CHAPTER 7

Emotional Design in Digital Media for Learning

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INTRODUCTION

More and more evidence still points to something that practitioners in education have known for millennia: human learning and performance cannot be simply described from a cognitive or even sociocultural perspective alone. In order to fully understand how we process the world around us, we need to consider our affective responses to the information we perceive. This is especially important for the designers of digital educational materials, as these materials offer many important opportunities to incorporate emotional considerations. However, few if any theories of learning with media consider emotions, and if they do, they do so only in very limited ways.

In this chapter, we first review definitions of key terms related to emotion and learning, and summarize research on emotional design in digital media for learning. We then present a theoretical framework of learning from digital media that emphasizes the integration of emotional and cognitive processing and of related design factors, and describe a resulting research agenda for the study of emotional design.

DEFINING EMOTION, MOOD, AFFECT

There are many definitions of "emotion," "mood," and "affect," and a lack of general agreement regarding this terminology among scholars. We will selectively focus on two comprehensive conceptions of emotion (Roseman, 1984, 2011; Russell, 2003). Because of their sophisticated and relatively dynamic nature, we have found that these two models have strong potential for informing instructional design.

Roseman's (1984) initial model built on Arnold's (1960) conception that emotion is a tendency to move toward or away from a specific object. This view highlights the motivational and behavioral aspects of

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emotion (Roseman, 2011). This motivational foundation of emotion corresponds to *action readiness* in Frijda's theory (1986), *emotional interpretations* according to Lewis (Lewis, 2000; Lewis & Douglas, 1998), and *emotion schemas* in Izard's model (2007, 2009). In addition, building on Lazarus (1968, 1991), Roseman (1984) conceptualized emotion as a *coping response*. In this view, each emotion represents a different mechanism or strategy (Roseman, 2011) for adaptation to life events.

By incorporating various characteristics of emotions that have been emphasized by different researchers, Roseman (2011) proposed a comprehensive conceptualization of emotions as *syndromes*. In this view, emotions are characterized by five different components, which Roseman (2011) called *response types*:

1. Phenomenological component (specific thoughts and feelings)
2. Physiological component (characteristic bodily response patterns)
3. Expressive components (specific manifestations in face, voice, and posture)
4. Behavioral component (action tendencies)
5. Motivational component (corresponding goals).

Roseman stressed that the combination of these five components corresponding to a particular emotion constitutes the *strategy* of that emotion. Hence, each emotion syndrome is a distinct strategy to facilitate adaptation in a particular situation.

Russell (2003) provided a similarly comprehensive conceptualization of emotions. According to Russell, two basic dimensions constitute *core affect*: (a) pleasant versus unpleasant affect; (b) arousal. An emotional episode is a function of core affect, in addition to two other experiences, namely, "perception of affective quality and attributed affect" (p. 150). Depending on the quality, intensity, and content of the individual's experience on these three dimensions, different types and intensities of emotion can be experienced.

Russell's "perception of affective quality" is similar to the experience that is commonly referred to as appraisal. In Russell's framework, affective quality is subject to the same two dimensions (pleasure and arousal) as core affect. The difference is that affective quality is experienced as located in stimuli, such as various objects that evoke emotion. For example, when an individual perceives a virtual agent on a computer screen as pleasing, she is experiencing the perception of affective quality.

Russell proposes core affect and the perception of affective quality as the *two primitives* of his framework. In this view, they are fundamental experiences that cannot be reduced into psychological components. As core components, they can be used to explain the formation of more complex experiences. Hence, the third factor in Russell's framework, attributed affect, occurs when the individual psychologically combines core affect with a particular object. In this combination, the object is perceived as the cause of one's affect. Russell stresses that attributed affect "guides attention to and behavior directed at the Object" and "is the main route to the affective quality of the Object" (p. 149).

Russell defines mood as an ongoing and a *free-floating* core affect that is generally not attributed to an object. An emotional episode typically has a shorter duration but a higher psychological complexity, as it also involves perceived affective quality and attributed affect. The feelings that people recognize in themselves as fear, anger, frustration, compassion, and joy are all examples of emotional episodes. On the other hand, such emotion categories (which Russell calls *prototypes*) do not define emotional life. Rather, according to Russell (2003), emotional life is characterized by a continuous experience of fluctuating core affect, with frequent experiences of affective quality and attribution of feeling to a specific object (p. 152). Occasionally, when the components of an emotional experience emerge in ways that *closely match* a specific emotion category, then the prototype of that emotion is experienced.

According to Russell, an emotional episode is not biologically or socially determined; rather it is psychologically constructed. By implication, there is substantial interpersonal and intrapersonal variation in emotional experiences, even among those that can be categorized under the same label of emotion, such as fear or anger. Consistently, an emotional episode "is constructed anew each time to fit its specific circumstances" (p. 151). To the extent that Russell's emphasis on construction reflects *change over time* (van Geert & Steenbeek, 2005), his approach can be seen as a *dynamic* account of emotion.

Another key aspect of Russell's framework has to do with the connection of emotion to action. While it is commonly held that emotions are action tendencies, Russell views this tendency to be quite general. According to Russell, the specific action of an individual cannot be directly predicted merely based on—knowledge of—the specific emotional category. Rather, because action emerges contextually, the specific characteristics of behavior are variable, based on situational factors.

Russell's emphasis on continuous core affect is generally consistent with Izard's (1977, 2007, 2009) notion that the human mind is continuously emotional. However, according to Izard (2009), what is continuously present is not core affect. Rather, "a discrete emotion or pattern of interacting emotions (though not necessarily labeled or articulated) in the conscious brain" (p. 4) is continuous. Despite sharp distinctions between these two perspectives as to the nature of affective or emotional experience and its process of emergence, they converge on continuous emotionality in the human mind. It is this convergence between competing perspectives that is most informative and noteworthy for educational design.

EMOTION AND COGNITION

Various emotion researchers have stressed that emotions are inherently motivational and interconnected with cognitions. For example, in Izard's (1977) *differential emotions theory* "affect and motivation are interchangeable terms that refer to all motivational phenomena—emotions, drives, and affective-cognitive structures" (Izard, 1993, p. 73). In this framework, affective-cognitive structures are units of experience and motivation which include both emotion and cognition. This notion corresponds to Lewis's concept of *emotional interpretations* (EIs; Lewis & Douglas, 1998), which represent spontaneous and repeated coupling of specific cognitions and emotions. EIs are "appraisal-emotion amalgams" (Lewis, 2000, p. 43) as organizing and motivating patterns that contribute to order in the dynamic activity of the human mind.

