner nonetheless identifying a learner's emotional/cognitive state is a critical indicator of how to assist the learner in achieving an understanding of the efficiency and pleasure of the learning process. In [10] the model describes the range of various emotional states during learning but didn't discuss how to deal with those states. In this paper we discuss our model of affective behavior during e-learning, which we define as 3-D Emotional Model (3-DEM) of e-learners. For the justification of the model see [6][13][17].

A. 3-Dimensional Emotion Model of Learners

The following 3-DEM (Figure 1) represents a complex scenario of emotional states of a student. We define eight emotional states at the very corners of the cube, at a particular time a student remains at a particular point in the 3-dimensional space of the cube which indicates a certain value of contentment (e.g. H′). Student's motivation depends on his/her physiological, mental, environmental factors and hence assessment, pace and fruitfulness of lesson varies differently over time. Thus we can imagine almost uncountable numbers of cubes (e.g. cube A B′ C′ D′ F′ E′ G′ H′), each might represent the mental state of a learner at a particular time, t, during learning.

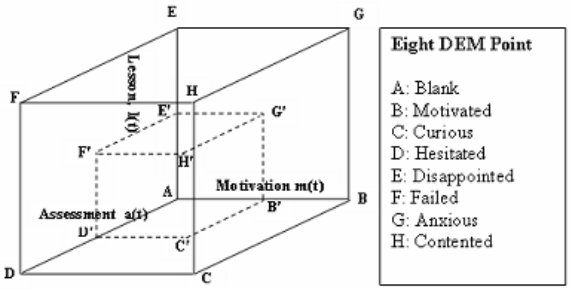

Figure 1: 3-Dimensional Emotion Model (3-DEM)

In a specific time, a student is motivated or hesitated or disappointed to some extent but at the same time he might be anxious or curious or failed while all these give him a certain degree of contentment. The following table is necessary to get a clear idea of the Eight DEM points. It indicates the eight emotional states along with corresponding emotional traits.

Table I Affective states and traits of an e-Leaner

Emotional Sate	Emotional Traits
Blank	Desire, Uncertainty, Hope, Imagination, Dull
Motivated	Interest, Comfort, Motivation, Approaching, Encouragement
Curious	Thrill, Trusting, Anticipatory, Expecting, Curiosity.
Hesitated	Discomfort, Confusion, Dissatisfaction, Hesitation
Disappointed	Shame, Embarrassment, Pessimism, Worry, Disappointment, Anger
Failed	Boredom, Tired, Exhausted, Inattentive, Inactive, Drowsy, Sad, Disgust
Anxious	Fear, Anxiety, Enthusiasm, Excitement
Contented	Pride, Confidence, Calm, Satisfaction, Lively, Happy, Contentment

B. Role-Action Modeling of Virtual Teacher

To correspond affectively with different affective states of e-learners we also figure out different roles, action and emotional characteristics of our virtual teacher.

Table II Affective Role Model of Virtual Teacher

DEM Points	Virtual Teacher's Affective Role Model		
	Role	*Action*	*Characteristics*
Blank	Promoter	Promotion	Friendly, Elaborative, Hopeful, Welcoming
Motivated	Parental	Stimulation	Encouraging, Wishful, Approaching
Curious	Pedagogue	Lesson /Teach	Informative, Pedagogy, Loving, Polite, Calm, Rationale
Hesitated	Advisor / Counselor	Motivation	Cheering, Confident, Enthusiastic, Caring
Disappointed	Buddy	Inspiration	Amicable, Cordial, Inspiring, Optimistic, Approving, Agreeable
Failed	Entertainer	Amusement	Energetic, Flexible, Jocund, Funny, Animated
Anxious	Coordinator	Explanation	Eloquent, Skillful, Agile, Helpful, Expressive
Contented	Admirer	Praise	Excited, Proud, Happy, Suggestive, Satisfied

Table II summarizes the affective role model of virtual teacher.

