An Affective Model of the Interplay Between Emotions and Learning

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Abstract

This article proffers a novel model by which to conceptualize the impact of emotions upon learning. We believe there is an interplay of emotions and learning, but this interaction is far more complex than previous theories have articulated. Our model goes beyond previous research studies not just in the emotions addressed, but also in an attempt to formalize an analytical model that describes the dynamics of emotional states during model-based learning experiences.

1. Introduction

> Why is there no word in English for the art of learning? Webster says that *pedagogy* means the art of teaching. What is missing is the parallel word for learning. In schools of education, courses on the art of teaching are simply listed as "methods." Everyone understands that the methods of importance in education are those of teaching—these courses supply what is thought to be needed to become a skilled teacher. But what about methods of learning?
>
> - Seymour Papert, *The Children's Machine*

Educators have traditionally emphasized conveying information and facts; rarely have they modeled the learning process. When teachers present material to the class, it is usually in a polished form that omits the natural steps of making mistakes (e.g., feeling confused), recovering from them (e.g., overcoming frustration), deconstructing what went wrong (e.g., not becoming dispirited), and starting over again (with hope and perhaps enthusiasm). Those of us who work in science, math, engineering, and technology (SMET) as professions know that learning naturally involves failure and a host of associated affective responses. Yet, educators of SMET learners have rarely illuminated these natural concomitants of the learning experience. The unfortunate result is that when students see that they are not getting the facts right (on quizzes, exams, etc.), then they tend to believe that they are either 'not good at this,' 'can't do it,' or that they are simply 'stupid' when it comes to these subjects. What we fail to teach them is that all these feelings associated with various levels of failure are normal parts of learning, and that they can be actually be helpful signals for *how* to learn better.

Expert teachers are very adept at recognizing and addressing the emotional state of learners and, based upon that observation, taking some action that positively impacts learning. But what do these expert teachers 'see' and how do they decide upon a course of action? How do student who have strayed from learning return to productive path, such as the one that Csikszentmihalyi [1990] refers to as his "zone of flow"?

Preliminary research by Lepper and Chabay [1988] indicates that "expert human tutors… devote at least as much time and attention to the achievement of affective and emotional goals in tutoring, as they do to the achievement of the sorts of cognitive and informational goal that dominate and characterize traditional computer-based tutors."

Skilled humans can assess emotional signals with varying degrees of accuracy, and researchers are beginning to make progress giving computers similar abilities at recognizing affective expressions. Although computers perform as well as people only in highly restricted domains, we believe that accurately 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. We also assume that computers will, much sooner than later, be more capable of recognizing human behaviors that lead to strong inferences about affective state.

Axis **-1. 0** **-0. 5** **0** **+0. 5** **+1. 0**

Anxiety-Confidence	Anxiety	Worry	Discomfort	Comfort	Hopeful	Confident
Boredom-Fascination	Ennui	Boredom	Indifference	Interest	Curiosity	Intrigue
Frustration-Euphoria	Frustration	Puzzlement	Confusion	Insight	Enlightenment	Ephipany
Dispirited-Encouraged	Dispirited	Disappointed	Dissatisfied	Satisfied	Thrilled	Enthusiastic
Terror-Enchantment	Terror	Dread	Apprehension	Calm	Anticipatory	Excited

-1. 0 **-0. 5** **0** **+0. 5** **+1. 0**

Figure 1 – Emotion sets possibly relevant to learning (in contrast to traditional emotion theories)

2. Affective Computing: Emotions and Learning

> The extent to which emotional upsets can interfere with mental life is no news to teachers. 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.
>
> **-** Daniel Goleman, *Emotional Intelligence*

In order to accomplish our goal, which is to embody a computer with the ability to identify a learner's affective state and respond accordingly, we must redefine, and in some cases, reengineer various aspects of educational pedagogy. To this end it is necessary for us to rethink our perspective of what is happening in education and based upon our hypothesis reengineer accordingly. Some of these beliefs will be theorized, perhaps beyond a practical level but not beyond a level needed for understanding them. We need to explore the underpinnings of various educational theories and evolve or revise them. For example, we propose a model that describes the range of various emotional states during learning (see Figure 1). The model is inspired by theory often used to describe complex interactions in engineering systems, and as such is not intended to explain how learning works, but rather is intended to give us a framework for thinking about and posing questions about the role of emotions in learning. Like with any metaphor, the model has limits to its application. In this case, the model is not intended to fully describe all aspects of the complex interaction between emotions and learning, but rather only to serve as a beginning for describing some of the key phenomena that we think are all too often overlooked in learning pedagogy. Our model goes beyond previous research studies not just in the emotions addressed, but also in an attempt to formalize an analytical model that describes the dynamics of emotional states during model-based learning experiences, and to do so in a language that the SMET learner can come to understand and utilize.

