Comparison of Intrinsically Motivating Factors in Educational Games

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Introduction

Good games are intrinsically motivating: playing the game is its own reward. Educators have sought to harness the motivational power of games to improve and supplement students' engagement and learning by placing instructional content into video games. However, if the learning content is not carefully integrated with the game, learners' intrinsic motivation can be undermined. Their motivation to play the game may be undermined if the educational content disrupts the flow of the game (Habgood & Ainsworth, 2001), and their motivation to learn the content may be undermined by the use of gameplay as an extrinsic reward for learning (Deci et al, 2001).

We consider an educational game to be *intrinsically integrated* with its learning content if the content is codependent with one or more intrinsically motivating factors of the game. The criteria for codependence depends on the specific factor, but in general a factor is codependent with the learning content if neither the nature of the factor nor the specific learning content can easily be swapped out for a different nature or content. We consider the integration to be *partial* if the content depends on a motivating factor or a motivating factor depends on the content. In this paper, we focus on the following four intrinsically motivating factors: *game mechanics*, *fantasy*, *goals*, and *curiosity*. Malone (1980) lists challenge, fantasy, and curiosity as intrinsically motivating aspects of games; we distinguish between two subcategories of challenge, game mechanics and goals, since their integration and motivational effects are described somewhat differently in the literature. Our definition of intrinsic integration is an adaption of that of Habgood and Ainsworth, which requires codependent integration of the motivating factors *fantasy* and *game mechanics*.

Intrinsically integrated games tend to harness learners' intrinsic motivation to play the game as motivation to learn the content. Unintegrated games tend to use the enjoyable experience of gameplay as an extrinsic motivator to engage with the learning content, but this type of educational game can sometimes be described by the phrase "chocolate-covered broccoli" - it incentivizes learning, but does not make the learning taste any better. Intrinsic motivation, by its nature, inspires students' curiosity and active learning. Extrinsic motivation, in all cases but supportive verbal feedback, undermines intrinsic motivation (Deci et al). Although extrinsic motivation in games may still improve student performance (Priest & Jones), the undermining of intrinsic motivation will lead to reduced "task engagement, cognitive flexibility, and conceptual understanding" (Deci et al). For these reasons, we seek to examine how intrinsic motivation to learn can be effectively fostered through intrinsically integrated educational games.

Extrinsic Motivation versus Intrinsic Motivation

Extrinsic motivation offers many advantages and disadvantages when it is used as a motivating factor in educational game design. One of the primary benefits of a lesser degree of integration between the curriculum content and the game is scalability. When the fun, intrinsically motivating aspects of a game do not involve educational content, this allows for curriculum content to be easily swapped in and out of a game. The versatile nature of these games allows for a large spectrum of content to be taught by a single game interface. This means a greater number of students in different courses can use the same game for their various learning goals. In addition, the complexity of the design process may be lowered when curriculum content does not have to be accounted for, since the game can be designed without considering specific learning goals.

Extrinsically motivating games have disadvantages as well. Many extrinsically motivating games are viewed by players as controlling, limiting their freedom and the enjoyment of the game. Priest and Jones (2015) claim that extrinsic game design has the potential to be perceived as strongly controlling primarily because of the interrupting gameplay between levels with questions that force the players to answer before they can continue. This is an example of the “chocolate-covered broccoli” concept that many of the researchers on this topic refer to. A context is often considered controlling “to the extent that people feel pressured by it to think, feel, or behave in particular ways,” according to Deci, Koestner, and Ryan. Priest and Jones (2015) argue that edutainment, or extrinsically motivating games, that use gameplay as a reward for learning content disrupt the overall “flow” experience for players by forcing them to regularly switch from gameplay to non-flow-inducing activity. The overall flow experience of a game is a key component in sustained enjoyment and interested.

Intrinsically motivating educational games, too, have an array of advantages and disadvantages. One of the primary advantages is the effectiveness of the central flow experience directed towards educational goals that results from harnessing intrinsic motivation. Habgood and Ainsworth discovered that flow is critical in creating and maintaining positive motivational appeal, and intrinsic integration helps ensure that the benefits of flow are directed toward educational goals (2011). Representational structure also enhances the flow of the game in conjunction with curriculum content (Habgood and Ainsworth, 2011). Based upon Cognitive Evaluation Theory, proposed by Deci and Ryan, extrinsic rewards can undermine a player’s self-perceived competence and self-determination, which are critical in sustaining interest and motivation (Deci, Koestner, Ryan). Intrinsically rewarding games do not suffer this effect. When educational content is weaved within the intrinsically motivating components of games seamlessly, this allows for learning to take place without compromising interest.

