14 Emerging Design Factors in Game-Based Learning: Emotional Design, Musical Score, and Game Mechanics Design

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Introduction

For many of the design factors described by the model of game-based learning (Plass, Homer, & Kinzer, 2015; Plass, Homer, Mayer, & Kinzer, chapter 1 in this volume), sufficient research exists to allow design recommendations for game designers. These factors include instructional support, feedback, and coaching (Lester, Spain, Rowe, & Mott, chapter 8 in this volume), self-regulation and reflection (Taub, Bradbury, Mudrick, & Azevedo, chapter 9 in this volume), adaptivity and personalization (Plass & Pawar, chapter 10 in this volume), narratives (Dickey, chapter 11 in this volume), multimedia design principles (Nelson & Kim, chapter 12 in this volume), and social mode of play (Ke, chapter 13 in this volume). However, for a number of other design factors described in the model, only a small body of research in the context of game-based learning exists. Three of these emerging factors are discussed in this chapter, including emotional design, the game's sound and musical score, and game mechanic design. We discuss these constructs and summarize the limited research available on these design factors in the context of game-based learning. Additional emerging factors are discussed in Tam and Pawar (chapter 15 in this volume).

Emotional Design

Playing video games is an emotional experience (Isbister, 2016; Plass et al., 2015). When playing a game, players' emotions are influenced by various game elements, as described by Loderer, Pekrun, and Plass (chapter 5 in this volume). Emotional design is the practice of identifying these elements and utilizing them to induce a range of emotions in players. In the realm of video games and learning, the goal of emotional design is to induce emotions to enhance learning outcomes (Plass & Kaplan, 2015).

Summary of Construct of Emotional Design

The idea of designing media to induce positive emotions has been around for a long time (Norman, 2004), but research on its application for learning is still sparse. Emotional design is "the use of a range of design features with the goal to impact learners' emotions to enhance learning" (Plass & Kaplan, 2015, p. 138). Virtually all game design features can be used to induce specific emotions in learners. This includes the visual representation of information, the design of interactions in the form of game mechanics, and the game sound.

The concept of emotional design for learning is based on research showing the relation between cognition and emotion (Isen, Shalker, Clark, & Karp, 1978; Izard, 1993). These findings show a causal link between emotional states and cognitive processes such as attention, perception, and memory (Derryberry & Tucker, 1994; Isen, Daubman, & Nowicki, 1987; Isen et al., 1978; Izard, 1993, 2007; Lewis, 2005). The results show that various cognitive processes are enhanced when a learner is in a positive emotional state. This has led to the development of theories describing how emotions affect learning. The control-value theory of achievement emotion describes the antecedents and effects of emotions experienced by learners (Loderer et al., chapter 5 in this volume; Pekrun, 2006; Pekrun & Stephens, 2010). In the context of learning with digital media, the integrated cognitive-affective theory of learning (ICALM) provides a theoretical foundation for the effect of emotion on learning. This theory posits that emotions play a central role in information processing to create mental models for learning. It suggests that learners select, organize, and integrate information through the reciprocal relation between cognitive and emotional processes, and hence emotions, cognition, and learning are inherently connected (Plass & Kaplan, 2015).

The ICALM theory is backed by empirical evidence investigating the affordances of media elements to induce emotions and, as a result, to improve learning outcomes (Mayer & Estrella, 2014; Plass, Heidig, Hayward, Homer, & Um, 2014; Plass & Kaplan, 2015; Um, Plass, Hayward, & Homer, 2012). This has led to the development of the integrative model of emotional foundations of GBL (EmoGBL), which describes the mechanisms for how learning processes and emotion interact to develop specific learning outcomes (Loderer et al., chapter 5 in this volume). EmoGBL describes proximal antecedents of emotion, such as appraisals of the situation and of the self, emotional transmission from human peers, virtual peers, teachers, or other game features; distal antecedents, such as achievement goals and beliefs; and the emotional design of the game-based learning environment. In our discussion of emotional design for learning, we focus on how specific game elements evoke emotions for improving learning outcomes.

