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Let There Be Dragons! Towards Designing an Engaging Quest that Enhances Curiosity and Learning About Genetics

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LET THERE BE DRAGONS! TOWARDS DESIGNING AN ENGAGING QUEST THAT ENHANCES CURIOSITY AND LEARNING ABOUT GENETICS

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by
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ABSTRACT

This study implemented a convergent parallel mixed methods approach to investigate game-based learning within an educational game compared to a modified entertainment game. Participants (N=31) were recruited from public middle and high schools as well as home school groups. Comparative data of participants' perceptions, preferences and learning outcomes were investigated to inform better educational game design. This study also considers player personality to determine how dispositional curiosity influences an individual's approach, acceptance, and interaction with novel learning environments, specifically games. Findings show a statistically significant gain in genetics academic knowledge after the game-based learning intervention. The difference in knowledge gained for the two games was not statistically significant. All dimensions of engagement, motivation and curiosity were statistically significantly higher for the modified entertainment game. Increases in scientific curiosity was statistically significantly higher for the modified entertainment game while scientific curiosity statistically significantly decreased after playing the educational game. Qualitative analysis revealed five themes and provided deeper understanding of game design features that enhance learning, curiosity and engagement from the player's perception. Integration of quantitative and qualitative results suggest overall convergence and enhanced understanding of theoretical and practical implications of this research and identifies key relationships between game design, player perceptions and learning outcomes to inform better educational game design and implementation.

DEDICATION

For Bruce, Glorian, Lena, Julie, JJ, Jaycie, Jensen,

Majik and Shae

And, to God Who provided me with a curious and creative brain

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CHAPTER ONE

INTRODUCTION

1.1 Introduction to the Research Study

Most researchers agree that commercial games are naturally engaging and motivational, and that learning occurs in game play (e.g., Gee, 2007; Squire, 2011). However, despite extensive knowledge regarding game design features that contribute to engagement, many educational games do not achieve the same level of engagement as popular commercial games (Becker, 2007). Some researchers consider engagement and education as opposing goals within games (Cheng et al., 2014; McNamara et al., 2009; Rai et al., 2009). Considering the extreme monetary and time commitments required to produce a successful commercial game, it is important to more fully understand the trade-offs between engagement and learning and the feasibility to achieve both when the game's purpose is academic achievement.

Current literature debates the exact nature of learning that occurs during game play (e.g., Boyle, et al., 2014; Dempsey et al., 1994; Emes, 1997; Randel et al., 1992; Vogel et al., 2006). Commercial games inherently support problem solving and thinking skills and incorporate a variety of learning theories into the design (Becker, 2007; Gee, 2007). Commercial games, especially role-playing games (RPGs), target player curiosity to increase engagement and persistence in the game world (Howard, 2016) and curiosity is known to enhance academic performance (von Stumm & Ackerman, 2013; von Stumm et al., 2011). Many educational games primarily target academic content, often at the expense of the entertainment value necessary for voluntary engagement by the player (Becker, 2007). Why do educational games often miss the mark on engagement and sometimes on learning outcomes as well? One way to answer this question is to directly compare an educational game to a popular entertainment game and investigate relationships between game design, player experiences, and learning outcomes. It is valuable to extend the definition of 'successful learning outcome' beyond content knowledge to include curiosity-related behaviors (e.g., exploratory, information-seeking, and persistence). Many games retain player engagement with quests that stimulate and reward curiosity (Howard, 2016). Curiosity related behaviors lead to increased interest, persistence and participation in resources internal and external to the game, which then enhance learning (Berlyne, 1954; 1960).

Trends in educational research indicate an increasing interest in how games may influence learning and thinking (e.g., Ke, 2009; Kebritchi & Hirumi, 2008; Qian & Clark, 2016; Wu et al., 2012;). Games may appeal to today's youth who are growing up with games. The digital generation think differently and have different expectations of their education system (Arnone et al., 2011; Beck & Wade, 2004). A recent survey showed over 183 million active gamers in the USA who reported playing over thirteen hours per week (McGonigal, 2011). The commercial game industry is lucrative as well. If you calculate the collective hours spent inside Blizzard Games' *World of Warcraft* environment, gamers have spent 5.93 million years playing and Blizzard games revenue were reported as five million per day (McGonigal, 2011, p. 53). Entertainment Software Association's 2018 report indicated that US gamers spent 29.1 billion dollars in 2017 on video game content and additional 7 billion on hardware and accessories. Shooter (25.9%) and action game (21.9%) genres were the best sellers, followed by sports (11.6%) and RPGs (11.3%). Sixty percent of Americans play video games daily and the average age of gamers is 34 yrs. old. Seventy percent of parents believe video games have a positive influence on their children's lives (EAS, 2018).

Engagement and motivation are fundamental to effective education and are especially important in game-based learning (GBL) environments (e.g., Kiili et al., 2014; Sabourin & Lester, 2014). Therefore, it is important to more fully understand how to design educational games that achieve high levels of engagement and motivation. However, it is challenging to consistently design a highly engaging game that yields statistically significant improved academic achievement (e.g., Becker, 2007; Kiili et al., 2014). One challenge for educational game design is the interdisciplinary skillset required of developers. The designer(s) must have deep understanding of game design theory, expertise in the academic domain knowledge, a foundation in learning theory, (e.g., Boyle et al., 2011) and an understanding of the game-player interaction. This interdisciplinary requirement suggests a holistic research design is beneficial for investigating GBL.

The overall play experience is a complicated dynamic relationship between the game's design and the individual player (Hunicky et al., 2004). The game design features directly impact the player's experience (motivation and engagement) (Hunicky et al., 2004). The player's preferences and personality also directly impact the player's experience (e.g., Whitton, 2010). When the player is engaged and having fun, they will interact with the game of their own volition and for countless hours as shown by recent game statistics (Koster, 2014; McGonigal, 2011; Schell, 2015). Consequently, a well-designed educational game that provides an engaging and fun experience for the player will increase exposure to academic content and may positively influence learning outcomes. Researchers have investigated user experience and interactions in games; however, consideration of design from an educational gaming perspective is relatively under-explored. This lack of research creates a barrier to replicating good game design or improving standards (Kiili et al., 2014).

Learning occurs during game play in both educational and entertainment games. However, no consensus has been reached in respect to the positive effect of GBL or to the exact nature of the learning outcomes (e.g., Boyle et al., 2014; Emes, 1997; Hays, 2005; Ke, 2009; Vogel et al., 2006; Wouters et al., 2013; Young et al., 2012). A meta-analysis on GBL concluded that players learn to play the game and do not learn domain specific content unless the learning is supported by other educational methods (Ke, 2009). Other research suggests GBL might be superior to traditional instruction because games increase motivation, engagement and exploration to acquire new information and skills (e.g., Boyle et al., 2014; Vogel et al., 2006). GBL studies indicate games can improve content knowledge, improve retention, develop more nuanced understandings, increase persistence, promote social knowledge construction, increase systems thinking and creativity, and develop scientific literacy (e.g., Barab et al., 2005; Brown & Thomas, 2006; Charsky & Mims, 2008; Gee & Hayes, 2010; Hickey et al., 2009; Squire, 2011; Steinkuehler & Squire, 2014; McCall, 2011; Moshirnia & Israel, 2010).

Researchers question the degree to which knowledge gained from game play transfers to other contexts (e.g., Biddell & Fischer, 1994; Egan, 1997; Fraser et al., 2014; Hou, 2015). Transfer refers to quality of learning and is defined as “ability to extend what has been learned in one context to new contexts” (Byrnes, 1996, p. 54). Exposure to knowledge and skills in one context generates familiarity that results in faster learning of similar concepts in new contexts (Bransford et al., 1999). Gamers transfer skills and knowledge learned in one game to new games. Academic content presented in games creates familiarity with the domain knowledge that may transfer to other contexts (Squire, 2004; 2012). Additionally, games may spark curiosity and interest about a topic that generates exploration and information-seeking external to the game that leads to deeper understanding and transfer (Arnone et al., 2011). This study proposes a pre-/post-genetics content knowledge test designed to gain some initial understanding of possible domain knowledge transfer by asking general and game-specific genetics questions along with observations of exploratory and information-seeking behaviors external to the game.

Learning outcomes other than domain specific content should be considered. The magnitude of knowledge has grown exponentially during the twenty-first century after the concept of a knowledge-based economy was introduced in 1996 (Leydesdorff, 2006). In response, the goal of education is shifting away from memorizing facts towards learning how to learn and think (Bransford et al., 1999). Games promote process-oriented learning, one of the primary characteristics of the new science of learning (Piaget, 1955; Vygotsky, 1978), and are considered preparation for future learning (Belenky & Nokes-Malach, 2012; Bransford & Schwartz, 1999). Innovative thinking skills, important to modern society, are supported in GBL (e.g., Qian & Clark, 2016). These skills, often referred to as 4C's (creativity, critical thinking, collaboration and communication), are supported by curiosity, which has been posed as the "missing 5th C" (Laur & Acker, 2017).

Curiosity plays an important role in player engagement and persistence in commercial games (Howard, 2016; Loewenstein, 1994). Additionally, curiosity can influence academic achievement on the same order of magnitude as intelligence (von Stumm & Ackerman, 2013; von Stumm et al., 2011). Curiosity influences an individual's propensity to voluntarily participate in novel activities and environments (Kashdan et al., 2018; Loewenstein, 1994). Stimulating curiosity can increase curiosity-related behaviors (question asking, exploration, information seeking) that support enhanced learning (Berlyne, 1954). Initial curiosity, that leads to deep engagement and sustained interest, may prompt engaged learners to seek information and experiences external to the gameplay (e.g., forums, wikis, videos, fan fiction, deviant art, and modding) and create peer-level curiosity and deeper learning (Arnone et al., 2011). Other researchers agree these online environments and media-production activities are a major source of learning contributed to games (Gee, 2012; Jenkins et al., 2006; Squire, 2011; Wenger, 1998). However, despite extensive research from the psychology field indicating curiosity is important to learning, there remains little consensus as to the definition, dimensionality or measurements of curiosity (Kashdan et al., 2018; Lowenstein, 1994). This lack of consensus makes it difficult to explore curiosity in other disciplines. To address this problem, Kashdan et al, (2018) conducted extensive research on curiosity to consider dimensions of curiosity (as opposed to simplified present/absent concepts) to develop a comprehensive curiosity measure that was mapped to various published valid personality measures. Limited research has been conducted on curiosity outside of psychology (Loewenstein, 1994). Even fewer studies have investigated curiosity as it relates to educational games. It is important to understand how games can be designed to stimulate curiosity, encourage exploratory and information-seeking behaviors, and enhance engagement so that more meaningful learning outcomes are supported.

Regardless of the exact nature of expected learning outcomes, the ability for any educational tool to produce improved learning is dependent upon student motivation and degree of engagement with the interaction (Sabourin and Lester, 2014). However, some researcher perspectives indicate learning and engagement are opposed outcomes in games; increasing learning decreases engagement and increasing engagement decreases learning (Cheng et al., 2014; McNamara et al., 2009; Rai et al., 2009). Other studies show negative emotions, specifically boredom, leads to disengagement, decreased learning, and strongly influences interactions with computer-based learning environments (Baker, D'Mello et al., 2010; Sabourin et al., 2011). Conversely, positive affects (e.g., engagement, concentration, enjoyment, and excitement) can enhance learning via increased persistence and better use of mental resources (Bless et al., 1996; Raghunathan & Trope, 2002). These negative emotions (boredom, frustration, anxiety, apathy) occur outside of the flow experience (Csikszentmihalyi, 1990) and/or when the three basic psychological needs (competence, autonomy and relatedness; self-determination theory) are not met (Ryan & Deci, 2000; Ryan & Deci, 2009). Obviously, the relationship between games and learning is a complex network of interactions that entails many variables.

To explore these relationships, the perspective of two well-known theories; *Flow Theory* (Csikszentmihalyi, 1990) and *Self-Determination Theory (SDT)* (Deci & Ryan, 1985; Ryan & Deci, 2000), were considered. Csikszentmihalyi's Flow Theory is targeted by the commercial game industry to increase engagement and player loyalty (Howard, 2016; McGonigal, 2011; Schell, 2015). Flow state is known to have a positive impact on learning, exploratory behavior and player attitudes (Webster et al., 1993). Educational games designed to support, rather than block, flow can enhance engagement and effective learning. However, many educational games disrupt the flow experience by inserting academic content and/or quizzes (Egenfeldt-Nielsen, 2005; Shute, 2011). Cognitive absorption extends Csikszentmihalyi's (1990) original flow structure to include curiosity and to define the context as involvement with computer software (Agarwal & Karahana, 2000). Trevino & Webster (1992) also extend the original structure of flow to include curiosity and immersion. Immersion is a highly related but independent concept that extends Flow Theory by defining three phases (engagement, engrossment, and total) (Brown & Cairns, 2004). The engagement and engrossment phases are considered sustainable whereas total immersion, equivalent to flow state, is considered as fleeting (Brown & Cairns, 2004). Since curiosity is key to learning and sustainable engagement is desirable, Csikszentmihalyi's (1990) original concept of flow was extended to include curiosity and immersion for this research study.

Self-determination theory (SDT) describes motivation as the satisfaction of basic human needs (autonomy, competence and relatedness) (Deci & Ryan, 1985; Ryan & Deci, 2000). This theory diverged from previous conceptualizations of motivation as a unitary phenomenon and distinguished different kinds of motivation based on an individual's reasons or goals underlying their actions (Deci & Ryan, 1985; Ryan & Deci, 2000). SDT describes motivation as composed of different amounts (level) and different orientations (underlying attitudes and goals) that lead to action (Deci & Ryan, 1985; Ryan & Deci, 2000). For example, a student can be motivated to interact with an educational game out of curiosity and interest; or alternatively because they desire a good grade or the approval of the teacher. According to SDT and Flow theories, intrinsic motivation relates to involvement with an activity (experience, object, or environment) because it is inherently interesting and enjoyable and this interaction results in high-quality learning and creativity (Csikszentmihalyi, 1990; Deci & Ryan, 1985; Ryan & Deci, 2000).

In summary, digital games are an important part of our technology focused society. Currently, most children and adolescents grow up playing digital games and interacting with technology that merges with most aspects of their daily lives (Arnone, et al., 2011). Educational games have the potential to support and improve learning, but current research lacks a consensus of the exact nature of these GBL learning outcomes as well as how those outcomes compare to traditional methods. This lack of consensus suggests that the full potential of digital games as learning environments is not fully understood (Mozelius et al., 2017). A well-designed game that is both motivational and engaging is required for effective learning. However, achieving both engagement and learning is a challenge (e.g., Becker, 2007, Shute, 2011). Curiosity may be one solution to this problem since it is important to engagement, intrinsic motivation and learning. However, limited research has been conducted on curiosity as it relates to GBL. Additionally, GBL research involves multiple disciplines and a complex network of interactions and variables. Yet, most current literature explores a limited number of variables in isolation. This study aims to extend current understanding of GBL and educational game design by adopting a holistic approach to explore the game-player dynamic in terms of relationships between game design features, game play experience (defined as engagement, motivation, and curiosity), player preferences (defined as trait curiosity and game preferences) and learning outcomes (academic achievement and curiosity-related behaviors such as exploration, information-seeking and intent to play).

1.2 Problem Statement and Research Questions

If students, expected to learn from educational games, perceive the game as unengaging or boring, then clearly the amount of interaction with the game environment and the effectiveness of the game as a learning tool is likely to be affected. A holistic approach is required to investigate this complex dynamic between the player/learner, game design, and outcomes (play experience and learning). The goal of this study is to explore complex interactions between the player and game related to engagement, motivation, curiosity and learning to better inform educational game design and implementation. A review of the literature identified several gaps in current research and made two problems salient. A better understanding of each of these problems will benefit GBL research and inform educational game design and implementation.

The first problem identifies the necessity for a game to be motivating and engaging for effective learning to occur (Malone, 1981). This research builds on current literature that suggests games have potential as novel, engaging learning environments (e.g., Qian & Clark, 2016). Current literature also enumerates game design features required for successful and engaging game design (e.g., Gee, 2007; Malone, 1981). Yet, many educational games fail to provide high levels of engagement. This study will adopt the perspective of motivational theories (SDT, Flow Theory), that outline conditions necessary for effective learning outcomes and engaging experiences, to investigate this research problem.

Hainey et al., (2016) identified the importance of game comparison studies, specifically comparing 2D and 3D games, and within a controlled experimental design for future research in GBL. A useful way to empirically investigate intrinsic motivation and engagement is to compare games with different features (Malone, 1981). To understand why educational games often fail to achieve the same level of engagement and success as commercial games, it would be helpful to directly compare a game design purposed for education *vs*. one purposed for entertainment. Few (if any) studies have made such a comparison. Game comparison studies have investigated different versions of the same game in three ways. First, researchers altered the game by changing internal features of the game (different quests or design features) (e.g., Chen et al., 2012; Chen et al., 2013; Denham, 2015; Habgood & Ainsworth, 2011; Hong et al., 2013; Hwang et al., 2013b; Kim & Shute, 2015; Miller et al., 2011; Nelson et al., 2014). Second, researchers altered external features of a game (different degrees of external scaffolds or support or different platforms) (e.g., Adams & Clark, 2014; Barzilai & Blau, 2014; Echeverria et al., 2012; Hwang et al., 2011). Finally, the same game was considered using different playing styles (single vs. multi; competitive vs. collaborative) (e.g., Brom et al., 2015; Chen et al., 2015; Plass et al., 2013). Yang and Chang (2013) compared two different technologies within a design-based context. The comparison group designed animations to teach a biology concept using Adobe *Flash* while the experimental group used *RPG Maker* to create a game to teach the biology concept (Yang & Chang, 2013). Therefore, a direct comparison of an educational game to a comparable entertainment game was not discovered in the literature review. It is a formidable task to identify an entertainment game that is directly comparable to an educational game, especially for academic content, which explains this gap in the literature. To this end, it was necessary to design a *mod* (modification of an existing game to add content or quests) such that an educational component could be integrated into the entertainment game chosen for this study.