Izard (2007) later revised his notion of affective-cognitive structures and proposed *emotion schemas*. An emotion schema is "the dynamic interaction of emotion and cognition" (p. 265), representing "processes involved in the dynamic interplay of emotion, appraisals, and higher order cognition" (p. 261). Emotion schemas motivate both cognition and behavior. They have "special and powerful effects on self-regulation and on perception, thought, and action" (Izard, 2009, p. 9). Thus, emotion research presents a view that: (a) emotions are ubiquitous and (b) inherently interconnected with cognition. Furthermore, (c) these connections exert powerful motivational influences. These three aspects of emotions have important implications for theoretical models of learning from multimedia and for designing instructional materials and processes. The effectiveness of instructional design will depend on the extent to which it takes into account the pervasive and motivating nature of emotions and their natural interconnectedness with cognition. These qualities are important aspects of the learning model we propose in this chapter.

Advances in emotion research and affective neuroscience have led scholars to make a strong case that emotions are formative in basic cognitive mechanisms, including memory, attention, and perception (Derryberry & Tucker, 1994; Isen, Daubman, & Nowicki, 1987; Isen, Shalker, Clark, & Karp, 1978; Izard, 1993, 2007; Lewis, 2005; Lewis, Haviland-Jones, & Barrett, 2010; Tucker, 2007). These studies supported the notion that these types of cognitive mechanisms are inherently motivated by virtue of their interconnectedness with emotion. An important aspect of this motivational mechanism is that "changes in emotional state influence higher cognition" (Rutherford & Lindell, 2011, p. 337). Emotions are seen as effective retrieval cues for long-term memory (Isen et al., 1978, 1987).

Similarly, through attention, various forms of automatic and deliberate cognitive processes "are focused and motivated by ongoing emotion that is always present in consciousness" (Izard, 1993, p. 85). Research found, for example, that positive emotions support the processing of information and communication, enhance negotiation, decision-making, creative problem-solving, and similar higher level cognitive activities (Erez & Isen, 2002; Konradt, Filip & Hoffmann, 2003). The importance of this notion for instructional design becomes clear when we consider that attention is central to learning. The process by which emotional activity contributes to changes in attention may be a key mechanism to understand and facilitate the role of emotion in learning.

EMOTIONS AND LEARNING

There has been a broad gap between the ubiquitous nature of emotions in learning (Pekrun & Stephens, 2010) and the focus of most educational research and practice, which has revolved around more cognitive issues. This gap is narrowing with the recent increase in approaches that acknowledge and examine the central role of emotions in education. This increasing recognition is part of a general trend in social sciences to view emotions "as being of critical importance for performance and the productivity of individuals, organizations, and cultures" (Pekrun & Stephens, 2010, p. 238). Still, the majority of educational research and practice is subject to the enduring effects of the old paradigm of the inherent separation of cognition and emotion. Consequently, emotions continue to be either ignored or regarded as peripheral, rather than central, to learning and teaching. Consequently, "students' emotions continue to be underresearched" (Pekrun, Elliot, & Maier, 2006, p. 583), and scientifically informed approaches about emotion are still largely absent in educational practice.

Evidence from emotion research and affective neuroscience has shown that emotion and cognition are inherently interconnected (Crick & Dodge, 1994; Derryberry & Tucker, 1994; Izard, 2009; Lewis, 2005; Tucker, 2007), leading to the inference that every information processing step of the learning process is emotional as well as cognitive. Moving emotions from the periphery to the center of educational research and practice has profound implications that can change the way we design and use instructional materials. This change will substantially increase the effectiveness of pedagogical practice and interventions, and increase the prediction of significant learning outcomes (Park, Plass, & Brünken, 2014; Pekrun et al., 2006).

The need to more fully consider the impact of emotion on learning is two-fold. First, a comprehensive scientific understanding is needed about the complexity of emotions as they occur in the real lives of individuals. Theoretical and empirical interdisciplinary advances in emotion research are promising in this direction (e.g., Izard, 2007, 2009; Lewis, 2005; Picard, 2010; Russell, 2003). Second, educational research and practice must take emotions seriously as inherently important and valuable phenomena in the learning process (Lemke, 2015). Recent evidence suggesting that instructional design can facilitate learning by fostering positive emotions is promising in this direction (Um, Plass, Hayward, & Homer, 2012). Efforts in both directions will reciprocally influence each other, as emotion research will inform and be informed by educational research and practice.

This process is facilitated by an important paradigm shift in educational technology and the learning sciences. That is, we are beginning to recognize not only that "learners have needs that are different from other kinds of users (Soloway et al., 1996)," but also that the learner as the user of technology must be viewed as a *complete being* (Picard & Klein, 2002, p. 142). This is a recognition that "humans are affective beings, motivated to action by a complex system of emotions, drives, needs, and environmental conditioning in addition to cognitive factors" (Picard & Klein, 2002, p. 142). By implication, the learner's efficiency and productivity, but also their emotions, wellbeing, and motivation acquire the status of primary importance in this new paradigm.

The way students respond to academic challenges is influenced by their emotional experiences, which may impede their learning and achievement (Ruthig et al., 2008). This influence of emotions on learning interacts with the effect of perceived control (Pekrun, 2006). Even though control is a contributor to the experience of achievement emotions, educational research and practice can benefit from taking into account differing levels of both control and emotions as separate factors in learning and achievement. Ruthig's finding points to the need to take into account important characteristics of individual students, while designing educational interventions. If educational design is flexible enough to adapt to the learner's emotions as well as their sense of control, it will be more likely to facilitate learning and achievement for a greater number of students.

Emotions have been shown to impact learning in authentic field settings. In one example, researchers were able to link self-reported arousal to students' regulation of their problem-solving efforts, and self-reported valence to cognitive regulation processes, although a link between the reported emotions and learning outcomes could not be established (Linnenbrink & Pintrich, 2002a,b). The importance of emotion in the context of learning is also highlighted by issues of emotional self-regulation (including regulation of emotions and their interconnected appraisals), which is considered a key process related to "the design of 'emotionally sound' (Astleitner, 2000) achievement environments" (Pekrun & Stephens, 2010, p. 250). This consideration must include the psychological and environmental conditions that help students experience "adaptive levels of emotions (lower boredom, lower anxiety, or higher enjoyment)" in addition to high levels of perceived control (Ruthig et al., 2008, p. 161).

An important aspect of emotional life may be the simultaneous experience of multiple emotions (Kaplan & Tivnan, 2014c; Pekrun, 2006; Roseman, 2011). This phenomenon represents substantial intrapersonal multiplicity in emotional experience within a given time and context. Consistently, it is reasonable to expect "mixtures of emotions" (Pekrun, 2006, p. 323) in achievement and learning contexts. This multiplicity has important implications for instructional design, as it presents inherent pedagogical opportunities and challenges. The intrapersonal multiplicity of emotional experience has the potential to make the learning process more engaging and highly motivating, but also overwhelming and frustrating.