Emotional Design in Games for Learning

Various game elements have a strong influence on players' emotional states. Game characters and game environments are known to be effective in this regard (Anderson et al., 2017; Isbister, 2016; Riva et al., 2007). *Game characters* are intentional agents that take actions in a game environment. They represent either players or nonplayer characters (NPCs). Game characters have a strong influence on emotional states of players, as they can convey emotions through facial expressions (Plass et al., in press), postures (Clavel, Plessier, Martin, Ach, & Morel, 2009), and movement (Fagerberg, Ståhl, & Höök, 2003). Different design features of game characters influence their ability to induce players' emotions. These include static features, such as shape, color, and dimensionality (Mayer & Estrella, 2014; Park, Knörzer, Plass, & Brünken, 2015), and dynamic features, such as expressions, postures, gestures, and movement (Clavel et al., 2009; Dittmann, 1987; Fagerberg et al., 2007; Plass et al., in press). Multiple studies have investigated the effect of manipulating shapes and colors of characters on emotion induction (Mayer & Estrella, 2014; Plass et al., 2014; Plass & Kaplan, 2015; Um et al., 2012). Results from these studies have shown that game characters with round shapes and warm colors lead to higher emotion induction and better learning outcomes. In addition to shape and color, the dimensionality of game characters also affects emotion induction. A study conducted by Hovey, Pawar, & Plass (2018) found significant effects when comparing differences in emotional arousal from 3-D versus 2-D characters. In this study, participants played the same learning game in immersive 3-D and 2-D environments. Results showed that participants experienced higher emotional arousal in the 3-D version than in the 2-D version, but these findings have not yet been linked to learning outcomes.

Dynamic features of game characters, such as their expression, posture, and movement, also play an important role in emotional design. Game characters can convey their emotional state through *facial expressions* and in turn can generate an affective response in players (Paiva et al., 2004). In a study conducted by Plass et al. (in press), participant ratings of game characters expressing happy and sad emotions were compared to the ratings of the same characters expressing neutral emotions. Results showed that characters with happy and sad expressions were rated as more emotionally inducing than characters with a neutral expression (Plass et al., in press). These findings illustrate the affordance of game characters to influence player emotions using character expressions. Game characters can also convey their emotions through body language. The *body posture* of characters, when paired with facial expressions, conveys their emotional state (Clavel et al., 2009). Some studies have shown that body postures convey the intensity of felt emotions (Dittmann, 1987), while others have shown that they provide a context for interpreting facial expressions and verbal cues of emotions (Harrigan, Rosenthal, & Scherer, 2008). These findings suggest that character postures can support other emotional design features. In addition to postures, *body movement* is also an important factor in nonverbal displays of emotions. The manner of movement can ascribe specific emotional states to a game character and hence frame players' emotional expectations. A study by Fagerberg, Ståhl, and Höök (2003) provides preliminary support to this claim by identifying three underlying dimensions of movement—shape, effort, and valence—associated with emotional expressions. In this study, researchers used Laban and Lawrence's (1974) framework of movement analysis to categorize emotions into groups with specific movement characteristics. For example, anger was associated with spreading, rising, and advancing movements, while sadness was conveyed through enclosing, descending, and retiring movements (Fagerberg et al., 2003). These outcomes indicate that body movement is another useful feature for emotional design in games.

Game environments are virtual spaces that host gameplay. All game characters and game events act in the context of these spaces. Because game environments situate players and characters in a virtual world, they play an important role in influencing players' emotions. This phenomenon was investigated by Riva et al. (2007), who studied the effect of three virtual environments—anxious, relaxing, and neutral—in inducing emotions. The researchers manipulated environmental features such as shape, scenery, and lighting to elicit different emotions, and found significant differences in ratings of sadness, anxiety, and happiness for the different environments. These results suggest that different features of game environments, such as shape, scenery, and lighting, can be designed to evoke distinct emotional states in players (Riva et al., 2007). The *shape* of an environment can be considered the architecture of the play space. Studies have shown that factors such as space geometry and ceiling height can influence information processing, emotions, and cognitive processes (Meyers-Levy & Zhu, 2007; Shemesh et al., 2017). Similarly, *scenery* plays an important role in setting the context of the environment. Research comparing player affect and stress in natural and urban virtual environments has found that natural environments facilitate higher levels of positive affect and lower levels of stress (Anderson et al., 2017). The *lighting* of the game environment also influences emotional states of participants. The effect of environmental lighting has been studied extensively in the real world (Knez, 1995; Knez and Kers, 2000; Kumari & Venkatramaiah, 1974). Research has shown that higher luminescence leads to increased physiological arousal (Kumari & Venkatramaiah, 1974). The color of lighting has also been found to induce different emotional states in participants. Knez (1995) found that warm (reddish), bright light and cool (bluish), dim light induced positive moods. These findings can be extended to virtual game environments to evoke desired affective states. So far, research on effects of lighting in virtual environments has been studied in combination with sound, music, and texture manipulations (Riva et al., 2007), making it difficult to associate emotional differences to lighting alone.