For a game to achieve high levels of engagement as well as successful learning outcomes, the designer must navigate a complex network of interrelated variables with respect to game design features and player experience. Individual players have greatly varying attitudes and dispositions towards games, commercial and educational, that influence the individual's unique play experience. The majority of GBL research isolate limited game design features, theories and learning outcomes. Consequently, these previous studies lack an integrated understanding of complex relationships among critical factors related to engagement, motivation, learning and educational game design. This study will also add to current understanding through a holistic approach used to compare three different game designs from the player/learner perspective and initiate an understanding of potential relationships between game design features, learning, engagement and motivation.

Based on the literature review and the first identified problem, this study investigated the following research questions.

RQ1. What impact do game design features have on player engagement and motivation in educational games as compared to commercial entertainment games?

RQ2. What impact does the integration of learning content into a game design have on player engagement, motivation and learning?

RQ3. How does the game's design influence the game play experience and learning outcomes from the player's perspective when playing an educational game compared to an entertainment game?

The second problem that became salient upon completion of the literature review was the broad definition of successful learning outcomes. There is much debate about the nature of learning outcomes generated by game play, the effectiveness of such learning outcomes, the source of GBL (internal to the game, external to the game, or both), and the degree of transfer (e.g., Boyle et al., 2014; Dempsey et al., 1994; Emes, 1997; Randel et al., 1992; Vogel et al., 2006). However, few studies have considered curiosity as a potential learning outcome, or learning support, within the context of educational games. Game design features that stimulate curiosity are important to player engagement

(Malone, 1981, Provenzo, 1991). Curiosity is also important for learning to occur. Curiosity, as a personality trait, determines an individual's propensity to seek out, recognize and embrace novel, uncertain, or conflicting environments and/or information (Kashdan et al., 2009, Kashdan et al., 2018; Loewenstein, 1994). Situational stimuli that evoke state curiosity increase persistence (Loewenstein, 1994). Some researchers suggest it may be possible to manipulate emotional-motivational curiosity (state curiosity) to increase situational interest and/or influence trait curiosity to some degree (Loewenstein, 1994).

This study extends existing literature by considering curiosity from three perspectives. First, the study considers trait curiosity, as player personality/preference, that may influence their tendency to accept and voluntarily participate in games for learning. Second, the study considers game features that incite state curiosity resulting in curiosity-related behaviors (questions asked, exploration, information-seeking, and persistence) that enhance learning. Finally, the study considers domain specific curiosity to explore game features that may enhance scientific curiosity. Therefore, two additional research questions were investigated during the study.

RQ4. Can game design features heighten curiosity towards integrated learning content?

RQ5. Does an individual's trait curiosity influence how they approach a novel learning environment (GBL) and then influence interactions, engagement and motivation within that environment?

Finally, this study adopts a convergent parallel mixed methods approach to investigate the research problem in a holistic manner to gain an integrated understanding of the research problem. The literature review suggests a complex interaction between game, player, and outcomes (learning and play experience). To understand the complexity of this study as a whole, it is helpful to consider both quantitative and qualitative data. For the purpose of integration of results from the two strands of data collected, the following research question is posed.

RQ6: What game design features enhance (or inhibit) the game-player-learning experience and how do these features influence engagement, motivation, curiosity and learning in a GBL environment from the learners' perspective?

1.3 Definitions

Game. There are numerous definitions for *game*. Common to all posed definitions are the concepts of choice, rules, conflict, feedback and voluntary engagement (Koster, 2014; McGonigal, 2011). Schell (2015) defines a game as a fun (i.e. pleasure with surprises) problem-solving activity approached with a playful attitude (i.e. play is manipulation that satisfies curiosity). These definitions for games apply to sports, board games, non-digital games as well as video games. For this study, a game was considered as a structured experience that provokes positive emotions and inspires voluntary participation (McGonigal, 2011) and within the context of digital video games. However, this would eliminate many educational games as games if they are not voluntary activities. Therefore, some leniency was taken with the voluntary aspect of game-player interaction to define a game. As such, all games chosen for this study were considered as a game regardless of evidence (or lack of) for voluntary play.

Educational game. Educational games range in definition to include gamification of classrooms (e.g., adding badges, leaderboards), edutainment (e.g., games that include content knowledge and entertaining attributes comparable to commercial video games), simulations, and serious games. Serious games are designed with the primary purpose of education rather than pure entertainment (Susi et al., 2007). For this study, educational game is defined as a digital game whose primary purpose is to provide academic content.

Game-based learning (GBL). GBL is defined as an environment where game play and embedded educational content enhance knowledge and skills acquisition. The game promotes activities that require problem-solving and challenges that provide players/learners with a sense of achievement (e.g., Kirriemuir & McFarlane, 2004; McFarlane et al., 2002). The literature review focused on digital video game studies as opposed to other types of game mediums.

Engagement. O'Brien and Toms (2008, p. 949) define engagement as "a quality of user experiences" that is characterized by certain attributes (to include challenge, aesthetic appeal, sensory appeal, novelty, interactivity, feedback, perceived control, motivation, interest, awareness and affect). Many of these characteristics overlap Flow Theory (Csikszentmihalyi, 1975; 1990) and SDT (Deci & Ryan, 1985; Ryan & Deci, 2000). Researchers indicate that engagement can be measured via these engagement-related attributes (e.g., Flow and affective states) (D'Mello et al., 2007) and student motivation (Johns & Woolf, 2006; de Vicente & Pain, 2002).

Curiosity. There remains a lack of consensus on the definition, dimensionality, and ways to measure curiosity (e.g., Loewenstein, 1994; Kashdan et al., 2018). An extensive review of curiosity was conducted (Appendix A). For the purposes of this study, the function of curiosity was defined as "to seek out, explore, and immerse oneself in situations with the potential for new information and/or experiences" (Kashdan et al., 2018, p. 130). Kashdan's et al., (2018) research on curiosity is adopted for this study because they integrated multiple curiosity theories and measurements to develop an integrated concept of curiosity as multi-dimensional and mapped these dimensions to various personality measures to create curiosity profiles for heterogenous populations.

Information-seeking behavior. Information-seeking behavior relates to the way people search for and use information. Information-seeking behavior is a purposeful, active behavior as a consequence of a need to solve a problem or satisfy a goal (Wilson, 1981).

Exploratory behavior. Berlyne (1954) defined exploratory behavior as an appetitive tendency to explore or investigate a novel environment and as a motivation related to curiosity. Others consider exploratory behavior and information-seeking to be interchangeable, defining exploration as a choice of actions towards a goal (obtaining information) that can involve physical or mental acts with the purpose of altering the observer's epistemic state (Gottlieb et al., 2013). This study differentiates information-seeking and exploratory behavior based upon the primary goal prompting the behavior. In games, players may wander around and explore the environment to enjoy the beauty of the world or to take a break (period of relaxation) after a difficult and tense quest encounter. These exploratory behaviors are not for the purpose of obtaining information, but they do influence engagement. However, other explorations may be with the purpose of finding information relevant to completing a quest, and this type of exploration was considered as information-seeking behavior.

Interest. Malone (1981) considered interest and curiosity to be interchangeable. Arnone et al., (2011) describes a cyclic relationship where initial curiosity can trigger sustained interest that leads to deep engagement and then re-trigger curiosity to lead to deeper levels of interest and deeper learning. This study considered situated interest as highly related to curiosity.

Motivation. Motivation is defined as an impetus, desire, energy, or inspiration to act towards some goal (Ryan & Deci, 2000). A set of reasons that causes an individual to repeatedly perform certain behaviors is considered motivation (Annetta, 2010). Challenge, curiosity, control and purpose are areas encompassed by intrinsic motivation (Malone, 1981) and overlaps Flow Theory (Csikszentmihalyi, 1990).

Flow theory. As originally conceived by Csikszentmihalyi (1975, 1990), Flow Theory is a psychological theory related to optimal experience in a goal-driven activity that requires balance between challenge and the individual's skill level and is a highly energized state of focused attention and concentration. More recently, the flow structure was expanded to include curiosity and immersion (engagement, engrossment, and total/flow) (Agarwal & Karahana, 2000; Brown and Cairns, 2004).

Self-determination theory (SDT). Self-determination theory is a theory of human motivation that encompasses a motivational structure of extrinsic motivation (of varying levels and orientations) and intrinsic motivation. The model considers motivation as the need to satisfy three basic human needs (competence, autonomy and relatedness). (Deci & Ryan, 1985; Ryan & Deci, 2000).

CHAPTER TWO

LITERATURE REVIEW

Currently, youths grow up playing games and tend to prefer active environments where multiple stimuli occur simultaneously (Annetta, 2010). These young people tend to think differently from past generations, have different expectations for learning, and expect technology to blend consistently into play and work (Arnone et al., 2011; Beck & Wade, 2004). Learning environments that are active, situated, experiential, problem-based and provide immediate feedback promote effective learning (Boyle et al., 2011). Well-designed games include learning theory and methods that match some best practices of education (e.g., Barab et al., 2008; Collins & Halverson, 2009; Gee, 2008; Mayo, 2009; Plass et al., 2013; Shaffer, 2008; Squire 2008). Well-designed educational games deserve serious consideration as valuable educational tools that may appeal to twenty-first century youths.

2.1 Serious Game? Is This an Oxymoron?

At first glance, the terms *serious* and *game*; *work*, *education* and *play*, appear contradictory. But are they? Some researchers suggest there is a mandated trade-off between engagement and learning in games (Cheng et al., 2014; McNamara et al., 2009; Rai et al., 2009; Woo, 2014). However, research shows that animals and humans learn through play (e.g., van Eck, 2006). Recent neuroscience research indicates our brain rewards us for learning and curiosity (Berridge, 2003; Biederman & Vessel, 2006; Bodner, 2017; Jepma et al., 2012; Klenowski et al., 2015). Functional Magnetic

Resonance Imaging (fMRI) reveals the same area of the brain (dopaminergic center, reward center) activates when we are learning, tackling a complex problem or exhibiting curiosity (Gruber et al., 2014). Release of this endogenous chemical cocktail of endorphins provides reward and pleasure similar to exogenous sources of pleasure (e.g., sex, drugs, and alcohol) that many people actively seek (Biederman & Vessel, 2006; Bodner, 2017; Jepma et al., 2012; Klenowski et al., 2015). The commercial game industry is aware of this hard wiring in our brains and targets elements that promote learning, problem-solving and curiosity to increase player persistence and profits (Koster, 2014; McGonigal, 2011; Schell, 2015). Koster (2014) states, regarding *FUN*, “learning IS the drug”.

Game design literature encompasses all types of games (e.g., sports, table-top, digital media and video games). Features, that make games such a large part of our lives, are common to all games. The game research targeted in this study briefly overviews games in general and narrows down to focus on digital video games. Games are powerful learning environments because of how our brain works to recognize and understand patterns (Koster, 2014). Despite debate regarding the exact definition of the term *game*, all games are “iconified representations of human experience that we practice with and learn patterns from” (Koster, 2014, p. 36). Common to all proposed definitions of game, is the concept of voluntary interaction (Koster, 2014, McGonigal; 2011). At the foundational level, games are environments designed to provide an experience with which players voluntarily engage (Koster, 2014; McGonigal, 2011; Schell, 2015). This experience is unique for each player because experience occurs in the mind and the mind is driven by player motivation. The experience does not exist outside of the player-game interaction (McGonigal; 2011). This dynamic is what makes games feel so important to the player (Schell, 2015). Games are unique in that they are an active medium, unlike books or movies, that allow the player to practice, run permutations, and get immediate feedback response that informs their experience (Koster, 2014). Additionally, games make learning fun because there are no high-stakes consequences (Koster, 2014; McGonigal, 2011; Schell, 2015).

The term *educational game* collectively describes many differently designed environments (educational games, edutainment, serious games, serious educational games (*SEGs*), simulations, and virtual worlds) that target diverse educational goals, and vary significantly on entertainment features incorporated into the game (Annetta, 2010). At the core, the purpose of the game (education vs entertainment) is the key distinguishing characteristic. However, are designers required to choose one purpose over the other? Commercial game designers know how to inspire extreme effort, facilitate cooperation and collaboration, and inspire curiosity and interesting thinking (McGonigal, 2011). Game designs that successfully combine entertainment features with instructional content have potential to enhance motivation, engagement and impact learning outcomes (Clark, et al., 2011; Cheng et al., 2014; Echeverría et al., 2011; Giannakos, 2013; Sanchez & Olivares, 2011). However, this combination is challenging.

2.2 What Can Students Learn While Playing Games?

Games are appealing to educational researchers because well-designed games produce high levels of motivation and engagement (Shaffer, 2006; Tobias & Fletcher, 2011; van Eck, 2006; van Eck 2007). However, recent literature reports mixed conclusions from empirical evidence regarding improved learning correlated to games (e.g., Ke, 2009; Ke, 2016; Vogel et al., 2006; Shaffer et al., 2005; Tobias & Fletcher, 2011, Denham, 2015; Wouters et al., 2013). Educational researchers, who primarily targeted learning, attitudes, intrinsic motivation, and efficacy, generally agree that some form of learning occurs while playing games (e.g., Durkin, 2010; Ferguson, 2007; Giannakos, 2013; Habgood & Ainsworth, 2009; Kato, 2010; Spence & Feng, 2010; Squire, 2008; Virvou et al., 2005; Young et al., 2012). The effectiveness of GBL depends on the nature of the learning outcomes fostered and the game's features (Clark et al., 2011; Clark et al., 2016; Hays, 2005; Vogel et al., 2006). This lack of consensus, regarding the nature of and potential for academic learning in games indicates more research is required.

Ke (2009) states, based on a meta-analysis of GBL, most studies revealed that players only learn how to play the game unless educators provide educational support external to the game. Games require players to learn rules and skills in early quests, then apply new knowledge to more difficult levels. Commercial game designers utilize multiple learning theories to ensure that the player learns how to play the game to avoid player frustration and burnout (Becker, 2007). If the game only teaches the player to play the game, what exactly do they learn?

Game mechanics are the rules and physics of the game (Hunicky et al., 2004). These rules are basically mathematical constructs. Therefore, the game teaches the player calculation of odds, prediction of events, decision making, and lessons about power and status (Koster, 2014). The dynamics of the game is the game-player interactions (Hunicky et al., 2004). Complex 3D games teach spatial relationships (mapping space, interpreting symbols, assessing risk, classification and collection, survival skills) (Koster, 2014). Aesthetics of the game are the narrative, story, fantasy, audio-visual effects, non-player character interactions, and the game environment and are associated with emotional attachment to the game (Hunicky et al., 2004). Aesthetics can stimulate curiosity by encouraging exploration (Howard, 2016). Exploration of conceptual space is critical to success in life because it promotes understanding of reactions to change over time and teaches probabilities and problem-solving techniques to control this change (Koster, 2014).

Most video games have elements of power, status and teamwork (McGonigal, 2011; Schell, 2015). Games teach reaction times, tactical awareness, assessing weakness, forming alliances, and other skills relevant to corporate settings and social networking (Koster, 2014). Casual online social games (e.g., Farmville) teach about operating a business and networking (Koster, 2014). RPGs (role-playing games) and MMORPGs (massively multi-player online role-playing games) rely on networking and forming teams who build strategies and make decisions to creatively solve problems in the game (Shute, 2011). Single player RPGs have social networks external to the game where players discuss strategy and tactics. RPGs generally require the player to manage extensive inventories and design elaborate character builds. These complex games teach resource allocation, territory control, collaboration, cooperation and competition (Koster, 2014). These skills and knowledge (e.g., sensory-motor skills, spatial reasoning, creative problem solving, systems thinking, decision making, resource management, networking, scientific reasoning and technology use) learned in the context of games are process skills that should transfer readily to other contexts.

Flexible transfer is a qualitative aspect of learning. Bransford et al. (1999) suggests a key aspect of transfer is the speed at which concepts are applied to new contexts. For example, word processors have certain features in common. A person who learns a specific word processor in one context should be able to more rapidly learn a different word processor in a new context (Bransford et al., 1999). Learning in any one context, regardless of the context (school or game), is not conducive to flexible transfer of knowledge (Bransford et al., 1999). Environments that encourage learners to explore multiple solutions and perspectives of a complex problem can facilitate flexible transfer (Bransford et al., 1999). Games can provide interesting environments that motivate students to expend effort to solve complex problems (Bransford et al., 1999; McGonigal, 2011; Schell, 2015).

