Toward a Systematic Approach to Evaluating Emotional Design in Learning Games

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Abstract: Emotional design has emerged as a critical area of research in game-based learning (GBL). Initial studies have yielded promising results indicating that learning games can be designed to purposefully induce specific emotions that support learning processes and outcomes. Yet, existing studies have not always yielded consistent results with regard to the expected effects of emotional design in learning games (Plass & Hovey, 2021). In order to make sustained and significant progress in this area, researchers have called for a systematic approach to evaluating the impact of emotional design on players' emotions, learning processes, and learning outcomes (Loderer et al., 2019; Plass et al., 2019; Plass & Hovey, 2021). This paper draws upon research approaches from existing emotional design studies to propose an initial outline for such a systematic approach.

Overview

Human emotions are a ubiquitous phenomenon. They are evoked by everything around us: people, places, events, objects, and so on. Learning environments, whether face-to-face or digital, are no exception. Emotional responses can be brought on by learning environments for any number of reasons: the first day of a new class might elicit feelings of excitement, anticipation, or curiosity; preparing to take an important exam might spark anxiety; giving a presentation could be accompanied by feelings of confidence, dread, or a mixture of both; collaborating with peers on an assignment can be fun or frustrating; and completing a challenging task can induce a sense of pride, accomplishment, or *fiero*. We can think of learning environments as emotional spaces; understanding the role that emotions play in these spaces has significant implications for learners, educators, and learning designers.

Education research paid little attention to emotions until the turn of the century, and even today the field is still playing catch-up (Pekrun & Linnenbrink-Garcia, 2014). However, recent progress has narrowed the knowledge gap on emotions and learning (Calvo & D'Mello, 2011; Heidig et al., 2015; Loderer et al., 2020), and we now know that emotions directly influence cognitive processes such as attention, perception, memory, and reasoning (Vuilleumier, 2005; Phelps, 2004; Jung et al., 2014; Isen et al., 1987). Cognitive models of learning have been updated to include affective processes as significant mediators of, and even co-equal to, cognition (Moreno & Mayer, 2007; Plass & Kaplan, 2016). For scholars of game-based learning (GBL) and related fields, understanding the role of emotions in game-based learning environments (GBLEs) is crucial for improving methods of designing learning games. Yet, there is a long road ahead before we can fully bring to bear the power of emotions for optimizing learning outcomes, especially in GBLEs.

At the crux of this is *emotional design*, which is the design of multimedia features to intentionally induce emotional states that support learning (Um et al., 2012). Emotional design is an emerging area of GBL research that has considerable importance for the future of the field (Pawar et al., 2019), and uncovering ways to rigorously evaluate emotional design in GBLEs is particularly pertinent (Loderer et al., 2019). GBL researchers have already broken ground on this front, shedding light on design approaches that practitioners can employ now, as well as providing guidance for future emotional design research (Dickey, 2011; D'Mello et al., 2014; Plass et al., 2020). In some cases however, research has yielded inconsistent results concerning the expected effects of emotional design (Plass & Hovey, 2021). For instance, some studies detected learning gains but not the intended emotional change (Li et al., 2020); other studies reported no effect on either emotions or learning outcomes (Münchow et al., 2017); still other studies generated findings on general "positive" or "negative" feelings with notable differences in short-term learning gains, but no difference in long-term gains (Cheng et al., 2020).

In order to wrangle these inconsistencies and make headway on fully understanding the impact of emotional design, GBL researchers have called for a systematic approach to evaluating the ways that game design elements—visual aesthetics, audio and musical score, game mechanics, narrative, and incentive systems—influence specific emotions, learning processes, and learning outcomes (Loderer et al., 2019; Plass et al., 2019; Plass & Hovey, 2021). Building off of research designs from existing studies, this paper makes an initial proposal as to how such a systematic approach might look.

Previous Studies

A number of studies on different aspects of emotional design in GBLEs have emerged over the past decade, ever since Um et al. (2012) first published findings on the use of color and visual shapes to induce positive emotions within a computer-based lesson on immunization. The study suggested that emotional design principles could indeed be applied to multimedia learning materials to induce positive emotions that support learning; the authors also noted they could not fully make claims about the impact of each individual design feature, as they had not been examined independently. A later study by Plass et al. (2020) extended this work by separately examining the effects of color, shape, expression, and dimensionality of characters. Their findings suggested that all four design features induced positive emotions, with expression and dimensionality having the strongest effects; they also noted that their findings were limited by virtue of using only self-reports to measure emotions, rather than a combination of measures as recommended by other researchers (D'Mello et al., 2014). In addition, their studies only tested for changes in affective states, not for changes in learning outcomes.