Future Directions for Research on Emotional Design

The importance of emotions in cognition and learning has been established by empirical research (Izard, 1993, 2007; Pekrun & Stephens, 2010) and by theories such as CVT, ICALM, and EmoGBL. Many fields, including product design, advertising, and consumer marketing, have incorporated these findings into their design processes (Bagozzi, Gopinath, & Nyer, 1999; Demirbilek & Sener, 2003; Norman, 2004). Although emotions are playing an important role in game-based learning, there is only preliminary research on emotional design, linking methods of inducing emotions to corresponding learning outcomes (Mayer & Estrella, 2014; Plass et al., 2014; Plass & Kaplan, 2015; Um et al., 2012). These studies have investigated a limited number of visual aspects of emotional design, such as game characters and game environments. As games include various other elements that can be utilized for evoking emotional responses in users, research should explore the effect of additional game design elements. For example, the effect of audio design and musical scores, or interaction design and game mechanics, on emotion elicitation should be investigated in the context of game-based learning. Furthermore, with the emergence of technologies such as virtual reality, augmented reality, and mixed reality, approaches to emotional design that take advantage of the affordances of these media should be investigated. As a long-term goal, emotional design should be integrated as a fundamental feature in the design of game-based learning environments.

Musical Score

The musical score of a game is comprised of the sounds and music used as auditory stimuli in the game. The arousal and mood hypothesis (Thompson, Schellenberg, & Husain, 2001) suggests that music is a stimulus that influences listeners' arousal and mood, which then affect performance on cognitive tasks. Studies have suggested that arousal and valence, the two dimensions of emotions in Russell's (1980) circumplex model of affect, can influence performance on various cognitive tasks, including creative problem solving (Ashby, Isen, & Turken, 1999; Ilie & Thompson, 2011), arithmetic (Hallam, Price, & Katsarou, 2002), information integration (Estrada, Isen, & Young, 1997), decision making (Isen & Means, 1983), and spatial ability (Husain, Thompson, & Schellenberg, 2002). It has been argued that musical tempo is associated with influencing arousal, while musical mode primarily affects mood (Husain et al., 2002). In this section, we explore the impact of music on learners in different environments.

Summary of Construct of Musical Score

In our definition, the musical score in a game includes all sounds and music used by a game. The most noticeable aspect is usually the game's sound track, but environmental sounds and sounds in response to player actions are included as well. These sounds can serve multiple objectives. On an affective level, they can induce emotions in the player, which link to their motivational objectives. A game's music and sounds can also have cognitive objectives, such as providing information to players, giving cues, and providing feedback (Plass et al., chapter 1 in this volume).

Music in computer games has evolved from the rudimentary sounds in the early days to music today that is written specifically for games, with the music resembling virtually every existing style (Munday, 2007). Game music incorporates various musical styles, including gothic, classical, rock, new age, jazz fusion, and even its own invented style (Belinkie, 1999). Game music is usually precomposed and recorded by game composers, though in some cases procedurally generated music is used (Collins, 2009).

Munday (2007) identified three main functions of game music: environmental, immersion, and diegetic. For the *environmental* function, Munday (2007) suggests that game music enriches players' perception of the game world. Scholars have argued that game music provides nonvisual information, including game theme and state (Whalen, 2004), ascribes meaning to game objects and environment (Chion, 1994), and provides crucial information for players to interpret the game environment (Cohen, 2000).

Concerning the *immersion* function, Munday (2007) argues that music is a crucial factor in influencing a player's sense of immersion. Sanders and Cairns (2010) suggest the choice of music can increase or decrease a player's sense of immersion. A player's enjoyment of music is suggested as one of the major factors in determining the player's level of immersion. Whalen (2004) contends that game music that complements the game's narrative may encourage immersion.

Finally, for the *diegetic* function, Cohen (2000) suggests that music adds meaning to the game story by confirming visual information and resolving ambiguity. Whalen (2004) argues that game music with different rhythms and tempos helps players identify safety and danger stages in the game narrative.