Many researchers have identified potential weaknesses of intrinsically integrated games that students' intrinsic motivation. Priest and Jones identify the practical obstacle in heavily integrated games that they don't naturally generalize to other educational concepts and subjects (2015). Some researchers claim that integrated games may make it harder to actually learn the curriculum content because it doesn't allow players to reflect and soak in the content, especially in fast-paced action games. Intrinsically integrating learning content within frantic action games could make it difficult to learn the educational content because the learner must cope with two forms of competing demands simultaneously, the educational and gameplay elements (Habgood and Ainsworth, 2011). Habgood and Ainsworth also point out that intrinsically integrated games potentially create knowledge that cannot be easily applied outside the game context. From previous studies that they have analyzed, they have found that some children find it difficult to apply the mathematical knowledge from the studies acquired in one context to a different one and that intrinsic integration could create knowledge that is highly specialized (Habgood and Ainsworth, 2011). There is the possibility that learning that occurs in the game "stays in the game". These observations are important to recognize so that researchers can fully understand the potential challenges that intrinsically integrated games possess in order to be effective. Both extrinsically and intrinsically motivating components in educational games have advantages, disadvantages, and learning implications.

Game Mechanics

While game mechanics are a central design choice in all games, educational or not, and can heavily induce intrinsic motivation within the players, there is a large spectrum of how integrated educational content is with a game's mechanics. We define game mechanics as the repeated actions a player takes to progress in a game. Players are often motivated by game mechanics that instill a sense of gaining mastery of the mechanics. A player's self-perceived competence can contribute to their motivation. Deci and Ryan (1980) introduced Cognitive Evaluation Theory, which states that "underlying intrinsic motivation are the innate psychological needs for competence and self-determination" (Deci, Koestner, & Ryan, 2001). Cognitive Evaluation Theory is broken down into two parts: Self-determination Theory and the self-perceived competence of a player. Deci and Ryan state that events that decrease perceived self-determination or competence undermine intrinsic motivation, whereas those that increase perceived self-determination or competence enhance intrinsic motivation (Deci, Koestner, & Ryan, 2001). Gee also discusses this idea and claims that "for learners of all levels of skill there are intrinsic rewards… growing mastery and signaling the learner's ongoing achievement" (Gee, 2003, p. 67; cited by Dondlinger). Thus, it is important for educational game designers to create mechanics that give players a blossoming sense of control, power, and mastery.

Another major avenue in which game mechanics heavily increase the intrinsic motivation of players is through optimization of the central flow experience of the game. Flow is defined as a "balance between the challenges perceived in a given situation and the skills a person brings to it" at any given point in the game (Csikszentmihaly, 1988, p.30, cited by Habgood & Ainsworth). No activity can sustain its flow for long unless both the challenges and the skills become more complex (Csikszentmihaly, 1988). Only when a player is at his or her optimal level of difficulty will they remain engaged and in conversation with the game content. Gee discusses the "Regime of Competence" Principle, which is defined as the continual point at which a player is challenge at the edge of his or her abilities (Gee, 2003). The game mechanics serve as a means to achieve this optimal level of challenge. Strategies of design that lead to engagement lead to challenges and interaction choices within a game, according to Dickey (Dickey, 2006; cited by Dondlinger). Game mechanics are a major area where engagement levels are produced, self-perceived competence and self-determination are sensed, and where overall flow experience is created and maintained.

We seek to understand how the intrinsic motivation to engage with game mechanics can be extended to learning content. As discussed above, when players gain mastery of the core game mechanics through the flow experience, in which the difficulty increases as their skill increases, their self-perceived competence increases, leading to greater intrinsic motivation. Game mechanics, then, are intrinsically integrated with educational content when the player's level of skill in the core game mechanics depends on their level of skill in the educational content. That is, a player cannot get better at the game without getting better at the learning content. We define the degree of intrinsic integration as the ratio between the amount of time a player spends building mastery at skills in the game that require curricular knowledge to the amount of time they spend building mastery at any skill in the game. If the game is fully integrated, all time spent practicing game mechanics will be time spent learning educational content. If the game is not integrated, no time spent getting better at the game will contribute to the player's learning, and all learning must be done aside from the core game mechanics.

Fantasy

Fantasy is the simulated, imaginative context or "world" in which a game is played. A game may consist of a images on a video monitor, cards on a board, or drawings on paper. In any of these media, however, there is usually a self-contained context that the players of the game hold in their awareness with any degree of rules, history, and similarity with the real world. Some games may not include a fantasy context if they occur solely in the real world. Malone makes the distinction that "games that include fantasy show or evoke images of physical objects or social situations not actually present" (1980, p. 164). Fantasies afford intrinsic motivation due to their ability to boost players' self-perceived control over the fantasy context and from "the emotional needs they help to satisfy in the people who play them" (Malone, 1980).