While visual aesthetics have been the largest focus of emotional design research in multimedia learning and GBLEs to this point (Pawar et al., 2019; Plass & Hovey, 2021), a handful of studies have taken approaches to evaluating other design features. Bowers et al. (2013) compared the affective qualities of first-person and third-person narrative text pre-activities for priming military trainees to engage in a combat simulation; the study yielded no significant differences between the narrative perspectives, although the authors urged further investigation. Dickey (2011) conducted exploratory research on the ways that players interacted with *Murder on Grimm Isle*, a mystery adventure game, identifying curiosity as a possible motivator for engaging with the game's ambiguous open-ended narrative. D'Mello et al. (2014) investigated the impact of intentionally confusing players by presenting them with conflicting information through trialogues with non-playable characters (NPCs). In that study, the treatment groups receiving conflicting information outperformed groups that did not receive conflicting information. In summary, each of these studies used different approaches to testing the effects of emotional design, yielding different types of results. Bowers et al. studied the emotional design of a *supplemental* activity that was external to the actual learning simulation; Dickey conducted an exploratory study to uncover potential hypotheses; and D'Mello et al. investigated developed hypotheses rooted in affective theories about confusion.

Theoretical Foundations

Game-Based Learning (GBL)

GBL is defined by Plass et al. (2019) as "games with specific learning goals" (p. 3). There is no single theory of GBL; rather, Plass et al. provide a model of GBL supported by cognitive, affective, motivational, and sociocultural theoretical foundations. Each of these foundations influence several game design elements, including visual aesthetics, audio and musical score, game mechanics, learning mechanics, assessment mechanics, and incentive systems. The process for creating and optimizing a playable learning game includes playtesting, usability research (Plass et al., 2018), and design-based research (Hoadley, 2004).

Control-Value Theory of Achievement Emotions (CVT)

Pekrun (2006) proposed the Control-Value Theory of Achievement Emotions (CVT), an integrated framework specifically concerned with emotions in academic contexts. In this framework, emotional states are considered to arise from a learner's appraisal of control over, and valuation of, prospective outcomes (anticipation of success or failure), retrospective outcomes (experience of success or failure), and feelings about the activity itself (positive or negative). Depending on the perceived levels of control and value toward the activity, learners will experience positive or negative emotions. A meta-analysis by Loderer, Pekrun, & Lester (2020) verified the viability of CVT as a solid theoretical foundation for future research on emotions and learning.

Integrative Cognitive-Affective Model of Learning with Multimedia (ICALM)

Plass and Kaplan (2016) proposed the Integrated Cognitive-Affective Model of Learning with Multimedia (ICALM), which integrated CVT, the Cognitive-Affective Theory of Learning with Media (CATLM; Moreno & Mayer, 2007) and affective computing (Picard, 2003), as well as Russell's (2003) concept of core affect and Izard's (2009) notion of emotion schemas. They held that the role of affect in Moreno and Mayer's (2007) model constitutes a third, separate yet intertwined channel from visual and auditory forms of cognitive information processing.

Emotional Design Principle in Multimedia Learning

The Emotional Design Principle in Multimedia Learning (Plass & Hovey, 2021) states: "people learn better from multimedia materials when the materials' design induces an emotional state conducive to learning without significantly increasing the need to process irrelevant information" (p. 324). The implication is that emotional design requires the redesign of *existing* features—rather than the addition of *new* ones—in order to mitigate any associated cognitive load. For instance, the addition of seductive details (such as decorative images) to a piece of multimedia might induce a positive response, but the effort necessary to process the new feature could offset any potential benefits of the redesign. On the other hand, changing the colors of an *existing* graphic in the same piece of multimedia could induce the desired affective changes while having minimal impact on cognitive load.