Music and Affect

Music can be used as an agent to induce emotion change, which can lead to performance improvements (Thompson et al., 2001). In a controversial line of inquiry, research found increases in listeners' performance on measures of spatial abilities after listening to music composed by Mozart (Rauscher, Shaw, & Ky, 1993). Thompson et al. (2001) conclude that the "Mozart effect" is an example of enhanced performance induced by positive mood and arousal. According to the arousal and mood hypothesis, this effect is not specific to Mozart's music or a specific musical stimulus but can be found with other music that is similarly engaging or creates pleasant stimuli. Nantais and Schellenberg (1999) demonstrated that listening to a short narrated story can also enhance spatiotemporal task performance. They concluded that preference is a crucial factor in influencing arousal and mood. The condition preferred by a learner enhances arousal and mood and hence increases performance. The arousal and mood hypothesis also applies across different cognitive tasks, age groups, and cultures. Schellenberg, Nakata, Hunter, and Tamoto (2007) found that adolescents performed better on an IQ subtest after listening to up-tempo music, while five-year-old Japanese children became more creative and energetic with their drawings after being exposed to familiar children's songs. However, extreme levels of arousal and negative mood can inhibit performance. Yerkes and Dodson (1908) suggest an inverted U-shaped relationship between arousal and performance. When arousal levels are either very high or very low, performance is impacted negatively.

Tempo, Mode, and Affective States

The influence of music's tempo and mode on emotional state has been examined extensively. Musical tempo has been argued to be the most important factor that influences a listener's affective state (Hevner, 1937). Up-tempo music may enhance performance, but it could also act as a stressor (Mayfield & Moss, 1989). Some studies have shown that music in major mode is associated with happiness, while minor mode is associated with sadness (Mayfield & Moss, 1989). Hevner (1937) suggests that minor mode is associated with "sad and heavy" and "dreamy and sentimental," while major mode is associated with "happy and bright" and "exciting and elated" emotional states Husain, Thompson, and Schellenberg (2002) argue that tempo and mode affect enjoyment. Higher enjoyment is experienced with fast tempo in music in major mode, while in music in minor mode, there is slightly more enjoyment with slower tempo.

Music and Performance in Games

There is some research investigating the effect of music on performance in games. Research found, for example, that low-arousal music leads to faster lap times in a driving game than high-arousal music (North & Hargreaves, 1999). The researchers suggested that high-arousal music has a higher cognitive load demand than low-arousal music and hence affected driving performance. Cassidy and Macdonald (2010) argue that music preference and tempo are crucial factors influencing performance in a driving game. They conclude that players who listen to self-selected music and high-arousal music perform better than players who listen to experimenter-selected music and low-arousal music. On the other hand, there are mixed results from participants memorizing facts in a virtual learning environment with and without background music (Fassbender, Richards, Bilgin, Thompson, & Heiden, 2012). Participants using a semicylindrical three-projector display system performed better with background music than without it. However, participants using a three-monitor display system performed better without background music. Cognitive load and familiarity with the technology are the potential explanations for these results.

Future Directions for Research on Musical Score

There is a paucity of research dedicated to the study of music in the context of games for learning. Future research should address questions regarding music for such games in multiple areas. One question to investigate is how different types of music influence a learner's behavior in different types of learning games, such as games with different learning goals and of different genres. Research has found that learners behave differently under different conditions—with music that varied in tempo and mode, without music, and with self-selected music. We need a better understanding of the factors and mechanisms that influence learners' behaviors under these different conditions. We also need to understand the role of learners' music preferences and their impact on their learning behavior. Lastly, future research should be conducted with participants with a broader range of demographic attributes.

Game Mechanics

Game mechanics are tools for gameplay (Fabricatore, 2007). Salen and Zimmerman define the mechanic as "the experiential building blocks of player interactivity. It represents the essential moment-to-moment activity of players, something that is repeated over and over throughout a game" (Salen and Zimmerman, 2004, p. 317). Mechanics allow players to receive information and interact with the environment to produce output. The game *Angry Birds*, for example, features a sling mechanic that allows the player to hurl birds at standoffish pigs. The game *All You Can E.T.* features a shooter mechanic that feeds hungry aliens with either cupcakes or milkshakes (see figure 14.1).