C. Transition of Emotional State of Learners

Koda & Maes [5] suggest that more expressive agents have greater motivational impact. However, Dietz & Lang [2] found that while users preferred agents showing more emotion and performed better on a memorization task with the emotion-showing agents, the results were not statistically significant. One of the first suggestions of endowing computer tutors with a degree of empathy was made by Lepper and Chabay [8]. They argued that motivational components are as important as cognitive components in tutoring strategies and those important benefits would arise from considering techniques to create computer tutors that have an ability to empathize. So we formulate Emotional-State Transition (EST) of virtual teacher for the expected behavior of virtual teacher towards the student with appropriate affects.

Following, in figure II, we mention role and action of virtual teacher which we call the expected behavior of virtual teacher corresponding to learns' emotional state. The main goal of the agent's interaction is to provide affects to lead the learners' emotional state to contented state. At the end of each state in EST Rule 4, any of the rules from 1 to 3 applies to lead a student "Contented" state. For example, a learner's emotional state is blank at the outset, at that time the virtual teacher behaves as a promoter to promote the course by friendly and welcoming attitude. Then the learner might feel Motivated or Hesitated or Disappointed and depending upon the emotional state of the learner; virtual teacher will interact with corresponding affect. For example, if the student is Motivated the agent will have parental role to stimulate the learner for lesson or to earn an assessment and as so on. For details see [17]. Hence the sensing of the learner's emotional state (identified by physiological phenomena) has been described in section 4. In fact there is lots of research about sensing human affects by capturing and processing various signals of human body (e.g. ECG, BP, RP, Skin Conductance etc.) For some evidences refer to [13].

C. Behavioral Rules of Virtual Teacher

Before designing the behavioral dynamics of virtual teacher we would like to describe the emotionality or affective characteristics of the virtual teacher by several functions. Our virtual teacher has currently 15 affective functions to render its personality with respect to different roles (e.g. counselor etc.). The functions are: *Friendliness, Expressiveness, Encouragement, Parental, Optimism, Pedagogy, Loving, Politeness, Rationale, Confidence, Animated, Funny, Agility, Happiness* and *Recommending*. For detail of these functions see [17]. To get an idea about these emotion functions, *Friendliness* function has been discussed below.

