5 Emotional Foundations of Game-Based Learning

Kristina Loderer, Reinhard Pekrun, and Jan L. Plass

Emotional Foundations of Game-Based Learning: The Basic "What" and "Why"

By some estimates, the average student will have spent 10,000 hours playing computer-based games by age 21—as much time as they will have spent at school (McGonigal, 2010). Therefore, taking advantage of students' motivation to engage in gaming to help them acquire knowledge seems to be an especially promising way to advance learning in the twenty-first century. However, the mechanisms underlying successful game-based learning (GBL) remain poorly understood. In this chapter, we focus on one important group of factors that likely shape digital GBL: learners' emotions.

Increasing learners' enjoyment and alleviating boredom are often advertised as major selling points of GBL. The National Foundation for Educational Research, for instance, lists "learning through intense enjoyment" as one of the constitutive features of digital GBL (Perrotta, Featherstone, Aston, & Houghton, 2013, p. 9). However, research shows that GBL involves not only enjoyment but also periods of frustration, boredom, or confusion (e.g., Conati & Gutica, 2016). Moreover, comparisons of GBL and non–game-based learning environments have produced mixed results with regard to their relative effectiveness in promoting enjoyment and reducing negative emotions (Rodrigo & Baker, 2011). At the same time, research indicates that emotions can strongly impact learners' processing of information as well as their motivation to learn, and, as a result, overall learning outcomes (Pekrun & Linnenbrink-Garcia, 2014a). Consequently, any comprehensive attempt to understand and harness the educational affordances of GBL will have to include its emotional foundations. Specifically, it requires consideration of *antecedents* of different emotions, including specific features of GBL environments (GBLEs), learner differences, and interactions between these variables, as well as *effects* of these emotions on learning.

This chapter provides a review of these emotional foundations of digital GBL. We first provide examples of emotion-relevant elements of GBL, using the well-studied intelligent game *Crystal Island* (Rowe, Shores, Mott, & Lester, 2011) as a case study. Next, we define emotion and discuss types of emotions relevant to GBL. We then offer an integrative model of the emotional foundations of GBL and use this model to review the extant literature. Finally, we derive implications for the design of emotionally sound GBLEs and outline directions for future research.

Incorporating Emotions into GBL: The Case of *Crystal Island*

Crystal Island (Lester, McQuiggan, & Sabourin, 2011) is an intelligent learning environment that leverages several components of the emotional pull of games for learning middle school biology. It centers on a narrative designed to lure players into the game and keep them emotionally engaged throughout the learning experience. Players take on the role of a medical field agent given the task of identifying and curing an infectious disease that has mysteriously befallen a team of researchers stationed on an island. This emotional immersion is supported by 3-D visuals depicting a volcanic island landscape as well as a host of lifelike embodied agents with which players interact in their quest to solve the medical mystery and save the infected patients (see figure 5.1).

Crystal Island seeks to foster autonomous, inquiry-based learning by allowing students to explore the island, collect clues, and test hypotheses by using virtual lab equipment to identify the contaminant at their own pace. These opportunities for self-directed learning are balanced with direct instruction through virtual personnel as well as a worksheet designed to scaffold learners' recording of information, hypotheses, and diagnoses (figure 5.2). The dynamic decision-network-based architecture of the game tracks and adapts to students' learning progress, providing informative feedback through pedagogical agents and action-contingent changes in the virtual world. These design features are aimed at sustaining curiosity and enjoyment while preventing boredom or frustration by providing sufficient challenge and facilitating mastery.

Recent work on *Crystal Island* has included automatic affect recognition and provision of affective support, which may entail changes in the GBLE (e.g., providing metacognitive prompts) or involve emotionally responsive, empathic agents (Lester et al.,

Figure 5.1
Crystal Island volcanic landscape and camp nurse with an infected patient in the virtual infirmary (Lester, Ha, Lee, Mott, Rowe, & Sabourin, 2013).

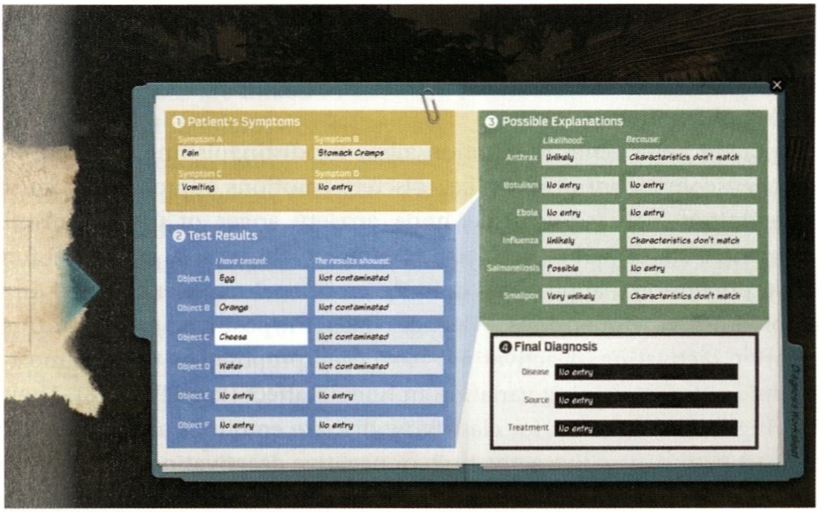

Figure 5.2
Diagnosis worksheet for data collection and evaluation in *Crystal Island* (Lester, Ha, Lee, Mott, Rowe, & Sabourin, 2013).

2011). These agents mimic learners' emotions and signal understanding, or exhibit a different emotional state to enhance the learner's emotional condition. Thus, *Crystal Island* deploys a variety of strategies to promote emotions that are adaptive for learning and students' well-being. Similar principles have been incorporated in other GBLEs as well, including, for example, the motivationally enhanced game-based reading comprehension tutor *iSTART-ME* (Jackson & McNamara, 2013), the narrative-centered math game *Heroes of Math Island* (e.g., Conati & Gutica, 2016), or the simulation game *The Incredible Machine* (Sierra Online Inc., 2001), designed to teach various physics principles through interactive puzzles.

Constructs of Emotion

Definition of Emotion

Emotions constitute reactions to environmental (e.g., an exam situation) or person-internal events (e.g., recalling past experiences of an exam). They consist of multiple coordinated processes, which include (1) *affective components*, including subjective feelings (e.g., positive excitement connected to enjoyment); (2) *cognitive components*, consisting of emotion-specific thoughts (e.g., confidence in one's ability to solve a current task); (3) *physiological components*, supporting concomitant action (e.g., physiological activation for enjoyment); (4) *motivational components*, encompassing behavioral tendencies (e.g., tendencies to approach and invest effort in enjoyment); and (5) *expressive* *components*, including facial, postural, and vocal expression (e.g., speaking in a firm voice; Shuman & Scherer, 2014).

Classification of Emotions

Multicomponent approaches to emotion allow for distinguishing different emotions based on their component profiles (i.e., discrete emotions approach). From this perspective, emotions such as joy, pride, hope, anxiety, anger, or shame constitute distinct experiential states that serve specific cognitive, behavioral, and social functions. In contrast, dimensional approaches describe emotional experience based on a small number of affective dimensions. Valence (pleasant/positive, unpleasant/negative) and activation (activating, deactivating) have been proposed as the two most important dimensions for explaining variation in human affect (Russell, 1978). They can be viewed as higher-order factors for classifying discrete emotions as positive activating, positive deactivating, negative activating, or negative deactivating (table 5.1). In addition, emotions can be grouped according to their object focus; that is, the type of event at which they are directed (Pekrun, 2006). Object focus is important because it determines whether emotions pertain to the learning task at hand or not, thus influencing

Table 5.1
Valence × activation classification of learning-relevant emotions

	Valence	
Activation	Positive (pleasant)	Negative (unpleasant)
Activating	Enjoyment	Anxiety
	Hope	Anger
	Pride	Frustration[a]
	Gratitude	Shame
	Admiration	Envy
	Surprise[b]	Surprise[b]
	Curiosity	Confusion
Deactivating	Relief	Disappointment
	Contentment	Frustration[a]
	Relaxation	Boredom
		Sadness
		Hopelessness

Note: This classification is derived from established taxonomies of achievement emotions (Pekrun & Perry, 2014) and epistemic emotions (Pekrun et al., 2017).
[a] Frustration can comprise elements of (activating) anger and (deactivating) disappointment.
[b] Valence may vary based on the emotion-eliciting event (positive, negative).

their functions for learning. With regard to learning, including GBL, the following groups of emotions may be most important.

Achievement emotions are linked to activities or outcomes that are judged according to competence-based standards of quality. Emotions tied to achievement activities such as enjoyment or boredom during learning are referred to as *activity emotions*. Emotions that relate to success and failure outcomes are *outcome emotions*. These include prospective emotions such as anxiety or hope, focusing on future failures and successes, as well as retrospective emotions related to past achievement, such as pride, relief, shame, and disappointment.

Epistemic emotions are caused by cognitive qualities of task information and the processing of that information, such as surprise, curiosity, or confusion. They have been labeled epistemic because they pertain to epistemic aspects of cognitive activities, including knowledge acquisition (Brun & Kuenzle, 2008; Pekrun, Vogl, Muis, & Sinatra, 2017).

Social emotions include social achievement emotions, such as admiration or envy, that are related to the successes and failures of others, as well as social emotions, such as sympathy or hate, that pertain to the qualities of interpersonal relationships. In GBL, such emotions may arise when interacting with fellow learner-players (Brom, Šisler, Slussareff, Selmbacherová, & Hlávka, 2016) or game characters (Kim & Baylor, 2006). Both subgroups of emotions can influence learners' engagement (Linnenbrink-Garcia, Rogat, & Koskey, 2011).

Topic emotions are elicited by the contents covered by material to be learned. These may be of an empathic nature and, for instance, evoked by the fate of a virtual character. Other examples include emotions related to controversial scientific events, including anger and frustration when learning about climate change, for example, with the educational game *Mission Green* (Ghafi, Karunungan de Ramos, Klein, Lombana Diaz, & Songtao, 2011).

Aesthetic emotions are affective responses to the qualities of visual and performing arts (Scherer, 2005). Examples include awe, admiration, disgust, joy, or sadness, imbued, for instance, by specific musical arrangements (Silvia, 2009). Adaptive functions of these emotions involve experiencing pleasure, regulating arousal levels, or social bonding (Scherer & Coutinho, 2013). Aesthetic emotions are linked to peripheral elements of the environment but may nevertheless shape learning.

Technology emotions are responses to specific technology. Scholarly interest in these emotions can be traced back to the 1990s and the spread of information technologies into educational, organizational, and private realms. The initial focus was on computer anxiety (Powell, 2013) and resulted in the development of emotionally grounded models of technology use and acceptance (Davis, 1989) that are still relevant in today's media-saturated societies (consider, for instance, experiences of frustration caused by limited internet speed; see Butz, Stupnisky, & Pekrun, 2015). Technological advances and increasing functional complexity may thus induce both positive and negative emotions toward the learning environment that, in turn, influence task-related engagement.

Learners may also be experiencing *incidental emotions* that are triggered by events outside the learning environment (e.g., disputes with siblings). While these are not directly tied to learning, they may nevertheless shape learners' engagement in a task. For instance, an individual experiencing negative emotions may have difficulty focusing on the task at hand.

For most emotions, object focus may vary. For example, frustration may be triggered by perceptions of personal incompetence (achievement focus), cognitive incongruity resulting from an unsolved task (epistemic focus), contents such as manmade pollution (topic emotions), or ongoing hindrances in using the digital interface to interact with a learning game (technology focus). As such, attending to the object focus of emotions is also pivotal for a deeper understanding of the emotional impacts of different GBLEs.

Emotional Foundations of GBL: An Integrative Framework

As illustrated, GBL is laden with a multitude of emotions that may relate to different aspects of the learning situation. In this section, we propose an integrative model of emotional foundations of GBL that aims to take this emotional diversity into account while highlighting common mechanisms of these emotions that can guide the design of emotionally sound GBLEs (see figure 5.3). The basic structure of this model is provided by the control-value theory (CVT) of achievement emotions (Pekrun, 2006; Pekrun & Perry, 2014), a platform for research on emotions and learning across different research paradigms and educational environments. We extend this framework to other groups of learning-relevant emotions by considering the emotional impact of cognitive incongruity (Graesser, D'Mello, & Strain, 2014; Muis, Pekrun, et al., 2015), Plass and Kaplan's (2016) integrated cognitive affective model of multimedia learning (ICALM), and the intelligent tutoring and games framework (ITaG; McNamara, Jackson, & Graesser, 2010), which systematizes affective functions of GBLE features. We first address the antecedents of emotions in GBL, then discuss their functions for learning, and finally deduce principles for designing GBLEs from an emotional perspective.