Integrative Model of Emotional Foundations of Game-Based Learning (EmoGBL)

The Integrative Model of Emotional Foundations of Game-Based Learning (EmoGBL: Loderer at al., 2019), incorporates CVT and ICALM, along with the intelligent tutoring and games framework (ITaG; McNamara, Jackson, & Graesser, 2010). EmoGBL maps out feedback loops between, among other things: (1) appraisal processes, including control and value appraisals; (2) learner emotions; (3) learning processes; (4) learning outcomes; and (5) the game-based learning environment, which particularly includes emotional design of visual aesthetics, audio and musical score, game mechanics, narrative, and incentive systems. EmoGBL also takes Russell's (2003) dimensional perspective of emotions, placing them on a space defined by orthogonal axes of *valence* (positive vs. negative feelings) and *arousal* (activating vs. deactivating feelings). Positive activating emotions have been generally shown to support learning, while positive deactivating and negative activating emotions have effects that are less predictable (Loderer et al., 2019).

A Proposed Outline for a Systematic Approach

Below, I attempt to articulate an outline for a systematic approach to researching emotional design in GBLEs, specifically learning games. The approach is largely based on similar approaches designed by NYU CREATE, whose research on emotional design over the past several years has yielded fruitful results (Plass et al., 2018; Plass et al., 2020). The outlined approach is illustrated in Figure 1 and described in more detail further in this section.

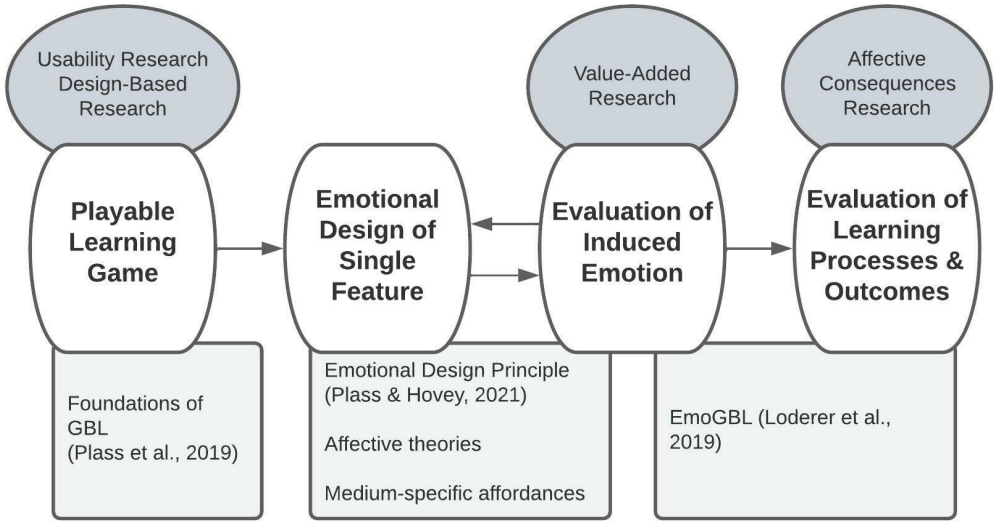

Figure 1
Outlined Systematic Approach to Evaluating Emotional Design in GBLEs

Playable Game for Learning

The outlined approach makes two assumptions from the outset. The first of these is that the researcher is *starting with a playable learning game* that has been designed and developed with guidance from theoretical foundations of GBL (Plass et al., 2019) and optimized through playtesting, usability research, and design-based research. It is not necessary for the researcher to have been involved in the design of the base version of the game; what is important is that the researcher begins with a game that effectively teaches what it is designed to teach, with measurable learning outcomes.

Emotional Design of Single Feature

The second assumption of this approach is that *the researcher has a hypothesis in mind* when setting out to do emotional design. Following the Emotional Design Principle, a single specific feature of a game element should be redesigned with the intent of inducing a targeted emotion. By way of example, "redesigning a character" is too broad, as any number of character design features—color, shape, expression, dimensionality, and so on—could constitute such a redesign. "Changing the color of a character," on the other hand, meets the level of specificity required, as "color" is a *single feature* of the game element, i.e. "the character." Design decisions are best guided by GBL literature and other related and relevant fields. For instance, when D'Mello et al. (2014) set out to induce confusion through trialogues, they cited studies suggesting that certain types (or "flavors") of confusion correlated positively with increased learning outcomes. Likewise, Um et al. (2012) referred to the "baby-face bias" phenomenon when discussing why round shapes were more likely to induce positive emotions than sharp or rectangular shapes.