EMOTIONAL DESIGN IN DIGITAL MEDIA FOR LEARNING

The emotions that learners experience in digital learning environments may not be different from those in other types of learning environments. But digital learning environments offer many more ways of influencing learners' emotions, using a number of design features that are under the control of the learning designer. We use the term *emotional design* to describe the use of a range of design features with the goal to impact learners' emotions to enhance learning. Some of these design features relate to the way information is presented, and others to the way the interactions in the environment are structured (Plass & Schwartz, 2014).

Emotional Design Through Information Representation

For information representation, the visual design of the learning materials themselves can impact emotions that in turn impact learning. There is a general notion that physically attractive stimuli have a positive impact on learning—"what is beautiful is good" (Dion, Berscheid, & Walster, 1972). In fact, research has shown that children associate brighter colors with more positive emotions, and darker colors with more negative emotions (Boyatzis & Varghese, 1994). Several studies on multimedia learning have implied that different aesthetic designs can induce emotions and that these emotions affect users' performance and cognitive processes (Harp & Mayer, 1997; Mayer & Moreno, 1998; North & Hargreaves, 1999; Szabo & Kanuka, 1998; Tractinsky, Katz, & Ikar, 2000; Wolfson & Case, 2000). Other researchers found that the design of various multimedia elements, such as the visual design, design layout, color, and sound in multimedia environments, resulted in positive user perceptions about learning (Tractinsky et al., 2000; Wolfson & Case, 2000).

Another established effect is the *baby-face bias*, which describes how people or things with round features and large eyes are perceived as baby-like (Lorenz & Generale, 1950). Unlike shapes featuring sharp edges, these round features induce a positive affect in the learner by evoking baby-like personality attributes—innocence, honesty, and helplessness. Anthropomorphism research, which studies the attribution of uniquely human characteristics and qualities to nonhuman beings, inanimate objects, or natural or other phenomena, has reported similar effects (Dehn & Van Mulken, 2000; Disalvo & Gemperle, 2007; Hongpaisanwiwat & Lewis, 2003; Reeves & Nass, 1996).

Based on this research on shapes and colors, we have, in our own research, investigated whether these visual emotional design elements can, in fact, impact learning. Our research with college students provided evidence that the use of round shapes and warm colors in the visual design of learning environments is able to induce positive emotions in learners that in turn facilitate comprehension and transfer of learning scientific materials

(Um et al., 2012). The design of that study used a combination of two visual design elements: color and shape, to manipulate the emotional impact of the materials without adding new information. Therefore, in a follow-up study, we investigated to what extent each of these design elements separately contributed to the impact on emotion and learning (Plass, Heidig, Hayward, Homer & Um, 2014). This study was able to replicate the effect of emotional design on comprehension we found in our 2012 study, but not the effect for transfer. In addition, this follow-up research revealed that round face-like shapes induced positive emotions both alone and in conjunction with warm colors. Interestingly, we found that warm colors alone did not affect learners' emotions. *Comprehension* was facilitated by warm colors, by round face-like shapes, and by combinations of both design features. *Transfer*, on the other hand, was facilitated by round face-like shapes when used with neutral colors.

Another interesting result of this study was that the mood induction procedures we had used, which consisted of watching funny cartoon movies, resulted in elevated feelings of excitement, enthusiasm, determination, and attentiveness, relative to those who did not view the cartoon; however, these elevations were not sustained over the course of the learning session. In contrast, the visual emotional design features resulted in elevated feelings of being inspired, interested, and enthusiastic, and were sustained during the learning session (Plass et al., 2014). We have since been exploring other promising ways of emotional design via information representation, such as through game characters, for which we found that their visual design (color and shape), but also their movement and associated sounds impacted learners' emotion, as can be seen in Figure 7.1 (Biles, Szczuka, Plass, & Krämer, 2014; Szczuka, Biles, Plass, & Krämer, 2013).

Emotional Design Through Interaction Design

For learning interactions, a number of different ways have been explored that impact learners' emotions. They can be based on the INTERACT model that describes how learners' actions include behavioral, cognitive, and affective activity, and how these kinds of activities affect one another during learning, see Figure 7.2 (Domagk, Schwartz, & Plass, 2010). The effect of interactivity on emotion has been investigated using a number of different approaches. Below we will discuss two of them, namely a focus on the situational interest that the activity generates, and the use of guided activity, such as involving animated pedagogical agents.

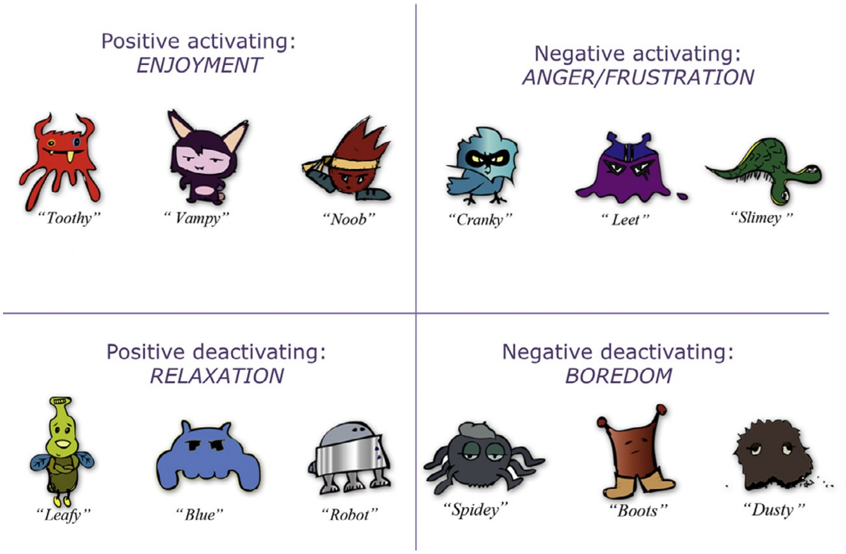

Figure 7.1 Emotional design via game characters' color, shape, movement, and sound.

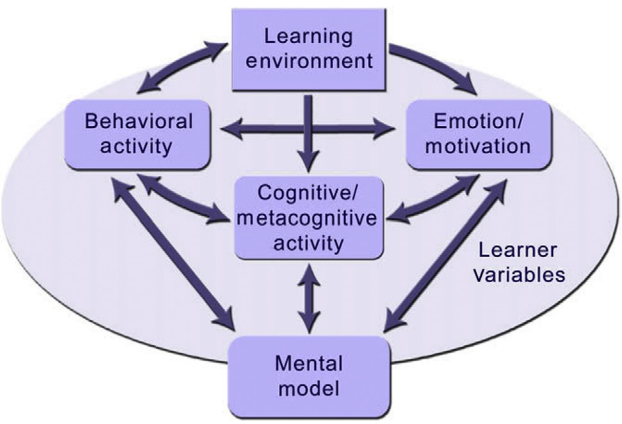

Figure 7.2 INTERACT model describing cognitive, behavioral, and emotional activity in multimedia learning.