Antecedents of Emotions in GBLEs

Emotions can be stimulated by different factors. Our model considers two groups of proximal factors that may be particularly important in GBLEs: (1) appraisals of the self and situational contingencies (arrow 1 in figure 5.3) and (2) emotional transmission from (actual or virtual) peers or instructors as well as other GBLE features (e.g., musical score, arrow 2 in figure 5.3). The influence of distal factors such as learner characteristics and GBLE features are thought to be mediated by these factors.

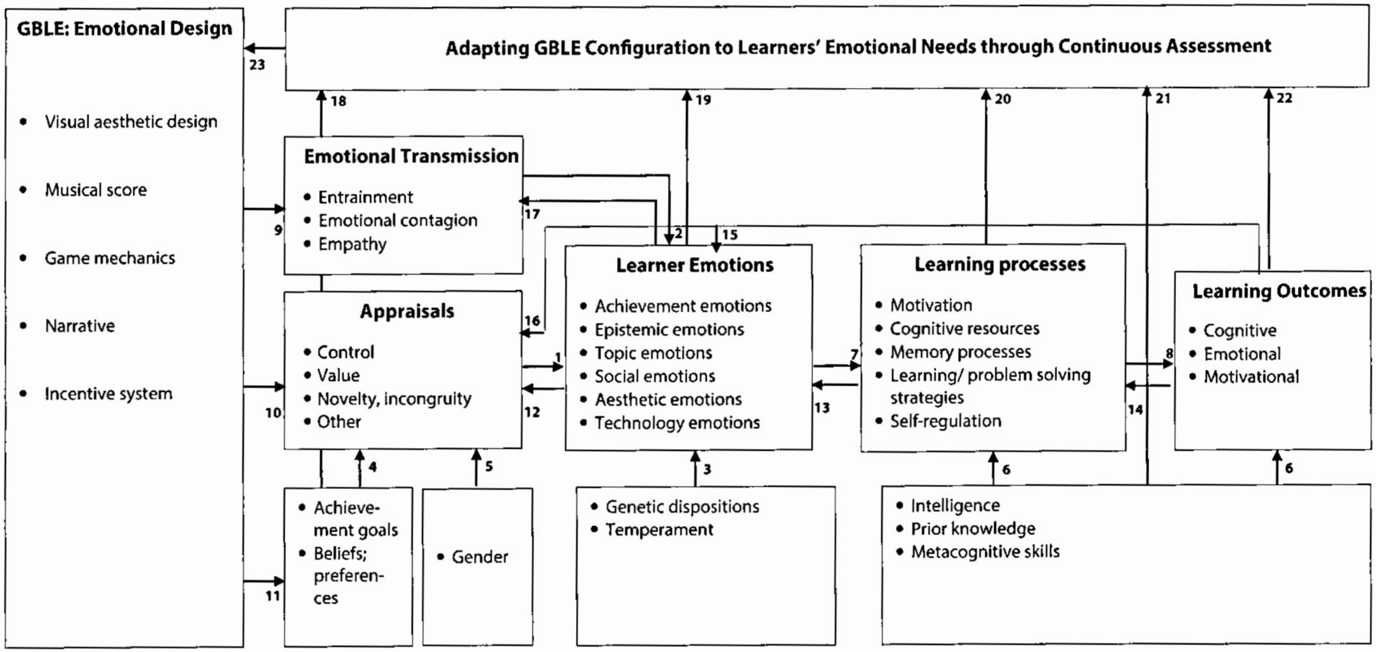

Figure 5.3
Integrative model of emotional foundations of GBL.

Proximal antecedents: appraisal processes Appraisal theories postulate that "usually, people's emotions arise from their perceptions of their circumstances" (Ellsworth & Scherer, 2003, p. 572). Appraisals are critically important in preparing adaptive thought and action via emotion in settings that are shaped by cultural evolution and thus require careful interpretation of situational demands, such as learning and achievement settings. Depending on the type of emotion, appraisals can relate to different aspects of an event.

Achievement emotions According to the CVT, achievement emotions are determined by the perceived controllability and value of achievement activities and outcomes. *Perceived control* pertains to the extent to which one is in command in a given achievement situation, as implied by causal expectancies regarding future tasks (self-efficacy and outcome expectations), causal attributions of success and failure, and competence appraisals (e.g., self-concepts of ability; see Pekrun, 2006). *Perceived value* includes subjective importance (e.g., stemming from interest or instrumental usefulness) as well as direction (positive vs. negative; i.e., goal congruence in terms of events either supporting or impeding goal attainment). Rewards or punishments are key game elements that shape achievement values and related emotions. The lowered emphasis of failure in GBLEs as compared with classroom-based achievement situations may also impact learners' value perceptions by shifting the focus from avoiding failure to embracing mistakes as a natural part of learning, which we have described as graceful failure (Plass, Homer, & Kinzer, 2015).

The CVT posits that achievement emotions are a joint function of perceived control and value (table 5.2). For outcome emotions, expectancies (prospective outcome emotions; e.g., hope or anxiety) and attributions (retrospective outcome emotions; e.g., pride or shame) are considered important. However, retrospective joy, sadness, or frustration may be directly induced by perceived successes or failures (Weiner, 1985). For activity emotions, appraisals of personal competence as well as value are seen as primary antecedents. Both sufficient control and positive value are required for positive achievement emotions, whereas negative achievement emotions are linked to appraisals of low control and sufficient negative value. Boredom, in contrast, is linked to lack of either positive or negative value (see the summary of supporting evidence in Pekrun & Perry, 2014; see also Putwain et al., 2018, for recent empirical support of these assumptions).

Epistemic emotions Epistemic emotions arise when tasks produce cognitive incongruity; for instance, by presenting unexpected, contradictory, or complex information (e.g., Vogl, Pekrun, Murayama, & Loderer, 2019). In the game *Operation ARIES!* (Millis et al., 2011), designed to teach scientific critical thinking, learners engage in trialogues with an expert agent and a peerlike student agent to discuss the methodological qualities of empirical studies. To induce incongruity, the agents are staged to disagree on

Table 5.2
Typical appraisal combinations for major achievement emotions

		Appraisal	
Emotion	Typical scenario	Control	Value
Prospective outcome emotions			
Joy	High expectation of success	High	Positive
Hope	Uncertain expectation of success	Moderate	Positive
Anxiety	Uncertain expectation of failure	Moderate	Negative
Hopelessness	Low expectation of success or high expectation of failure	Low	Positive/ negative
Retrospective outcome emotions			
Joy	Success	Irrelevant	Positive
Sadness	Failure	Irrelevant	Negative
Relief	Unexpected success	Low	Positive
Disappointment	Unexpected failure	Low	Negative
Pride	Success caused by internal factors	Internal	Positive
Shame	Failure caused by internal factors	Internal	Negative
Gratitude	Success caused by others' actions	External	Positive
Anger	Failure caused by others' actions or one's own lack of effort	External/ internal	Negative
Activity emotions			
Joy	Positive evaluation of current task	High	Positive
Anger	Negative evaluation of current task (e.g., as aversively requiring effort)	High	Negative
Frustration	Current task involves obstacles	Low	Negative
Boredom	Current task is either insufficiently or exceedingly challenging	High or low	None

Note: Value refers to the valence of the emotion-eliciting event, with positive=pleasant activity/ positive outcome (success) and negative=unpleasant activity/negative outcome (failure). For hopelessness, the focus may either be on unattainable success (positive outcome) or unavoidable failure (negative outcome).

Adapted from Pekrun (2006).

their evaluations of study designs. A typical sequence of epistemic emotions experienced in this context can include (1) surprise over the agents' disagreement, (2) curiosity if surprise is not fully dissolved, (3) confusion if incongruity increases as both game agents provide compelling arguments, (3) anxiety in the case of severe incongruity and information that disturbs existing beliefs, (4) enjoyment when the problem is solved, or (5) frustration or boredom when cognitive equilibrium cannot be restored (Graesser et al., 2014).

In addition to cognitive incongruity, epistemic emotions can be linked to changes in learners' control-value appraisals. Perceptions of epistemic control can derive from the degree of complexity and uncertainty ascribed to cognitive tasks embedded in the learning game, as well as one's perceived ability to cope with this complexity and overcome uncertainty. The extent to which activities are judged to be important and either stimulating (positive) or aversive and uninteresting (negative) contributes to the perceived epistemic value of the in-game activities.

Social emotions Control-value appraisals may also contribute to the arousal of social emotions. Weiner (1985, 1995) proposed that an individual should experience envy over another's success if they attribute this success to that person's (uncontrollable) ability rather than their (controllable) effort. This approach can be extended by considering the individual's self-directed appraisals of control. Specifically, individuals may envy others for their successes if they perceive their own control over their achievement to be low. In this constellation, others' successes or one's personal failures are often viewed as undeserved (Feather, 2006). In contrast, if others' successes are perceived as deserved, admiration may be triggered.

If another person fails, sympathy or compassion may arise if the individual feels in control over their own achievement while perceiving the other person as lacking control, undeservingly. Perceiving others' failures as deserved, however, may evoke schadenfreude (i.e., joy over another's misfortune). Such emotions may be particularly relevant in GBLEs in which students compete with other learners or virtual agents or are at least aware of each other's progress and game score as in the competitive variant of *Factor Reactor*, a game designed to train arithmetic fluency in middle school students (Plass et al., 2013).

Learning may also involve social emotions beyond achievement. Socially oriented appraisals underlying relationship-focused emotions may also involve control and value. These are likely linked to perceptions of status (i.e., acceptance vs. rejection) in the case of internally directed control appraisals, responsibility and intention in the case of external control, and general like versus dislike of others and the importance attached to specific relationships (Hareli & Parkinson, 2008). Such affiliative affect may be brought into GBL contexts through real-life or virtual interactions between learners who already know each other. They can also arise in GBLEs that include more extensive social interaction, for instance to enhance conceptual learning through joint elaboration (Meluso, Zheng, Spires, & Lester, 2012) or to train social-emotional skills (Nikolayev, Clark, & Reich, 2016).

Topic emotions and aesthetic emotions Appraisal antecedents of these emotions have been less studied. Recent work on emotions in science learning has emphasized learners' individual interest toward topics (Hidi & Renninger, 2006) in shaping perceived value. Positive values of a topic should foster positive emotions such as enjoyment, whereas negatively valued topics may trigger content-related anxiety (e.g., when learning about potential consequences of sociopolitical conflicts) or anger (e.g., when firm believers of creationism are confronted with evolutionary perspectives). Individuals' convictions regarding the (un)controllability of such events likely also play a role in the arousal of topic-related emotions, as suggested by studies examining students' learning about environmental issues in hypermedia environments (e.g., Zumbach, Reimann, & Koch, 2001).

Aesthetic emotional experience has also been conceptualized as a matter of personal perception. Important evaluative dimensions are intrinsic pleasantness (e.g., sensory consonance or harmony versus dissonance), controllability of the design (e.g., options for adjusting color schemes to one's preferences), and novelty. GBLE designs evaluated as pleasant, stimulating, and controllable are linked to increased positive emotions, whereas the opposite pattern is characteristic of negative aesthetic emotions (Silvia, 2005).

Technology emotions Personal control over and value of digital tools also impact learners emotionally. Many factors can influence perceived controllability of technological devices, including design elements that either facilitate or hinder ease of navigation. In combination with perceived utility versus inadequacy of technology, control is expected to prompt different emotions in similar ways as it influences achievement emotions (table 5.2). For example, technology-related enjoyment is linked to high control and high positive value (e.g., usefulness), whereas lower levels of control and lack of value assigned to technology are likely precursors of negative emotions such as anxiety or frustration (Butz et al., 2015).

Empirical evidence Barring differences in the specific referents of appraisal, we suggest a common control-value appraisal pattern across different groups of emotions: subjective control is posited to alleviate negative emotions and strengthen positive ones, while ascriptions of personal importance should generally intensify emotional experiences. Boredom is seen as an exception, as it can involve perceptions of excessive personal control and is typically intensified by lack of value (Pekrun, 2006).

Classroom-based research has confirmed that perceived control over learning relates positively to students' enjoyment, hope, and pride and negatively to their anger, anxiety, shame, hopelessness, and boredom (see the reviews in Pekrun & Perry, 2014; Pekrun, 2018). Similar links have been found for students enrolled in online courses (Artino, 2009; Marchand & Gutierrez, 2012) or interacting with multimedia (Stark, Malkmus, Stark, Brünken, & Park, 2018) as well as virtual reality environments (Noteborn, Bohle Carbonell, Dailey-Hebert, & Gijselaers, 2012). The perceived value of learning is positively related to both positive and negative emotions, except boredom (e.g., Artino & Jones, 2012), confirming that the importance of success and failure amplifies these emotions except for boredom. Initial evidence suggests that the relevance of control-value appraisals extends to emotions in GBLEs (Sabourin & Lester, 2014).