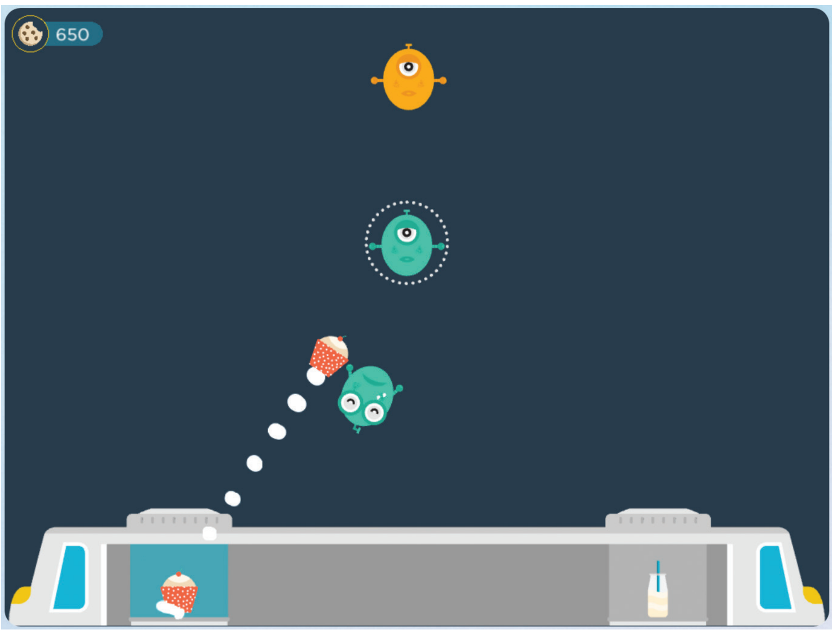

Figure 14.1
Shooter mechanic in the game *All You Can E.T.* (CREATE, 2015).

According to the mechanics, dynamics, and aesthetics (MDA) framework, the game mechanic is an essential component that determines game dynamics and the aesthetic experiences of games (Hunicke, LeBlanc, & Zubek, 2004). Game scholars, researchers, and designers have provided a variety of definitions of game mechanics. Salen and Zimmerman (2004) describe core game mechanics as activities that players perform repeatedly. Core game mechanics allow players to make meaningful decisions and hence create meaningful gameplay experience. Hunicke, LeBlanc, and Zubek (2004) contend that game mechanics are defined by game actions, behaviors, and control mechanisms. Sicart (2008) further suggests that game mechanics are actions carried out by players in the game world with the goal of interaction, where the actions are constrained by game rules or the game world. In this section, we explore different aspects of mechanics in games for learning and their effects on learners.

Summary of Construct of Game Mechanics

The high quality and educational effectiveness of the learning experience are two of the most important goals of learning-game design. Games for learning motivate and engage learners in order to achieve these goals. Plass et al. (2015) argue that a game mechanic is a crucial game design element that allows games to engage learners at multiple levels, including affective, behavioral, cognitive, and sociocultural domains. Scholars have suggested that game mechanics are a determining factor in promoting learning in educational games (Aleven, Myers, Easterday, & Ogan, 2010; Gunter, Kenny, & Vick, 2008; Plass et al., 2015). There are two important considerations for designing effective game mechanics for educational games. First, game mechanics should incorporate principles of the learning sciences (Aleven et al., 2010; Gunter et al., 2008; Homer & Plass, 2014). By incorporating such principles when designing game mechanics, games can support learning that is aligned with findings of the learning sciences and related theories (Aleven et al., 2010). Second, the game mechanic should be integrated with the learning content (Aleven et al., 2010; Gunter et al., 2008; Habgood, Ainsworth, & Benford, 2005). When learning content and game mechanics are aligned, learners' interest is higher, and learning outcomes are more likely to be achieved. Such an alignment also allows learning and gameplay to progress seamlessly without interrupting the flow of the games (Gunter et al., 2008).

Game Mechanics and Learning Mechanics

In order to describe the specific requirements for mechanics in games for learning, scholars introduced the concept of *learning mechanics* (Plass, Homer, Kinzer, Frye, & Perlin, 2011). While game mechanics describe the major building blocks of play activities, learning mechanics describe the major building blocks of learning activities (Plass & Homer, 2012). For example, a learning mechanic in *Crystal Island* (Lester et al., chapter 8 in this volume) involves communicating with game characters to collect information.