Situational Interest

Situational interest is described as an immediate affective response to particular stimuli and conditions that originate from the learning environment, a response that may be fleeting or lasting, and that directs learners' attention to the task (Hidi, 1990; Hidi & Renninger, 2006; Mitchell, 1993; Rotgans & Schmidt, 2011; Schraw, Flowerday, & Lehman, 2001). Situational interest is different from learners' individual interest, which describes their intrinsic desire and tendency to engage in a particular subject matter or activity over time. Situational interest is of importance as research has found that it is essential in the development of individual interest (Hidi & Renninger, 2006).

We have found evidence that a number of different design elements in interactive learning environments, such as games for learning, can impact the situational interest experienced by the learner. Among them are the game mechanics, the social mode of play, and the use of badges. In one study, we compared two versions of a geometry puzzle game for middle-school students, *Noobs vs. Leets*. The only difference between these versions was the game mechanics, i.e., the essential game play that the game afforded. In one version, players were asked to solve geometry problems of angles in quadrilaterals by computing a missing angle (numeric condition); in the other, they were asked to select the rule that needed to be applied to solve the problem (rule condition). Results showed that the numeric condition, based on the situation, was more interesting than the rule condition, suggesting that the selection of the game mechanic has an impact on learners' affect (Plass et al., 2012).

We also compared three versions of a game on factoring for middle-school students that facilitated either individual play, competitive play of two players, or collaborative play of two players. Results of this study showed that competition and collaboration elicited greater situational interest than the individual play, suggesting that the social mode of play is able to impact affect (Plass, O'Keefe, et al., 2013). Finally, we designed a version of the *Noobs vs. Leets* game that awarded the learner different types of digital badges for the completion of in-game learning-related tasks. We found that the design of the badges impacted learners' situational interest, in addition to learning outcomes (Biles & Plass, in press; Plass, O'Keefe, Biles, Frye, & Homer, 2014).

Guided Activity Principle—Animated Pedagogical Agents

According to the *guided activity principle* for *interactive multimodal learning environments,* "students learn better when they interact with a pedagogical agent who guides their cognitive processing" (Moreno & Mayer, 2007, p. 315). Animated pedagogical agents play instructional roles to support sociocognitive aspects of multimedia learning; can follow social conventions; and provide empathetic responses to learners (Hayes-Roth & Doyle, 1998). These agents are represented visually, often with human features, and with optional auditory (speech) features. Considering the inherent interconnectedness of cognition and emotion (Lewis, 2005; Tucker, 2007) and applying insights from *affective computing* (Picard, 2003), a corollary to this principle can be derived for emotional design. That is, students are likely to learn better when interacting with a pedagogical agent who facilitates the learner's emotional self-regulation.

A skillful tutor adjusts not only her emotional expressions (such as tone of voice), but also the content of the instruction according to her perception of dynamic emotional changes in her student. Is this a realistic expectation for a virtual pedagogical agent? The existence of systems that respond to changes in aspects of emotional experience suggests that advancements in technology and scientific understanding could fulfill this expectation. There are promising developments in the field of affective computing (Calvo, 2010; Hudlicka, 2003; Picard, 2003; Picard & Klein, 2002; Picard, Vyzas, & Healey, 2001), which suggest that emotionally intelligent *human computer interactions* (HCI) are not only possible, but also necessary for increasing the wellbeing of users as well as efficiency.

Research has shown that animated pedagogical agents can increase motivation (Moreno, Mayer, Spires, & Lester, 2001), and result in higher interest and lower perceived difficulty of learning materials (Mitrovic & Suraweera, 2000). When such systems induce confusion and engagement (flow), they have positive correlations with learning, but when they induce boredom, the correlation is negative (Craig, Graesser, Sullins, & Gholson, 2004; D'Mello & Graesser, 2014). Learning materials induce a state of cognitive disequilibrium in learners, which can be a result of obstacles to their goals, interruptions, anomalies, and the like (D'Mello & Graesser, 2012; Graesser & D'Mello, 2011). In such cases, there are alternative consequences. Learners may either experience negative emotions and disengage or, when they manage to overcome the source of the disequilibrium, experience positive emotion and higher engagement (Baker, D'Mello, Rodrigo and Graesser, 2010; D'Mello & Graesser, 2012; Sabourin, Mott, & Lester, 2011). Studies in which learners' emotions were continuously monitored, and in which the agent responded to the learners' emotional state through empathy, support, or even cheeky comments, found mixed results on learning outcomes (D'Mello, Craig, Fike, & Graesser, 2009; D'Mello & Graesser, 2014). This highlights how difficult it is to determine the best response to the detected emotions.

THE THEORETICAL FOUNDATION OF EMOTIONS AND LEARNING

The research we have discussed so far shows the importance of an integrated model of emotion and cognition for designing and studying multimedia learning, and we now propose such a model, which focuses on emotional design for multimedia learning. Among the theories that inform our work on emotional design are theories on achievement emotions (Pekrun, 2000); theories incorporating affective elements into multimedia learning (Moreno & Mayer, 2007); and theories of affective computing (Picard, 1997). We will summarize these theories before discussing our approach to integrating them into an Integrated Cognitive-Affective Model of Multimedia Learning.

Pekrun's (2000) Control Value Theory of Achievement Emotions

The Control Value Theory of Achievement Emotions is an integrative framework that describes the antecedents and effects of emotions experienced by learners, i.e., in academic settings or achievement situations (Pekrun, 2006; Pekrun & Stephens, 2010). This theory is relevant for instructional design, as it shows that learning can be facilitated through positive achievement emotions, such as enjoyment. This is possible to the extent that instructional design evokes and fosters appraisals of control and positive value for the task and object of learning. These emotions are in turn likely to increase "interest and motivation to learn" (Pekrun, 2006, p. 326), and facilitate self-regulation and performance in the learning process (Pekrun & Stephens, 2010). Consistently, positive emotions are likely to facilitate internalized motivation (Pekrun, 2006), which, according to the Self-Determination Theory (SDT; Deci & Ryan, 1985; Ryan & Deci, 2000), is operationalized as increased autonomy. This insight can be considered together with the notion that increased autonomy and internal sense of control facilitate positive emotions. It follows that there is a dynamic and reciprocal relationship between positive achievement emotions and autonomy, as they influence each other over time in a positive feedback loop.