Similarly, studies on epistemic emotions during learning have reported positive associations between perceived epistemic control and curiosity as well as enjoyment, and negative associations with confusion, frustration, and boredom (Muis, Psaradellis, et al., 2015). Task value correlated positively with curiosity and enjoyment and negatively with boredom (Muis, Psaradellis, et al., 2015; Pekrun et al., 2017). These relations of perceived competence and value with curiosity or confusion have also been observed within *Crystal Island* (Sabourin & Lester, 2014). Furthermore, several studies support the proposed role of control and value in the elicitation of social achievement emotions (e.g., Rudolph & Tscharaktschiew, 2014). Finally, Butz et al. (2015, 2016) gathered evidence for the appraisal profiles of technology emotions. Perceptions of control and usefulness of technology related positively to enjoyment of technology use and negatively to anxiety, anger, and boredom.

Taken together, research corroborates the relevance of control-value appraisals for different groups of emotions. Most of the available evidence stems from research involving learning that is not game based. However, basic functional mechanisms of emotions, including their appraisal structures, are posited to generalize across different learning settings (see section on contextual specificity versus relative universality of emotions). A recent meta-analysis of emotions in technology-based learning environments supports this claim (Loderer, Pekrun, & Lester, 2018). Mean correlations between control-value appraisals and emotions followed the theoretically expected patterns and remained fairly robust across different types of environments.

Proximal antecedents: emotional transmission Pathways to emotion include affective attunement to sensory input (e.g., pictures, music) as well as emotions displayed by others. Scherer and Coutinho (2013) distinguish three types of emotional transmission: entrainment, contagion, and empathy (arrow 2 in figure 5.3).

Entrainment has been defined as "the process through which two physical or biological systems become synchronized by virtue of interacting with each other" (Trost, Labbé, & Grandjean, 2017, p. 96). Research has focused on synchronization of autonomic physiological (e.g., cardiac activity) and sensorimotor processes (i.e., movement) with external auditory rhythms of musical pieces (e.g., beat, tempo). Entrainment subconsciously drives changes in emotions by influencing physiological and motor-expressive components, a mechanism that may be particularly pertinent to the arousal of aesthetic emotions (Scherer & Coutinho, 2013). Importantly, this mechanism may help explain previously observed effects of musical score on videogame players' (e.g., Hébert, Béland, Dionne-Fournelle, Crête, & Lupien, 2005; Lipscomb & Zehnder, 2004; see also Eich, Ng, Macaulay, Percy, & Grebneva, 2007) and learners' (Dickey, 2015) emotions.

Emotions can also be "caught" directly from external stimuli by means of *emotional contagion*. Emotional contagion constitutes a largely unconscious process driven by observation and automatic mimicry of expressive cues of others (e.g., facial expression;

see Hatfield, Cacioppo, & Rapson, 1994). Emotional contagion is likely an important driver of convergence between teacher and student emotions in the classroom (Frenzel, Becker-Kurz, Pekrun, Goetz, & Lüdtke, 2018). Such contagion may also occur in GBLEs. An example is collaborative learning games that allow social interactions with fellow learners supported by video or voice chat (Admiraal, Huizenga, Akkerman, & ten Dam, 2011). Similarly, emotions expressed by digital agents may carry over to learners (Gratch & Marsella, 2005). For example, Krämer et al. (2013) showed that participants interacting with smiling agents smiled longer than those interacting with nonsmiling agents.

In digital and game-based learning, empathy has been examined for empathic environments that automatically infer and respond to learners' emotions through agents' emotional displays (D'Mello & Graesser, 2012; McQuiggan & Lester, 2007). Conversely, learners may attempt to understand emotions expressed by others. For instance, bored learners may be intrigued by agents overtly enjoying a task and feel into this positive emotion by decoding and reenacting its underlying appraisals. Similarly, in collaborative GBL, learners may share their peer's expressed frustration at not being able to solve a task (Järvenoja & Järvelä, 2005).

Distal antecedents: learner characteristics Individual characteristics of learners may influence their emotional experiences during GBL. This includes physiologically bound temperament (arrow 3 in figure 5.3; see also Stemmler & Wacker, 2010). Other central factors are learners' achievement goals, implicit theories of intelligence, epistemic beliefs, aesthetic preferences, gender, and cognitive abilities (arrows 4–6 in figure 5.3).

Mastery-approach goals focused on task mastery and personal improvement should direct learners' attention toward the controllability and positive values of learning activities, thus fostering enjoyment of learning and reducing boredom. In contrast, *performance-approach goals* focused on outperforming others should direct attention toward positive outcome appraisals, and *performance-avoidance goals* focused on avoiding being outperformed by others should shift attention toward negative outcome appraisals, thus facilitating positive or negative outcome emotions, respectively. These relations have been observed in traditional classroom settings (Pekrun, Elliot, & Maier, 2006) and in online courses (Yang & Taylor, 2013). Few studies have examined the role of achievement goals for learners' emotions in GBLEs (for an exception, see McQuiggan, Robison, & Lester, 2010).

Learners' *implicit theories of intelligence* (Dweck & Leggett, 1988) are thought to influence subjective control over learning and thus the arousal of emotions. Learners who believe that ability is malleable (incremental theorists) exhibit higher subjective control than learners who view ability as a fixed, inborn trait (entity theorists; King, McInerney, & Watkins, 2012). Initial research indicates that positive emotions in digital learning and GBL are linked to incremental beliefs, and negative emotions, such as anxiety, are linked to entity beliefs (Arroyo, Burleson, Tai, Muldner, & Woolf, 2013; Tempelaar, Niculescu, Rienties, Gijselaers, & Giesbers, 2012).

Gender is expected to influence appraisals and emotions based on gender stereotypes regarding competencies in different subject domains. For example, females typically report less enjoyment and more anxiety, shame, and hopelessness in mathematics than males do (Chang & Beilock, 2016; Frenzel, Pekrun, & Goetz, 2007). These differences were driven by differences in control-value appraisals, with females reporting lower competence beliefs and less intrinsic value of mathematics (Frenzel, Pekrun, & Goetz, 2007). These patterns have also been obtained with learners taking online mathematics and statistics classes (Tempelaar et al., 2012) or interacting with gamified intelligent math tutoring systems (Arroyo et al., 2013).

Gender stereotypes may also explain differences in technology emotions considering that technology is still largely viewed as a male domain. Girls still report significantly less experience with as well as enjoyment of computers and GBL (Admiraal et al., 2014). Gender may also be linked to preferences for game design. Girls have been found to prefer narrative development and cooperative games, whereas boys tend to prefer games with competitive elements (Admiraal et al., 2014). However, while preadolescent boys spend significantly more time (up to 13 hours per week) playing games than girls do, many girls also favor stereotypically male videogame genres, including first-person shooter games, suggesting that traditional gender differences may be disappearing (Homer, Hayward, Frye, & Plass, 2012).

Epistemic beliefs regarding the nature of knowledge and knowing influence the arousal of epistemic emotions (Muis, Pekrun, et al., 2015). Cognitive incongruity arising from misalignment between individuals' beliefs and the cognitive quality of a specific learning task may increase perceptions of value resulting from novelty but decrease perceived control, which should give rise to different emotions (Trevors, Muis, Pekrun, Sinatra, & Muijselaar, 2017). Accordingly, when confronted with learning material presenting divergent views on a topic, individuals who view knowledge as consisting of definite information determined by a single authority are likely to experience surprise, confusion, anxiety, or frustration. In contrast, those who endorse constructivist beliefs and view knowledge as complex and requiring careful evaluation may experience curiosity and enjoyment (Muis, Pekrun, et al., 2015). As such, GBLEs may differ in their epistemic appeal to individuals.

Individuals may also differ in their *aesthetic preferences* regarding color schemes or musical arrangements (Plass & Kaplan, 2016; Street, Forsythe, Reilly, Taylor, & Helmy, 2016) that influence how they respond emotionally to GBLE design. Recent research has also sought to identify links between aesthetic emotions and personality traits. Fayn, MacCann, Tiliopoulos, and Silvia (2015) showed that individuals higher on the Big Five trait "openness to experience" are more likely to experience interest when confronted with novel or unusual design elements.

As *cognitive ability* and *prior knowledge* influence achievement, they facilitate positive achievement emotions and reduce negative ones. This link may be mediated by the impact of success and failure on appraisals of control and value (Reeve, Bonaccio, & Winford, 2014). Similarly, prior experience with technology typically shows positive relations with positive technology-focused emotions such as enjoyment and negative relations with negative technology-focused emotions (e.g., Cheung & Sachs, 2006).

Distal antecedents: emotional design of GBLEs Our model posits that characteristics of GBL can affect learners' emotions by influencing their appraisals, by emotional transmission, and by shaping their beliefs (arrows 9–11 in figure 5.3). This opens a wealth of possibilities for creating emotionally sound GBLEs, which we will discuss. As design decisions should be guided by knowledge regarding adaptive and maladaptive functions of emotions for GBL, we first examine how different emotions may foster or impede learning with games.

Functions of Emotions for GBL

Both the cognitive-motivational model of emotion effects that is part of the CVT (Pekrun, 2006) and the ICALM (Plass & Kaplan, 2016) argue that emotions impact learning outcomes through cognitive and motivational mechanisms (arrows 7 and 8 in figure 5.3). This idea is grounded in research showing that affective states influence learning-relevant cognitive processes such as allocation of attention, memory storage and retrieval, and problem solving, as well as motivational tendencies and behavior (Barrett, Lewis, & Haviland-Jones, 2016). We consider four mechanisms that are of particular importance.

Motivational processes Positive activating emotions (table 5.1) can mobilize motivational energy and fuel learning. Specifically, enjoyment and curiosity during gameplay can reinforce investment of effort in learning tasks (e.g., Vogl et al., 2019). Positive outcome emotions such as pride of having mastered a difficult task and subsequently feeling hopeful in tackling the next game level can also provide powerful sources of motivation to learn. This may apply to positive social achievement emotions as well, such as admiring others.

Negative motivational effects are expected for negative deactivating emotions such as boredom aroused by monotonous narrative structures of GBLEs, or hopelessness emerging from repeated failures to complete tasks and proceed through the game. Boredom especially may increase tendencies to engage in off-task behavior such as playing around with personalization features of one's game avatar (Snow, Jackson, Varner, & McNamara, 2013) or gaming the system; that is, attempting to "succeed in an educational environment by exploiting properties of the system's help and feedback rather than by attempting to learn the material" (Baker et al., 2008, p. 186). Gaming the system to avoid learning is commonly observed not only in intelligent tutoring systems or online course formats but also in learning games intended to engage students through fun activities and aesthetically appealing design (Baker, D'Mello, Rodrigo, & Graesser, 2010; Loderer et al., 2018).

Positive deactivating and negative activating emotions often have variable motivational effects. Positive deactivating emotions such as relief over unexpected success can undermine immediate motivation to invest effort but may reinforce commitment to individuals' achievement goals and reengagement with the learning task in the long term. Negative activating emotions such as anxiety and shame can undermine intrinsic motivation to learn but can induce strong extrinsic motivation to increase effort and avoid failure, which has been observed both in the classroom (Turner & Schallert, 2001) and across various digital learning environments (Loderer et al., 2018). Anger or envy in response to others' achievements may also motivate students to learn more and outperform peers.

Cognitive resources Resource allocation models of emotion (Ellis & Ashbrook, 1988), as well as cognitive load theory (Sweller, 1994), suggest that emotions impose an extraneous cognitive load; that is, they make demands on working-memory resources, which are then not available to perform complex tasks. The CVT and ICALM propose a more nuanced view that considers the object focus of emotions. Emotions with task-external referents, such as joy over weekend plans or frustration about nonfunctioning technology, disrupt attentional focus. In contrast, enjoyment or curiosity targeted at the learning activity may focus attention on task completion. Multimedia learning studies employing eye tracking to measure attention indicate that positive emotions induced via autobiographical recall prior to learning can distract attention and undermine learning (Knörzer, Brünken, & Park, 2016). However, positive states induced through visual elements of multimedia environments can reduce self-reported cognitive load (Plass, Heidig, Hayward, Homer, & Um, 2014; Um, Plass, Hayward, & Homer, 2012) and sustain attentional focus on relevant information (Park, Knörzer, Plass, & Brünken, 2015). Recent work has also shown that decorative pictures accompanying instructional texts in multimedia learning environments can be beneficial for learning when pictures have a positive affective charge and are strongly connected to the content of the material to be learned (Schneider, Dyrna, Meier, Beege, & Rey, 2018).

These positive effects stand in contrast to negative effects *seductive details* have on learning gains (e.g., Lehman, Schraw, McCrudden, & Hartley, 2007). One explanation for positive effects of some features of aesthetic design may be that these features prompt low-intensity positive moods that boost learners' motivation to stay focused without distracting attention away from relevant material (Park, Flowerday, & Brünken, 2015).

Memory processes and learning strategies Emotions facilitate different modes of processing contents covered by GBLEs. Experimental mood research indicates that positive states promote top-down, relational, and flexible processing, whereas negative states lead to bottom-up, analytical, and more rigid thinking (Fiedler & Beier, 2014). One implication is that emotions impact storage and retrieval of learning material. While positive emotions can lead to enhanced integration of information in memory, negative states can increase precision in processing single units of information (Spachtholz, Kuhbandner, & Pekrun, 2014; see also Kuhbandner & Pekrun, 2013, for affective influences on retrieval-induced forgetting). This is likely to be the case during GBL as well.