Learning that is tangential to the game is related to the concept of transfer. Environments that provide opportunities to create products and use new skills and knowledge are particularly motivating (Bransford et al., 1999). Some scholars suggest game related online communities are where most of the learning occurs (Gee, 2012; Jenkins et al., 2006). For example, Skyrim players frequently encounter non-player characters (NPCs) who state, “I used to be an adventurer like you until I took an arrow in the knee” (Bethesda Game Studios, 2016). Gamers were curious about this concept and started conversations in game forums which led to research of Viking medicine to verify (or not) that an arrow to the knee would in fact end your adventures. They found that Viking medicine was primitive consisting of curses, magic and medicinal herbs. When magic and herbs didn't work, amputation was the available treatment. Patients frequently died from this medical procedure. Gamers verified that an arrow to the knee would in fact put an end to your adventures and they created videos to share this knowledge with other gamers (gametheory.com). This example indicates curiosity about a problem in the game led to exploration and information-seeking external to the game. Therefore, it is important to understand how games can incite curiosity about academic topics.

When the targeted learning outcome is academic achievement, certain challenges arise. It is challenging to design a game that promotes academic learning and maintains the entertainment value of the game (Chen et al., 2016; Clark et al., 2011; Clark et al., 2016; Denham, 2015; Echeveria et al., 2012). In fact, some perspectives suggest engagement and education are diametrically opposed in games. These researchers suggest engagement and learning require trade-offs because highly entertaining engaging games encourage unproductive play tangential to learning and reduce player efforts to process academic content (e.g., Lancaster et al., 2007; Woszczynski et al., 2002; Yager et al., 1997; Cheng et al., 2014; Hallinen et al., 2009; Rai et al., 2009; Rowe et al., 2009). Learning gains are negatively impacted because students must focus most of their mental resources on the complex processes of the game (Beserra et al., 2014; Hwang et al., 2013; Schrader & Bastiaens, 2012; Woo, 2014). Additionally, our brains are expert at pattern recognition (Koster, 2014; Mills, 2006; Schell, 2015). When players ascertain the game's pattern, they find the optimal path to the goal, which is a valuable skill (lateral thinking).

However, pattern recognition may circumvent academic content (Koster, 2014; Schell, 2015). Trade-off perspectives suggests an unnatural relationship between engaging games and education; where one can either be engaged and unlikely to learn, or they can learn but experience limited engagement (McNamara et al., 2009; Rai et al., 2009; Woo, 2014).

In support of this perspective, Cheng et al. (2014) found too much playfulness negatively predicted learning outcomes and concluded that students' mental resources were focused on the game play while educational goals were ignored. Conversely, findings from an empirical study exploring relationships between learning in a narrative-centered environment (*Crystal Island*) and engagement found that students who reported higher levels of engagement achieved improved learning outcomes and improved problem-solving performance (Rowe et al., 2011). Therefore, it is important to explore the degree to which engagement and education, in games, are opposed (or not) and determine which trade-off decisions are necessary.

One solution to this controversy may be to expand the definition of learning. Educational games are often designed from the perspective of traditional educational practice by focusing on explicit knowledge. Entertainment games excel at tacit understanding (Koster, 2014; McGonigal; 2011). Educational games may not enhance learning because memorizing facts to pass tests is not considered as fun (Graesser et al., 2009). Game quests should be designed to challenge players to think in interesting novel ways rather than simply memorize facts (Kilb et al., 2014). Games, designed as such, have the power to provide enjoyable engaging experiences that shifts learning focus away from rote memorization of facts towards exploration, information-seeking, and information-use (Garris et al., 2002). Vygotsky (1986) states “spontaneous concepts” (or intuitive concepts) can be scaffolded with explicit scientific concepts to help develop deeper understanding. Games provide problem solving spaces (Gee, 2007) that invite players to explore, think, experiment and discover. Designers can balance engagement and education if the extrinsic knowledge is intrinsically integrated into fun parts of game with efforts to maintain the game’s flow (Habgood, 2007; Habgood & Ainsworth, 2009; Habgood & Ainsworth, 2011). These well-designed games may benefit educational practice faced with a new generation of learners who have different expectations of their learning environments (Arnone et al., 2011; Beck & Wade, 2004).

2.3 Traditional Education Practices *vs*. Game-based Learning

In a way, education is a game (See Table 2.1) (Schell, 2015). So why does school not feel like a game? More importantly why do educational games not feel like a game? Our brain rewards us for learning, so learning is fun (Berridge, 2003; Biederman & Vessel, 2006; Bodner, 2017; Jepma et al., 2012; Klenowski et al., 2015). However, education is not always fun because many educational experiences are poorly designed (Schell, 2015) and/or the method of transmission is wrong (Koster, 2014). Traditional views of the education system, as content delivery, produces passive learners and “effective test takers” rather than successful learners who are interesting and creative thinkers (Ritchhart et al., 2011; Csikszentmihalyi, 1997).

Table 2.1

Components Common to Education and Games

Education Practice	Game Mechanics & Dynamics
Series of assignments	Goals
Requirements for assignment	Rules
Assignments turned in to teacher	Quest completed
Due dates	Time limits
Grades (as feedback)	Scores (as feedback)
Assignments get harder	Adaptable challenge
End of year final	Boss level
Can only pass if mastered skills in course	Can only win if mastered previous levels

Current educational practices may negatively affect quality and motivation of student learning (Gee, 2004). Traditional education practices that restrict learner's control and the high-stakes consequences of standardized tests often block intrinsic motivation and achievement (Putwain & Remedios, 2014). Reliance on standardized testing should shift towards focus on student's power to learn and emphasis on dimensions central to life-long learning (e.g., curiosity, creativity, confidence and collaboration) (Broadfoot, 2005). These learning environments that support intrinsic motivation sustain engagement, support high school completion, and decrease academic related anxiety and depression (Froiland, 2011; Froiland et al., 2015; Ryan & Deci, 2000). Students are more likely to be happy, emotionally healthy, and achieve more in school when they are intrinsically motivated to learn, interested, and are deeply engaged with the learning environment (Ryan & Deci, 2000; Bransford et al., 1999).

Well-designed games motivate players in ways that traditional educational practices cannot (Yee, 2006). Games, designed to support flow, have the power to shift self-awareness away from extrinsic rewards (standardized test scores, grades) towards more intrinsically motivated orientations (Csikszentmihalyi, 1990). Learning and mastery goals, common to games, make learning more enjoyable than extrinsic motivations (e.g., failure avoidance, grades) (Kover & Worrell, 2010). Studies indicate intrinsic motivation predicts engagement which in turn predicts academic achievement (e.g., Froiland & Oros, 2014; Greene et al., 2004; Grolnick et al., 2007; Walker et al., 2006). Conversely, incorporating extrinsic rewards into intrinsically motivating activities has detrimental effects (Deci et al., 1999). Yet, many educational games adhere to traditional practice by designing gamified tasks (e.g., leaderboards and badges) directly related to grades which shifts awareness back to an extrinsic orientation (Csikszentmihalyi, 1990; Ryan et al., 2006). In games, rewards that seem extrinsic (e.g., scores, more powerful equipment, gold) are actually intrinsic because they have no externally substantive connection (Koster, 2014; McGonigal, 2011; Schell, 2015). According to positive psychology, 'blissful productivity', the sense of being fully immersed in an activity that produces immediate and obvious results, is an intrinsically rewarding concept (McGonigal, 2011; Schell, 2015). Game rewards (e.g., gold earned, leveling up, more powerful weapons or armor) are powerful intrinsic motivators because they provide proof of the player's productivity, direct impact on the environment and self-improvement (McGonigal, 2011; Schell, 2015). Curiosity is another powerful intrinsic motivator that supports engagement, interest and deeper learning (e.g., Loewenstein, 1994; Arnone et al., 2011). Many game genres, especially RPGs, specifically target and reward curiosity to increase engagement and persistence (Howard, 2016).

One challenge for traditional education is the heterogeneous nature of student abilities and preferences. Frequently, the two intellectual spectrum extremes, where gifted students become bored with easy content at the same time struggling students are left behind, are ignored (Annetta, 2010). Commercial games use highly sophisticated artificial intelligence to adjust to each player and create individual learning experiences for students (McGonigal, 2011; Schell, 2015). Games, defined as player-game generated experience, should have the capability to provide unique experience for each individual and promote interest, curiosity and learning.

2.4 Educational Game Implementation and Design Challenges

Trends in educational research indicate increased interest in games as novel learning environments (e.g., Qian & Clark, 2016). However, there are substantial barriers to widespread acceptance and implementation of games in the educational system. Some barriers are time constraints (gamers spend countless hours playing) and controlled pace (games are variably paced unique to the individual) in classrooms (Schell, 2015). The development process, for any game, is complex, time consuming and costly (McGonigal; 2011). Attempts to insert academic content into a game purposed for entertainment creates various tensions (e.g., transmission of knowledge vs. construction of knowledge, freedom vs. control, and learning vs. playing) that manifest when the designer interrupts the flow of game play to explicitly prompt a player to reflect on learning content (Wouters et al., 2011). Existing design approaches, related to entertainment games, do not directly transfer to educational game designs (Westera et al., 2008).

Frameworks, for educational game design, originate from diverse disciplines (e.g., learning and psychology, educational gaming, simulations, and serious games) and successful design requires multidisciplinary specialist (e.g., learning psychologists, learning scientists, artists, computer programmers, gaming experts, content experts, and narrative experts) (e.g., Mettler & Pinto, 2015; Wouters et al., 2011). Complexity and confusion, regarding educational games, are increased because each of these disciplines have unique terminology, taxonomies, and perspectives (e.g., Wouters et al., 2011; Hays, 2005; Ke, 2016). Many existing frameworks provide insufficient design instructions, lack pedagogical perspective, and fail to consider complexity of the game design process (e.g., creative process unique to each game) (Westera et al., 2008). GBL research primarily focuses on effectiveness of learning and rarely consider game design features or processes (Ke, 2016). Therefore, educational game design remains largely fragmented with respect to underlying theories, frameworks and design standards (Echeverria et al., 2012b; Mettler & Pinto, 2015; Westera et. al, 2008; Wouters et al., 2011; Hays 2005; Ke, 2016). This complexity and lack of cohesion in GBL literature makes consistently well-designed games a challenge.

2.5 Theoretical Foundations

2.5.1 Engagement

After a comprehensive review of the theoretical foundations of engagement, O'Brien and Toms (2008, p. 949) defines engagement as "a quality of user experiences" that is characterized by certain attributes (to include challenge, aesthetic appeal, sensory appeal, novelty, interactivity, feedback, perceived control, motivation, interest, awareness and affect). Engagement research is complicated because it involves how students behave, think and feel (Fredericks et al., 2004). Engagement fosters self-efficacy (Eccles & Wigfield, 2002) and sustains and deepens interest (Csikszentmihalyi et al., 1993; Renninger & Hidi, 2002). According to Renninger et al. (2004), individuals exhibit three types of engagement. Participative engagement is engagement with learning that is prompted by a parent- or teacher-imposed goal. Affective engagement catalyzes interest and is exhibited when the experience is enjoyable. Cognitive engagement is exhibited when the individual is intrinsically motivated and fully committed to learning (Renninger, 2000; Renninger et al., 2004). Reeve (2006) describes three types of engagement as behavioral (on-task behavior), emotional (positive) and cognitive (invested efforts). This study defines engagement in accordance with O'Brien and Toms (2008).

2.5.2 Flow Theory

Flow theory is a psychological theory related to optimal experience in a goal-driven activity that requires balance between challenge and the individual's skill level (Csikszentmihalyi, 1975; 1990). Csikszentmihalyi (1990, p. 4) defines flow as "the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it." Autotelic nature is the defining characteristic of flow activity. The individual chooses to engage with the activity, the activity itself is the reward; therefore, the individual is in control of their own happiness (Csikszentmihalyi, 1990; Deci & Ryan, 2006). "Games are the quintessential autotelic activity" (McGonigal, 2011; p. 50).

Flow structure consists of nine dimensions (balanced challenge and skills, concentration, clear goals, immediate feedback, deep involvement (i.e. absorption), sense of control, lowered self-awareness, altered sense of time, autotelic activity) (see Figure 2.1) (Csikszentmihalyi, 1990). These nine dimensions are often seen in good games.

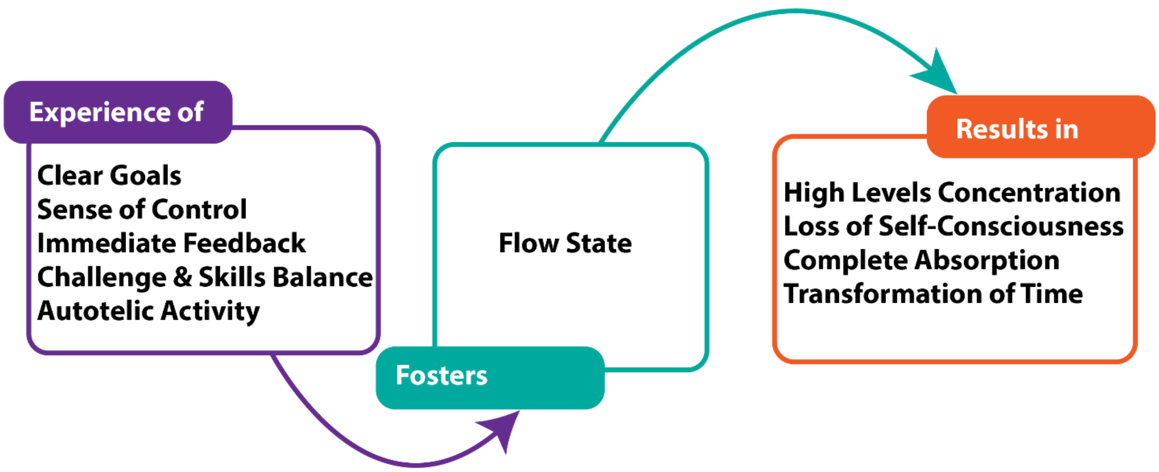


Figure 2.1. Nine dimensions of flow. Adapted from Csikszentmihalyi, 1990

Flow is considered a growth and discovery model. A single activity, performed at the same level, will lead to boredom and frustration over time. The desire to experience enjoyment again, drives the individual to seek out slightly more difficult challenge that will stretch their current skill and knowledge and/or explore to discover new opportunities for using them (Schell, 2015). The intense concentration associated with flow oscillates between tension and relaxation but is not generally considered to be sustainable (Schell, 2015). This oscillation, between tense and release, excitement and relaxation, provides both pleasure of variety and pleasure of anticipation (McGonigal, 2011).

Flow is considered pleasurable; however, it is not considered to be equivalent to fun. For example, meditation is a flow state, but seldom described as fun. Flow often leads to mastery, but mastery itself tends to decrease fun. Fun often occurs at the edge of flow (Koster, 2014, p. 98). This *edge of flow* concept is related to the *Zone of Proximal Development* (ZPD) (Vygotsky, 1978). ZPD describes a zone of optimal learning experience where a task can be accomplished with the help of others. In the case of games, the game is the helpful other (Koster, 2014). Fun occurs in the zone where challenges are slightly above current ability and knowledge, but where the individual can be successful with minimal help (Koster, 2014).

Educational game designers should consider the overlap between these two theories to support learning. Extreme conditions (boredom or apathy; frustration or anxiety) may result in disengagement and are detrimental to successful learning (Baker et al., 2010). Flow theory emphasizes the importance of adaptive challenge such that optimal experience is achieved, and players persist in the activity resulting in enhanced learning (Csikszentmihalyi, 1990). A subtle connection between *ZPD* and *Flow* is noticed when scaffolds are designed to encourage engagement in difficult tasks by “marking critical features” of the problem which helps the learner identify discrepancies between their current position and the desired outcome (Wood et al., 1976). Rather than scaffolds designed to make the task easier, scaffolds that enhance engagement encourage learners to persist in complex situations and are productive for learning (Kapur & Bielaczyc, 2012; Wood et al., 1976).

After intense concentration in a flow state, challenge is overcome as skills and knowledge increase. A release of flow state, as a feeling of victory over adversity, is called *fiero* and is a powerfully emotional experience related to mastery (McGonigal, 2011). Mastery helps the player feel competent to push past current limits and face intense meaningful challenge. In other words, flow represents ability to learn and overcome challenges and fiero is the payoff upon success and this combination is what players often refer to as epic (Zac Hill, designer of Magic the Gathering, in McGonigal, 2011). Scientific research has documented fiero as a powerful neurochemical high provided by our brain's reward circuitry and games designed to rapidly cycle between flow and fiero are generally among the most successful (McGonigal, 2011).

Flow has a positive impact on academic achievement, creative accomplishment, talent development, exploratory behavior, persistence and players' attitudes (Hamari, et al., 2016; Webster et al., 1993). Games are known to be intrinsically motivating and successfully engaging when they facilitate the flow experience (Kiili, 2005; Salen & Zimmerman, 2004). Therefore, a major goal for educational game designers is to create games such that the challenges are related to learning tasks and such that flow experience is possible (Kiili, 2005).