Similarly, because emotions and appraisals influence each other over time (Pekrun, 2006), their relationships may be better characterized in terms of a dynamic feedback loop (Lewis, 1995, 2002), rather than unidirectional causation. Learning may be shaped by a similarly dynamic process of interconnected components: "Emotions are assumed to affect learning and achievement, but success at learning influences students' appraisals and emotions. By implication, emotions, their individual and social antecedents, and their effects are linked by reciprocal causation over time" (Pekrun, 2006, p. 327).

What are some of the important ways by which emotional design can promote competence and positive value for learning tasks and materials? One of the key factors is for design features to support the learner's sense of autonomy: "the individual has to learn how to adapt to situational demands while preserving individual autonomy—inevitably a process guided by appraisals" (Pekrun & Stephens, 2010, p. 241). In this context, supporting autonomy requires design characteristics that make it clear to the learners that important aspects of both the process of engaging in a learning task, and its outcomes, are relatively under their control, given sufficient effort.

Another key phenomenon is the *intrinsic value* of the learning activity (Pekrun, 2006). Intrinsic value represents a positive motivation for engaging in the learning activity for its own sake. From a control-value theory perspective, enjoyment can be predicted to be the strongest when high intrinsic value is combined with an appraisal that the learning activity is *sufficiently controllable* (Pekrun, 2006, p. 323) by the learner. By establishing this combination of control and value, emotional design can facilitate enjoyment as a positive activity emotion, and reduce the likelihood of negative activity emotions, such as anger and frustration.

A related mechanism by which instructional design can facilitate positive emotions is by evoking and reinforcing specific types of goals. Considering evidence that mastery goals are positively associated with enjoyment, hope, and pride (Pekrun et al., 2006), design features that facilitate these goals can be expected to promote positive emotions in the learning process. By contrast, design features that evoke and reinforce performance-avoidance goals will promote negative emotions, such as anxiety, hopelessness, and shame (Pekrun et al., 2006).

An important implication of Pekrun's framework is that emotional experience varies (intrapersonally and interpersonally), based on *object focus*. That is, an individual's emotional experience will be different depending on whether appraisals of activity or outcome trigger emotions. Pekrun further differentiates outcomes as retrospective and prospective, to be associated with different emotions.

Furthermore, to the extent that people can experience multiple emotions (Roseman, 2011) simultaneously or successively in a short time, emotional experience can be affected by both activity and outcome appraisals. People can have various degrees of activity-focused emotions, such as enjoyment, relaxation, frustration, or boredom, combined with outcome-focused emotions, such as hope, relief, anxiety, hopelessness, pride, sadness, and disappointment. According to Pekrun, anger can be triggered both by activity and outcome-related appraisals. Emotionally intelligent designs of HCI must take into account the task characteristics and possible individual characteristics that are likely to trigger activity and outcome appraisals, which evoke multiple emotions. Considering that negative emotions such as anxiety, boredom, and hopelessness reduce performance (Pekrun, 2006; Pekrun & Stephens, 2010), an important function of emotional design is to minimize the likelihood of such emotions and promote self-regulation when they appear. What are some of the key factors of emotional design, which could make a difference toward this aim?

Pekrun and Stephens (2010) presented a list of important qualities about instructional design that are likely to facilitate performance and learning through their positive impact on achievement emotions: (a) cognitive quality of instruction; (b) motivational quality of instruction; (c) autonomy support; (d) goal structures and expectations; (e) feedback and consequences of achievement. Among these factors, motivational quality of instruction and autonomy support are most directly related to emotional design. From a Self-Determination Theory perspective, these two factors are interconnected because autonomy support improves the quality of motivation. According to Pekrun and Stephens (2010), the motivational quality of instructional design can be enhanced to the extent that "supervisors, teachers, and peers deliver both direct and indirect messages conveying achievement values" (Pekrun & Stephens, 2010, p. 245). For example, from an SDT view, the design of learning tasks and environments can support the fulfillment of basic psychological needs of relatedness, autonomy, and competence.

Moreno and Mayer's (2007) Cognitive Affective Theory of Learning with Media

Moreno proposed an addition to Mayer's (2005) Cognitive Theory of Multimedia Learning (CTML) into which she incorporated motivational as well as metacognitive factors that mediate multimedia learning (Moreno, 2007; Moreno & Mayer, 2007). In learning with multimedia, learners first select relevant information and build verbal and visual mental representations of what was presented. They then organize this information in working memory, connect the verbal and visual representations with one another, and integrate them with prior knowledge. Because working memory can only hold a limited amount of information (Baddeley, 1986; Cowan, 2001), processing of multimedia information is performed under these memory constraints. Multiple factors impact the amount of cognitive load a learner experiences, such as the difficulty of the materials and the demands of the learning task (Plass, Moreno, & Brünken, 2010).

Moreno's additions to CTML recognize that motivation as well as metacognition mediate the cognitive processing of multimedia information. By doing so, she expands the CTML to include the first noncognitive element.

Both motivation and metacognition have a large body of research in support of their impact on learning, and Moreno added them as supplemental factors to a system that has cognitive processing at its core.

Picard's (1997) Affective Computing

Affective computing describes computational approaches to the detection and deliberate induction of affect (Picard, 2003). Applying the emphasis of Picard and Klein (2002) on the importance of emotional needs, an important function and purpose of emotional design emerges. That is, emotional design in the learning process can contribute to the wellbeing of the learners by taking into account and helping to fulfill the learners' emotional needs. According to Picard and Klein (2002), these needs include both *emotional skill needs*, such as empathy and self-awareness, and *emotional experiential needs*, such as feeling connected to others and understood and accepted by them. Emotional design of instructional processes can help learners fulfill both types of needs.

For example, by using physiological measures, such as face recognition, heart-rate variability, and skin conductance, a computer can recognize key emotional states and related changes in the user. The communication of such information to the user can help increase emotional skill needs by contributing to self-awareness and experiential needs by helping "the user to feel as if his or her strong affective state has been effectively communicated" (Picard & Klein, 2002, p. 145). A key factor that Picard and Klein (2002) emphasize toward meeting emotional needs is "to consider the closest human analogy to the human-computer interaction being designed, and ask how that interaction might make a person feel" (pp. 150-151).

This consideration implies that human-to-human interaction and human-to-computer interaction (HCI) share fundamental features about the nature and importance of human emotions. This idea may be of utmost importance for instructional design that is centered on computer technology. Instructional designers do not have to see an inherent split and dichotomy between these two contexts of interaction. Rather, instructional design may benefit from understanding their common features.

As Picard and Klein suggest, addressing the user's emotional needs does not require the computer to have the emotional qualities of a human being. The emotional needs of the human user can still be addressed and at least partially fulfilled during the interaction with the program, even when the user is aware that the agent with whom she is interacting is not a human being.

Significant developments in this direction can be seen as functions of "the recent shift from computers as tools to computers as partners and socially intelligent agents, and intelligent decision-aids" (Hudlicka, 2003, p. 21). Consistently, the field of affective computing is flourishing, with many projects toward "building machines that have several affective abilities, especially: recognizing, expressing, modeling, communicating, and responding to emotion" (Picard, 2003, p. 56).