Accordingly, positive activating emotions should promote the use of flexible and deep learning strategies such as elaboration, organization of material, or critical thinking. However, select negative activating emotions such as confusion may also catalyze critical thinking and elaborative processing as a means of reducing cognitive incongruity during gameplay. Negative activating emotions such as anxiety or shame, in turn, should primarily facilitate rigid rehearsal of material. In contrast, deactivating emotions can undermine any strategic efforts, yielding superficial processing. This may be particularly true for negative deactivating emotions such as boredom or hopelessness.

Supporting evidence can be found not only for emotions in traditional learning environments (Pekrun & Linnenbrink-Garcia, 2014a) but also in digital learning environments (Artino & Jones, 2012; Loderer et al., 2018; Plass et al., 2014; Um et al., 2012). For GBL, Sabourin and Lester (2014) showed how students' emotions related to their inquiry strategies in solving *Crystal Island*'s mystery. Students reporting enjoyment and curiosity engaged in more effective problem solving by gathering goal-relevant information and testing meaningful hypotheses as compared with learners who experienced frustration or boredom. Curiosity was positively related and boredom negatively related to problem-solving efficiency (i.e., number of lab tests conducted, time taken to deduce the solution).

Self-regulation of learning Self-regulation requires flexibility to adapt thought and action to task demands and individual goals (Azevedo, Johnson, Chauncey, & Burkett, 2010). This is particularly important in GBLEs that put learners in charge of managing their own learning, for instance by providing open-ended environments. Because positive activating emotions promote flexible strategy use, they are expected to facilitate self-regulation of learning. Negative emotions, such as anxiety or shame, in turn facilitate reliance on external guidance. In contrast, negative deactivating emotions likely reduce overall engagement in learning. Accordingly, enjoyment and curiosity have been found to relate positively, and boredom to relate negatively, to learners' self-regulation (Artino & Jones, 2012; Muis, Psaradellis, et al., 2015; Pekrun et al., 2002).

Learning outcomes Given the multifaceted impact of emotions on various functional mechanisms of learning, their effects on overall learning outcomes are inevitably complex. Net effects likely depend on the interplay between task demands, learner characteristics (e.g., working-memory capacity, acquired strategies for self-regulating GBL), and different cognitive and motivational processes triggered by emotion. Positive activating emotions likely enhance learning under most conditions. Accordingly, our meta-analysis revealed significant positive relations of enjoyment and curiosity with achievement across diverse technology-based environments, including GBLEs (Loderer et al., 2018). In contrast, negative deactivating emotions, such as boredom, are generally detrimental to learning (Tze, Daniels, & Klassen, 2016).

Achievement effects of positive deactivating and negative activating emotions are more difficult to predict. Positive deactivating emotions may reduce task attention and strategic efforts but increase long-term motivation to learn. It is an open question whether the interplay of these mechanisms facilitates or reduces overall achievement. Negative activating emotions produce task-irrelevant thinking and undermine intrinsic motivation to learn but can promote extrinsic motivation and facilitate rehearsal of contents, which can be conducive to specific GBLE tasks, such as rule memorization. However, the modal impact of these emotions on cognitive outcomes is likely to be negative (Goetz & Hall, 2013).

In sum, emotions are important drivers and not mere by-products of learning. However, simply equating pleasant emotions with positive effects, and unpleasant emotions with negative effects, on learning does not adequately capture the complex ways in which emotions can impact GBL.

Theoretical Corollaries

Feedback loops between emotions, their antecedents, and their outcomes Our model proposes that emotions, their antecedents, and their outcomes are linked by reciprocal causation (arrows 12–17 in figure 5.3; see also Pekrun, 2006). GBLEs and learner characteristics shape emotions through individual appraisals and emotional transmission, and these emotions in turn impact learning. However, emotions can also feed back into learners' appraisals. For instance, being curious about game contents can grow appraisals of intrinsic value of these contents. Furthermore, learning activities and their outcomes reciprocally influence emotions and their antecedents (Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017). Success and failure at learning are critical sources of learners' competence beliefs and the emotions driven by these beliefs.

In classroom contexts, learners' expressed emotions and achievements can shape the reactions of teachers or peers, including emotional responses (e.g., pity) as well as instrumental behavior (e.g., design of appropriate learning tasks). Similarly, during GBL, players' emotions may be reciprocated by emotionally expressive virtual or human instructors or peers. Affect-aware GBLEs offer remediation to combat ineffective learning or uphold adaptive emotions based on real-time diagnosis of learners' cognitive, motivational, or emotional states (Calvo & D'Mello, 2012). Thus, learners' emotions may reciprocally influence the concurrent configuration of GBLEs, which, in turn, shapes their subsequent emotional trajectories (arrows 18–23 in figure 5.3).

Contextual specificity versus relative universality of emotions during learning We extend insights from general emotion research to GBLEs because functional mechanisms of emotions, including their linkages with appraisal antecedents and learning outcomes, are thought to be universal across individuals, genders, subject domains, cultures, and different learning environments. Basic functions of emotions are bound to species-specific characteristics of the human psychological apparatus, such that lawful processes in emotional experience are a genuine, universal characteristic of human nature (Pekrun, 2018).

However, as individuals may differ in their appraisals and susceptibility to emotional transmission, they may respond differently to objectively similar events. This property of emotional functioning is also endorsed by the CVT, which emphasizes that incidence rates, intensity, and decay rates of emotions may vary as a function of individual differences, learning environments, and cultures. An important case in point is differences in emotions experienced in GBLEs versus other learning environments. Playful learning is often described as affectively adaptive, which is supported by studies showing that students who learn with a game report more enjoyment than those receiving standard training (e.g., Jackson & McNamara, 2013). This difference is likely linked to different perceptions of the two environments, with the playful variant triggering evaluations that were more favorable.

Studies examining relative universality have demonstrated that levels of emotions can vary across academic domains, genders, settings (e.g., homework vs. classroom learning), and cultures. However, linkages of emotions with control-value appraisals and achievement are largely invariant across these dimensions (see the review in Pekrun, 2018). Similarly, in the meta-analysis by Loderer et al. (2018), relations between emotions and appraisals, as well as learning outcomes, were largely invariant across type of technology-based learning environment, gender, and cultural context. By implication, the cause-and-effect mechanisms of emotions outlined in the previous sections provide a foundational set of guidelines for designing emotionally sound learning environments. Next, we discuss how these can be realized in game-based settings.

Implications for the Emotional Design of GBLEs

Learning games aim to boost learning outcomes by providing platforms for playful and thus enjoyable interaction with contents. These interactions need to be thoughtfully designed to have this effect (Plass et al., 2015). Merely adding game elements, such as reward systems, to tedious activities or poorly constructed tasks results in environments often described as "chocolate-covered broccoli" (Laurel, 2001) that actually give rise to frustration or boredom. Whereas research on the impact of GBLE design on learner emotions is still sparse, meta-analyses show that differences between motivation during learning games and motivation during nongame instruction are generally small but positive (Clark, Tanner-Smith, & Killingsworth, 2016: $\bar{g} = 0.35$; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013: $\bar{d} = 0.26$).

Learners vary in their beliefs, design preferences, and prior knowledge, predisposing them to different emotional reactions. Learning also involves natural phases of joy, anxiety, confusion, or frustration, especially during complex learning. However, research indicates that applying principles of emotional design can enhance learning for all individuals (Plass & Kaplan, 2016). In this section, we discuss how GBLE design may influence learners' emotions (arrows 9–11 and 18–23 in figure 5.3) and deduce general principles for game design from an emotion perspective. Following the approach in Plass et al. (2015), we will describe the effects of visual aesthetic design, musical score, game mechanics, narrative, and incentive systems.

Visual Aesthetic Design

One of the first features learners notice about an educational game is its "look." According to Egenfeldt-Nielsen, Smith, and Tosca (2008, p. 129), visuals "add to the atmosphere, provide a sense of realism, and generally make the world seem alive." In our meta-analysis, learners' curiosity differed across aesthetic designs of learning environments (Loderer et al., 2018). While visual GBLE design may appear as a superficial quality, learners may disengage or even choose not to play a particular game if its overall look and feel is unappealing (McNamara et al., 2010).

Basic emotion-relevant features of visual design include shape and color. Color influences mood. Wolfson and Case (2000) provide evidence that warm red coloring elicits greater feelings of arousal than cool blue coloring. Um et al. (2012) found that infusing multimedia learning environments with bright and saturated warm colors (yellow, pink, and orange) increased learners' positive emotions and enhanced their comprehension as well as knowledge transfer compared to a neutral environment using grayscale colors, a finding that has been replicated by Mayer and Estrella (2014). However, other findings suggest that the color red may signal "danger" or, in achievement contexts, "failure" (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007; Gil & Le Bigot, 2016), thus prompting negative emotions, whereas green colors can evoke positive associations of hope, growth, and success (Lichtenfeld, Elliot, Maier, & Pekrun, 2012). Moreover, children tend to connect bright colors with positive emotions and dark colors with negative ones (Boyatzis & Varghese, 1994). However, there may be cultural and individual differences in color preference (Taylor, Clifford, & Franklin, 2013) such that it may be useful to adapt color schemes to personal tastes. This can be extended to other visual design elements—enabling learners to modify design aspects such as icons may enhance enjoyment of learning by increasing perceived control and intrinsic value through player autonomy (Cordova & Lepper, 1996).

Shape design can also influence learners' emotions. Plass et al. (2014) showed that round, facelike shapes in a multimedia learning environment induced positive emotions. This may be because round shapes resemble human physiognomy and baby-like qualities connoted with positive attributes such as innocence, safety, and honesty (baby-face bias; see Plass & Kaplan, 2016). Shape and color may also serve to highlight contrast and guide attention to increase positive emotions and reduce negative ones by helping learners experience mastery and personal control. This also applies to higher-order visual effects, such as learning from dynamic simulations of scientific phenomena (Plass, Homer, & Hayward, 2009).

In a similar vein, the visual appearance of agents that are used in some environments may modulate learners' emotions. This can be done simply by adhering to general rules of aesthetics but also by manipulating the perceived similarity between learners and the agent (Domagk, 2010). Physical attractiveness as well as realistic, life-like design and motion can positively impact learners' affective responses to virtual characters (Shiban et al., 2015). Agents that resemble the learner in age, gender, and expertise (i.e., peer vs. expert agents) are more positively evaluated by learners and more effective at increasing positive emotions (Arroyo et al., 2013; Baylor, 2011). In GBLEs that permit learners to create *virtual selves* (i.e., avatars), the ability to customize these avatars positively affects players' identification with them (Turkay & Kinzer, 2014), and fidelity in visual representation likely influences the general intensity of learners' emotional involvement in the game (Yee & Bailenson, 2007). For games based on fantasy worlds or fictional realms, however, agent realism may be less helpful emotionally.

Musical Score

GBLEs often rely on sound and music to enliven their narrative. Auditory stimuli can increase learners' enjoyment by extending the sensory experience. In addition, music may directly influence emotions via rhythmic entrainment or associations to real-world events induced by emotional tone. The addition of audible feedback may increase the perceived pleasantness of gameplay, irrespective of specific audio characteristics (Nacke, Grimshaw, & Lindley, 2010). By exposing participants to several variants of a Mozart sonata, Husain, Thompson, and Schellenberg (2002) found that a higher musical tempo increased perceived arousal, whereas mode (major vs. minor) impacted emotional valence. Enjoyment ratings and subsequent performance on a spatial abilities task were highest for the fast-major rendition, confirming that positive activating states are particularly conducive to cognitive performance.

A closely related design feature is the vocal sound of nonplayer characters. Baylor contends that "research conclusively indicates that having a human (as opposed to a computer-generated) voice is preferable to enhance social presence" and that for the design of nonplayer characters "a human voice can lead to increased interest" (Baylor, 2011, p. 295) since it is perceived as more appealing. According to Nass and Brave (2005), important features to attend to in terms of implementing authentic and pleasant voices concern (1) volume, (2) pitch and prosody, and (3) rate of speech. In addition, vocal sounds may infect learners via emotional contagion. For example, an agent voicing excitement over embarking on an in-game quest may entice learners to join in this positive emotional activation.

Acoustic characteristics of GBLEs may also influence their effectiveness in guiding attention to important contents and emotional events within the game, such as an approaching enemy (Collins, 2009; Pawar, Hovey, & Plass, 2017). Explanations that must be integrated with information presented visually (e.g., diagrams) typically lead to better retention if presented in auditory rather than visual mode, particularly in cases where both sources of information are essential for understanding and are thus complementary (e.g., Fiorella, Vogel-Walcutt, & Schatz, 2012). Sound can also be used to give feedback on task performance and make learners aware of mistakes. Such sound feedback can be used to downplay failure or add a celebratory note to success, thus inducing positive emotions.