There is a lot of variation among educational games in how integrated their fantasy contexts are with their learning content. In "extrinsic fantasies," the player's application of the learning content or skill result in progress in the fantasy context, but the skill does not depend on the fantasy. A single fantasy can be used across many types of learning content with no changes to the fantasy context (Malone). Games with "intrinsic fantasy", in contrast, teach a skill that depends on the fantasy. As mentioned above, these tend to be less scalable because game designers cannot simply create a game for one fantasy and apply arbitrary curriculum. On the other hand, intrinsic fantasies can provide valuable learning context. Waraich claims "for any learning task to be meaningful to the learner they must have both a sufficient context for the learning and motivation to perform the tasks that will help them learn… learning environments that incorporate a strong narrative can meet these requirements if the learning tasks are… tightly coupled with the narrative" (2004, p.98; cited by Dondlinger). In addition to providing context, intrinsic fantasies also help learners form associations. According to Malone, "players are able to exploit analogies between their existing knowledge about the fantasy world and the unfamiliar things they are learning." There are some concerns that students player integrated fantasies may find it "difficult to transfer their understanding from concrete representations to alternative representations" (Habgood & Ainsworth, p. 175). Although well-integrated fantasies improve intrinsic motivation and provide context for learning, knowledge learned to apply to gameplay may not transfer to abstract knowledge. Designers must be careful to ensure students understand how concepts they learn in the game apply outside of the game.

To address how the intrinsic motivation to play a game with a compelling fantasy can be extended to motivation to learn, we need to consider what is motivating about fantasies. One aspect is that in a context decoupled from reality, risks are lower, and failure comes with a reduced penalty. Players tend to feel freer to explore and make mistakes in fantasy contexts. Along this dimension, a fantasy context is integrated with learning content to the extent that failures and mishappenings in the fantasy context coincide with failures in applying the skill being learned or practiced. Another aspect is the degree of control that unreal worlds give to players, which can boost their perceived self-determination. A fantasy context may be coupled with learning content along this dimension to the extent that the nature of the control a player exerts depends on the learning content, and the degree of control depends on the player's mastery of the learning content.

Goal

Among the current literature landscape, a clearly stated and identifiable goal is one of the most commonly cited components of a truly engaging and rewarding game. The best goals are often not simply goals of learning and using a skill, but rather are often practical or fantasy goals (Malone). Even if the skill you are learning is necessary to achieve the goal, it doesn't have to be the goal itself. Games that create subgoals in pursuit of an overall higher purpose have been found to be effective, especially games that typically present the player with a series of short, medium, and long-term goals. Swartout and van Lent found that goals of different levels help motivate learners to continue playing (Linehan, Kirman, Lawson, Chan 1981). "Games methodically teach players the skills needed to meet complex challenges. Long, complex tasks are broken down into short, simple components. These components are trained individually before being chained together" (Linehan, Kirman, Lawson, Chan 1981). This process of completing incremental steps towards a greater goal teach strong learning principles in acquiring knowledge as well. Even if the main goal of a game cannot be broken down, simply having a clear end goal in a game is one of the biggest components to fostering intrinsic motivation. Malone states that "goals and challenges are captivating because they engage a person's self-esteem" (Malone). In our study of the integration with goal components of a game and the educational content, the intertwining of both would potentially result in a greater increase in a student's understanding and retention of the educational goals and principles. The isolation of this component in regards to integration has not been studied by researchers within our current knowledge of the literature on this topic. We have speculated the reasoning behind why creating game goals that are integrated with curriculum content may be more effective for students. Because their intrinsic motivation is being fostered beyond simply the game's goals and are integrated with curriculum content, this drives a more focused approach to creating a mindset for students around the content, and redirects to focus to not simply the game. We predict that intertwining these two would increase the learning effectiveness of the game.

Malone has found that games that are endless or have no perceived higher purpose to the game mechanics are incredibly disengaging for players, and they often lose interest very quickly. Part of this is due to the lack of feedback and indication of progress within the game. Malone has identified that some ways to accomplish levels of goals and challenge is through variable difficult level, hidden information, and randomness because challenge is perceived as present only if the player is neither certain he or she can win nor certain he or she will lose. Feedback also aids motivation to work towards goals. Positive performance feedback leads to perceived competence. Negative performance feedback can be discouraging if it diminishes perceived competence, but otherwise can add to the perceived challenge. Negative feedback, however, can be utilized in effective ways in order to teach students when they make mistakes and gives them the freedom to make mistakes. Rather than simply reinforcing the right answers repetitively, showing students wrong answers also deepens their understanding of the curriculum content and material. Malone explains that "players must be able to tell whether they are getting closer to the goal, and this *performance feedback* may or may not be the same as… *informative feedback*" (Malone). Performance feedback in relation to the higher goals is key for both effective game design, and also effective educational training for the students.