There are two major characteristics of learning mechanics. First, they are not playable mechanics but rather are design patterns of learning interactions, and need to be instantiated as game mechanics (Plass et al., 2011). Different game mechanics can be instantiated from the same learning mechanic, depending on the target audience, game genre, context, and learning goals. In our example, how the learner communicates with game characters can be implemented in different ways. They may simply walk up to them and talk to them, they may have to communicate in writing, or they may use a communication device. Second, design of learning mechanics should be grounded in the learning sciences (Arnab et al., 2015; Plass et al., 2011). This theoretical basis of learning mechanics allows game designers to implement game mechanics that can facilitate learning as well as gameplay (Plass et al., 2011).

The most important function of game mechanics in educational games is to facilitate learning. Meaningful learning activities are introduced to learners when appropriate game mechanics are implemented based on learning mechanics. This can be done in many ways. For example, Arnab et al. (2015) contend that game mechanics should allow experiential learning during gameplay. Game mechanics should help learners acquire new knowledge or skills through interactions in the game world.

Game Mechanics and Learning Mechanics Design

Learning mechanics define the essential learning interactions that take place within a game (Plass, Perlin, & Nordlinger, 2010). Learning theories such as situated learning, cognitive apprenticeship, anchored instruction, and many others can be used as foundations when designing learning mechanics. Domagk, Schwartz, and Plass (2010) provide the INTERACT model, an integrated model of interactivity for designing and understanding learning interactions. This model suggests that interactivity should be designed considering affordances related to medium, learner characteristics, motivation, emotion, the learner's mental model, and learner activities. The model describes an interconnected dynamic relationship between learning system and learners. Domagk et al. (2010) argue that this model allows interactivity to be considered and designed holistically in an integrated system context.

Since multiple game mechanics can be derived from a single learning mechanic, it is important to ensure that each implementation of game mechanics is able to meet the learning objectives (Arnab et al., 2015). The evidence-centered design (ECD) framework (Mislevy, Almond, & Lukas, 2003) provides a systematic process to ensure that design of the game mechanics is aligned with learning mechanics to achieve the intended learning goals. Game designers can apply the ECD framework when designing and validating learning game mechanics. The student model in ECD defines variables related to students' knowledge and skill, the task model is for designing tasks to achieve this knowledge and skill, and the evidence model describes what evidence should be collected from students' task performance. Together, these three models can help game designers design game mechanics that provide opportunities for learners to elicit observable evidence of the targeted knowledge and skill for assessing the intended learning goals (Mislevy et al., 2003).

The integration of the game mechanics with learning content has been suggested by several scholars. Gunter et al. (2008) contend that learning content in games should be organized and introduced in a hierarchical structure such as Bloom's taxonomy. Habgood et al. (2005) suggest that learning material should be integrated with game structure, where learners explore the content through game mechanics and gameplay. One of the few studies that investigated this effect was conducted by deHaan, Reed, and Kuwanda (2010). The researchers studied the effect of a learning mechanic in a music video game on cognitive load and vocabulary recall among undergraduate students in Japan. In a yoked design, one group played the game, which involved a mechanic of flipping burgers under time pressure that was unrelated to vocabulary learning. A participant in the other yoked group watched a player on a second monitor but without actively engaging with the mechanics. Results showed that participants in the group that watched but did not play had higher incidental vocabulary learning and reported experiencing lower cognitive load than the players. These results suggest that a game mechanic that is not aligned with the learning objective introduces extraneous cognitive load that hinders learning.

A small number of studies compared different game mechanics and their effects on learning. Plass et al. (2012) designed two versions of a middle school math game with two different mechanics. They found that learners performed better in the conceptual rule mechanic, where players had to specify which rule they would apply to solve a geometry problem of angles in quadrilaterals, than in the arithmetic mechanic, in which they had to provide the numeric response (angle) of the solution. On the other hand, the arithmetic condition generated more situational interest among players than the concept condition (Plass et al., 2012).

Two experiments on mechanics in a simulation for learning compared an exploratory mechanic with a direct instruction mechanic. The exploratory mechanic allowed learners to use sliders as controls to explore a simulation about the ideal gas laws, while the direct instruction mechanic allowed learners to watch videos of the simulation exploration by an expert. The first experiment, using a less complex simulation with only two variables, revealed that the exploratory mechanic was more effective overall for science learning, as shown by a transfer test. The second study, using a more complex simulation with three variables, showed that learners' executive functions determined which mechanic was more effective. Learners with lower executive functions benefited more from the direct instruction mechanic, but learners with higher executive functions benefited more from the exploratory mechanic (Homer & Plass, 2014).