Game Mechanics

Game mechanics refers to the sets of rules and activities afforded to the learner throughout the game (Ke, 2016; Plass et al., 2015). Key dimensions include the overall match between overt game mechanics and underlying learning goals (e.g., skills to be practiced), task clarity, task demands, scaffolding, and social interaction. These task qualities can strongly affect both actual mastery and perceived competence, and thus learners' emotions during gameplay.

Game mechanics and learning content A well-developed game for learning should include targeted learning mechanics that were informed by learning theory and that are instantiated as corresponding game mechanics (e.g., calculating angles within the framework of building an in-game character's house; Plass et al., 2012). Designers of learning games need to develop activities that provide learners with opportunities to engage effectively with learning materials. Mismatches between targeted learning outcomes and actual learner activities afforded by the game mechanic limit cognitive effectiveness and run the risk of reducing self-efficacy and prompting negative emotions such as frustration.

Task clarity and demands Comprehension can be enhanced by considering known constraints (e.g., limited working-memory capacity) and reducing extraneous cognitive load to facilitate information processing (Plass et al., 2009). As ease of comprehension translates to higher self-efficacy, enhancing clarity should be emotionally beneficial. Game designers may, for example, represent key information through iconic rather than symbolic information, which requires higher mental effort (Plass et al., 2009).

The relative difficulties of tasks can also influence perceived control over learning, and the match between task demands and competencies can influence learners' valuation of the learning game, further affecting their emotions. Demands that are either too high or too low may reduce the intrinsic value of tasks to the extent that boredom is aroused (Pekrun, 2006). However, there may be circumstances where cognitive impasses induced by high demands can increase learning gains. D'Mello, Lehman, Pekrun, and Graesser (2014) used a modified version of *OperationARIES!* to induce confusion through staged disagreements between virtual agents when training scientific reasoning, which led to increased retention and knowledge transfer. Confusion can be elicited through provision of unexpected, counterfactual, or contradictory information, false feedback, and tasks that exceed learners' current skills. However, to be productive, confusion needs to lead to resolution activities, which requires that the learner have the capability to resolve the confusion and that the GBLE provide appropriate scaffolds when needed (D'Mello, Blanchard, Baker, Ocumpaugh, & Brawner, 2014, p. 41).

Scaffolding Cognitive scaffolding includes adjusting the task difficulty, repeating content, providing supplemental explanations, using advance organizers to structure information and facilitate navigation in the game space, and supportive messages by game characters (Arroyo, Muldner, Burleson, & Woolf, 2014). Metacognitive scaffolding guides learners toward effective problem solving (e.g., providing hints, rephrasing problem statements), modifies ineffective strategies (e.g., "Let's think again: What are the steps we have to carry out to solve this one?" Arroyo et al., 2014, p. 82), and prompts goal setting and self-monitoring. The meta-analysis by Loderer et al. (2018) found that scaffolding resulted in higher levels of enjoyment, likely due to positive effects on perceived control over learning.

However, the dosage of such interventions may modulate their impact on mastery perceptions. Frequent reminders or calls to change one's learning approach may hinder rather than promote self-regulation and result in a loss of perceived autonomy and control. Therefore, intelligent games that infer learners' cognitive states, account for individual differences in prior knowledge as well as learning pace, and "interfere" only where necessary may be most effective (Janning, Schatten, & Schmidt-Thieme, 2016). Promising developments also include algorithms that allow learner-controlled problem selection in gamified intelligent tutoring systems, including open learner models (e.g., visualizations of a system's learning analytics that reveal learning progress; see Long & Aleven, 2017) or provision of customized cues (e.g., "That was too easy for you. Next time, go for a more challenging problem—it's much more exciting and it will help you increase your learning!" Arroyo et al., 2014, p. 81). Such scaffolds may help avert loss of control when students are overwhelmed by too much autonomy (e.g., because of poor planning and monitoring capabilities).

Social interaction Games can involve social interaction with fellow players or virtual agents. Social interaction can influence learners' emotions in two ways. First, interlocutors may influence one another via emotional contagion and empathy. This makes it possible to regulate learners' emotions through modeling (e.g., enthusiastic expression and exclamations such as "This looks like fun!"), parallel empathy (i.e., replicating the learner's state), and reactive empathy (i.e., displaying emotions that differ from the learner's state in order to alter it). The features of agent design described earlier may be important moderators of the effectiveness of such interventions. For instance, realistic agents might provide more convincing role models and thus more powerful interventions.

Second, opportunities for social exchange may fulfill students' needs for relatedness, thus making the game more enjoyable (Sheldon & Filak, 2008). However, social contact per se may not suffice in building positive emotion: the perceived quality of interaction is key (Heidig & Clarebout, 2011). Supportive, empathy-driven interaction may be most beneficial. For instance, polite "face-saving" measures such as delivering hints using collective formulations (e.g., "How about we solve for x?") instead of directives (e.g., "You need to solve for x"; Lane, 2016, p. 51) can positively impact learners' affective responses.

In addition, the cooperative or competitive structure of interaction can influence students' emotions by impacting their goals during learning. While both cooperative and competitive formats may increase situational interest and enjoyment relative to individual modes of play, cooperation seems to be most effective (Ke & Grabowski, 2007), except for the acquisition of procedural skills, where collaborating and negotiating with others may reduce performance and competition and individual learning may be more efficient (Plass et al., 2013). Competition can prompt performance-avoidance goals (Murayama & Elliot, 2012), which shift learners' focus toward possible failure and lack of control, thus making negative emotions more likely. Moreover, competitive goal structures imply that some individuals have to experience failure and are thus "predestined" to experience negative emotions. As such, cooperative game formats, perhaps interspersed with appropriately scaffolded competitive activities, may be most conducive to encouraging learners' positive emotions.

Narrative

Well-constructed narratives are gripping because they entail a delicate balance of adhering to common episodic schemas creating expectations about upcoming events while at the same time building suspense that sustains attention (McNamara et al., 2010). Narrative can increase enjoyment during GBL (Cordova & Lepper, 1996). Effective games include compelling story lines that contextualize learning and provide an overarching framework connecting rules of play, in-game character roles, events, and incentives.

The success of a game's story line may derive from its alignment with the knowledge or skills to be taught. Such alignment is essential to the meaningfulness of narrative (Ke, 2016). However, meta-analytic findings suggest that games using irrelevant or little-developed story lines produce higher learning outcomes than games with a highly relevant and developed plot, suggesting that "some thin narratives are incredibly engaging, whereas some thick narratives may be dull" (Clark et al., 2016, p. 113) or too complex for students to follow. Thus, a narrative's accessibility and genuine entertainment value (e.g., creation of suspense, inclusion of humoristic elements) may be more critical for sparking curiosity and enjoyment. Creating credible agent personalities involves decisions about communication styles (i.e., formal vs. colloquial), which should vary with agents' specific functional roles (e.g., expert vs. peer agent or protagonist vs. antagonist; see Johnson & Lester, 2016).

Games allow nonlinear narrative structures that enable learners to see their actions impacting the game environment, which can increase perceived control. Narrative may be most engaging when it does not simply serve to advance the story but when the interplay of narrative and player choices actually constructs the story (Dickey, 2015). Student-centered narrative design that involves learners in story creation may enhance valuation of the game as well as perceived autonomy and control (Whitton & Hollins, 2016). To the degree that plot development is contingent on successful task completion, it also allows providing feedback without overtly emphasizing failure, thus dampening potentially harmful effects of making mistakes on learners' perceptions of competence.

Incentive System and Feedback

Learning games include specific incentives (i.e., reward and punishment) that seek to keep learners motivated. Incentive systems include progress bars, point score systems, badges, opportunities to change the environment (e.g., appearance of one's avatar), or access to game levels and virtual goods. Incentives impact learners' perceptions of the value of activities. Because they are typically contingent on learners' in-game performance, they also comprise feedback about individuals' learning progress that influences their perceived control.

The instrumental value of incentives within the game can vary. Rewards that entail access to additional fun activities or unlock new levels with new content focus on building value through inherently valuable content. Such incentives may be particularly conducive to increasing enjoyment or curiosity by boosting interest (McNamara et al., 2010). Extrinsic incentives include rewards that allow learners to trade earned points for their choice of avatar design or color scheme, or tallying scores for comparison with other players through leaderboards. Such incentive systems can enhance the value of learning through external compensation. They may provide an important means for emotionally engaging learners who perceive the content as having little appeal and can serve as a means to build interest value.

Incentives can also differ in their emphasis on specific goal orientations. Different standards for defining achievement can imply individualistic (mastery), cooperative, or competitive (normative) goal structures. These structures can be communicated through rules for awarding points (e.g., for individual improvement vs. outperforming other players) and by feedback messages (e.g., referencing improvement in correct solutions vs. how one performed in relation to others). Incentives and feedback reflecting mastery- or performance-approach goals can facilitate positive emotions (Pekrun, Cusack, Murayama, Elliot, & Thomas, 2014). Mastery standards and mastery-approach goals are held to be most adaptive, because they may lead learners to focus on the intrinsic values of game activities. Normative standards and performance-approach goals may nonetheless challenge and excite learners to engage with the learning game.

Evidence collected by Plass and colleagues (see Biles & Plass, 2016) suggests that administering badges focused on social comparison (e.g., "You figured out the straight angle rule faster than most players!") can lead to higher learning outcomes than mastery badges (e.g., "You have mastered the triangle rule!"). In the mastery condition, learners reporting high situational interest in the game's contents performed better than those with low situational interest. Situational interest did not affect performance in the performance badge and no badge conditions. These findings point to interactions between goal-priming incentives and interest, but more research is needed to clarify these relations.

Mastery-oriented feedback can be augmented with control-enhancing statements derived from attributional retraining (Perry, Chipperfield, Hladkyj, Pekrun, & Hamm, 2014). Arroyo et al. (2014) showed that focusing agent-delivered feedback on the controllability of learning and the importance of effort (e.g., "Good job! See how taking your time to work through these questions can make you get the right answer?" Arroyo et al. 2014, p. 81) can reduce negative emotions such as frustration and anxiety. Such messages seek to regulate learners' emotions by prompting adaptive control appraisals. To reduce boredom, feedback can focus on appraisals of the utility value of learning contents (see Harackiewicz & Priniski, 2018).

Two additional factors are learner choice and salience of rewards. A choice between different rewards can increase perceived autonomy and control over learning but may come at the cost of learners becoming sidetracked by peripheral elements such as avatar modification (McNamara et al., 2010). For salience, visually elaborate or acoustically supported presentation of extrinsic rewards can enhance their emotional pull but may undermine intrinsic valuation of the learning game—a critical effect, especially if rewards are presented frequently (Abramovich, Schunn, & Higashi, 2013). Constantly flagging badges can overemphasize the value of achievement at the cost of the game's playfulness, which can be particularly detrimental to learners who struggle and experience failure. Formulating feedback and awarding incentives based on individual learner progress rather than raw achievement, as outlined by Arroyo et al. (2014), may help alleviate this issue.

In sum, crafting emotionally effective learning games requires a host of decisions at different levels of game design. Design strategies map onto different phases of the emotion process. They can target appraisal antecedents of learners' emotions through appropriate construction of game mechanics and tasks, narrative structures, visual and sound elements, and incentive structures, as well as the emotion itself through design features that enable emotional contagion or empathy.

Open Questions and Directions for Future Research

Emotions are powerful drivers of learning across all types of learning environments. However, compared with the number of studies focusing on cognitive aspects of learning games and game design, emotion research is lagging behind. We outline five major directions for future research on emotions in GBL. These areas echo questions that concern the field of educational emotion research as a whole, which suggests that collaborative efforts are needed to advance this field (Pekrun & Linnenbrink-Garcia, 2014b; Plass & Kaplan, 2016).

Clarifying the Construct Domain of Emotions

Future work needs to address boundaries between domains distinguishing emotion from adjacent categories, as well as the internal structures of these domains. There is general consensus that emotions such as joy, anger, or anxiety are core members of the domain of emotions, but there are other constructs for which this is unclear, such as metacognitive feelings. For internal structures, it remains unclear whether dimensional or discrete emotion approaches are better suited for describing a learner's affect. For game design, this makes a crucial difference in terms of the emotional granularity considered. D'Mello, Blanchard, Baker, Ocumpaugh, and Brawner (2014) argue that discrete representations are preferable to dimensional ones when devising affect-sensitive instructional strategies, because emotions of the same dimensional category (e.g., negative activating anxiety vs. anger) can have different antecedents that require different regulation strategies. In addition, parameters of emotions (e.g., intensity, expressive behavior) can vary between individuals and cultures, implying that any approach to emotion definition and emotional design needs to be validated across different groups of learners.