3. Guiding Theoretical Frameworks: Developing an Advanced Technology

> The older [learning theories] deal with the activity that is sometimes caricatured by the image of a white-coated scientist watching a rat run through a maze…newer [thinking is] more likely to be based upon the theories of performance of computer programs than on the behavior of animals… but… they are not about the art of learning… they do not offer advice to the rat (or to the computer) about how to learn.
>
> **-** Seymour Papert, *The Children's Machine*

Before describing the model's dynamics, we should say something about the space of emotions it names. Previous emotion theories have proposed that there are from two to twenty basic or prototype emotions (see for example, Plutchik, 1980; Leidelmeijer, 1991). The four most common emotions appearing on the many theorists' lists are fear, anger, sadness, and joy. Plutchik [1980] distinguished among eight basic emotions: fear, anger, sorrow, joy, disgust, acceptance, anticipation, and surprise. Ekman [1992] has focused on a set of from six to eight basic emotions that have associated facial expressions. However, none of the existing frameworks seem to address emotions commonly seen in SMET learning experiences, some of which we have noted in Figure 1. Whether all of these are important, and whether the axes shown in Figure 1 are the "right" ones remains to be evaluated, and it will no doubt take many investigations before a "basic emotion set for learning" can be established. Such a set may be culturally different and will likely vary with developmental age as well. For example, it has been argued that infants come into this world only expressing interest, distress, and pleasure [Lewis, 1993] and that these three states provide sufficiently rich initial cues to the caregiver that she or he can scaffold the learning experience appropriately in response. We believe that skilled observant human tutors and mentors (teachers) react to assist students based on a few ‘least common denominators’ of affect as opposed to a large number of complex factors; thus, we expect that the space of emotions presented here might be simplified and refined further as we tease out which states are most important for shaping the companion’s responses. Nonetheless, we know that the labels we attach to human emotions are complex and can contain mixtures of the words here, as well as many words not shown here. The challenge, at least initially, is to see how our model and its hypothesis can do initially with a very small space of possibilities, since the smaller the set, the more likely we are to have greater classification success by the computer.

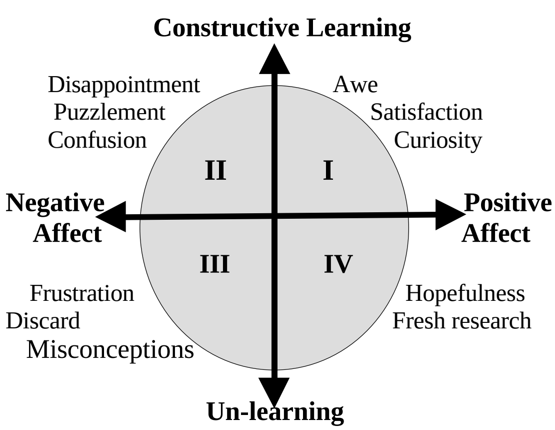

Figure 2a – Proposed model relating phases of learning to emotions in Figure 1

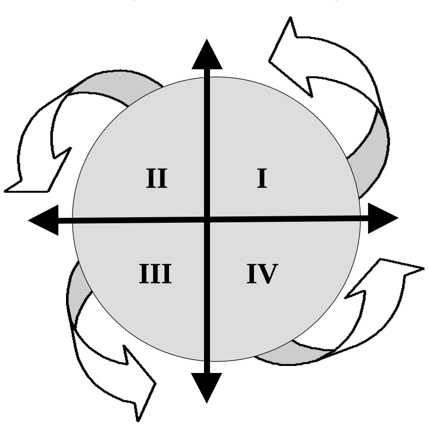

Figure 2b – Circular and helical flow of emotion

Figures 2a and 2b attempt to interweave the emotion axes shown in Figure 1 with the cognitive dynamics of the learning process. The horizontal axis is an Emotion Axis. It could be one of the specific axes from Figure 1, or it could symbolize the n-vector of all relevant emotion axes (thus allowing multi-dimensional combinations of emotions). The positive valence (more pleasurable) emotions are on the right; the negative valence (more unpleasant) emotions are on the left. The vertical axis is what we call the Learning Axis, and symbolizes the construction of knowledge upward, and the discarding of misconceptions downward. (Note: we do not see learning as being simply a process of constructing/deconstructing or adding/subtracting information; this terminology is merely a projection of one aspect of how people can think about learning. Other aspects could be similarly included along the Learning Axis.)

The student ideally begins in quadrant I or II: they might be curious and fascinated about a new topic of interest (quadrant I) or they might be puzzled and motivated to reduce confusion (quadrant II). In either case, they are in the top half of the space, if their focus is on constructing or testing knowledge. Movement happens in this space as learning proceeds. For example, when solving a puzzle in *The Incredible Machine*, a student gets an idea how to implement a solution and then builds its simulation. When she runs the simulation and it fails, she sees that her idea has some part that doesn’t work – that needs to be deconstructed. At this point it is not uncommon for the student to move down into the lower half of the diagram (quadrant III) where emotions may be negative and the cognitive focus changes to eliminating some misconception. As she consolidates her knowledge—what works and what does not—with awareness of a sense of making progress, she may move to quadrant IV. Getting a fresh idea propels the student back into the upper half of the space, most likely quadrant I. Thus, a typical learning experience involves a range of emotions, moving the student around the space as they learn.