Research by Kinzer et al. (2012) operationalized a choice mechanic by providing learners the choice of selecting their own nonplayer character as an instructional guide in a geometry game. Results suggest that a choice mechanic positively influences learners' learning outcomes, motivation, and in-game performance. Hew, Huang, Chu, and Chiu (2016) concluded that game mechanics such as badges, points, and leaderboards motivate college students to cognitively engage in tasks that are more difficult and to produce a higher quality of artifacts in a gamified learning environment. Learners also became more motivated to participate.

Future Directions for Research on Game Mechanics

Learning mechanics and game mechanics are among the most important elements in the design of engaging and effective games for learning. There are increasing efforts to examine the importance of learning mechanics and game mechanics design in learning games (Arnab et al., 2015; Lameras et al., 2017; Plass et al., 2011; Proulx, Romero, & Arnab, 2017). Arnab et al. (2015) proposed a learning mechanics and game mechanics model for designing and analyzing educational games. Plass et al. (2011) proposed developing a library of learning mechanics and game mechanics to allow game designers to better understand how game mechanics should be designed from learning mechanics. However, there is only limited evidence on the effect of learning mechanics and game mechanics design on learners and learning outcomes.

In future research, the structure of game mechanics should be investigated. Fabricatore (2007) proposes an architectural model of game mechanics. This model describes how game mechanics are made up of two major components, core mechanics and satellite mechanics. Satellite mechanics include enhancement, alternate, and opposition mechanics with the purpose of introducing variations to the core mechanics. Variations in core mechanics can enhance challenges and sustain motivation (Fabricatore, 2007). Future research should investigate how different design patterns of satellite mechanics support and complement core mechanics.

Future research should examine how game mechanics can be instantiated from learning mechanics to maximize educational effectiveness. Plass et al. (2010) argue that games can engage learners in affective, behavioral, cognitive, and sociocultural domains. More research is required to show how game mechanics that foster engagement at affective, behavioral, and sociocultural levels can lead to cognitive engagement that results in improved learning rather than introducing extraneous processing demands. More research needs to investigate how, when, and to what extent the combination of different types of engagements promotes or hinders learning.

We also need a better understanding of how different game mechanics, derived from different learning approaches, influence different learners and their learning outcomes. The findings by Homer and Plass (2014) showed, for example, how the effects of specific mechanics depend on learner variables such as executive functioning skills. Future research should be conducted that includes learners with different characteristics and attributes.

Finally, there are no established processes or design patterns for how to align academic content with game mechanics. Gunter et al. (2008) argue that academic content should be integrated within the game mechanics to allow learners to synthesize and apply the content to create new knowledge to progress to the next higher level. On the other hand, Habgood et al. (2005) suggest that learning content should be represented within the interactions in the game world and delivered through parts of the game that are most fun to play with. The study by deHaan et al. (2010) showed how critical these design decisions are and how game mechanics that are not well designed can hinder learning. Future work should therefore focus on examining design patterns integrating academic content with game structure and mechanics, and their effects on learning.

Conclusion

For several of the design factors described in the model of game-based learning (Plass et al., chapter 1 in this volume; Plass et al., 2015), only limited empirical research exists that investigated design-specific questions as well as the effects design has on learning outcomes in the context of games for learning. In this chapter, we focused on three of these design factors: emotional design, musical score, and game mechanics. Emotional design, which has the goal of facilitating learning by using a range of design factors to induce emotions conducive to learning, has been investigated outside games and been found to have a positive effect on learning. Even though only limited evidence from research with games exists, it is likely that this effect, which has been studied mostly outside games, will be present in games for learning as well. This is especially likely because of the large range of design features in games that can be used to induce emotions. One of these design features is the musical score and game sound, which has been shown to affect learning and performance outside games, and we presented limited evidence that similar effects can be found in games.

Game mechanics, the central building blocks of learner activity in the game, has received surprisingly little attention from researchers. This may be because of methodological problems, as changing the game mechanic often means that an entirely different learning strategy is used. However, the evidence we discuss shows that mechanics have a strong potential to affect learning, and a game's effectiveness may very well hinge on a well-designed mechanic.

Overall, these three design factors are likely to play an important role in the design of games for learning. We therefore made recommendations for future research that should be conducted in order to provide empirical evidence supporting specific design decisions and linking these design factors to learning outcomes.

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