2.5.3 Self-Determination Theory

Self-determination theory (SDT) is a theory of motivation, development and wellness (Appendix K). Most psychology literature discusses motivation as a unitary concept (differs only in amount). However, SDT considers motivation as a more nuanced and complex construct capable of facilitating high quality behaviors. The primary distinction is the separation of motivation into two types; autonomous motivation and controlled motivation. Autonomous motivation describes an individual acting with a full sense of willingness, volition and choice. Regardless of the nature of the activity, the individual will exhibit interest and enjoyment. In contrast, controlled motivation describes a situation where the individual is performing an action for the sole purpose of obtaining some separable reward or avoiding some punishment (carrot and stick model). In this situation, the individual feels pressured or obliged to act (Deci & Ryan, 1985; Ryan & Deci, 2000).

Autonomous motivation is proven to increase performance, engagement and well-being. Two types of autonomous motivation include intrinsic motivation and internalized extrinsic motivation. Intrinsic motivation describes participation in an activity because it is personally interesting and enjoyable. In contrast, extrinsic motivation describes participation in an activity because of some separable outcome. The second type of autonomous motivation is a higher order extrinsic motivation that has been internalized by the individual, therefore has become autonomous. When an individual identifies and understands the value of an extrinsically motivated activity and integrates it into part of themselves, the activity becomes autonomous. (Deci & Ryan, 1985; Ryan & Deci, 2000).

The second distinction is based on the concept that all humans have a basic set of psychological needs (see Figure 2.2). Competence is the need to feel effective in relation to whatever activity the individual is performing. Relatedness is the need to feel cared for, care for others, and belong to a group that is valued by the individual. Autonomy, as a need, must be satisfied for optimal performance, optimal wellness and prevention of negative psychological consequences. (Deci & Ryan, 1985; Ryan & Deci, 2000).

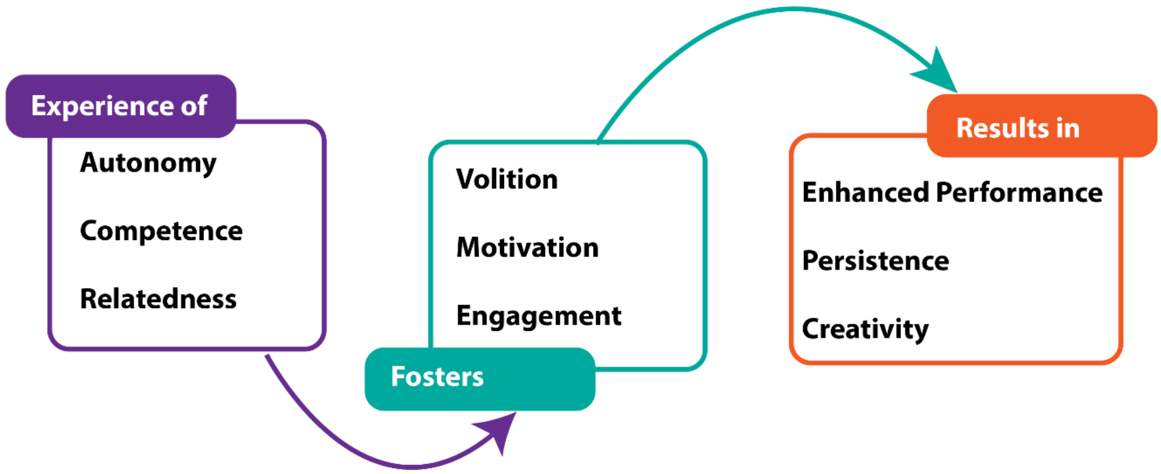


Figure 2.2. Self-Determination Theory, basic psychological needs for well-being. Adapted from Ryan & Deci, 2000

2.5.4 Curiosity

At the London Paralympics opening ceremony, Stephen Hawking (2012) said "look up at the stars, not down at your feet. Try to make sense of what you see and wonder about what makes the universe exist. Be curious." Curiosity involves forward thinking that extends beyond satisfaction with current state of knowledge and drives noble quests and scientific discovery (Dann, 2013). Human cognitive structures and ability to reason make extraordinary advances possible, and this inventiveness is highly dependent on curiosity (defined as an insatiable need to learn and understand) (Gottlieb et al., 2013).

Numerous psychology-based studies examined curiosity as isolated components resulting in an overwhelming list of terms that describe a similar set of behaviors and emotions (e.g., novelty-seeking, openness to experience, need for cognition, ambiguity tolerance, uncertainty tolerance, tolerance for frustration, sensation-seeking, and intrinsic motivation) (Kashdan et al., 2018). To more fully understand curiosity and to inform this research problem, an extensive literature review of the history and theory of curiosity was conducted (Appendix A).

Psychology research agrees that curiosity is key to learning, well-being and even survival (Berlyne, 1954, 1960, 1965; Loewenstein, 1994). Humans and intelligent animals spend time and energy in information-seeking and exploration independent of foreseeable profit suggesting that learning itself is a reward (Berlyne, 1954; Gottlieb et al., 2013). Less research has been conducted outside of psychology (Loewenstein, 1994). Most of the research regarding curiosity and GBL has considered curiosity tangentially or theoretically. It would be beneficial to examine possible relationships between curiosity and GBL to enhance engagement and learning.

2.5.5 Curiosity and Education

Curiosity is considered critical to life-long learning (von Stumm et al., 2011). The importance of curiosity is stressed in academic standards, but directives and guidance for promoting curiosity in the classroom or for assessing it in current accountability focused systems are limited (Dann, 2013). Failure to nurture a child's curiosity risks the danger of switching curiosity off (Dewey, 1910). More recently, Day (1982) states that the learning environment should be designed to help students manage their individual *Zone of Curiosity.* The Zone of Curiosity lies in the optimum area that occurs between *Zone of Relaxation* (insufficient arousal) and *Zone of Anxiety* (too much arousal) (Day, 1982).

To maintain the Zone of Curiosity, the individual must perceive competence to be successful and assign value to the information. The Zone of Curiosity is where the student is motivated to seek information, ask questions and persist in exploration to resolve conflict or ambiguity and/or obtain missing information (Day, 1982). Lack of competence causes the individual to exit the zone and leads to frustration, anxiety and withdrawal (Day, 1982). The Zone of Curiosity follows Berlyne's inverted-U curve describing the pleasure / displeasure responses generated by curiosity. When an individual perceives stimuli as too challenging or too novel such that any interaction increases familiarity or chance of resolution, pleasure is increased. Conversely, displeasure results when the individual perceives the stimuli as redundant (too familiar). In this situation, adding elements of surprise, ambiguity, complexity or novelty will increase pleasure (Berlyne, 1954; 1960). Berlyne's (1954; 1960) inverted-U theory provides guidance for increasing interest or curiosity and as such may help maintain the Zone of Curiosity for the individual such that relaxation or anxiety zones are avoided.

In Summary, several zones of optimal experience and learning are established in theoretical literature and supported in research (see Figure 2.3). These zones can be considered from a growth and development perspective. Flow Theory (Csikszentmihalyi, 1990), Zone of Proximal Development (Vygotsky, 1978), and Zone of Curiosity (Day, 1982) overlap and are relevant to engaging game designs that promote learning. ZPD has been described as the "edge of flow where fun exists" (Koster, 2014). ZPD describes a zone of optimal learning where children can overcome a challenge with help (Vygotsky, 1978). Flow experience describes a zone of optimal experience where challenge and skills are matched, but above average, in an autotelic activity (Csikszentmihalyi, 1990; Nakamura & Csikszentmihalyi, 2009). The Zone of Curiosity also describes a zone of optimal experience and learning that avoids states of anxiety and frustration or relaxation and boredom (Day, 1982). SDT and Flow Theory both describe optimum experience related to intrinsic motivation that produce positive affect and influence learning (Ryan & Deci, 2000; Csikszentmihalyi, 1990). These theories are relevant to an investigation of the relationships between game design, game play experience (motivation and engagement), curiosity and learning.

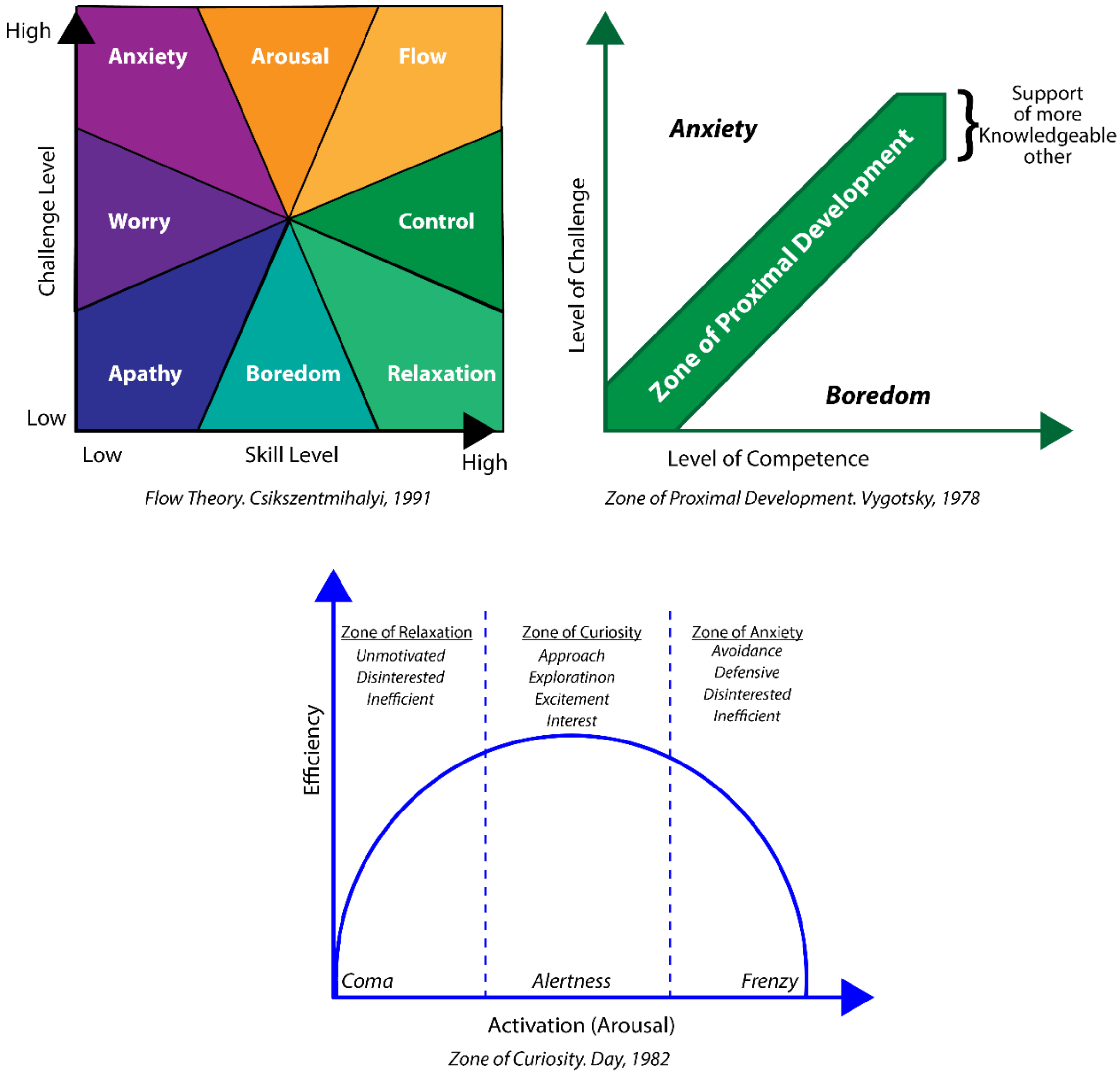


Figure 2.3. Three zones of optimal experience and learning (Flow, ZPD, and Curiosity). Adapted from Csikszentmihalyi, 1991 Flow Theory, Vygotsky, 1978 Zone of Proximal Development, and Day, 1982 Zone of Curiosity.

2.5.6 Curiosity and Interest

Curiosity (as a reaction to novelty) results in pleasurable feelings of interest or aversive feelings of uncertainty, both of which motivate exploration (Litman & Jimerson, 2004). However, curiosity does not automatically progress to greater learning, mastery or information-seeking (Arnone et al., 2011). Perceptions of one's ability to find and use missing information (i.e. competence) influences the degree to which individuals act on their curiosity (Arnone et al., 2009; Loewenstein, 1994; White, 1959). The size of the knowledge domain and the individual's belief that the missing information can be found in that domain influence the degree to which individuals act on their curiosity (Loewenstein, 1994). The individual must possess exploration and information seeking skills to successfully navigate the knowledge domain. For example, when you google *game-based learning* and get 492,000,000 results (as of August 26, 2018), what process is used to navigate those results? What level of desire is required to explore a sufficient sample to gain critical information? Therefore, competence is required for curiosity to develop into desire to explore and subsequently become sustained interest (Arnone et al., 2011).

Interest is a predisposition to re-engage specific content over time that impacts attention and learning (Hidi & Renninger, 2006). Interest is defined as four sequential steps characterized by affect, increasing knowledge and cognitive processing. Each of the four steps are potential motivators for curiosity and can enhance learning and engagement (Hidi & Renninger, 2006). Building on this concept of interest, Arnone et al, (2011) posed a model of curiosity, interest and engagement as a related dynamic construct. Curiosity can trigger interest resulting in deep engagement and learning. Interest can re-trigger curiosity, depending on the environment, leading to deeper engagement. If curiosity is sustained, situational interest is maintained. This interest, curiosity, engagement dynamic can then emerge into well-developed individual interests and peer level curiosity seen in affinity spaces (Gee, 2012) and participatory cultures (Jenkins et al., 2006) (Arnone et al., 2011). These online communities support opportunities to share and discuss interests such that peer curiosity is stimulated, and exploration is deepened (Arnone, et al., 2011). Therefore, the game can trigger curiosity at the individual level and lead to collaborative curiosity via chat rooms, social networks, affinity spaces (Gee, 2004) or participatory cultures (Jenkins et al., 2006). Participatory cultures emerge from interactive technologies where skills shift from individual expression to community involvement and from media use to media production (Jenkins et al., 2006). Affinity spaces are informal learning cultures that adapt to individual interests (short and long term) (Gee, 2012). Participatory cultures and affinity spaces are where much of the learning, stimulated by games, occurs (Gee, 2012; Jenkins et al., 2006)

2.5.7 Curiosity Related Behaviors

Berlyne's (1954, 1960) seminal work on curiosity indicated that curiosity is a powerful intrinsic motivator for exploratory and information-seeking behaviors. Humans, and animals, are biologically wired for exploration and information-seeking as is evidenced by the dopaminergic system in our brains that generates intrinsic rewards (pleasure and positive emotions) when we learn (Berlyne, 1960; Berridge, 2003) and is activated by curiosity stimulation (Kang, 2009). Neuroscience research commonly considers exploratory behaviors as related to random actions or personal tendencies to seek novel, uncertain or surprising events based on the concept that novelty presents an intrinsic reward. This type of exploratory behavior can result in discovery but does not guarantee learning (Gottlieb et al., 2013).

Loewenstein's (1994) model of curiosity as an information-gap, suggests curiosity arises when an individual becomes aware of a discrepancy between current level of knowledge and a reference point (knowledge needed or desired) and presents as an uncertainty state that creates feelings of deprivation. This information-gap prompts exploratory and information-seeking behaviors that result in learning (Loewenstein, 1994). One limitation of this perspective is that a person cannot be curious without prior knowledge of the context because it would be impossible to establish the starting and reference points (Gottlieb et al., 2013).

Gottlieb et al., (2013) defines another type of exploratory process (common in machine learning), that does not require prior knowledge, where strategies for problem-solving are developed and where the learner is required to experiment, make decisions, and improve by exploring alternative strategies. In developmental robotics studies, this type of exploration occurs in open-ended environments and learning develops autonomously based on intrinsic interest (Baranes & Oudeyer, 2013). Successful learning in this study was defined as ability to improve one's predictions of consequences resulting from one's actions and the ability to solve self-generated problems (Baranes & Oudeyer, 2013). This type of exploratory behavior is common to games where players often experiment to discover which strategy is most powerful and successful. The indication that curiosity can arise without prior knowledge is important to educational game designers such that it may be possible to generate domain specific curiosity that arises from game play by integrating missing information into the quest.

2.5.8 Summary

Independent fields of research view curiosity through domain related theoretical lenses and rarely attempt to adopt a multidisciplinary perspective (Arnone et al., 2011). Much of the prior research has focused on taxonomy resulting in a plethora of definitions and dimensions leading to different terms describing the same phenomena or similar terms describing different phenomena thereby impeding understanding (Kidd & Hayden, 2015; Kashdan et al., 2018). This lack of cohesion and the lack of consensus regarding the definition, dimensionality, and measurements of curiosity seriously inhibits establishing rigorous research in the curiosity field, especially as related to other constructs (Kidd & Hayden, 2015; Kashdan et al., 2018; Arnone et al., 2011). Therefore, a gap in current GBL literature regarding curiosity is evident. This study adopts Kashdan et al. (2018) definition of dimensional curiosity and associated measures (5DC) to investigate curiosity in GBL.