As affective computing can serve toward "minimizing user frustration and maximizing user satisfaction" (Picard & Klein, 2002, p. 167), so can emotional design in education substantially improve learning and wellbeing. Similar to the role of affective computing, emotional design in education can utilize and facilitate the process by which "emotions aid in intelligent interaction and decision making" (Picard, 2003, p. 63). Therefore emotional design can make learning and teaching more compatible with the actual emotionally grounded process of how the human mind works and changes. As a result, through emotional design, digital learning environments can serve the needs of the *whole person*.

TOWARD AN INTEGRATED COGNITIVE-AFFECTIVE MODEL OF MULTIMEDIA LEARNING

To the extent that HCI can be designed to *address user affect* (Hudlicka, 2003), the principles of affective computing can be applied to education in order for computer-based instructional design to fulfill important educational needs. In particular, if computer systems can recognize the user's affect and respond accordingly, instructional materials using these systems can address emotions effectively in the learning process. Increasing the accuracy of affect recognition is a worthwhile and important endeavor. Upon recognition, whether or not, and how and when the system will respond to the learner's affect are critical decisions. Instructional designers must make such decisions depending on the specific characteristics of a given task and the aims of the particular application. Accumulation of empirical findings about the dynamic, temporal relationships between learner's affect, learner's motivation, and various forms of system response will be highly valuable for more informed and effective design decisions.

Given the knowledge of the user's affective state and its likely effects and the user's desired state for the objectives of the HCI, we must decide whether or not the system should respond to this state, and how or what affective behavior, if any, the system should display to induce a desired user state or behavior (Hudlicka, 2003, p. 8).

Addressing a learner's affect can be an important aspect of emotional design, enabling scholars and educators to both understand the complex role of emotions in learning and facilitate this role in order to improve the efficiency and effectiveness of the learning process. Furthermore, just as the benefits of affective computing increased efficiency and productivity, this approach may also improve the motivation and wellbeing of learners.

These outcomes will be initiated as emotional design reduces the negative emotional states, such as frustration, boredom, stress, and anxiety, and increases the positive emotions, such as hope and enjoyment, and indeed, facilitates self-regulation of all possible (negative and positive) emotional experiences throughout the learning process. It is important for this general vision to be adjusted based on the specific demands and characteristics of each learning application (e.g., a particular educational game or simulation). For greater benefit, this contextualization can be extended to take into account interpersonal variability, namely, the variable emotional and motivational needs and demands of individual learners. For example, moderate and manageable levels of stress and anxiety can be adaptive as part of the motivation process of certain individuals in some learning tasks. In this context, Hudlicka's (2003) characterization of the "broad aim of affective HCI" directly applies to and informs emotional design in instructional technology:

> *Regardless of whether or not affective factors will ultimately be considered in a particular human–machine context, it is critical that the system designers accurately assess the range of possible affective states the users may, or should, experience during interactions with the system, and that they understand their effects on the user, and thus on task performance. Such understanding then allows informed decisions regarding which affective considerations must be addressed, when and how. (p. 7)*

The necessary shift to consider the user or the learner as a complete human being with affective needs (Picard & Klein, 2002) is accompanied by a parallel shift in how we view the computer and the individual interacting with it. That is, there is a tendency to characterize the user and the computer together as a whole unit in terms of "collaborative systems, integrated human-machine systems," reflecting "a deep and significant shift in underlying design philosophy and objectives, and indeed in the expectations we now have of computer systems" (Hudlicka, 2003, p. 2). This holistic view resonates with the developmental vision of Kurt Lewin (1946), an early pioneer of the dynamic systems (DS) perspective (for a discussion, see Thelen &

Smith, 1994). According to Lewin (1946), human behavior and development must be viewed "as a function of the total situation" (p. 791), in which the person and the context constitute a unified whole.

A direct implication of this dynamic developmental view is the characterization of human mind and behavior in terms of tendencies or probabilities instead of rigid rules or fixed properties. To the extent that learning is a developmental process, it involves "the emergence and consolidation of new possibilities and tendencies for behavior to coalesce in real time" (Lewis & Douglas, 1998, p. 160). The emerging mental and behavioral tendencies are various strategies and motivations that are both cognitive and emotional at the same time (Lewis, 2005). Consistently, according to Lewis and Douglas, human behavior and development can be explained through *emotional interpretations* (EIs), as both products and building blocks of mental and behavioral organization. As spontaneously and repeatedly occurring patterns of interactions between cognition and emotions, EIs inform and guide decisions and actions.

Relatedly, Izard (2007, 2009) proposed *emotion schemas* as similarly dynamic structures with a motivating role in judgment and behavior. Therefore, in order to understand and facilitate the learner's actions and decisions in a learning environment, it is useful to consider the possible combinations of emotions and cognitions that serve as dynamic motivating forces. Because of the *soft-assembly* of the human mind (Kaplan & Tivnan, 2014a,b; Kloos & Van Orden, 2009), emotion-cognition interactions will occur in ways that are context-specific. Specific features of instructional design may evoke and support specific combinations of emotions and cognitions, which in turn will influence the learner's interactions with the instructional materials. This view implies that the learner's intrapsychic motivational dynamics (ongoing combinations of emotions and cognitions) and the features of the learning context are interconnected. In summary, (a) there is a continuous and inherent interconnectedness between emotion and cognition, and (b) dynamic cognition-emotion interactions (IEs or emotion schemas) emerge and operate in ways that are highly contextualized (and hence sensitive to contextual factors). Furthermore, (c) dynamic cognition-emotion interactions serve as motivating forces that guide human adaptation and learning in specific contexts. These three insights, coming from both emotion research and the DS perspective, contribute to, and inform, the new learning model we propose.

Figure 7.3 shows the Integrated Cognitive Affective Model of Learning with the Multimedia (ICALM) model we propose for the purpose of emotional design in multimedia learning. The system incorporates Moreno and

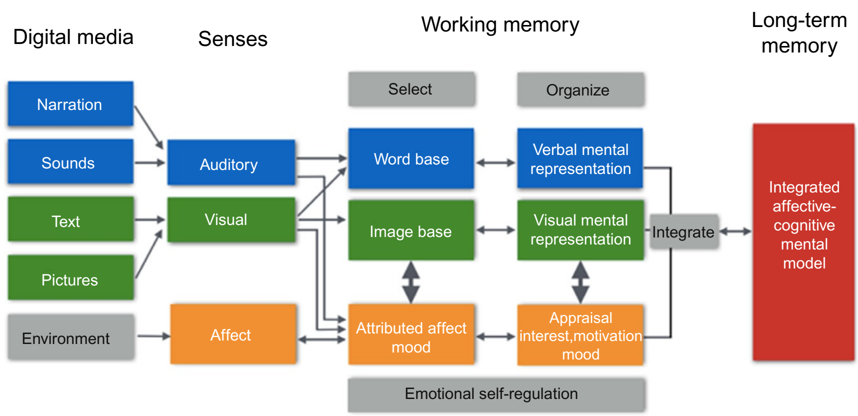

Figure 7.3 Integrated cognitive affective model of learning with multimedia (ICALM).