Dynamic and Multimodal Measurement of Emotions

Educational researchers and computer scientists have made significant headway toward implementing online assessment of emotion by considering different "channels," such as physiology, facial expression, and subjective feeling, and examining how technology inherent to the learning environment can be used to measure emotions in more holistic ways (D'Mello, Dieterle, & Duckworth, 2017). While the accuracy of these methods leaves room for improvement, this direction is promising. First, automated multichannel methods consider the multicomponent nature of emotions. Supplementing self-report with measurement of facial expressions or physiological processes may improve measurement validity, as not all emotion components are consciously accessible. Second, such approaches take the dynamic nature of emotion into account, providing a richer analysis of fluctuations in learners' emotions through continuous real-time assessment. This is of central importance for developing emotion-sensitive games. Automated methods also afford continuous assessment of emotion without interrupting the natural flow of learning and circumvent response biases such as social desirability.

Evaluating the Emotional Design of GBLEs

Researchers have begun to consider how learning environments, both classroom and technology based, can be shaped in emotionally sound ways (Lester et al., 2014; Plass & Kaplan, 2016). However, there is a need for a more systematic, rigorous evaluation of the impact of design features of learning games on emotions conducive to learning. Emotional effects of design choices need to be examined more closely at all levels of game design (i.e., visual and sound design, game mechanics, narrative, and incentive structures; see figure 5.3). In doing so, possible transitions and influences between different emotions should be examined. For example, GBLEs hold great potential for inducing positive aesthetic emotions, so it would be useful to know whether these emotions also foster learners' intrinsic valuation of learning and learning-directed emotions. Answers to such questions may also settle the ongoing debate on the seductive detail effect (Park, Flowerday, & Brünken, 2015) by shedding light on whether emotions triggered by decorative GBLE elements can promote enjoyment *of learning*, motivation to invest effort, and ultimately learning outcomes.

Considering Inter- and Intraindividual Factors in the Emotional Design of GBLEs

The majority of studies in educational psychology have relied on between-person analyses, and emotion research is no exception. Whereas analyses based on covariation between persons are well suited for investigating individual differences, they do not contribute to our understanding of the variation that occurs within an individual across time, nor do they adequately address predictive or cause-and-effect relations between variables within individuals (Murayama et al., 2017).

Considering variation of emotions and their antecedents both between and within persons is particularly relevant for developing intelligent games that offer tailored learning environments. Design research needs to evaluate how the emotional impact of game features may vary for learners who differ in age, gender, cultural background, goal orientations, or prior knowledge, and how emotional impact may differ and evolve within individuals as they progress through the game. For example, prior knowledge likely varies between learners at baseline, implying that different degrees of task difficulty and scaffolding are required to maintain optimal levels of challenge. As learners gain knowledge through completing in-game activities, they may benefit—both cognitively and emotionally—from more autonomy. Therefore, an important avenue for future work is to develop games that are able to shift power from system-controlled personalization (adaptivity) to learner-based customization (adaptability) as learners become more skilled.

Building Integrative Theoretical Frameworks

It is tempting to assume that capturing emotional processes will require different theoretical models for different types of learning environments. Given that these processes are fundamental to the nature of learning, extant theories should be just as relevant to GBL as they are to formats that are more traditional (Plass et al., 2015). However, researchers and game designers are faced with the issue of selecting from an unwieldy array of different constructs and theories in this field. As many existing theoretical models are complementary rather than mutually exclusive, integration is needed to move the field forward. Theoretical integration is especially needed to promote cross-fertilization across disciplines that to date have worked in relative theoretical and empirical isolation, such as inquiry on emotion in educational psychology versus affective computing. We hope that the integrative model of emotional foundations of GBLEs presented in this chapter is an initial, useful step in this direction.

References

Abramovich, S., Schunn, C., & Higashi, R. M. (2013). Are badges useful in education? It depends upon the type of badge and expertise of learner. *Educational Technology Research and Development, 61*(2), 217–232. doi:10.1007/s11423-013-9289-2

Admiraal, W., Huizenga, J., Akkerman, S., & ten Dam, G. (2011). The concept of flow in collaborative game-based learning. *Computers in Human Behavior, 27*, 1185–1194. doi:10.1016/j.chb.2010.12.013

Admiraal, W., Huizenga, J., Heemskerk, I., Kuiper, E., Volman, M., & ten Dam, G. (2014). Gender-inclusive game-based learning in secondary education. *International Journal of Inclusive Education, 18*, 1208–1218. doi:10.1080/13603116.2014.885592

Arroyo, I., Burleson, W., Tai, M., Muldner, K., & Woolf, B. P. (2013). Gender differences in the use and benefit of advanced learning technologies for mathematics. *Journal of Educational Psychology, 105*, 957–969. doi:10.1037/a0032748

Arroyo, I., Muldner, K., Burleson, W., & Woolf, B. P. (2014). Adaptive interventions to address students' negative activating and deactivating emotions during learning activities. In R. A. Sottilaire,

A. C. Graesser, X. Hu, & B. Goldberg (Eds.), *Design recommendations for adaptive intelligent tutoring systems: Vol. 2. Instructional management* (pp. 79–91). Orlando, FL: US Army Research Laboratory.

Artino, A. R. (2009). Think, feel, act: Motivational and emotional influences on military students' online academic success. *Journal of Computing in Higher Education, 21*, 170–175. doi:10.1007/s12528-009-9020-9

Artino, A. R., & Jones, K. D. (2012). Exploring the complex relations between achievement emotions and self-regulated learning behaviors in online learning. *The Internet and Higher Education, 15*, 170–175. doi:10.1016/j.iheduc.2012.01.006

Azevedo, R., Johnson, A., Chauncey, A., & Burkett, C. (2010). Self-regulated learning with MetaTutor: Advancing the science of learning with metacognitive tools. In M. S. Khine & I. M. Saleh (Eds.), *New science of learning: Cognition, computers and collaboration in education* (pp. 225–247). New York, NY: Springer.

Baker, R. S. J. d., D'Mello, S. K., Rodrigo, M.M. T., & Graesser, A. C. (2010). Better to be frustrated than bored: The incidence, persistence, and impact of learners' cognitive–affective states during interactions with three different computer-based learning environments. *International Journal of Human-Computer Studies, 68*, 223–241. doi:10.1016/j.ijhcs.2009.12.003

Baker, R. S. J. d., Walonoski, J., Heffernan, N., Roll, I., Corbett, A., & Koedinger, K. (2008). Why students engage in "gaming the system" behavior in interactive learning environments. *Journal of Interactive Learning Research, 19*, 185–224.

Barrett, L. F., Lewis, M., & Haviland-Jones, J. M. (Eds.). (2016). *Handbook of emotions* (4th ed.). New York, NY: Guilford Press.

Baylor, A. L. (2011). The design of motivational agents and avatars. *Educational Technology Research and Development, 59*, 291–300. doi:10.1007/s11423-011-9196-3

Biles, M. L., & Plass, J. L. (2016). Good badges, evil badges: Impact of badge design on learning from games. In L. Y. Muilenburg & Z. L. Berge (Eds.), *Digital badges in education: Trends, issues, and cases* (pp. 39–52). New York, NY: Routledge, Taylor & Francis.

Boyatzis, C. J., & Varghese, R. (1994). Children's emotional associations with colors. *Journal of Genetic Psychology, 155*, 77–85. doi:10.1080/00221325.1994.9914760

Brom, C., Šisler, V., Slussareff, M., Selmbacherová, T., & Hlávka, Z. (2016). You like it, you learn it: Affectivity and learning in competitive social role play gaming. *International Journal of Computer-Supported Collaborative Learning, 11*, 313–348. doi: 10.1007/s11412-016-9237-3

Brun, G., & Kuenzle, D. (2008). A new role for emotions in epistemology? In G. Brun, U. Doğuoğlu, & D. Kuenzle (Eds.), *Epistemology and emotions* (pp. 1–32). Aldershot, England: Ashgate.

Butz, N. T., Stupnisky, R. H., & Pekrun, R. (2015). Students' emotions for achievement and technology use in synchronous hybrid graduate programmes: A control-value approach. *Research in Learning Technology, 23*. doi:10.3402/rlt.v23.26097

Butz, N. T., Stupnisky, R. H., Pekrun, R., Jensen, J. L., & Harsell, D. M. (2016). The impact of emotions on student achievement in synchronous hybrid business and public administration programs: A longitudinal test of control-value theory. *Decision Sciences Journal of Innovative Education, 14*, 441–474. doi:10.1111/dsji.12110

Calvo, R. A., & D'Mello, S. (2012). Frontiers of affect-aware learning technologies. *IEEE Intelligent Systems, 27*, 86–89. doi:10.1109/MIS.2012.110

Chang, H., & Beilock, S. L. (2016). The math anxiety–math performance link and its relation to individual and environmental factors: A review of current behavioral and psychophysiological research. *Current Opinion in Behavioral Science, 10*, 33–38. doi:10.1016/j.cobeha.2016.04.011

Cheung, E. Y. M., & Sachs, J. (2006). Student teachers' acceptance of a web-based information system. *Psychologia, 49*, 132–141.

Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research, 86*(1), 79–122. doi:10.3102/0034654315582065

Collins, K. (2009). An introduction to procedural music in video games. *Contemporary Music Review, 28*(1), 5–15. doi:10.1080/07494460802663983

Conati, C., & Gutica, M. (2016). Interaction with an edu-game: A detailed analysis of student emotions and judges' perceptions. *International Journal of Artificial Intelligence in Education, 26*, 975–1010. doi:10.1007/s40593-015-0081-9

Cordova, D. I., & Lepper, M. R. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology, 88*(4), 715–730. doi:10.1037/0022-0663.88.4.715

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319–340. doi:10.2307/249008

Dickey, M. D. (2015). *Aesthetics and design for game-based learning*. New York, NY: Routledge.

D'Mello, S., Dieterle, E., & Duckworth, A. (2017). Advanced, analytic, automated (AAA) measurement of engagement during learning. *Educational Psychologist, 52*, 104–123. doi:10.1080/00461520.2017.1281747

D'Mello, S., Lehman, B., Pekrun, R., & Graesser, A. (2014). Confusion can be beneficial for learning. *Learning and Instruction, 29*, 153–170. doi:10.1016/j.learninstruc.2012.05.003

D'Mello, S. K., Blanchard, N., Baker, R., Ocumpaugh, J., & Brawner, K. (2014). I feel your pain: A selective review of affect-sensitive instructional strategies. In R. A. Sottilaire, A. C. Graesser, X. Hu, & B. Goldberg (Eds.), *Design recommendations for adaptive intelligent tutoring systems: Vol. 2. Instructional management* (pp. 35–48). Orlando, FL: US Army Research Laboratory.

D'Mello, S. K., & Graesser, A. C. (2012). AutoTutor and Affective AutoTutor: Learning by talking with cognitively and emotionally intelligent computers that talk back. *ACM Transactions on Interactive Intelligent Systems, 2*, 22–39.

Domagk, S. (2010). Do pedagogical agents facilitate learner motivation and learning outcomes? *Journal of Media Psychology, 22*, 84–97. doi:10.1027/1864-1105/a000011

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256–273. doi:10.1037/0033-295X.95.2.256

Egenfeldt-Nielsen, S., Smith, J. H., & Tosca, S. P. (2008). *Understanding video games: The essential introduction*. New York, NY: Routledge.

Eich, E., Ng, J. T. W., Macaulay, D., Percy, A. D., & Grebneva, I. (2007). Combining music with thought to change mood. In J. A. Coan & J. J. B. Allen (Eds.), *Handbook of emotion elicitation and assessment* (pp. 124–136). New York, NY: Oxford University Press.

Elliot, A. J., Maier, M. A., Moller, A. C., Friedman, R., & Meinhardt, J. (2007). Color and psychological functioning: The effect of red on performance attainment. *Journal of Experimental Psychology: General, 136*, 154–168. doi:10.1037/0096-3445.136.1.154

Ellis, H. C., & Ashbrook, P. W. (1988). Resource allocation model of the effects of depressed mood states on memory. In K. Fielder & J. Forgas (Eds.), *Affect, cognition and social behaviour* (pp. 25–43). Toronto, Canada: Hogrefe.

Ellsworth, P. C., & Scherer, K. R. (2003). Appraisal processes in emotion. In R. J. Davidson, K. R. Scherer, & H. H. Goldmsith (Eds.), *Handbook of affective sciences* (pp. 572–595). Oxford, England: Oxford University Press.

Fayn, K., MacCann, C., Tiliopoulos, N., & Silvia, P. J. (2015). Aesthetic emotions and aesthetic people: Openness predicts sensitivity to novelty in the experiences of interest and pleasure. *Frontiers in Psychology, 6*. doi:10.3389/fpsyg.2015.01877

Feather, N. T. (2006). Deservingness and emotions: Applying the structural model of deservingness to the analysis of affective reactions to outcomes. *European Review of Social Psychology, 17*, 38–73. doi:10.1080/10463280600662321

Fiedler, K., & Beier, S. (2014). Affect and cognitive processes in educational contexts. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 36–55). New York, NY: Taylor & Francis.