2.6 Game Design and Game Play Experience

"There is something essentially unique about the way games structure experience" (McGonigal, 2011; p 21). There are numerous and diverse ways to define a game in educational research. However, gamers don't care, they just know a game when they feel it (McGonigal, 2011). Good games have meaningful choices, clear and diverse goals, immediate substantive feedback and rules that place limitations on the player such that problem solving, exploration and discovery, and creative and interesting thinking are required (Koster, 2014; McGonigal, 2011; Schell, 2015). Good educational games successfully integrate learning concepts into the game in an intrinsic manner (Habgood &

Ainsworth, 2009, 2011) and sustain flow experience (Kiili, 2005). Commercial role-playing games tend to be the most open game genre and focus on evoking curiosity and encouraging exploration and discovery. Curiosity is key according to Todd Howard (director and executive producer of Bethesda Game Studios) who states, “My guiding design principle when I create role playing games like Skyrim is to build a world that piques the player's curiosity. A world that rewards curiosity and exploration in any way it can” (Howard, Todd, 2016).

2.6.1 Curiosity and Interest in Game Design

A designed learning environment can have various impacts on learners because of individual differences in curiosity. A learning environment that stimulates positive affects (e.g., flow, curiosity, enjoyment) for some learners may create negative affects (e.g., anxiety, frustration, stress) for others based on the tolerance for ambiguity, complexity, uncertainty and novelty (Arnone, 2003; Day; 1982; Gorlitz, 1987). Of equal importance, curiosity can influence academic achievement on the same order of magnitude as intelligence and should be continuously nurtured and supported (Friedman, 2007; von Stumm & Ackerman, 2013; von Stumm et al., 2011).

*2.6.1.1 Trait curiosity***.** Hassan et al. (2015) considered the mediating role of trait curiosity (i.e. epistemic) in the context of higher education medical students (N=150; mean age=34) between personality and learning. Trait epistemic curiosity was significantly correlated with conscientiousness (factor of personality found to most prominently affect learning), openness to experience and agreeableness. The authors conclude that epistemic curiosity is a significant explanatory variable in the relationship between learning and personality and that certain personality profiles facilitate learning (Hassan et al., 2015).

In another study, Hardy et al. (2017) examined trait epistemic curiosity effects on creative problem-solving processes. Participants (N=122, undergraduates, mean age = 19.88) completed a curiosity questionnaire, then solved a complex marketing problem in a low-fidelity simulation. Results indicate epistemic curiosity (associated with interest), after being controlled for gender, general mental ability, domain expertise and personality, positively influences quality and originality of problem solutions and the effect was fully mediated by information-seeking behavior (Hardy et al., 2017).

2.6.1.2 State Curiosity. State curiosity may be more practically useful. Evidence suggests state curiosity can be manipulated and may influence trait curiosity to some degree (Loewenstein, 1994). Games can stimulate curiosity and increase interest such that greater engagement and deeper learning occurs (Arnone et al., 2011). Gruber et al. (2014) used a combination of functional magnetic resonance imaging (fMRI) and behavioral analysis to investigate how curiosity (as emotional-motivational state curiosity) influences memory and learning. The study confirmed high states of curiosity are connected to memory and learning via anticipatory brain activity in the dopaminergic system (the reward center of the brain). The findings where statistically significant and indicated that stimulation of curiosity prior to learning creates more effective learning experiences and that a curious state enhances incidental learning (Gruber et al., 2014).

2.6.1.3 Evoking curiosity. Psychology and neuroscience research suggest curiosity can be evoked by various underlying mechanisms such as novelty (previously unencountered stimuli), surprise (violation of expectations), conceptual conflict (incompatible information), uncertainty (e.g., unknown outcomes, unknown risks, question about skill level needed to meet a challenge, etc.), and anticipation of acquiring new knowledge (Jirout & Klahr, 2012; Kidd & Hayden, 2015). Game design features, such as fantasy and narrative, challenging quests, and perceptual elements in the game world, can be used to stimulate curiosity consequently increasing motivation and engagement (Dickey, 2011). Games can create cognitive conflict by making gaps in information salient or using elements of surprise or mystery to generate curiosity (Graesser & Olde, 2003) or by intentionally violating the players expectations (Litman et al., 2005).

Situations in the game environment can be designed to intentionally violate player expectation to stimulate curiosity. However, if the game itself violates player expectations, it may be counterproductive. Results from a GBL study where twenty undergraduates played an educational game designed to teach argumentative and persuasive writing (*Murder on Grimm Isle*) found that Students initially engaged with the game and subsequently searched for typical game mechanics. When the educational game design violated these expectations, the players attempted to deconstruct the game. Curiosity helped transition learners from their expectations of a "*GAME*" and their actual experience when the educational game violated their pre-existing schemas. Curiosity was instrumental in continued player engagement with the game rather than disengagement and withdrawal (Dickey, 2011).

2.6.1.4 Intent to play. Psychology research portrays a dual nature to curiosity (Appendix A). Is curiosity good for scientists and bad for the proverbial cat? Researchers agree curiosity is key to learning and scientific discovery (e.g., Arnone et al, 2011; Dewey, 1910). Other research explores curiosity related to detrimental behaviors such as gambling, drug and alcohol abuse, and early sexual exploration (e.g., Klenowski, et al., 2015). Passion and impulsivity in gamers are often related to negative impacts of games related to addiction (Puerta-Cortes et al., 2017). A study, using an online questionnaire (N=630 university students), was conducted to investigate influences of passion and impulsivity related to game habits, choice of game, play time, and intensity in the context of problematic videogame play (Puerta-Cortes et al., 2017). The authors found connections between impulsivity and passion and video gamer profiles. Findings indicate different types of passion predicted hours of play, all types of passion predicted intensity of play and game preference, dysfunctional impulsivity was associated with intensity of play and greater time spent in the game, and preference for MMORPGs was associated with functional impulsivity (Puerta-Cortes et al., 2017). While these authors did not target curiosity *per se*, curiosity is described as passion (Hume, (1777)/1888) and impulsivity is defined as one dimension of curiosity (Loewenstein, 1994). These findings reveal potential for curiosity to increase persistence and intent to play that does not necessarily fall into the category of addiction.

2.6.2 Flow and Immersion

One prominent way games can increase active engagement, motivation, and learning is to design flow experiences (Csikszentmihalyi, 1975; 1990). Greater perceived flow correlates with larger degrees of exploratory learning strategies (Trevino & Webster, 1992). Educational games often disrupt flow by interrupting the game's progress with a pop-up quiz or dialog box with learning content (Shute, 2011). This overt action on the designer's part forces the player to change attention which breaks concentration and flow (Annetta, 2012). Additionally, many educational games fail to support flow because they focus on practice and repetition required for memorization and provide inappropriate challenge (Kiili, 2005, Annetta 2012). Games can facilitate flow by designing clear goals, appropriately challenging problems, and immediate feedback (Kiili, 2005) and intrinsically integrating learning content into the game's mechanics, dynamics and aesthetics (Habgood & Ainsworth, 2009, 2011).

2.6.2.1 Challenge. Yannakakis & Hallam (2007) used Feedfoward and Fuzzy Neural Networks (NN) to quantitatively investigate qualitative factors of challenge and curiosity in relation to entertainment value of games. Results demonstrate that appropriate non-extreme levels of challenge and curiosity generate high values of entertainment. Overall, entertainment is low when challenge is too high, and curiosity is too low. If challenge is too low, entertainment value drops independently of curiosity. Fuzzy NN showed that entertainment is very high, even if challenge is too low, when curiosity is very high (Yannakakis & Hallam, 2007).

Additionally, flow is considered a growth and development model. Completing challenges builds skills and knowledge. New skills and knowledge are then used to solve more difficult problems until mastery is achieved (Nakamura & Csikszentmihalyi, 2009). For example, Middle School students, after being taught a growth mindset (belief that rigorous mental exercises help an individual to become smarter), preferred challenging tasks with greater learning opportunity over simple tasks that made them appear smarter (Blackwell et al., (2007).

2.6.2.2 Immersion. The dynamic relationship between player and game creates a challenge to maintain flow. As challenges increase in difficulty, enticing rewards for player efforts must be provided, or flow will end, and the player will become disengaged (Annetta, 2010). Therefore, it is beneficial to consider immersion as a closely related but independent concept. Immersion has three phases (engagement, engrossment, and total). The first two phases are sustainable (Brown & Cairns, 2004; Jennett et al., 2008). Increased immersion creates greater engagement and intrinsic motivation to accept challenges in the game and succeed in the goals (Annetta, 2010; Yee, 2006). Engagement and intrinsic motivation increase persistence and effort regarding game challenges and creates a flow state (Csikszentmihalyi, 1990). When immersion is total, the player will feel at one with the activity and nothing else matters (Jennett et al., 2008).

One way to increase immersion is to provide players with the means to establish a unique identity (avatar). The avatar (player's virtual presence) allows the player to become fully immersed in the game and interact with its rich narratives and fantasies. This immersion results in enhanced motivation to interact with and succeed in the game (Yee, 2006). For example, high school students were more fully engaged with genetics (time on task, concentration) when given a unique identity which increased perceived immersion in a game compared to the control condition (traditional science laboratory) (Annetta et al., 2014).

2.6.3 Self-Determination Theory (Autonomy, Competence & Relatedness)

Self-determination theory describes a taxonomy of human motivation based on three basic psychological needs (see Figure 2.2). Intrinsic motivation is the gold standard of this model where individuals actively engage and try to understand the world and integrate it into a cohesive self (Deci, 2015). Human nature is to be active and engaged, mastering ambient challenges and motivating themselves to stretch and grow beyond immediate ability, so that they experience growth and development (Bransford et al., 1999; Deci, 2015). Active learners demonstrate agency as they set goals, make plans, and revise their thinking (Vygotsky, 1978; Bandura, 2001) which supports autonomy and competence. Satisfaction of autonomy, competence, and relatedness generates positive emotions and well-being (Deci & Ryan, 1985; Ryan & Deci, 2000). When asked "How do I motivate my employees?"; Deci replied "You are asking the wrong question. You should be asking: How do I create an environment within which employees will motivate themselves" (Deci, 2015).

2.6.3.1 Intrinsic motivation. Self-determination theory indicates intrinsic motivation leads to engagement (Ryan & Deci, 2009). Engagement is a key mediator between intrinsic motivation and academic performance (Skinner et al., 2009). A survey of 1575 high school students found an indirect positive relationship between intrinsic motivation and student GPA via engagement, and a moderate association between goals and intrinsic motivation (Froiland & Worrell, 2016). The authors conclude intrinsic motivation, engagement and goals increase enjoyment of learning (Froiland & Worrell, 2016). Of importance, a racially and ethnically diverse population was intentionally targeted for the survey. Relationships between intrinsic motivation, engagement and academic achievement were the same across all groups suggesting that motivation is equally important in majority and under-represented populations and that interventions designed to support intrinsic motivation and engagement are beneficial to students of various racial and ethnic backgrounds (Froiland & Worrell, 2016).

2.6.3.2 Autonomy. Autonomy, as defined by SDT, is a sense of willingness and volition which results in engagement, sustained interest and excitement (Deci, 2015). Perceived autonomy has been related to higher intrinsic motivation and enjoyment in the context of games (Przybylski et al., 2010). Autonomy and flow state are both supported by elements of choice, control, and freedom.

Openness (or linearity), as a game design feature, refers to the degree of freedom and control allowed the player (Rouse, 2005; Warren, 2009). Open systems, that allow freedom to explore and experiment, provide a holistic sense of connections and increases understanding of complex systems (Schell, 2015). Elements of freedom and control are related to the players perceived flow experience, autonomy and competence. Additionally, freedom to explore and ability to choose interactions that are personally interesting should support curiosity.

Generally, high degrees of openness that allow greater degrees of player choice (e.g., path through game, challenge level, playing style, problem solving strategies) ensure that players of varying abilities and preferences can enjoy a game (Chen, 2007). Research suggests players prefer freedom and choice over game designs that constrain freedom (Ryan et al., 2006). Linear game designs vary greatly on types and degree of constraints (e.g., prescribed sequence of quests, degree of choice within a specific quest). Therefore, linearity does not necessarily decrease enjoyment as evidenced by popular linear games (e.g., *Monopoly, Portal 2)* (Kim & Shute, 2015). Educational games may prefer linear designs to force players to follow predetermined sequences related to the targeted learning content and subsequent assessment (Kim & Shute 2015). The design decision regarding degree of openness or linearity may be one area of learning – engagement trade-off that is difficult to resolve, especially if increased content knowledge is the targeted outcome.

Two versions of a computer game, *Physics Playground*, with different degrees of linearity were compared to explore effects on game-based assessment, learning and enjoyment (N = 102; mean age = 20.4) (Kim & Shute, 2015). Results showed that changing just one game design element (linearity) significantly influenced player-game interactions and changed the evidentiary structure of the embedded assessments. Physics understanding (via pre-/post- test) significantly improved for the non-linear game version and no improvement was found for the linear version. No significant differences in enjoyment between the two versions were indicated. The authors suggest enjoyment may not have been influenced since the games were identical in all aspects except the sequence of levels (linear or non-linear). Players had the same degree of choice within a given level (Kim & Shute, 2015).

Role playing games (RPGs) are generally associated with large degrees of player freedom and control. Bethesda games, like Skyrim and Fallout 4, are designed to encourage emergent and surprising gameplay (Howard, 2016). This open game design means multiple quests are going on simultaneously, there is always some degree of chaos as game systems and player choices intertwine and tangle up in unanticipated ways, and results in a lot of emergent complexity and opportunity for curiosity to arise (Howard, 2016). The increased opportunity for exploration and opportunity to pique interest and/or curiosity may be one explanation for the greater level of understanding of physics in Kim & Shute's (2015) game comparison study.

Another form of freedom that RPG games are known for is customization. Customization is a series of meaningful choices, afforded the player, that shape the game environment (e.g., avatar appearance, character builds, open world exploration, and modding). Customization influences curiosity, flow, immersion, autonomy, competence and relatedness. Avatar customization and character builds generally requires trade-offs between powers and deficiencies. Trade-offs require the player to choose a strategy that will eventually shape their game play experience (e.g., A Bosmer (wood elf) in Skyrim resists disease and poison and receives a +10-archery bonus, but skill points accumulate slower for other play styles such as two-handed weapons or magic). Customized avatar appearance is a creative self-expression mechanism that generates greater emotional attachment and enhances immersion and relatedness. Players build strong empathetic attachments to their avatar to such degree they wince in imagined pain when the avatar is injured and exhibit relief when the avatar escapes harm (Schell, 2015).

Freedom to customize the player experience and explore the game world supports curiosity. Novice players initially expressed curiosity about the game's novelty, then other motivational features of the game (challenge, confidence, social interaction and customization) kept them engaged (Turkay & Adinolf, 2015). Curiosity about hidden areas, narrative, fantasy, and the avatar generated attention focus on the game. These players spent a lot of time customizing their avatars and the customized avatar increased interest in the game because the player wanted to interact with their avatar and win battles with the character. This initial curiosity about the novelty, followed by increased interest about the customized avatar, led to increased confidence in the game world and resulted in greater persistence and intent to play. Motivation decreased during the last game play session which was attributed to the unnatural time limits imposed by the study (Turkay & Adinolf, 2015). However, since some research considers novelty-seeking a component of curiosity, and this study targeted novice players, an alternate explanation may be that novelty effects lessened over time.

2.6.3.3 Relatedness. The avatar also connects the player to the game world and other players. Therefore, the avatar is important for creating feelings of belonging as well as feelings of uniqueness and importance (Annetta, 2010). Annetta & Holmes (2006), using a serious education game, allowed graduate students choice of 100 available avatars *vs*. two choices (standard male, standard female only). Students given the choice of 100 avatars, reported greater satisfaction with the course and stronger social presence with classmates and teachers. The study results showed that students, not given a unique identity via their avatar, were less invested in the game, and perceived less immersion (Annetta & Holmes, 2006).

This social aspect of games, and relatedness, can be enhanced via interactions with other real players (in a multiplayer game or via online communities emerging from single or multi-player games) or with non-player characters (NPCs) who become real via the game's rich narrative, fantasy and artificial intelligence. Gamers react to nonplayer characters and real-life players in a similar manner (Hoyt et al., 2003). Especially in 3D environments with extensive detail and artificial intelligence, NPCs can appear extremely realistic via appearance, facial expressions, and personality. These complex 3D environments with rich narrative and fantasy can seem more real to the player than real life (McGonigal, 2011). Therefore, these life-like NPCs have potential to stimulate curiosity in the player. In a study using a robot (as opposed to a virtual character), children had significantly higher curiosity measures after interacting with a social robot that exhibited curious behaviors. Children were asked to interact with a robot while using a mobile story telling app. The curious robot was designed to behave with enthusiasm about learning and exploration and to challenge the child by suggesting novel interactions with the storytelling app. The non-curious robot asks the child to show it words but does not express overt or explicit desire to learn new things. The authors conclude that interactions with autonomous social robots within a digital environment programmed to exhibit curious behaviors can guide and promote children's curiosity (Gordon et al., 2015). Therefore, there is potential for in-game NPCs to stimulate curiosity if they are designed to exhibit curiosity.