Crucially, the emotional design of the single feature should avoid introducing any additional features, seductive details, or other elements that increase cognitive load, as doing so would potentially offset any benefits gained from the new emotional design (Plass & Hovey, 2021). Below are a few examples of redesigned game elements that have been examined in previous studies:

- Color of NPCs ("warm" vs. "cool" or "neutral")
- Shape of NPCs (round vs. rectangular)

- Facial expression of NPCs (happy vs. sad or neutral)
- Dimensionality of NPCs (2D vs. 3D)
- Perspective of narrative (first-person vs. third-person)
- NPCs presenting consistent information vs. conflicting information

Researchers might additionally consider the unique affordances of the hardware on which the game is played. For example, virtual reality (VR) has the potential to induce senses of presence and agency that are more intense compared to those induced by other forms of interactive digital media, which could result in observable differences in learning outcomes (Makransky & Petersen, 2021). In this instance, one might give heed to studying the effects of VR features on senses of presence and agency. In general, whether studying a 2D or 3D digital game, VR game, augmented reality (AR) game, or mixed reality (MR) game, researchers might be advised to tailor their design approach to the hardware.

Evaluation of Induced Emotion

In this phase, researchers address the question: "Does the redesigned version of the game induce the targeted emotion?" To do so, researchers should favor a value-added research approach (Mayer, 2014), comparing the base version of the game with the redesigned version in order to determine if the implemented emotional design induced the intended emotion. Measuring emotions is a complex undertaking with no prescriptive "gold standard" available (Graesser, 2020), so any research design of this nature should carefully select appropriate instruments for measuring players' emotions. Researchers suggest using multiple measures—namely self-reports, questionnaires, and behavioral observation protocols—in order to triangulate data and paint as complete a picture as possible (D'Mello et al., 2014; Plass et al., 2020; Plass & Hovey, 2021). A failure to detect the target emotion or any otherwise significant changes in affect could be attributable to, among other things, unforeseen confounds, issues with measurement (including implementation errors or selecting the wrong instruments), and so on. In any case, it may be necessary to return to the *emotional design* phase and iterate on the attempted design; and the relationship between the *emotional design* and *evaluation of induced emotion* phases of this framework might be thought of as a design process in its own right.

Evaluation of Learning Processes and Outcomes

Once findings from the *evaluation of induced emotion* phase suggest that the emotional design of the single feature reliably induces the targeted emotion, attention should turn to measuring the effect on learning outcomes. This calls for an *affective consequences research* approach (Plass et al., 2019) to measure the effect of the redesigned game on learning processes and outcomes. EmoGBL posits that changes in learner emotions should have observable effects on learning processes such as motivation, cognition, memory, problem solving, self-regulation, and others (Loderer et al., 2019). When designing research for this phase, it should be kept in mind that other influential factors on learning processes may include players' intelligence, prior knowledge, and metacognitive skills (Loderer et al., 2019). Comparing the effects of the base version of the game with those of the redesigned game should yield insights into how the induced target emotion impacts learning.

Conclusion

As education research continues to firm its grasp on the role of emotions in learning, avenues for future work reveal themselves, particularly with regard to emotional design for learning games and other forms of interactive digital media. Research that targets specific game features, and the ways they influence emotions and learning, is an increasingly acknowledged area of need (Plass & Kaplan, 2016; Loderer et al. 2019, Pawar et al., 2019). There is a considerable amount of ground to cover in this area, and there is a particular need to focus on design elements beyond visual aesthetics, which have received

more exploration to this point (Pawar et al., 2019). This paper proposed an initial outline for a systematic approach to evaluating the effects of game design features on emotions and learning, and future studies on emotional design should continue to consider such systematic approaches (Plass & Hovey, 2021). Learning games or simulations that have been optimized by results of playtesting, usability research, and design-based research are potential starting points; emotional design should be carried out on a single specific game feature with a hypothesis in mind; value-added research, designed around multiple emotional measures, should confirm that the targeted emotion was successfully induced; and affective consequences research should measure the effects of the redesigned game on learning processes and outcomes. As research in GBL continues, and theoretical frameworks are refined, so too will our approaches to emotional design research be updated and systematized.

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