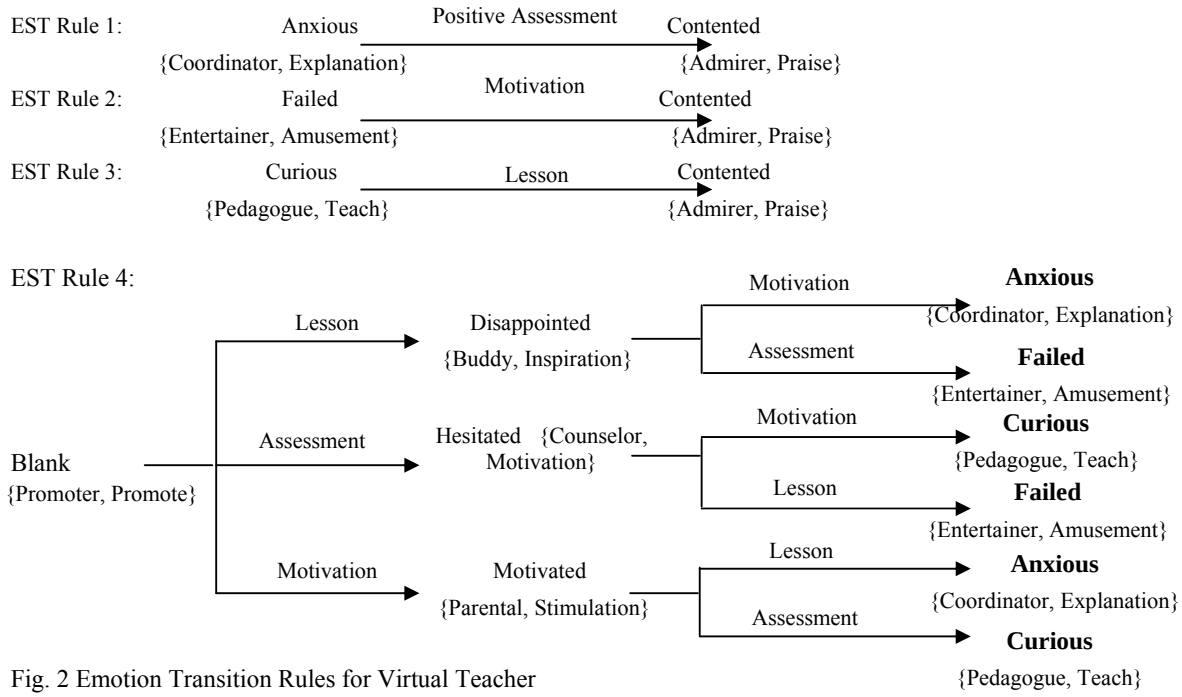

Fig. 2 Emotion Transition Rules for Virtual Teacher

Friendliness: This affective value indicates how much friendly our teacher will be. The parameters considered to define friendliness are: Companionability, Amity, Benevolence, Cordiality, Kindness and Agreeableness. So what does *Friendliness (Agent, Student)* mean? To us this indicates a functional value that gives a measure indicating the friendliness factor of the virtual teacher. Hence to design the function the aforementioned parameters are used and values get assigned according to Student's profile (e.g. demography, culture etc.). We assume intensities friendliness, $f \in \{1,\ldots., 5\}$, which indicates the fuzzy values like *not friendly (Strict)*, *friendly but less cordial*, *friendly and cordial*, *friendly but less agreeable*, *friendly and agreeable(flexible)* respectively. Following we enlist the Behavioral Dynamics (BD) of our virtual teacher using our affective functions.

<Role, Action>: {Promoter, Promotion}

BD1(A,S)=Friendliness(A,S)∧Elaboration(T,S)…...(1)

<Role, Action>: {Parental, Stimulation}

BD2(A,S)=Encouragement(A) ∧ Parental(T,S) ∧ Optimism (A, S)…… …..……..……. (2)

<Role, Action>: {Pedagogue, Teach}

BD3 (A,S)=Elaboration(T, S) ∧ Pedagogy (A, S) ∧ Loving(A,S)∧Politeness(A,S)∧Rationale(A,S) ……. (3)

<Role, Action>: {Advisor/Counselor, Motivation}

BD4 (A, S) = Encouragement (A)∧Confidence (A, T) ∧ Loving(A,S)∧Politeness(A,S)∧Rationale(A,S)……. (4)

<Role, Action>: {Buddy, Inspiration}

BD5 (A, S) = Friendliness (A, S) ∧ Encouragement (A) ∧ Optimism (A,S) ∧ Loving(A,S)…….…..... (5)

<Role, Action>: {Entertainer, Amusement}

BD6 (A, S) = Friendliness (A, S) ∧ Animated (A, S) ∧ Funny (A, S)…….... (6)

<Role, Action>: {Coordinator, Explanation}

BD7 (A, S) = Elaboration (T, S) ∧ Friendliness (A, S) ∧ Agility (A) ∧ Pedagogy (A, S) …….. (7)

<Role, Action>: {Admirer, Praise}

BD8 (A, S) = Animated (A, S) ∧ Happiness (A) ∧ Recommending (A) ∧ Optimism (A, S) ……..... (8)

For example, the output of relation 1 may characterize that with respect to Student, (S) the Virtual Teacher, (A) needs to be *friendly but less agreeable* and *Highly Elaborative* for the Topic T and at the same time the role and action of the teacher for relation 1 oblige to behave hopeful and welcoming (by uttering some pre-stored natural text, for example).

IV. EXPERIMENT TO ASSOCIATE PHYSICAL SIGNALS TO EMOTIONAL STATES OF A LEARNER

Affective arousal can be determined from Skin Conductance (SC) data and valence (positive vs. negative reactions) can be inferred from measures of Heart Rate (Picard [13]).We examined the relationship between levels of the bio-signals and the subjective reactions of participants. Participants were asked when they felt most involved in the learning process, and we compared their answers with the data from the Bio-sensor interface. Fig. 3 shows the setup of our experiment system.