Avatars and NPC (personalities, appearance and backstories) are part of the game's aesthetics. Players voluntarily discover and enter novel worlds of events, connected by paths of unknown destination, through stories. Once engaged with the story, exploration becomes specific. The twists and turns of the unfolding game narrative provide complexity, novelty and surprise that “keeps our attention and specific curiosity alive” (Bianchi, 2014, p. 20). Stories are used to create detailed lives and personalities for NPCs in RPGs which causes players to form attachments, empathize with NPCs’ struggles and problems, and desire to help these game characters (Koster, 2014; McGonigal, 2011). One experimental study (N=29; mean age = 23.0) recruited participants from the internet to compare the game *ReMission* (educational game to increase knowledge of cancer; hopelab.org) with a researcher modification adding foreshadowing/backstory to increase curiosity (Wouters et al., 2011). A self-developed questionnaire revealed significant effects (d = .74) in favor of the experimental condition reporting a higher level of curiosity compared to the group not exposed to foreshadowing elements (Wouters et al., 2011).

2.6.3.4 Competence. Competence is related to self-efficacy, mastery, and balance between challenge and skill. Perceptions of competence and mastery are positively supported by information-seeking experiences and promote greater breadth and depth of exploration (Wu & Miao, 2013). Adaptive challenge is related to competence and flow theory as a growth model. The challenge should be above average so that the player’s abilities and knowledge are improved. Challenge that is too difficult leads to frustration or anxiety; too easy leads to boredom, disengagement, or worse apathy (Csikszentmihalyi, 1990). Games uniquely rely on competence by starting out with simple quests and gradually become more complex and challenging while providing meaningful choices where players have control over their progress. (e.g., Skyrim dungeons are generally smaller when the boss-level is easy and much larger if the boss-level is difficult so that the player has time to build necessary skills to succeed).

Feedback systems also support competence. Aesthetics (e.g., story, audio-visual effects, artificial intelligence (NPC behavior), and game controls) provide immediate and visual feedback (part of the game’s dynamics). Feedback provides means for learners to engage in reflective practice and actively monitor their learning experiences (Bransford et al., 1999; Ericsson & Charness, 1994). Games provide continuous feedback such that students can actively monitor their understanding and build new knowledge (Barron et al., 1998; Bereiter & Scardamalia, 1993; Kafai, 1995; Schwartz, Lin et al., 1995).

Feedback systems can be defined in numerous and diverse ways. One of the simplest feedback systems is assignment of points. More complex, substantive feedback mechanisms are more effective support for flow experience and learning. Games reveal missing information that starts the player on a quest. The problem should be challenging, or players may assume there is one single solution (Annetta, 2010). Failure becomes a learning experience because it creates opportunity to experiment with different strategies and solutions. If an obvious simple solution exists and immediate success occurs, players will not invest effort to consider alternatives (Annetta, 2010). If the problem seems too complex or too difficult, they may quit (Annetta, 2010). Low-stakes failure, exploration and discovery in games can provide realistic problem-solving experiences that traditional classroom cannot replicate (Annetta, 2010).

These low-stakes failure feedback systems allow players to push the system until it breaks. When games give players permission to fail, not only is failure fun, but it is also incredibly educational as players can attempt to solve the same problem in multiple creative ways as well as try on different perspectives (Schell, 2015). This type of failure feedback is important to prepare students as future scientists by teaching them how to experience failure multiple times and teaching them how to learn from that experience (Gerber, 2012). Additionally, failures in a game often lead to curiosity because players ask why did this fail? Or if a solution works in the game, but would not work in real life, curiosity arises to address the inconsistency (Schell, 2015).

Many educational games concentrate on feedback that only relates to content (Annetta, 2010). Feedback that directly connects game play to external expectations (e.g., grades and test scores) shifts motivation orientation to extrinsic. When extrinsic rewards are applied to intrinsically motivating activities, motivation and engagement decrease (Deci & Ryan, 1985; Ryan & Deci, 2000). Additionally, this practice inhibits flow by changing focus back to self-awareness and external demands that break the autotelic nature of the activity (Nakamura & Csikszentmihalyi, 2009). Rather than providing extrinsic rewards (e.g., leaderboards, badges), feedback that is dramatic, highly visible and entertaining changes failure into an enjoyable learning opportunity (Koster, 2014; McGonigal, 2011). Failure feedback designed to be visually interesting and fun increases engagement and persistence in the problem-solving activity and gives players opportunities to be creative in their solutions and strategies.

Complex feedback systems inform the player of their progress in the game (e.g., progress towards goals, where they are in the narrative, what is required to complete the quest, what is needed to continue towards other quests or the boss level, current skill level, character improvement available, inventory and resources available, character health etc.) (Koster, 2014; McGonigal,2011). In other words, these complex feedback systems can inform the player's information gap and manage the size of the knowledge domain related to resolving the gap.

Information gaps are related to competence as well as curiosity. The information gap theory indicates that once a gap in one's knowledge becomes salient, motivation will increase towards exploration until the missing information is resolved (Loewenstein, 1994). Recognition of this gap requires an individual to understand their current state of knowledge and desire more knowledge. The individual must also believe they have the capability and resources to obtain the missing information. If the gap is too large, frustration and anxiety will occur. If the gap is too redundant, boredom will result (Loewenstein, 1994). This concept is related to Day's (1982) Zone of Curiosity and to the need for competence (Deci & Ryan, 1985).

It is difficult to measure the information-gap, defined as an individual's perceived state of knowledge compared to level of knowledge they desire (Gentry et al., 2002). One study used *confidence* (measurable variable) as a proxy for the knowledge students currently know and *importance* (measurable variable) as a proxy for the knowledge students want to know (Gentry et al, 2002) and found that the curiosity gap model is supported. Results of this study (undergraduates n = 210; high school n = 74; middle school n = 113) indicated that students with low confidence (low prior knowledge) and high perceptions of importance (the required knowledge is associated with high-stakes failure, or is perceived as unobtainable within the environment and context available), may be prone to learned helplessness and were more likely to perform poorly in class (Gentry et al., 2002). This study supports Loewenstein's hypothesis that curiosity is stronger as resolution of the information-gap is close (small information-gap) and when gaps are large, curiosity is low.

2.6.4 Summary

Results of these studies support some anticipated design implications. it is reasonable to anticipate the ability to leverage game design features focused on engagement to foster curiosity both internal and external to the game. Curiosity, initially evoked in the game play, can foster greater engagement, sustained interest and deeper learning by prompting the player to seek out online communities and develop peer-level curiosity. Adoption of game design principles targeted by the commercial game industry can stimulate curiosity towards specific academic content and generate exploration and information-seeking behaviors. Regarding the trade-off perspective of engagement and education in games, games designed to support flow, satisfy basic human needs and stimulate curiosity should increase engagement and increase intent to play. A highly engaging game that increases voluntary interaction and persistence in the environment will result in greater exposure to learning content and increase familiarity with academic concepts such that learning occurs. A single design feature change can impact outcomes. Therefore, a holist approach to this research can increase understanding of educational game design.

2.7 Well-designed Educational Games: Why RPGs?

Theoretically, good game design principles are well documented (Gee, 2007; 2012), however, in practice there remains challenges for designing good educational games. Designers face the challenge of creating the idealized highly engaging educational game that will compel learners to achieve demonstrable excellence through their own volition (Klopfer et al., 2009). Designers must make many decisions such as game genre, academic content, age appropriate game play and aesthetics, game mechanics and many others. This study aims to explore game designs that support science education.

Students' interest in science increases when they identify with science and believe that success in science is possible (Chen et al., 2014). Conversely, students with a fixed view of science ability and no science identity do not find science interesting (Chen et al., 2014). Students do not find science courses engaging because they fail to see relevance to their daily lives (Chiang et al., 2014). Engagement can be increased by using role-playing simulations (Hardy & Totman, 2011).

Everyone's reality is based on their unique experiences. Complex RPGs create immersive 3D experiences for players that often feel as real and meaningful as real-life experiences (Schell, 2015). Players can try on different identities and explore different perspectives which leads to insights because the game is a novel reality. Educational RPGs, designed such that players can try on the role of a scientist, may allow individuals to imagine success as a real scientist and aim for careers in science (Schell, 2015). These new technologies provide interactivity making it possible to create learning environments where students can learn by doing and connect their interests to disciplinary goals

(Greenfield & Cocking, 1996). Role-playing has educational value related to concrete learning experience, understanding relevant concepts, developing models and theories, developing practical skills, and increasing motivation, engagement and satisfaction (Ranchhod et al., 2014).

Previous research shows potential for educational games, virtual worlds and RPGs to improve science identity, scientific literacy and domain knowledge (e.g., Annetta et al., 2014; Barab et al., 2005; Clark et al., 2011; Dede, 2009; Fraser et al., 2014; Hickey et al., 2009; Kafai, 2010; Ketelhut & Nelson, 2010; Lester et al., 2014; Meluso et al., 2012; Miller, et al., 2011; Nelson et al., 2014). Studies also show educational games can increase student's engagement and persistence with scientific practices (e.g., Barab et al., 2005, Clark et al., 2011; McQuiggan et al., 2008). Furthermore, characteristic design elements of RPGs are stimulation of curiosity and opportunities for exploration and discovery (Todd Howard, 2016). These design features support the exploration of potential relationships between curiosity (trait, state, domain specific), the game's design and play experience. Therefore, this research targeted the RPG genre and the academic topic of basic genetics.

2.8 Conceptual Model for Research Investigation

Based upon the previous literature review, a conceptual model is proposed as one possible relationship between the various concepts discussed (see Figure 2.4). Based on theory and research, the conceptual model combines related game elements into proposed systems to simplify this initial inquiry. These design systems (See Table 2.2) were identified to vary, to some degree, between the three games used in this study.

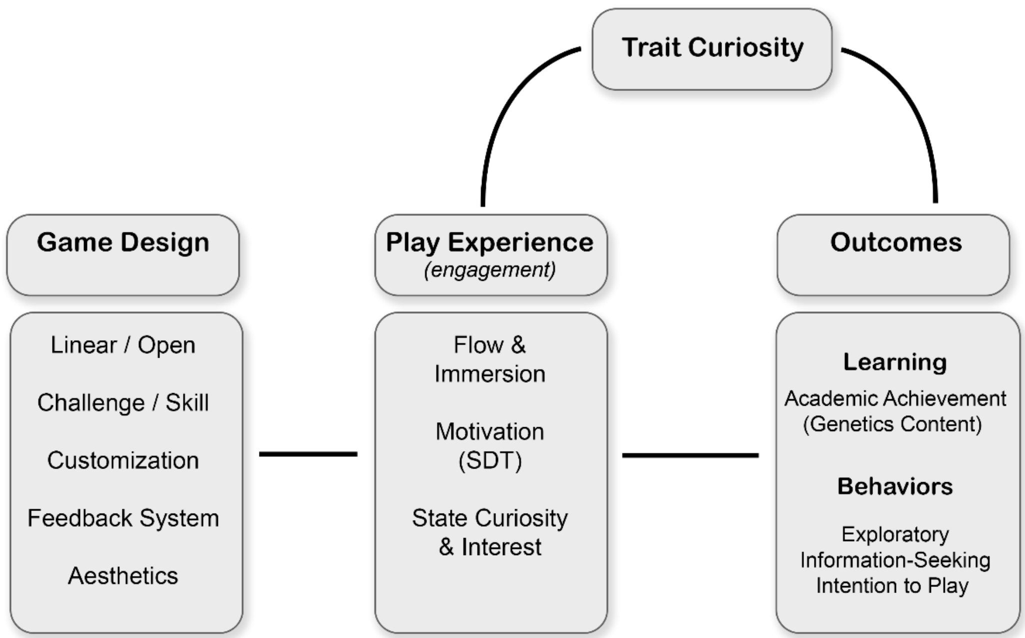


Figure 2.4. Conceptual mode for research study of game design, play experience, curiosity and learning outcomes.

This conceptual model extends flow theory to include immersion which can be supported by aesthetics, feedback systems, customization, adaptive challenge and freedom of open designs. Game designs that satisfy the three basic psychological needs (competence, autonomy and relatedness) allows the player to control their own motivation. Finally, design elements that provide opportunity to trigger and sustain curiosity and interest may lead to domain specific interest and curiosity-related behaviors (exploration, information-seeking) resulting in more meaningful learning. Trait curiosity may influence player perceptions and attitudes towards the game via their assessment of the game as novel, worthy of their attention and their ability to deal with possible stress related to a novel uncertain environment.

Table 2.2

Game design systems for the conceptual model

Design System	Description	Play Experience Influenced
Open / Linear	Relates to freedom, choice and control for game sequence, challenge level, exploration & discovery	Flow Autonomy Competence Curiosity (exploration)
Challenge / Skill	Game features that balance challenge & skills: levels, boss levels, mini-quests & puzzles, player skill, avatar skill, game difficulty settings	Flow Autonomy Competence Curiosity (information gap maintenance)
Customization	Customization: player creates unique play experiences. Avatar customization, character builds, meaningful choices, modding	Flow / Immersion Autonomy Relatedness Curiosity (Interest)
Feedback Systems	Feedback systems: immediate and substantive, range from simple to complex. Rewards, consequences, progress, fun failure.	Flow Autonomy Competence Curiosity (information-gap)
Aesthetics	Aesthetics include sound effects, music, visuals, narrative, fantasy, NPCs, tactile sensations, etc. Emotions can be elicited by the game aesthetics (e.g., awe & wonder, attachment, empathy, surprise, uncertainty, novelty, etc.)	Flow / Immersion Relatedness Curiosity (perceptual stimuli, interest)

CHAPTER THREE

METHODS

3.1 Introduction

The goal of this study is to extend current understanding of educational game design and implementation by investigating characteristics of three different role-playing games (RPG) relative to the individual's play experience, learning outcomes and state curiosity. Furthermore, this study seeks to extend current understanding of curiosity and GBL by exploring potential relationships between dispositional curiosity and tendencies to approach and interact with novel learning environments such as games.

After providing a rationale for the methodological approach, this chapter describes the (a) participants and settings for this study, (b) roles of the researcher and facilitator, (c) games selected for the intervention, (d) measurements, (e) data collection procedures, and (g) data analysis procedures. Lastly, the chapter concludes with trustworthiness measures for the study.

3.2 Convergent Parallel Mixed Methods Research Design

The holistic nature of this investigation aims to understand relationships among variables related to game design features and learning outcomes while also exploring the complexity of the data through multiple perspectives. The intent for adding quantitative measures is to view the research from a general perspective, identify significant relationships between variables of interest, and test whether the intervention affects outcomes of interest. The intent of adding qualitative data is to provide contextual, personal experience and perspectives drawn from participants. I collected both types of data to generate a more complex understanding of the research problem than could be derived from either singular method. A mixed methods design suits this research because it combines strengths of quantitative (i.e. objective measures, trends and generalizations) and qualitative methods (i.e. subjective interpretation, details, and depth) (Patton, 1990) enabling the researcher to compare quantitative statistical results with qualitative findings to yield a complete understanding of the research problem, and to validate and/or illustrate one data set with the other (Creswell & Plano Clark, 2018).

The philosophical and theoretical foundations of this study require a mixed methods approach. This research was guided by a pragmatic paradigm focused on the practical consequences of research findings and utilization of multiple methods of data collection to inform the study. Pragmatism allows for consideration of theoretical foundations that informed the research conceptual model (see Figure 2.4) and the mod design while acknowledging the importance of a variety of individual perspectives. Mixed methods research is practical for a pragmatic paradigm in that it allows the researcher to use all available methods to answer the research questions.

People naturally solve problems through abductive thinking (e.g. combining inductive and deductive logic) allowing them to use both numbers and words to enhance understanding (Morgan, 2007). I used deductive and inductive logic to investigate the research problem from both top-down and bottom-up perspectives. I consulted current theory and built broader themes emergent from participant perspectives to gain a deeper understanding of the data. I conducted an extensive review of theoretical foundations (e.g. learning theory, game theory, and curiosity theory) to identify key variables of interest and inform my research questions. I took a hypo-deductive approach to establish expectations of results and to create conceptual models that guided the mod design and the scientific inquiry (Kelle, 2015).

The goal of this study is to inform better educational game design from the learner's perspective. Therefore, the practical application of the results is important and hypothesis generation is necessary for a more complete interpretation of the findings. For this purpose, I took an inductive interpretive approach (Creswell, 2015) to gain deeper meanings emergent from varied perspectives of the participants and for hypothesis generation necessary to modify the conceptual model for future research. I decided to use a mixed methods approach because it allows both hypothesis testing and hypothesis generation, the hallmark of mixed methods research, and supports the philosophical and theoretical stance taken for this inquiry (Creswell & Plano Clark, 2018).

Variations exist in mixed methods research designs and have fluctuated over time. For this study, the current typology of three core designs by Creswell & Plano Clark (2018) were considered. These core designs are dependent upon timing and intent. The researcher's intent may be to explore, explain or converge and the ordering of data collection is considered in the timing (sequential or parallel) (Creswell & Plano Clark, 2018). The intent of this research is to obtain a more complete understanding of the problem, validate quantitative findings with qualitative findings by comparing the two data sets, and illustrate one data set with the other.

A literature review, of game theory and learning theory, suggests there is a complex network of interactions between player, learning and game. A well-designed game should give the player choice of actions which then have consequences. The game provides feedback to the player so the player can learn. (Figure 3.1). To fully understand this relationship, it is necessary to quantitatively measure key variables and qualitatively consider player preferences and perspectives. A convergent parallel mixed methods design facilitates direct comparison of objective perspectives derived from survey instruments with participant perspectives drawn from open response, focus groups, and observations during game play. Therefore, participants have a voice and statistical trends can be reported (Creswell & Plano Clark, 2018). To address the research questions, a convergent parallel mixed methods design was used as a guiding framework to inform research design decisions (Figure 3.2) (Creswell & Plano Clark, 2018).