If one visualizes a version of Figures 2a and 2b for each axis in Figure 1, then at any given instant, the student might be in multiple quadrants with respect to different axes. They might be in quadrant II with respect to feeling frustrated; and simultaneously in quadrant I with respect to interest level. It is important to recognize that a range of emotions occurs naturally in a real learning process, and it is not simply the case that the positive emotions are the good ones. We do not foresee trying to keep the student in quadrant I, but rather to help them see that the cyclic nature is natural in SMET learning, and that when they land in the negative half, it is only part of the cycle. Our aim is to help them to keep orbiting the loop, teaching them how to propel themselves especially after a setback.

A third axis (not shown), can be visualized as extending out of the plane of the page—the Knowledge Axis. If one visualizes the above dynamics of moving from quadrant I to II to III to IV as an orbit, then when this third dimension is added, one obtains the 'excelsior spiral that climbs the tree of knowledge.' In the phase plane plot, time is parametric as the orbit is traversed in a counterclockwise direction. In quadrant I, anticipation and expectation are high, as the learner builds ideas and concepts and tries them out. Emotional mood decays over time, either from boredom or from disappointment. In quadrant II, the rate of construction of working knowledge diminishes, and negative emotions emerge as progress flags. In quadrant III, the learner discards misconceptions and ideas that didn't pan out, as the negative affect runs its course. In quadrant IV, the learner recovers hopefulness and positive attitude as the knowledge set is now cleared of unworkable and unproductive concepts, and the cycle begins anew. In building a complete and correct mental model associated with a learning opportunity, the learner may experience multiple cycles around the phase plane until completion of the learning exercise. Each orbit represents the time evolution of the learning cycle. Note that the orbit doesn't close on itself, but gradually moves up the knowledge axis.

A computerized *Learning Companion*, which would track a learner through their learning journey, be sensitive to their affective state and respond appropriately, could, we believe, use models such as these to assess whether or not learning is proceeding at a healthy rate. The model could help guide it in exploring strategies for making decisions about when best to intervene with a hint, word of encouragement, or observation (typically in quadrants III and IV.) Thus, we see the computerized *Learning Companion* as helping to scaffold the learning experience by trying to keep the learner moving through this space, e.g., not avoiding quadrant III, but helping them to keep moving through it instead of getting stuck there. The models may also be useful to learners in aiding in their own metacognition about their learning experience, especially helping them identify and work with naturally-occurring negative emotions in a productive and cognitively satisfying way. And, as a vicarious outcome, this model could be utilized by human teachers when dealing with students.

4. References

[1] Chen, L.S., T.S. Huang, T. Miyasato, and R. Nakatsu, "Multimodal human emotion/expression recognition," in Proc. of Int. Conf. on Automatic Face and Gesture Recognition, (Nara, Japan), IEEE Computer Soc., April 1998.

[2] Csikszentmihalyi, M. (1990). Flow: The Psychology of Optimal Experience, Harper-Row: NY.

[3] DeSilva, L.C., T. Miyasato, and R. Nakatsu, Facial emotion recognition using multi-modal information, in Proc. IEEE Int. Conf. on Info., Comm. and Sig. Proc., (Singapore), pp. 397-401, Sept 1997.

[4] Donato, G., M.S. Bartlett, J.C. Hager, P.Ekman, and T.J. Sejnowski, Classifying facial actions, IEEE Pattern Analy. and Mach. Intell., vol. 21, pp. 974--989, October 1999.

[5] Ekman, Paul. (1992). Are there basic emotions?, Psychological Review, 99(3): 550-553.

[6] Goleman, D., (1995). Emotional Intelligence. Bantam Books: New York.

[7] Huang, T.S., L.S. Chen, and H. Tao, Bimodal emotion recognition by man and machine, ATR Workshop on Virtual Communication Environments, (Kyoto, Japan), April 1998.

[8] Leidelmeijer, K. (1991). Emotions: An Experimental Approach. Tilburg University Press.

[9] Lepper. M.R. and R.W. Chabay (1988). Socializing the intelligent tutor: Bringing empathy to computer tutors. In Heinz Mandl and Alan Lesgold (Eds.), Learning Issues for Intelligent Tutoring Systems, pp. 242-257.

[10] Lewis M., (1993). Ch. 16: The emergence of human emotions. In M. Lewis and J. Haviland, (Eds.), Handbook of Emotions, pages 223-235, New York, NY. Guilford Press.

[11] Papert, Seymour (1993). The Children's Machine: Rethinking School in the Age of the Computer, Basic Books: New York.

[12] Picard, Rosalind.W., (1997). Affective Computing. Cambridge, MA: MIT Press 1997.

[13] Plutchik, R. 'A general psychoevolutionary theory of emotion,' in Emotion Theory, Research, and Experience (R. Plutchik and H. Kellerman, eds.), vol. 1, Theories of Emotion, Academic Press, 1980.

[14] Scheirer, J., R. Fernandez and Rosalind. W. Picard (1999), Expression Glasses: A Wearable Device for Facial Expression Recognition, Proceedings of CHI, February 1999.