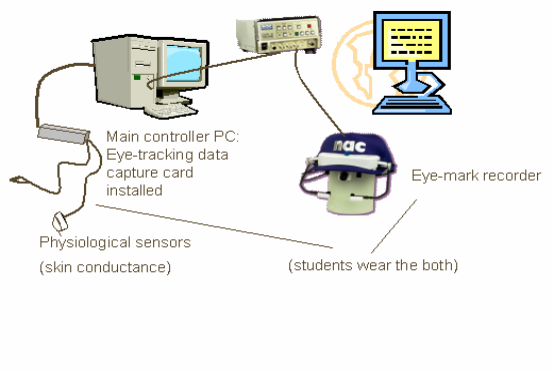

Fig. 3 Bio-sensor Interface

In order to investigate participants' overall affective state during the learning process we developed a sample lesson on Biology and asked few participants to take the lesson. We connected the physiological sensors to the participants during their learning time and collected data for further analysis. Since the signal values of participants may vary significantly depending on individual differences, room temperature, and other factors, physiological values were first normalized. Fig. 4 shows a photo of one of our participants connected with sensors. In Figure 5, the SC and HR data are shown in different colors. We also used eye tracker to track the eye-movements and pupil-responses of the participants at the time of experiment. Table III indicates the names of the physiological variables we tried to capture by our sensors and their corresponding possible values are also listed.

Fig. 4 Experimental Scenario

Now, in order to map the learner's affective state to any of the eight states mentioned above we used the combination of values of those physiological variables. The justification of associating the bio-signal values to emotion state is made by considering the feedback given by the students and also by consulting medical science literature. For some details see [13].

Fig. 5 Graph of SC and HR

Table III Physiological Variables and Values

Variable Name	**Values**
Heart Rate	Increase, Normal, Decrease
Skin Conductance	High, Normal, Low
Eye Movement	Fluctuating, Fixed-Region, Out-of-Range
Pupil Response	Contracted, Diluted
Mouse/Keyboard Activity	High, Normal, Low
Blood Pressure	High, Normal, Low

V. CONCLUSION

For enhancing quality and improving accessibility to education and training the use of e-learning is one of the keystones for building the knowledge society. Because e-learning has an instructor, students, and a computer, LaRose and Whiten [7] proposed that instructional immediacy in this context is comprised of three corresponding variables: *computer immediacy, student immediacy,* and *teacher immediacy*. Computer immediacy refers to the closeness that develops between learner and computer in the course of e-learning; the need for computer immediacy is also supported by Reeves and Nass [14], who advocate giving media personality by incorporating the same conventions of etiquette, that characterize human conversation. Student immediacy describes the behaviors that create a feeling of closeness between learners in an educational setting. Finally, teacher immediacy refers to "teaching behaviors that enhance closeness to and nonverbal interaction with another" [7]. The efforts described here focus on all the three immediacies. In the future work we would like to build an conversational character agent underpinned the aforementioned behavioral dynamics and program the agent by Multimodal Presentation Markup Language (MPML) [19] that supports affective tagging of agent. The proposed agent will express affect according to behavioral dynamics and render its action corresponding to roles by uttering different patterns of pre-stored texts and animation to communicate positive affect to the learners.

Table IV Mapping Sensor-Signals to 8 emotional states

Emotion State	Heart Rate	GSR Response	Eye-Movement	Pupil Response	Mouse/Keyboard Activity	Blood Pressure
Blank	Normal	Low	Fluctuating	Contracted	Low	Normal
Motivated	Increased/ Normal	High	Fixed-Region	Diluted	High/Normal	High/ Normal
Curious	Increased	High	Fluctuating	Contracted	High	High
Hesitated	Increased	High	N/D	Diluted	N/D	High
Disappointed	Decrease	N/D	N/D	Contracted	N/D	Low
Failed	Normal/ Decrease	High	Out-of-Range	N/D	N/D	Normal/ Decrease
Anxious	Increase	High	Fluctuating	Contracted	High	High
Contented	Normal	High	Fixed-Region	Diluted	Normal	Normal

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