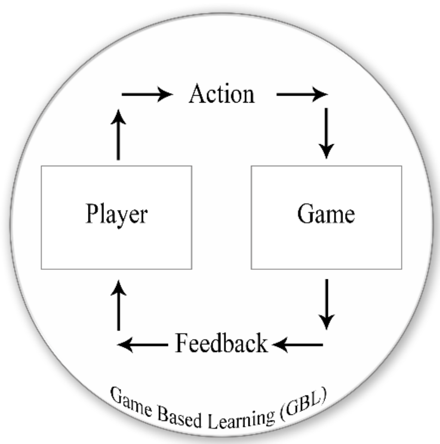


Figure 3.1. Diagram of the complex relationship between the player and game.

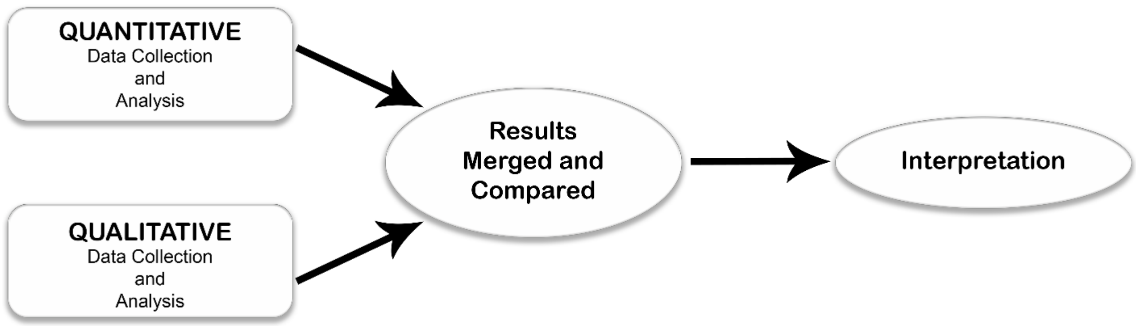


Figure 3.2. Visual overview of the Convergent Parallel Mixed Methods Research Design (Source: Creswell & Plano Clark, 2018).

One challenge to convergent design is the need to merge results from two different types of data (numeric and text) in a meaningful way (Creswell & Plano Clark, 2018). I formulated open response and focus group questions to target concepts of the Likert scale survey items while also allowing freedom of expression. The use of open response and close-ended questions on the survey allowed confirmation and validation of the close-ended items with the open response questions. Observable behaviors of interest were assessed in the close-ended survey questions to validate qualitative data. I developed an observation protocol (Appendix H) that matched variables on the surveys to ensure certain behaviors of interest were observed and to validate survey responses. The qualitative measures provide assurance that participants are interpreting close-ended questions as intended by allowing opportunity to freely express opinions and feelings. These steps promoted optimal combination of two types of data. However, it is also important to allow participants to freely express themselves such that unanticipated ideas and themes can emerge. As part of the observation protocol, I wrote extensive field notes describing interactions and conversations with the participants as they played the games to enrich the data. Participants were encouraged to describe their experiences and ideas to provide insight into emergent themes and provide interesting conversation that serve to validate and embellish quantitative survey findings.

A second challenge to convergent design is related to unequal sample size between quantitative and qualitative data (Creswell & Plano Clark, 2018). To minimize this problem, I collected quantitative and qualitative data on all participants on all variables of interest. All participants were observed. All participants were selected for focus groups. To encourage participation in the focus groups, the fifth day of game play was free choice of game. Although, some attrition occurred due to schedule conflicts and transportation issues, most participants engaged in the focus groups such that the diversity of participant experiences was represented.

According to Creswell & Plano Clark (2018), the convergent parallel design involves collecting and analyzing two independent strands of data in a single phase and merging the results of the two strands. The researcher then looks for convergence, divergence, and relationships between the two databases. The convergent parallel design consists of four major steps (Creswell & Plano Clark, 2018). The procedures for this study are overviewed in the procedural flowchart in Figure 3.3. First, quantitative and qualitative data were collected, for each participant, concurrently and independently with equal emphasis. Second, quantitative and qualitative data were analyzed independently. Numerical data from Likert scale measurements and pre/post genetics tests were analyzed using statistical analysis (e.g. descriptive, inferential). Qualitative data (text) were coded and analyzed for themes and patterns using qualitative methods. Results from each data set were presented and discussed. Third, at the point of interface, quantitative results of data collected from predetermined scales were compared with results of qualitative data (open response, focus group transcriptions and observations) to look for patterns, similarities or conflicts in responses. Finally, interpretation reveals to what extent and in what manner the two sets of results converge/diverge, relate, or combine to create a deeper understanding of the research topic. (Creswell & Plano Clark, 2018).

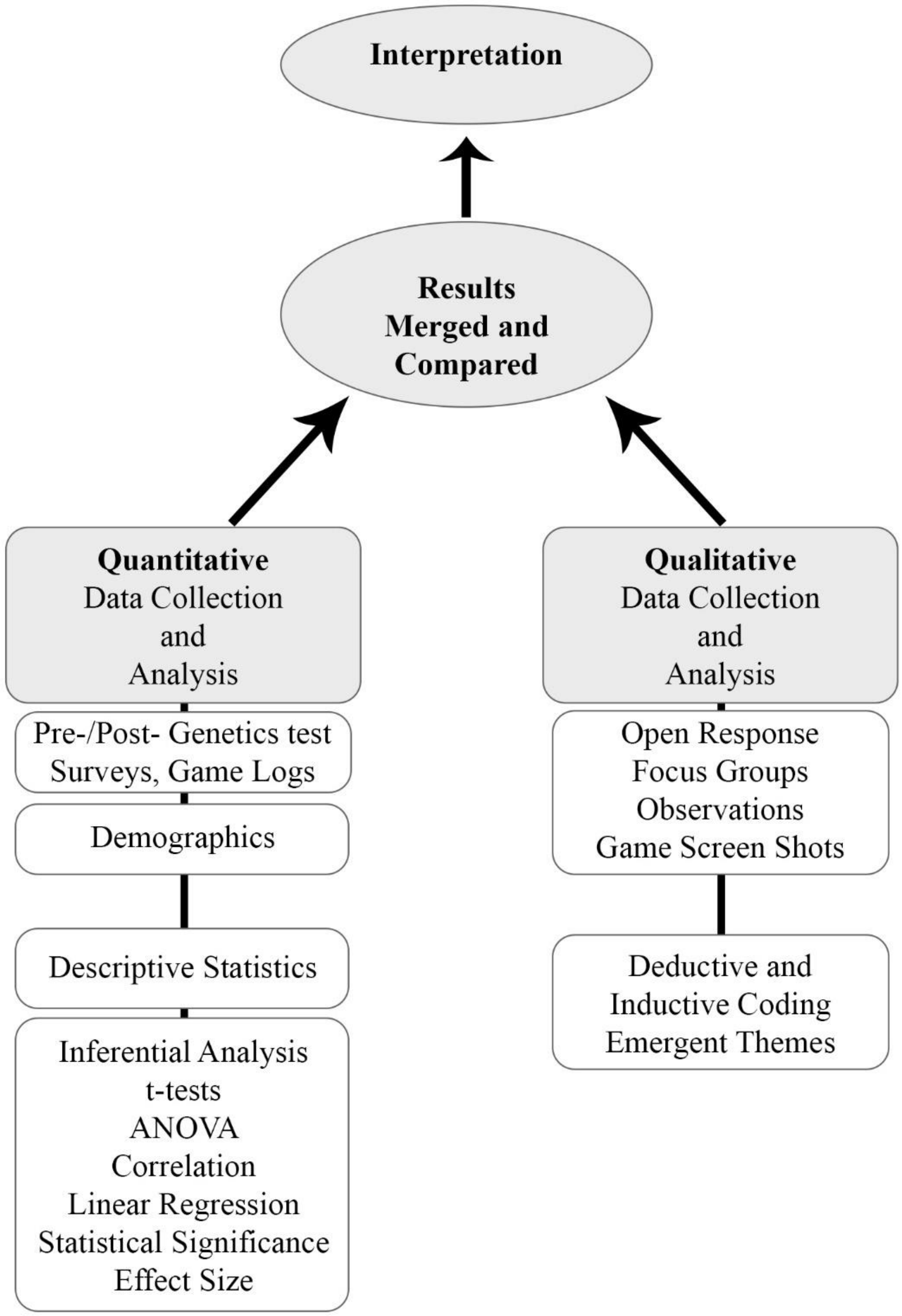


Figure 3.3. Procedural flowchart for convergent parallel mixed methods design for this study (modified from Creswell & Plano Clark, 2018).

3.3 Participants and Setting

3.3.1 Research Context and Computer Lab Setup

The setting for this study was a five-day video game camp conducted as an after-school program at Clemson University located in Clemson, South Carolina. The computer lab chosen for the study had twenty computers with operating systems and graphics cards capable of running the commercial game and genetics mod. Prior to the study, each numbered computer was assigned to a specific game license and Steam account. Steam is the free video game digital distribution service by Valve that provides game installation and automatic updating, along with community features such as friends lists, in-game voice and chat, and cloud saving. A Steam account was necessary to load and play Skyrim and DragonMist. I installed and tested Skyrim and DragonMist on each computer. I created a database to maintain game licenses and account information (e.g. logins, passwords, associated email addresses, and computer IDs).

I installed a compatible browser and Adobe Flash player on each computer so that the educational game would be operable. I created a genetics classroom for each of the three video game camp groups using the teacher dashboard tools in Radix and assigned the tutorial and genetics questlines along with remedial tasks available for unsuccessful quests. At the time of classroom creation, Radix automatically assigns login names for each student. I used one password for each of the three classroom groups. These login names, passwords and unique classroom identifiers were added to the database. Radix does not have game licenses, so any computer in the lab can run any individual's game based on the unique login, password and classroom identifier.

I created desktop icons for the DragonMist website and The Radix Endeavor website so participants would have easy access. I created name cards with login and password information and placed one at each computer on each day of the game play session to aid students in locating their computer. I used a seating chart to aid in observations and field notes (Appendix I). On the first day, computers had one of the two assigned games loaded for the participant. Computers on the left side of the lab were logged into *Radix*. Computers on the right side of the lab were logged into DragonMist. This setup was intentional to minimize cross-contamination resulting from participants observing, or interacting with, a game other than their assigned game.

On the first day, at time of arrival, the monitors were turned off and participants were asked to choose a computer with a name card and write their name above the login and password information. This process randomly assigned each participant to their research condition. The student's unique ID number was then added to the database to connect them to their game login and password. I opened the DragonMist website (http://www.dragonmist.org/game) on un-used computers for easy access since DragonMist is full screen game play. The full screen presentation creates a barrier for knowledge seeking behaviors because the participant had to close their game to access the internet or get up and walk to another computer in the lab. Radix is browser based and tabbed which makes internet access quick and easy during game play. This design provided an advantage to knowledge seekers because they could rapidly switch between open tabs in the browser. This design also proved to be a disadvantage because it was easy to engage in off-task behaviors. To address these potential biases between the games, I explicitly announced, each day, that participants were encouraged to collaborate and use any resource available to them (including the internet) to solve the quests and explore genetics. I also actively observed off-task behavior and guided participants back to the genetics content.

3.3.2 Participants

My target population was middle school to high school science students. I used non-probability voluntary sampling to recruit students with genetics prior knowledge comparable to (or exceeding) minimum science standards required of a sixth-grade public science curriculum. I recruited participants from middle schools, high schools, after-school programs and home-schools located in three counties in upstate South Carolina. Home-school recruitment included home school co-ops, private home-schooled students, and the public K12 home-school program.

I worked with the assistant-director of an after-school program who worked with several middle school and high school administrators as well as a regional after school activities director. She created a flyer and posted flyers at local middle and high schools, and after school programs. She also posted digital flyers on several after-school program facebook sites. I called home-school co-op directors for five co-ops located in three different counties in upstate South Carolina. They agreed to post flyers on their facebook sites. The flyer promoted the study as a free five day video game camp for middle and high school students, gamers and non-gamers welcome. Parents of interested students contacted me via email and I provided supplemental information outlining the details of the study and the genetics learning objectives as well as addressing any concerns.

A study sample was selected from the volunteers based on the following inclusion criteria: (a) students must be on an academic level comparable to typical public middle school or high school curricula, in other words, participants must have a minimum of a sixth grade prior knowledge of basic Mendelian genetics concepts, (b) students must have a maturity level, and parental permission, necessary to play DragonMist as part of Skyrim which has a M17+ rating, (c) students must be available for the afterschool video-game camp for two hours a day for five consecutive days, and (d) students must have transportation to and from the computer lab where the video game camp was conducted.

A review of current GBL, science education and curiosity literature suggest this is an age group who can benefit from educational support, specifically related to science and curiosity about science careers. For example, students' motivation and curiosity, in formal learning settings, seem to steadily decline starting in third grade continued through ninth grade and never return to the original level (Harter, 1981; Engel, 2009; Engel, 2011). One explanation may be the emphasis on mandated curricula and standardized testing which limits available time to foster curiosity or individual student interests (Arnone et al., 2011). Students who enjoy discussing science in informal contexts (e.g., summer camp, after school projects, home) may express disinterest in science within the evaluative context of formalized learning (Solomon, 2005; Renninger, 2007).

I also targeted this population because current literature suggests as early as middle school, students make future career path decisions and adjust their interest in math and science (Maltese & Tai, 2011; Tai, Liu, Maltese, & Fan, 2006). Students begin to lose their innate curiosity about science after elementary school (NRC, 2011). As few as 20% of middle school and high school students surveyed in 2008 expressed interest in science careers (Project Tomorrow, PASCO Scientific, 2008). Women scientists report that their experience in school was pivotal to their curiosity and interest about science (Maltese & Tai, 2010). Early intervention to cultivate curiosity and interest in math and science, especially for girls, is crucial (Maltese & Tai, 2010). One way to increase students' interest in science is video games (Mayo, 2009). Therefore, I targeted middle school through high school age participants who have some prior genetics knowledge to investigate GBL as an early to intermediary intervention for science education and scientific curiosity.

The intervention strategy supports this age range. The educational game, The Radix Endeavor, was designed by a team at MIT to meet NextGen science and Common Core math standards for middle school and high school. I designed DragonMist to directly match the learning objectives outlined in the teacher dashboard on the Radix website (Appendix B). Therefore, the selected games are appropriate for the participant age range.

All participants who signed up for the study were pre-screened to determine academic science curriculum level and maturity level compatible with the M17+ rating for Skyrim. This pre-screening was done by private communication with the parents and/or teacher. Pre-screening for the M17+ rating disclosed the violence in the Skyrim game play, occasional mature language, and the hyper-sexualized appearance of female avatars in the game. I informed parents that I designed the DragonMist mod to minimze the mature content; however, to stay true to the original game's narrative, a certain amount of action and violence was required. Skyrim is an open world game, player freedom and choice is a hallmark feature of the game, and I decided I could not compromise that design feature in the DragonMist mod. Therefore, parents were informed that the participant would be instructed to play DragonMist but their movement through the Skyrim environment would not be restricted and the student might encounter more mature content unrelated to genetics. I encouraged concerned parents to view the video walkthroughs of Skyrim and DragonMist provided on the DragonMist website prior to consenting to their child's participation in the study.

Academic pre-screening was necessary because home school organizations often do not adhere to public school grade categories. Therefore, acadmemic eligibility was determined via parent and/or teacher interview prior to the study to ensure each participant had some basic genetics knowledge comparable to a sixth grade science curriculum (or higher). Parental and participant consent was obtained prior to the first day of the study. IRB approval was obtained, no significant risks were expected, all participants were notified and returned completed consent forms prior to the first game play session.

Some parents wanted to be present during the study to support their child. Parents were presnt to aid students with learning disabilities and/or minimal experience with academic testing. Parents were available to monitor their child, but did not help with survey answers in any way. Parents were instructed to notify me when participants had questions or confusion related to survey completion.

A total of forty-two students (N=42) volunteered for the study. Six students dropped out of the study due to transportation issues. Parents of two students failed to give permission for the M17+ rating of Skyrim. Two third graders and one college sophomore participated in the video game camp and completed the surveys, but these data were excluded from analysis because the participants failed to meet the study's inclusion criteria. A total of thirty-one (N=31) students were determined to meet the selection criteria and were included in the study. One parent withdrew permission to play DragonmMist for one of the participants on the second day of the study. This student completed Radix and some of the measurements and dropped out of the study on day three. After the game play sessions began, all but four of the parents requested that their child play both educational games prior to the final free choice day when the focus group was conducted. This restriction created a control group (DraonMist → Skyrim) of four participants (n=4) creating limitations on generalizability of the control group findings. Twenty-nine of the thirty-one participants self-identify as gamers. Current statistics show that 91 to 97% of middle school and high school students are gamers (Jenkins, 2013; Resinger, 2011). Therefore, the participants of this study are representative of broader populations with respect to general game play experience.