Mayer's (2007) multimedia learning via selecting, organizing, and integrating visual and verbal information, and combines these processes with Russell's (2003) notions of core affect and attributed affect, and Izard's (2009) concept of emotion schemas. The main thesis of this model is that affective processes are intertwined with, and inseparable from, cognitive processes, and that the cognitive-affective processing of multimedia stimuli involves affective processes that make demands on cognitive resources, and vice-versa.

The multimedia environment induces affective responses, which we describe as "core affect." This core affect is experienced as the learner perceives auditory and visual information from the environment. Some of the experienced emotions may be attributed to specific sources, but they may also persist unattributed, as mood. This attribution is impacted by the information learners select from what is presented, but also impacts that selection process. As learners organize visual and verbal mental representations in working memory, affect that involves appraisal is experienced by the learner as interest and motivation, impacting the organization of these mental representations, but also being impacted by what is being processed. The integration of the different mental representations, which traditionally only involve verbal and visual mental representations, also includes the experienced affect, forming emotion schemas that are stored as long-term memory. Depending on the type of information the learner processed, this can either be semantic or episodic memory.

Research summarized by Mayer and Moreno (2003) suggests that effective instructional design must minimize cognitive load that arises from nonessential processing, i.e., processing that does not serve learning outcomes. Similarly, with this model we propose that effective instructional design must evoke and observe efficient emotional experience. This includes design that is compatible with individual's emotional self-regulation skills. Emotional overload will occur, for example, when the task evokes emotions that exceed the user's capacity for emotional self-regulation. Effective instructional design minimizes emotional overload. Furthermore, emotions that lead the user's attention away from learning objects or activities will not be beneficial.

An example for the deleterious impact of emotion on learning is the *stereotype threat* (Steele & Aronson, 1995). As research has shown, the stigmatizing of specific individuals, such as African-Americans (Steele & Aronson, 1995), women (Spencer, Steele, & Quinn, 1999), or White males (Aronson et al., 1999), results in emotional responses that interfere with cognitive processing, consume executive resources, and, as a result, negatively impact learning and performance (Schmader, Johns, & Forbes, 2008).

Learning is also compromised when the individual's diversity and intensity of emotional experience are below optimal levels. In such cases, particularly when positive achievement emotions, such as enjoyment and hope (Pekrun, 2006; Pekrun & Stephens, 2010) are not experienced strongly enough, the learner may lack the motivation and engagement for optimal performance and learning. Such a lack of motivation is likely to reduce creativity, and prevent the learning process from fulfilling its developmental potential for the individual. For example, when learners lack motivation, they may fail to engage in generative processing, even when cognitive capacity is available (Moreno & Mayer, 2007, p. 315). According to Moreno and Mayer, generative processing involves constructing a new understanding, which may integrate new information with existing knowledge.

This model makes several assumptions that are based on the literature described above, but also leads to research questions that should be investigated empirically. We describe some of these questions in the following section.

RESEARCH AGENDA FOR THE STUDY OF EMOTIONAL DESIGN

On the most fundamental level, research on emotional design is concerned with questions, such as: Which design elements of learning environments impact emotion? How do emotions impact learning outcomes? How can emotions be measured? What are the appropriate responses to the detected emotional state of the learner?

Research on Design Factors Impacting Learners' Emotion

Research has identified several design elements in digital media that impact learning. However, more research is needed to systematically document which emotions are induced by each of these elements. Based on our earlier differentiation, the design to be investigated should be related to information representation and interaction design. Information representation, for which we have begun to investigate factors, such as color, shape, and movement, should focus on interactions of these factors as well as on additional formats of information representation, such as sound. Interaction design has primarily been investigated via factors related to situational interest generated by the mode of play, mechanics design, personalization, and badges design, and by animated pedagogical agents. Research on the impact of interactions on emotion should focus on additional factors, such as narrative, and on the use of personalized messages to the learner. The latter has been shown to impact learning (Moreno & Mayer, 2000), but this effect has not yet been clearly linked to emotion.

The study of emotional design in specific contexts or for specific media raises additional questions. For example, for the design of video games, it is of interest that Russell's model (2003) describes emotion episodes as phenomenologically including and transcending core affect. One of the key distinctions between these two phenomena is that an emotional episode involves behavior directed at an object. This distinction is particularly relevant to people's experience with video games or virtual reality. Russell stresses that while virtual reality (e.g., a scary and threatening movie character) evokes core affect (e.g., fear) and corresponding physiological changes, it does not trigger the purposeful behavior (e.g., flight) associated with an emotional episode. Thus, according to Russell, experience with virtual reality usually involves core affect of a particular feeling, such as fear or sadness, and not its "full-blown emotional episode" (p. 155).

On the other hand, this behavioral criterion for the distinction between core affect and emotion episode becomes controversial, considering that many interactive video games simulate behavior. As virtual reality, a video game shares a common ground with Russell's example of a film, in that the individual *knows* that the stimulus is imaginary. However, playing a video game is very different from watching a film because of the interactive experience. Unlike a movie, a video game enables the user to simulate behaviors. Is this a sufficient condition for games to be evoking emotional episodes beyond core affect? In what significant ways do the control and manipulation of a game character's behaviors contribute to the player's emotional experience in a game? The exploration of such questions may be useful in order to explicate the nature of emotional experience in digital games and simulations in ways that could inform emotional design.

Research on the Impact of Emotion on Learning Outcomes

A number of questions need to be investigated in order to validate specific elements of the model we proposed. In particular, the interconnectedness and interplay of emotion and learning provides a number of challenges that research should address. One of these important questions for research on emotions and learning relates to the insight that emotion and learning do not have a linear and uniform relationship. In order to explain real-life complexity, new models and studies must take into account nonlinear relationships between emotions and learning, including the uniqueness of individual developmental pathways. For example, as Pekrun (2006) emphasized, "positive emotions are not always adaptive, and negative emotions not always maladaptive" (p. 327). Idiosyncratic factors, such as the individual's psychophysiological arousal response, self-regulation skills and related developmental history may moderate the learning effects of various emotions. For example, based on their self-regulation skills, some learners may use moderate degrees of negative emotions, such as anxiety and fear as motivators for high achievement; whereas smaller degrees of such emotions can be detrimental for other individuals who have low levels of emotional self-regulation.