Fiorella, L., Vogel-Walcutt, J. J., & Schatz, S. (2012). Applying the modality principle to real-time feedback and the acquisition of higher-order cognitive skills. *Educational Technology Research and Development, 60*, 223–238. doi:10.1007/s11423-011-9218-1

Frenzel, A. C., Becker-Kurz, B., Pekrun, R., Goetz, T., & Lüdtke, O. (2018). Emotion transmission in the classroom revisited: A reciprocal effects model of teacher and student enjoyment. *Journal of Educational Psychology, 110*(5), 628–639. doi: 10.1037/edu0000228

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics—a "hopeless" issue? A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education, 22*, 497–514. doi:10.1007/BF03173468

Frenzel, A. C., Thrash, T. M., Pekrun, R., & Goetz, T. (2007). Achievement emotions in Germany and China. *Journal of Cross-Cultural Psychology, 38*, 302–309. doi:10.1177/0022022107300276

Ghafi, N., Karunungan de Ramos, H. D., Klein, L., Lombana Diaz, M. C., & Songtao, J. (2011). *Mission Green*. Bremerhaven, Germany: University of Applied Sciences.

Gil, S., & Le Bigot, L. (2016). Colour and emotion: Children also associate red with negative valence. *Developmental Science, 19*, 1087–1094. doi:10.1111/desc.12382

Goetz, T., & Hall, N. C. (2013). Emotion and achievement in the classroom. In J. Hattie & E. M. Anderman (Eds.), *International guide to student achievement* (pp. 192–195). New York, NY: Routledge.

Graesser, A. C., D'Mello, S. K., & Strain, A. C. (2014). Emotions in advanced learning technologies. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 473–493). New York, NY: Taylor & Francis.

Gratch, J., & Marsella, S. (2005). Lessons from emotion psychology for the design of lifelike characters. *Applied Artificial Intelligence, 19*, 215–233.

Harackiewicz, J. M., & Priniski, S. J. (2018). Improving student outcomes in higher education: The science of targeted intervention. *Annual Review of Psychology, 69*, 409–435. doi: 10.1146/annurev-psych-122216-011725

Hareli, S., & Parkinson, B. (2008). What's social about social emotions? *Journal for the Theory of Social Behaviour, 38*, 131–156. doi:10.1111/j.1468-5914.2008.00363.x

Hatfield, E., Cacioppo, J., & Rapson, R. L. (1994). *Emotional contagion*. New York, NY: Cambridge University Press.

Hébert, S., Béland, R., Dionne-Fournelle, O., Crête, M., & Lupien, S. J. (2005). Physiological stress response to video-game playing: The contribution of built-in music. *Life Science, 76*(20), 2371–2380. doi:10.1016/j.lfs.2004.11.011

Heidig, S., & Clarebout, G. (2011). Do pedagogical agents make a difference to student motivation and learning? *Educational Research Review, 6*, 27–54. doi:10.1016/j.edurev.2010.07.004

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*, 111–127. doi:10.1207/s15326985ep4102_4

Homer, B. D., Hayward, E. O., Frye, J., & Plass, J. L. (2012). Gender and playercharacteristics in video game play of preadolescents. *Computers in Human Behavior, 28*, 1782–1789. doi:10.1016/j.chb.2012.04.018

Husain, G., Thompson, W. F., & Schellenberg, E. G. (2002). Effects of musical tempo and mode on arousal, mood, and spatial abilities. *Music Perception, 20*(2), 151–171. doi:10.1525/mp.2002.20.2.151

Jackson, G. T., & McNamara, D. S. (2013). Motivation and performance in a game-based intelligent tutoring system. *Journal of Educational Psychology, 105*, 1036–1049. doi:10.1037/a0032580

Janning, R., Schatten, C., & Schmidt-Thieme, L. (2016). Perceived task-difficulty recognition from log-file information for the use in adaptive intelligent tutoring systems. *International Journal of Artificial Intelligence in Education, 26*, 855–876. doi: 10.1007/s40593-016-0097-9

Järvenoja, H., & Järvelä, S. (2005). How students describe the sources of their emotional and motivational experiences during the learning process: A qualitative approach. *Learning and Instruction, 15*, 465–480. doi:10.1016/j.learninstruc.2005.07.012

Johnson, W. L., & Lester, J. C. (2016). Face-to-face interaction with pedagogical agents, twenty years later. *International Journal of Artificial Intelligence in Education, 26*(1), 25–36. doi:10.1007/s40593-015-0065-9

Ke, F. (2016). Designing and integrating purposeful learning in game play: A systematic review. *Educational Technology Research and Development, 64*(2), 219–244. doi:10.1007/s11423-015-9418-1

Ke, F., & Grabowski, B. (2007). Gameplaying for maths learning: Cooperative or not? *British Journal of Educational Technology, 38*(2), 249–259. doi:10.1111/j.1467-8535.2006.00593.x

Kim, Y., & Baylor, A. L. (2006). A social-cognitive framework for pedagogical agents as learning companions. *Educational Technology Research and Development, 54*(6), 569–596. doi:10.1007/s11423-006-0637-3

King, R. B., McInerney, D. M., & Watkins, D. A. (2012). How you think about your intelligence determines how you feel in school: The role of theories of intelligence on academic emotions. *Learning and Individual Differences, 22*, 814–819. doi:10.1016/j.lindif.2012.04.005

Knörzer, L., Brünken, R., & Park, B. (2016). Facilitators or suppressors: Effects of experimentally induced emotions on multimedia learning. *Learning and Instruction, 44*, 97–107. doi:10.1016/j.learninstruc.2016.04.002

Krämer, N., Kopp, S., Becker-Asano, C., & Sommer, N. (2013). Smile and the world will smile with you—the effects of a virtual agent's smile on users' evaluation and behavior. *International Journal of Human-Computer Studies, 71*, 335–349. doi:10.1016/j.ijhcs.2012.09.006

Kuhbandner, C., & Pekrun, R. (2013). Affective state influences retrieval-induced forgetting for integrated knowledge. *PloS One, 8*. doi:10.1371/journal.pone.0056617

Lane, H. C. (2016). Pedagogical agents and affect: Molding positive learning interactions. In S. Y. Tettegah & M. Gartmeier (Eds.), *Emotions, technology, design, and learning* (pp. 47–62). London, England: Elsevier Academic Press.

Laurel, B. (2001). *Utopian entrepreneur: Mediawork*. Cambridge, MA: MIT Press.

Lehman, S., Schraw, G., McCrudden, M. T., & Hartley, K. (2007). Processing and recall of seductive details in scientific text. *Contemporary Educational Psychology, 32*, 569–587. doi:10.1016/j.cedpsych.2006.07.002

Lester, J. C., Ha, E. Y., Lee, S. Y., Mott, B. W., Rowe, J. P., & Sabourin, J. L. (2013). Serious games get smart: Intelligent game-based learning environments. *AI Magazine, 34*(4), 31–45.

Lester, J. C., McQuiggan, S. W., & Sabourin, J. L. (2011). Affect recognition and expression in narrative-centered learning environments. In R. A. Calvo & S. K. D'Mello (Eds.), *New perspectives on affect and learning technologies* (pp. 85–96). New York, NY: Springer.

Lester, J. C., Spires, H. A., Nietfeld, J. L., Minogue, J., Mott, B. W., & Lobene, E. V. (2014). Designing game-based learning environments for elementary science education: A narrative-centered learning perspective. *Information Sciences, 264*, 4–18. doi:10.1016/j.ins.2013.09.005

Lichtenfeld, S., Elliot, A. J., Maier, M. A., & Pekrun, R. (2012). Fertile green: Green facilitates creative performance. *Personality and Social Psychology Bulletin, 38*, 784–797. doi:10.1177/0146167212436611

Linnenbrink-Garcia, L., Rogat, T. K., & Koskey, K. L. K. (2011). Affect and engagement during small group instruction. *Contemporary Educational Psychology, 36*, 13–24. doi:10.1016/j.cedpsych.2010.09.001

Lipscomb, Z. D., & Zehnder, S. M. (2004). Immersion in the virtual environment: The effect of a musical score on the video gaming experience. *Journal of Physiological Anthropology and Applied Human Science, 23*, 337–343.

Loderer, K., Pekrun, R., & Lester, J. C. (2018). Beyond cold technology: A systematic review and meta-analysis on emotions in technology-based learning environments. *Learning and Instruction.* doi: 10.1016/j.learninstruc.2018.08.002

Long, Y., & Aleven, V. (2017). Enhancing learning outcomes through self-regulated learning support with an Open Learner Model. *User Modeling and User-Adapted Interaction, 27*, 55–88. doi:10.1007/s11257-016-9186-6

Marchand, G. C., & Gutierrez, A. P. (2012). The role of emotion in the learning process: Comparisons between online and face-to-face learning settings. *The Internet and Higher Education, 15*, 150–160. doi:10.1016/j.iheduc.2011.10.001

Mayer, R. E., & Estrella, G. (2014). Benefits of emotional design in multimedia instruction. *Learning and Instruction, 33*, 12–18. doi:10.1016/j.learninstruc.2014.02.004

McGonigal, J. (2010). *Gaming can make a better world.* Ted 2010. Retrieved from http://www.iftf.org/our-work/people-technology/games/jane-mcgonigal-at-ted/

McNamara, D. S., Jackson, G. T., & Graesser, A. C. (2010). Intelligent tutoring and games (ITaG). In Y. K. Baek (Ed.), *Gaming for classroom-based learning: Digital role-playing as a motivator of study* (pp. 44–65). Hershey, PA: IGI Global.

McQuiggan, S. W., & Lester, J. C. (2007). Modeling and evaluating empathy in embodied companion agents. *International Journal of Human-Computer Studies, 65*, 348–360. doi:10.1016/j.ijhcs.2006.11.015

McQuiggan, S. W., Robison, J. L., & Lester, J. C. (2010). Affective transitions in narrative-centered learning environments. *Educational Technology & Society, 13*, 40–53. doi:10.1007/978-3-540-69132-7_52

Meluso, A., Zheng, M., Spires, H. A., & Lester, J. (2012). Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. *Computers & Education, 59*(2), 497–504. doi:10.1016/j.compedu.2011.12.019

Millis, K., Forsyth, C., Butler, H., Wallace, P., Graesser, A., & Halpern, D. (2011). Operation ARIES! A serious game for teaching scientific inquiry. In M. Ma, A. Oikonomou, & L. C. Jain (Eds.), *Serious games and edutainment applications* (pp. 169–195). London, England: Springer.

Muis, K. R., Pekrun, R., Sinatra, G. M., Azevedo, R., Trevors, G., Meier, E., & Heddy, B. C. (2015). The curious case of climate change: Testing a theoretical model of epistemic beliefs, epistemic emotions, and complex learning. *Learning and Instruction, 39*, 168–183. doi:10.1016/j.learninstruc.2015.06.003

Muis, K. R., Psaradellis, C., Lajoie, S. P., Di Leo, I., & Chevrier, M. (2015). The role of epistemic emotions in mathematics problem solving. *Contemporary Educational Psychology, 42*, 172–185. doi:10.1016/j.cedpsych.2015.06.003

Murayama, K., & Elliot, A. J. (2012). The competition-performance relation: A meta-analytic review and test of the opposing processes model of competition and performance. *Psychological Bulletin, 138*, 1035–1070. doi:10.1037/a0028324

Murayama, K., Goetz, T., Malmberg, L.-E., Pekrun, R., Tanaka, A., & Martin, A. J. (2017). Within-person analysis in educational psychology: Importance and illustrations. In D. W. Putwain & K. Smart (Eds.), *British Journal of Educational Psychology Monograph Series II: Psychological Aspects of Education—Current Trends: The role of competence beliefs in teaching and learning* (pp. 71–87). Oxford, England: Wiley.

Nacke, L. E., Grimshaw, M. N., & Lindley, C. A. (2010). More than a feeling: Measurement of sonic user experience and psychophysiology in a first-person shooter game. *Interacting with Computers, 22*, 336–343. doi:10.1016/j.intcom.2010.04.005

Nass, C. I., & Brave, S. (2005). *Wired for speech: How voice activates and advances the human-computer relationship*. Cambridge, MA: MIT Press.

Nikolayev, M., Clark, K., & Reich, S. M. (2016). Social-emotional learning opportunities in online games for preschoolers. In S. Y. Tettegah & W. D. Huang (Eds.), *Emotions, technology, and digital games* (pp. 211–229). London, England: Academic Press.

Noteborn, G., Bohle Carbonell, K., Dailey-Hebert, A., & Gijselaers, W. (2012). The role of emotions and task significance in virtual education. *The Internet and Higher Education, 15*, 176–183. doi:10.1016/j.iheduc.2012.03.002

Park, B., Flowerday, T., & Brünken, R. (2015). Cognitive and affective effects of seductive details in multimedia learning. *Computers in Human Behavior, 44*, 267–278. doi:10.1016/j.chb.2014.10.061

Park, B., Knörzer, L., Plass, J. L., & Brünken, R. (2015). Emotional design and positive emotions in multimedia learning: An eyetracking study on the use of anthropomorphisms. *Computers & Education, 86*, 30–42. doi:10.1016/j.compedu.2015.02.016

Pawar, S., Hovey, C., & Plass, J. L. (2017). *The impact of 2D vs. 3D audio on experienced emotions in a game-based cognitive skills training*. Manuscript submitted for publication.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review, 18*(4), 315–341. doi:10.1007/s10648-006-9029-9

Pekrun, R. (2018). Control-value theory: A social-cognitive approach to achievement emotions. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 165–190). Charlotte, NC: Information Age Publishing.