Feedback in relation to goals is a component that has a large learning impact for learning principles in the way students learn and master concepts. Integration of performance feedback, positive feedback, and negative feedback principles into the learning content of educational games offers improved concept master in students. If mastery of a concept can be described as a vertical line, then Incorporating only positive feedback about curriculum content in the game reinforces a student's understanding from only the right side of the line. However, integrating negative feedback with the content in the game allows the students to make mistakes, and understand what errors in their perceptions of the learning content may be in a safe, undaunting context. This negative feedback integration in games offers feedback from the left side of the line, thus allowing students to properly identify where the line is, or essentially the true mastery of the educational concept. Thus, integration of feedback for educational learning goals and the game design can be utilized to increase learning effectiveness in students when playing educational games.

Curiosity

Curiosity is well-documented as a source of intrinsic motivation and source of enjoyment in games (Deci et al, 2001; Malone, 1980; Dickey, 2006, cited by Dondlinger, 2007; Denis et al.; Garris et al.), but there is little research on how to integrate it with learning content. Malone (1980) distinguishes between *sensory* and *cognitive* curiosity. Sensory curiosity refers to audiovisual effects and polish that improve the aesthetics of the game, provide performance feedback, and convey information through a growing symbolic model of the game's fantasy, mechanics, and goals. Cognitive curiosity, on the other hand, refers to "the desire to bring better form to one's knowledge structures" (pg 166). This includes knowledge about the game's rules, story, and lore. If any of these knowledge domains are intrinsically integrated with the learning content, then, any curiosity about that domain will also be about the learning content. Likewise, symbolic information that afford sensory curiosity can be intrinsically integrated with learning content.

Curiosity is often sparked by unpredictability. If the player learns to predict exactly how the game system will respond to their actions, they will no longer be curious. Growing information about lore, storylines, goals, and rules is clearly unpredictable because there is no way to predict what will be learned next. Unpredictability can also be implemented using randomness or subtleties in the consistency of the system that the player must piece together over time. In general, game environments should be "*novel* and *surprising*, but not completely incomprehensible… the learner knows enough to have expectations about what will happen, but where these expectations are sometimes unmet" (Malone, 1980, pg 165). In other words, the player should have a mental model of the game environment with some degree of consistency, but with gaps in the knowledge of details. This is similar to the curiosity evoked by knowing the premise or outcome of a story, without knowing the progression of events. Garris et al. (2002) summarize these conditions of unpredictability that invoke curiosity as *mystery*: “mystery is enhanced by incongruity of information, complexity, novelty, surprise and violation of expectations (Berlyne, 1960), incompatibility between ideas and inability to predict the future (Kagan, 1972), and information that is incomplete or inconsistent (Malone & Lepper, 1987).”

Both types of curiosity contribute to the intrinsic enjoyment of gameplay, but cognitive curiosity is more compoundable and sustainable than is sensory curiosity. As the player learns, explores, and discovers, their knowledge base expands and there are opportunities to introduce new curiosities for yet unobtained knowledge that depend upon this *new* knowledge. According to Malone, “the way to engage learners’ curiosity is to present just enough information to make their existing knowledge seem incomplete, inconsistent, or unparsimonious” (pg 166). As the player’s knowledge becomes more consistent, new inconsistencies can be introduced to once again spark curiosity. Malone argues “environments should be neither too complicated nor too simple with respect to the learner’s existing knowledge” (pg 165). This “optimal informational complexity” is similar in principle to the “optimal difficulty” that yields *flow*, as discussed in the Game Mechanics section. The distinction is that curiosity drives growth of knowledge, whereas challenging game mechanics drive growth of ability (Malone, 1980).

In contrast to expanding knowledge structures, increasingly complex audiovisual effects are unlikely to sustain the player’s interest. The exception is if the effects are symbolically coupled with the types of incomplete knowledge discussed above: an audiovisual effect can be used through the symbolic model mentioned above to provide the player with feedback that challenges their mental model of the rules, story, and lore of the game.

To extend players’ motivation to fuel their curiosity to motivation to engage with learning content, the elements of the game that instill curiosity must be integrated with the learning content. Integration here does not simply mean that when there is a surprise or challenge to the player’s mental model of the game that it depends on some piece of the curriculum. Rather, when the player’s mental model of the game is challenged, the player’s mental model of the educational content should be simultaneously challenged by the same challenge. That is, whatever new, surprising, event or revelation is presented must be simultaneously curriculum-based *and* fantasy-, rule-, lore-, mechanics-, or goal-based. We refer to this as an *intrinsic cognitive challenge*, a new piece of information that sparks curiosity in the game and about the curriculum simultaneously. If it is possible to measure how curious a player becomes in response to a particular surprise, the degree of intrinsic curiosity is the ratio of curiosity driven by intrinsic cognitive challenges to that driven by all cognitive challenges in the game. As an approximation, it may be defined as the ratio of the *number* of intrinsic cognitive challenges to the total number of cognitive challenges.

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