Similarly, van Geert (2002) proposed that "the causes of human actions, performance, skills, and knowledge lie in the process of a temporal interplay between" (p. 320) the properties of three factors that are inherently interconnected: (a) the transcendental object(s); (b) the subject (e.g., a student); and (c) the context (e.g., the immediate educational context in which specific learning occurs). Applying this model to the learning process, transcendental objects are the specific learning materials as well as the tools of instructional design (such as a virtual pedagogical agent). The *properties* of such design materials and tools (e.g., taking into account changes in the learner's motivation and emotions) enable the learner "to intentionally relate to the object (in the broad sense of the word) in question" (p. 320). According to van Geert (2002), there are two key principles that characterize the relationships between these three sources of experience and understanding. First, the boundaries differentiating these three sources are *fuzzy* and *dynamic*, rather than absolute, exclusive, and static. "Because they come about as a result of the time-governed interplay among the factors, it is impossible—not only in practice but also in principle—to draw a sharp line between the factors or to specify their properties in a 'crisp' way" (pp. 320-321).

Research should explore, for example, how in an educational game, the developing cognitive and emotional skills of the learner are dynamically related to motivational properties of the specific tasks that are to be completed. It is neither necessary nor realistic to define the learning skills in a way that is completely independent of and distinct from the motivational properties of the game. This example also illustrates van Geert's (2002) second principle: "if we measure a person's psychological properties, we must, by necessity, also invoke the objects—again in the broadest possible sense of the word—and the contexts in which these psychological properties make sense, so to speak, and which are characteristic of the person in question" (p. 321). By implication, our definitions and operationalizations of learning skills, learning tasks, and design features must take into account and reflect the inherent mutuality (van Geert, 2002, p. 321) between the developing characteristics of learner, learning objects, and the learning context. These principles are useful for designing effective educational materials because they could help researchers and educators become aware of and specify the dynamic relationships between the subjects (learners), objects (what is to be learned), and the tools (e.g., computers and simulations) of the dynamic learning process.

Research on Measuring Emotions

There is evidence supporting the notion that key emotional states, such as anger, hate, grief, and joy, can be reliably differentiated and recognized, based on physiological measures, such as facial muscle tension, skin conductance, blood pressure volume, and respiration (Picard et al., 2001). This research should be extended to cover more emotions that are important in learning contexts, including curiosity, frustration, pride, anxiety, hope, and boredom (Pekrun, 2006; Picard et al., 2001). Identifying interpersonal commonalities and variability in the biological signals associated with key learning emotions can significantly contribute to effective emotional design of computer-based instructional materials.

The availability of several consumer grade tools to measure emotion offers promising examples in this direction. Some of these systems measure heart-rate variability (HRV) and heart-rhythm coherence. When heart-rate exhibits orderly variability, which is neither too low nor too high, then heart-rhythm coherence is high. As an aspect of wellbeing, coherence has been found to be particularly high under positive emotions, such as gratitude, appreciation, and compassion. Increased coherence is an indication of biopsychological resilience through which the organism can respond to mental and emotional demands flexibly without burning out. Throughout seconds and minutes, coherence can increase to the extent that HRV approximates an optimal range.

Systems, such as Heartmath Institute's emWave® Desktop system immediately respond to psychophysiological (including emotional) changes in the user, to the extent that such changes affect coherence. This biofeedback can in turn be taken into account by the user to alter his mental state in a desired direction. Consistently, appropriate use of mental imagery has been documented to have an immediate impact on coherence (Kaplan & Epstein, 2011). Because mental images are closely connected to and can easily evoke emotions (Kaplan, Epstein, & Sullivan Smith, 2014–2015), mental imagery is an effective process that can facilitate emotional self-regulation. In this research program, vivid mental images (involving a blue-golden light surrounding one's heart) were associated with a positive emotional experience and rapid increases in wellbeing, as measured quantitatively (Kaplan & Epstein, 2011), and reflected in participants' verbal self-reports (Kaplan et al., 2014–2015). This intimate and natural connection between mental imagery, emotions and wellbeing is an important phenomenon to consider while designing instructional materials that involve digital media presentations of various images.

Research on Appropriate Responses to a Learner's Emotional State

As methods to measure emotion improve to a point where a learner's emotional state can be detected at any time, the question arises how the system should respond to the emotions experienced by the learner.

Both learning and emotional experiences are dynamic processes, which unfold through changes over time. Therefore, emotionally intelligent instructional resources and tools must be dynamic rather than static. It is not sufficient for instructional resources to reflect what may be seen as general preferences for pleasant perceptions or mainly design to evoke positive affect. Rather, emotionally intelligent instructional resources require systems that are responsive to ongoing and changing emotional experiences of each individual user throughout the learning process. Designing instructional resources with such emotionally intelligent virtual pedagogical agents is the direction that will fulfill the significant potential of emotional design for improving learning. Such a dynamic approach will meet an emerging need in emotion research and affective computing to address "individual patterns of emotions, not just group differences" (Picard, 2010, p. 250). To this aim, educational research, practice, and design must take into account the idiosyncratic nature of individual emotional experience as it changes throughout the learning process. For example, animated pedagogical agents with affective sensing can detect confusion, boredom, or happiness, but what is the most appropriate response to this emotional state, especially since it is expected to be changing over time? How should responses vary by learner, and what learner variables need to be taken into consideration? Can agents be designed that learn how students react to a particular emotional response by the agent, and can adapt their responses accordingly?

From a dynamic systems perspective, substantial intrapersonal and interpersonal variability is expected in the roles of emotions in learning, as well as the intensities of various emotions as inherent aspect of the learning process. Similarly, substantial contextual variability in emotions is expected, based on the unique characteristics of specific learning tasks and environments (Hudlicka, 2003). Therefore, individualization and contextualization of instructional design are important, as applications must be flexible enough to adapt to individual circumstances of specific learners and tasks. Computers can be very useful tools for the individualization and contextualization of instructional materials. Such an individual-based and context-sensitive approach can be combined with research-based information regarding "generic effects of emotional states on different processes involved in attention, perception, cognition, and motor performance" (Hudlicka, 2003, p. 17).

CONCLUSION

In this chapter, we reviewed basic concepts related to emotion and learning, and summarized research on emotional design in digital media for learning. We then presented a theoretical framework of learning from digital media that highlights the intertwined and interconnected nature of emotion and learning. This framework shows the importance of considering emotional design factors in addition to cognitive design factors when designing multimedia learning materials. We concluded the chapter by developing a research agenda for the study of emotional design for multimedia learning. It is our hope that this chapter, as well as the other chapters in this volume, will influence the discourse both in academic and professional learning design communities to add considerations about learners' affect to the cognitive and sociocultural considerations that are still currently dominant.

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