Pekrun, R., Cusack, A., Murayama, K., Elliot, A. J., & Thomas, K. (2014). The power of anticipated feedback: Effects on students' achievement goals and achievement emotions. *Learning and Instruction, 29*, 115–124. doi:0.1016/j.learninstruc.2013.09.002

Pekrun, R., Elliot, A. J., & Maier, M. A. (2006). Achievement goals and discrete achievement emotions: A theoretical model and prospective test. *Journal of Educational Psychology, 98*, 583–597. doi:10.1037/0022-0663.98.3.583

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist, 37*, 91–105. doi:10.1207/S15326985EP3702_4

Pekrun, R., Lichtenfeld, S., Marsh, H. W., Murayama, K., & Goetz, T. (2017). Achievement emotions and academic performance: Longitudinal models of reciprocal effects. *Child Development, 88*, 1653–1670. doi:10.1111/cdev.12704

Pekrun, R., & Linnenbrink-Garcia, L. (Eds.). (2014a). *International handbook of emotions in education*. New York, NY: Routledge.

Pekrun, R., & Linnenbrink-Garcia, L. (2014b). Conclusions and future directions. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 659–675). New York, NY: Routledge.

Pekrun, R., & Perry, R. P. (2014). Control-value theory of achievement emotions. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 120–141). New York, NY: Routledge.

Pekrun, R., Vogl, E., Muis, K. R., & Sinatra, G. M. (2017). Measuring emotions during epistemic activities: The epistemically-related emotion scales. *Cognition & Emotion, 31*, 1268–1276. doi:10.1080/02699931.2016.1204989

Perrotta, C., Featherstone, G., Aston, H., & Houghton, E. (2013). Game-based learning: Latest evidence and future directions (NFER Research Programme: Innovation in Education). Slough: NFER.

Perry, R. R., Chipperfield, J. G., Hladkyj, S., Pekrun, R., & Hamm, J. M. (2014). Attribution-based treatment interventions in some achievement settings. In S. A. Karabenick & T. C. Urdan (Eds.), *Motivational interventions* (pp. 1–35). New York, NY: Emerald.

Plass, J. L., Heidig, S., Hayward, E. O., Homer, B. D., & Um, E. (2014). Emotional design in multimedia learning: Effects of shape and color on affect and learning. *Learning and Instruction, 29*, 128–140. doi:10.1016/j.learninstruc.2013.02.006

Plass, J. L., Homer, B. D., & Hayward, E. O. (2009). Design factors for educationally effective animations and simulations. *Journal of Computing in Higher Education, 21*, 31–61. doi:10.1007/s12528-009-9011-x

Plass, J. L., Homer, B. D., Hayward, E. O., Frye, J., Huang, T.-T., Biles, M., ... Perlin, K. (2012). The effect of learning mechanics design on learning outcomes in a computer-based geometry game. In S. Göbel, W. Müller, B. Urban, & J. Wiemeyer (Eds.), *Lecture Notes in Computer Science: Vol. 7516. E-learning and games for training, education, health and sports* (pp. 65–71). Berlin, Germany: Springer.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist, 50*(4), 258–283. doi:10.1080/00461520.2015.1122533

Plass, J. L., Homer, B. D., Milne, C., Jordan, T., Kalyuga, S., Kim, M., & Lee, H. (2009). Design factors for effective science simulations: Representation of information. *International Journal of Gaming and Computer-Mediated Simulations, 1*, 16–35. doi:10.4018/jgcms.2009010102

Plass, J. L., & Kaplan, U. (2016). Emotional design in digital media for learning. In S. Y. Tettegah & M. Gartmeier (Eds.), *Emotions, technology, design, and learning* (pp. 131–161). Amsterdam, Netherlands: Elsevier.

Plass, J. L., O'Keefe, P. A., Homer, B. D., Case, J., Hayward, E. O., Stein, M., & Perlin, K. (2013). The impact of individual, competitive, and collaborative mathematics game play on learning, performance, and motivation. *Journal of Educational Psychology, 105*, 1050–1066. doi:10.1037/a0032688

Powell, A. L. (2013). Computer anxiety: Comparison of research from the 1990s and 2000s. *Computers in Human Behavior, 29*, 2337–2381. doi:10.1016/j.chb.2013.05.012

Putwain, D. W., Pekrun, R., Nicholson, L. J., Symes, W., Becker, S., & Marsh, H. W. (2018). Control-value appraisals, enjoyment, and boredom in mathematics: A longitudinal latent interaction analysis. *American Educational Research Journal, 55*(6), 1339–1368. doi: 10.3102/0002831218786689

Reeve, C. L., Bonaccio, S., & Winford, E. C. (2014). Cognitive ability, exam-related emotions and exam performance: A field study in a college setting. *Contemporary Educational Psychology, 39*, 124–133. doi:/10.1016/j.cedpsych.2014.03.001

Rodrigo, M. M. T., & Baker, R. S. J. d. (2011). Comparing the incidence and persistence of learners' affect during interactions with different educational software packages. In R. A. Calvo & S. K. D'Mello (Eds.), *New perspectives on affect and learning technologies* (pp. 183–200). New York, NY: Springer.

Rowe, J. P., Shores, L. R., Mott, B. W., & Lester, J. C. (2011). Integrating learning, problem solving, and engagement in narrative-centered learning environments. *International Journal of Artificial Intelligence in Education, 21*, 115–133.

Rudolph, U., & Tscharaktschiew, N. (2014). An attributional analysis of moral emotions: Naïve scientists and everyday judges. *Emotion Review, 6*, 344–352. doi:10.1177/1754073914534507

Russell, J. A. (1978). Evidence of convergent validity on the dimensions of affect. *Journal of Personality and Social Psychology, 36*, 1152–1168. doi:10.1037/0022-3514.36.10.1152

Sabourin, J. L., & Lester, J. C. (2014). Affect and engagement in game-based learning environments. *IEEE Transactions on Affective Computing, 5*, 45–56. doi:10.1109/T-AFFC.2013.27

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information, 44*(4), 695–729. doi: 10.1177/0539018405058216

Scherer, K. R., & Coutinho, E. (2013). How music creates emotion: A multifactorial process approach. In T. Cochrane, B. Fantini, & K. R. Scherer (Eds.), *The emotional power of music: Multidisciplinary perspectives on musical arousal, expression, and social control* (pp. 121–145). Oxford, England: Oxford University Press.

Schneider, S., Dyrna, J., Meier, L., Beege, M., & Rey, G. D. (2018). How affective charge and text–picture connectedness moderate the impact of decorative pictures on multimedia learning. *Journal of Educational Psychology, 110*(2), 233–249. doi: 10.1037/edu0000209

Sheldon, K. M., & Filak, V. (2008). Manipulating autonomy, competence and relatedness support in a game-learning context: New evidence that all three needs matter. *British Journal of Social Psychology, 47*, 267–283. doi:10.1348/014466607X238797

Shiban, Y., Schelhorn, I., Jobst, V., Hörnlein, A., Puppe, F., Pauli, P., & Mühlberger, A. (2015). The appearance effect: Influences of virtual agent features on performance and motivation. *Computers in Human Behavior, 49*, 5–11. doi:10.1016/j.chb.2015.01.077

Shuman, V., & Scherer, K. R. (2014). Concepts and structures of emotions. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International Handbook of Emotions in Education* (pp. 13–35). New York, NY: Routledge.

Sierra Online Inc. (2001). The Incredible Machine: Even More Contraptions. [Computer software].

Silvia, P. J. (2005). Emotional responses to art: From collation and arousal to cognition and emotion. *Review of General Psychology, 9*, 342–357. doi:10.1037/1089-2680.9.4.342

Silvia, P. J. (2009). Looking past pleasure: Anger, confusion, disgust, pride, surprise, and other unusual aesthetic emotions. *Psychology of Aesthetics, Creativity, and the Arts, 3*(1), 48–51. doi:10.1037/a0014632

Snow, E. L., Jackson, G. T., Varner, L. K., & McNamara, D. S. (2013). The impact of system interactions on motivation and performance in a game-based learning environment. In C. Stephanidis (Ed.), *HCI international proceedings* (pp. 103–107). Berlin, Germany: Springer.

Spachtholz, P., Kuhbandner, C., & Pekrun, R. (2014). Negative affect improves the quality of memories: Trading capacity for precision in sensory and working memory. *Journal of Experimental Psychology: General, 143*, 1450–1456. doi:10.1037/xge0000012

Stark, L., Malkmus, E., Stark, R., Brünken, R., & Park, B. (2018). Learning-related emotions in multimedia learning: An application of control-value theory. *Learning and Instruction, 58*, 42–52. doi: 10.1016/j.learninstruc.2018.05.003

Stemmler, G., & Wacker, J. (2010). Personality, emotion, and individual differences in physiological responses. *Biological Psychology, 84*, 541–551. doi: 10.1016/j.biopsycho.2009.09.012

Street, N., Forsythe, A. M., Reilly, R., Taylor, R., & Helmy, M. S. (2016). A complex story: Universal preference vs. individual differences shaping aesthetic response to fractals patterns. *Frontiers in Human Neuroscience, 10*,. doi:10.3389/fnhum.2016.00213

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*, 295–312. doi:10.1016/0959-4752(94)90003-5

Taylor, C., Clifford, A., & Franklin, A. (2013). Color preferences are not universal. *Journal of Experimental Psychology: General, 142*, 1015–1027. doi:10.1037/a0030273

Tempelaar, D. T., Niculescu, A., Rienties, B., Gijselaers, W. H., & Giesbers, B. (2012). How achievement emotions impact students' decisions for online learning, and what precedes those emotions. *The Internet and Higher Education, 15*, 161–169. doi:10.1016/j.iheduc.2011.10.003

Trevors, G. J., Muis, K. R., Pekrun, R., Sinatra, G. M., & Muijselaar, M. M. L. (2017). Exploring the relations between epistemic beliefs, emotions, and learning from texts. *Contemporary Educational Psychology, 48*, 116–132. doi: 10.1016/j.cedpsych.2016.10.001

Trost, J. W., Labbé, C., & Grandjean, D. (2017). Rhythmic entrainment as a musical affect induction mechanism. *Neuropsychologia, 96*, 96–110. doi:10.1016/j.neuropsychologia.2017.01.004

Turkay, S., & Kinzer, C. K. (2014). The effects of avatar-based customization on player identification. *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS), 6*(1), 1–25. doi:10.4018/ijgcms.2014010101

Turner, J. E., & Schallert, D. L. (2001). Expectancy-value relationships of shame reactions and shame resiliency. *Journal of Educational Psychology, 93*, 320–329. doi:10.1037//0022-0663.93.2.320

Tze, V. M. C., Daniels, L. M., & Klassen, R. M. (2016). Evaluating the relationship between boredom and academic outcomes: A meta-analysis. *Educational Psychology Review, 28*, 119–144. doi:10.1007/s10648-015-9301-y

Um, E., Plass, J. L., Hayward, E. O., & Homer, B. D. (2012). Emotional design in multimedia learning. *Journal of Educational Psychology, 104*(2), 485–498. doi:10.1037/a0026609

Vogl, E., Pekrun, R., Murayama, K., & Loderer, K. (2019). Surprised–curious–confused: Epistemic emotions and knowledge exploration. *Emotion*. doi: 10.1037/emo0000578

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review, 92*, 548–573.

Weiner, B. (1995). *Judgments of responsibility: A foundation for a theory of social conduct*. New York, NY: Guilford Press.

Whitton, N., & Hollins, P. (2016). Collaborative virtual gaming worlds in higher education. *ALT-J Research in Learning Technology, 16*, 221–229. doi:10.1080/09687760802526756

Wolfson, S., & Case, G. (2000). The effects of sound and colour on responses to a computer game. *Interacting with Computers, 13*, 183–192. doi:10.1016/S0953-5438(00)00037-0

Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology, 105*(2), 249–265. doi:10.1037/a0031311

Yang, Y., & Taylor, J. (2013). The role of achievement goals in online test anxiety and help-seeking. *Educational Research and Evaluation, 19*, 651–664. doi:10.1080/13803611.2013.811086

Yee, N., & Bailenson, J. (2007). The Proteus Effect: The effect of transformed self-representation on behavior. *Human Communication Research, 33*, 271–290. doi:10.1111/j.1468-2958.2007.00299.x

Zumbach, J., Reimann, P., & Koch, S. (2001). Influence of passive versus active information access to hypertextual information resources on cognitive and emotional parameters. *Journal of Educational Computing Research, 25*, 301–318. doi:10.2190/G385-9XR8-6661-RC43