Participants received an Amazon gift card in the amount of thirty dollars if they completed all surveys and played both games. One participant dropped out after playing Radix, and received fifteen dollars. This participant completed more than half the surveys and some of the data was included in the study. Participants from the home-school co-ops requested a certificate of learning as part of their science hours requirements. This certificate was offered to all participants who completed the genetics quests in both games.

3.4 Role as Researher

Observation is an important technique for UX (user-experience) research (Sauro, 2015). Observations allow the researcher to understand how users interact with products, people, and challenges (Sauro, 2015). The role of the observer forms a continuum from complete observer (completely removed) to complete participant (completely engaged). On one extreme, a detached, unseen observer minimizes influence on participant behaviors but raises ethical questions about possible deception because the participants do not realize they are being observed (Sauro, 2015). Observer as participant creates limited opportunities for interactions with the participant. The goal is to remain neutral and understand how a person uses software to accomplish a goal (Sauro, 2015). Participant as observer allows the researcher to be fully engaged with the participant to build a unique understanding of the participants. This method increases the interactions between observer and participant, but the participants still understand the observer is conducting research (Sauro, 2015). At the other extreme, complete participant allows the observer to be completely engaged with the activity and participants are unaware that research is being conducted (Sauro, 2015). According to DeWalt & DeWalt (2010) participant-observation is an observation method that allows the researcher to take part in the daily activities, rituals, interactions, and events of a group of people. This observation method allows the researcher to become an insider so that people feel comfortable sharing their thoughts and experiences and producing an emic understanding (Bernard, 2011).

I chose to take the role of participant as observer for this study. The role of participant as observer allowed me to gain a more comprehensive perspective of the interactions between the player and the game than could be gained by simply observing the computer screens while they played (Jorgensen, 1989). Moreover, I could interact with the participants during game play to gain a better understanding of their emotions, experiences and behaviors (Glesne, 2011). As an insider, I could observe behaviors and question the participant about thoughts and feelings so that I could compare what they were doing with why they were doing it. In some cases, this observation method allowed me to observe attitudinal changes. Another benefit of adopting the role of participant-observer is that I could question participants about their thoughts and interactions with the game or learning content as the event occurred rather than relying on their interpretation of survey items or their memory during the concluding focus groups (DeWalt & DeWalt, 2010). One disadvantage of participant as observer involves inadvertent or intentional influence on the student's perception of the game or their genetics knowledge.

I recognized the reciprocal influence between myself and the participants created by my role as participant-observer (Corbin and Strauss, 2008). I played Skyrim for three years and logged over 700 hours of game play. This was a necessary endeavor such that I could design the genetics mod as well as answer any game mechanics or technical issues that might arise during the study. I also completed the genetics questline in Radix more than fifteen times to analyze the game mechanics and learning objectives so that I could directly compare the two games for academic learning outcomes. My influence in the study was unavoidable.

My gaming expertise and status as a modder (a gamer who creates original content for games), made me an insider in the classroom, which meant that my presence in the study was viewed as normal and made the participants comfortable sharing their game experiences with me (Jorgensen, 1989). An advantage from this relationship was that the students viewed me as a fellow gamer and showed genuine interest towards helping me improve educational game designs. Another advantage is that I had a level of expertise and familiarity with all the games such that I could answer any question posed without spending valuable time searching for game cheats on the internet. Through this level of gaming expertise and knowledge, I gained acceptance, trust and respect from the participants. This degree of insider status caused one disadvantage in that many participants were apologetic when they encountered difficulty or unpleasant situations in the games. To minimize potential bias due to their desire to please me, I encouraged them to be honest and emphasized how important their input would be to help designers create better educational games.

To minimize my influence, I continually checked my biases and engaged in self-reflection to consider how I might impact the data (Atkins & Wallace, 2012; Corbin & Strauss, 2008). Each day at the beginning of the session, I explicitly stated that participants' honesty, regarding positive and negative feedback on the games, was valuable to educational game design. I explicitly stated that they should not worry about hurting my feelings because I genuinely wanted to know how they would improve the games for entertainment value and teaching. After each game-play session, game logs were documented, and game screen shots were taken to objectively support the observations made that day. I also used self-reflection as I expanded the daily field notes to develop a more cognizant awareness of my conversations and interactions with the participants, my influence on their responses, and their influence on my observations.

It should be noted that at no point in the study did I intentionally guide a participant's game play experience or learning from the game. I explicitly avoided giving any opinion about any of the games or quests within the games while the students were playing. I only offered help if they asked a question or if I noticed that they were struggling with a game or concept. If a participant got frustrated or embarrassed about something that occurred in their game, I offered personal experiences to increase their competence and lessen their embarrassment.

I recognized that my role as a researcher and my interest in identifying features that enhance engagement and motivation to play the game, was not a priority over my ethical obligation to the participant. It was important that the participants learn something about genetics and fulfil some of their science requirements. Additionally, this research aims to explore the games' potential to teach academic content and/or incite curiosity about academic content that may lead to deeper learning. As a result, I was required to exert influence on native game play interactions (player's choice). I was obligated to actively guide participants towards completion of the genetics questlines in both games. To ensure there was no bias towards either game, I only offered genetics information if they specifically asked genetics questions. I also explicitly encouraged them to use any available resource and/or collaborate with classmates to learn the genetics concepts. I demonstrated the supportive website icons and told them they could use their computer or get up and move to an unoccupied computer as needed. I observed when students asked genetics questions so that I could evaluate the influence of information seeking behaviors on GBL. I also observed any participant who discussed genetics with a classmate, consulted printed materials that were provided, or searched the internet. When I observed off-task behaviors, I guided the participant back to the genetics quests and explained why it was important for them to finish that quest before moving to a different activity.

3.5 Game Designs Targeted for Comparison

The primary goal of this research is to understand how to design better educational games, that can teach academic concepts while maintaining a high level of engagement and motivation, by comparing an educational game with a popular entertainment game. As a necessary first step, I had to identify an educational and entertainment game that could be directly compared. The first task was to decide on a game genre and academic topic, then identify games with those attributes.

The role-playing genre was targeted because these games are known to rely on exploration and discovery, and to stimulate curiosity (Howard, 2016). Role-playing in virtual worlds engages the player and improves self-efficacy in science by enabling the player to see themselves as scientists (Fraser et al., 2014; Lester et al., 2014). Science was chosen as the academic topic for the following reasons: (a) science is important in a knowledge-based economy, (b) empirical research suggests GBL supports learning science (Fraser et al., 2014; Lester, 2014), (c) children start to lose interest and curiosity in science by the time they reach middle school (Solomon, 2005; Renninger, 2007), and (c) because many students perceive science as difficult and boring (NRC, 2011; Project Tomorrow, PASCO Scientific, 2008). Games may provide a more enjoyable and engaging way to learn science. Role-playing may incite curiosity about science careers and improve science self-efficacy. Therefore, it is important to understand how engaging game design relates to possible learning outcomes.

I identified desirable characteristics of an educational game as follows: (a) academic science content, (b) RPG genre, (c) targets middle school to high school age, and (d) available for teachers and researchers to download and use. I identified desirable characteristics of a commercial game as follows: (a) popular game with a loyal fandom as evidence of engagement and voluntary play, (b) RPG genre, (c) narrative and mechanics conducive to inserting science content as a quest, (d) complex game play appropriate for middle school to high school ages, (e) allows gamer generated content (mods), and (f) provides a modding toolkit. I spent the next three years researching and playing various games to identify potential candidates for the study.

After playing numerous educational and entertainment games, several educational games were selected that targeted various science academic topics for middle school to high school age groups. The choice of entertainment game was narrowed down to RPGs that allowed the gamer to modify the original game and provided necessary tool kits to do so. After I chose the educational RPG for the study, I selected a commercial game with mechanics and narrative that sparked a creative idea for a science related quest that would blend seamlessly with the original game. The two games selected for this study are The Radix Endeavor (Massachusetts Institute of Technology (MIT), 2016) and Skyrim (Bethesda, 2016).

The Radix Endeavor (MIT, 2016) is a 2.5D (pseudo-3D, 2D graphics used with techniques that simulate three-dimensional space) RPG designed to teach middle school and high school science and mathematics. The game was designed to meet Common Core math and NextGen Science standards. MIT's Education Arcade and Scheller Teacher Education Program received a Bill & Melinda Gates Foundation grant to develop an immersive learning experience to support high school math and biology education. The Radix Endeavor is promoted as a massively multiplayer online game (MMOG) designed to improve learning and interest in STEM (science, technology, engineering and math) for middle school and high school. Radix is a browser based simulated world where the student takes on a digital character (avatar) and completes educational quests by interacting with other players and non-player characters (NPCs) in the game (Figure 3.4).

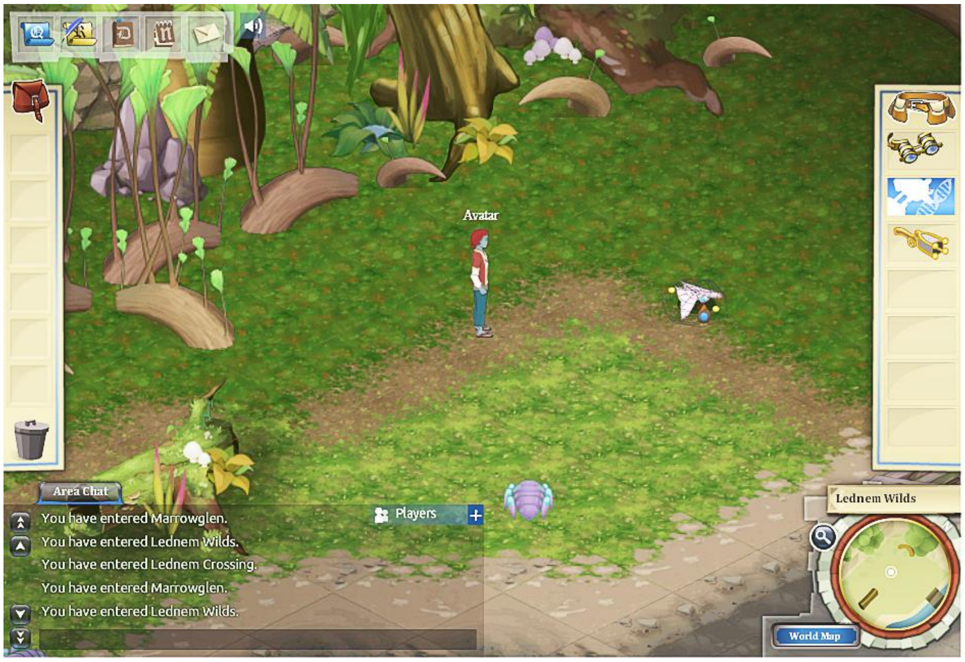


Figure 3.4. Game screenshot of The Radix Endeavor showing 2.5D environment, avatar and user interface

The Elder Scrolls V: Skyrim (Bethesda Games Studio, 2016) was chosen for this comparison study because it is a highly popular entertainment game as evidenced by its re-release in October 2016 after five years on the market and the extensive online community related to the game. During his DICE (Design Innovate Communicate Entertain) 2012 keynote speech, Bethesda Games Studios' game director and executive producer, Todd Howard, stated that over 10 million copies of The Elder Scrolls V: Skyrim had been shipped worldwide in less than one year after the game's first release date in November 11, 2011. At that time, based on Steam statistics, the average gamer's playtime was over 75 hours (Matos, 2012). Bethesda's release of *Skyrim Creation Kit* in early 2012 and its partnership with Valve Corporation (Steam's parent company) led to Skyrim being the second featured title, behind *Team Fortress 2*, in the Steam Workshop that features user-generated game content (mods) (Matos, 2012). By November 2016, Todd Howard confirmed that over 30 million copies of the game had been sold worldwide (Howard, 2016). According to SteamCharts, accessed January 15, 2020, average number of Skyrim Special Edition players in the last thirty days was 15, 473 with a net gain of +2725 and a peak of 26,377 players (SteamCharts: The Elder Scrolls V: Skyrim Special Edition, Jan. 2020). Skyrim Special Edition is also available for gaming consoles. Bethesda recently released a VR (fully immersion virtual reality) version of Skyrim. These statistics confirm the popularity of the game and the game is considered as one of the bestselling games of all time. Skyrim's mechanics, dynamics and aesthetics provide an opportunity to seamlessly insert genetics concepts without conflicts to the natural game play. Bethesda Games Studio also provides the necessary tools for modding the game. Therefore, Skyrim provides a rich opportunity for a comparison study since it is a fully immersive and complex 3D RPG that continues to maintain a fandom and high degree of loyalty and promotes gamer designed content (mods) (Figure 3.5). Skyrim is played in single player mode. However, an extensive online community, emerging from the game, offers opportunity for peer learning. Figure 3.5 shows a screen shot from Skyrim with my avatar riding her horse through a typical country setting in the game. The horse is a feature in the game that increases engagement and immersion as well as creates an interesting mode of travel through the environment.

Figure 3.5. Skyrim is a fully immersive 3D game environment as shown in this game screenshot of a typical location in the game.

Students for all game play conditions were told that they can seek help in any manner to include consulting fellow students, the researchers, or the internet. Radix has an in-game chat feature where students can seek help from peers, but the online community mainly targets educators. Skyrim has a rich online community as a resource but is only available external to the game. The Skyrim mod, DragonMist, is in alpha stage and not released publicly for gamers' access; therefore, currently has no online community support. To strengthen the study and to assess curiosity-related behaviors (exploration and information-seeking), I created a game forum and website, in a format that most gamers would expect, that will support DragonMist (DragonMist.org/game) (Figure 3.6). The website provides lore, hints, cheats, genetics information and video walkthroughs as well as a game forum. The site will also contain teacher and researcher support.

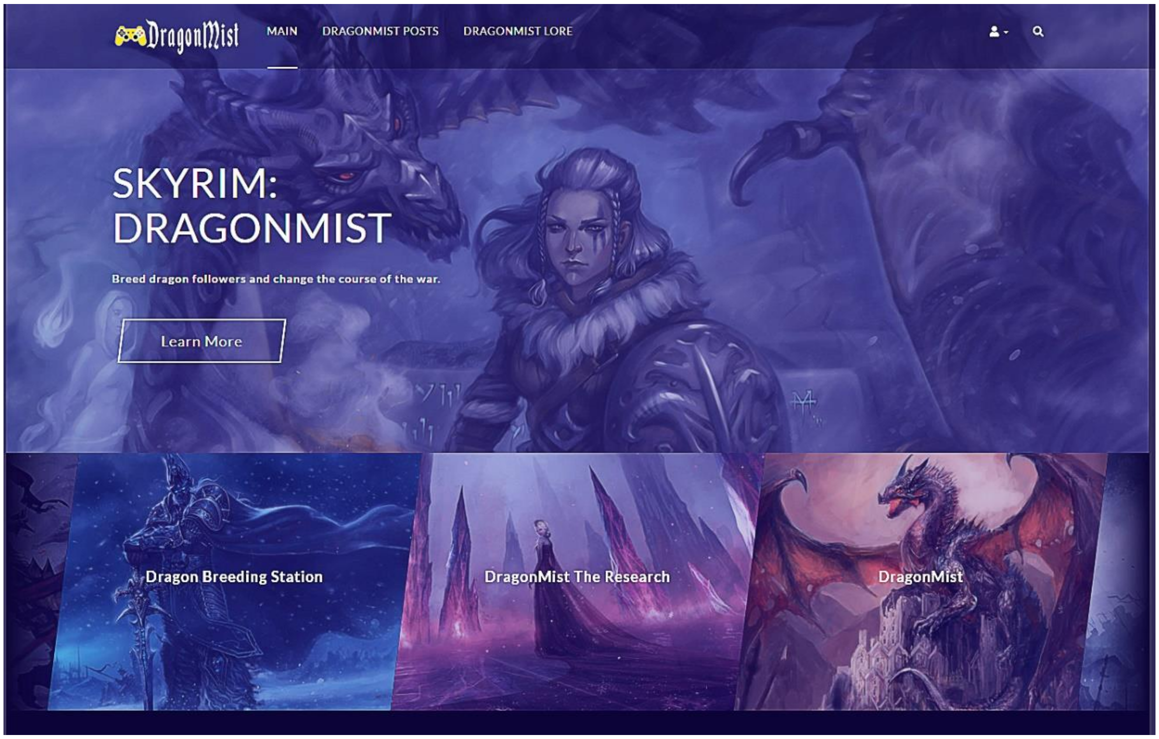


Figure 3.6. DragonMist website supports learning and provides a forum for players to share experiences and communicate.

3.6 DragonMist: Modding Skyrim

3.6.1 Learning Objectives in DragonMist

Skyrim is not expected to influence genetics knowledge or pique curiosity related to genetics as it contains no genetics related content. Therefore, the commercial game could not be directly compared to Radix for learning outcomes. Participants were asked to play Skyrim to provide a comparison for identifying design features that might differentially impact engagement due to incorporation of educational content. However, to compare a commercial game to an education game to assess academic learning outcomes, it was necessary to modify Skyrim by adding a genetics quest. I designed DragonMist to integrate a genetics related quest into the Skyrim environment that would match the stated learning objectives in the educational game *(*Radix) while remaining true to *Skyrim's* narrative. The learning objectives incorporated into the DragonMist questline were derived from the Radix teacher dashboard and are listed in Appendix B. I took every measure to integrate this learning content seamlessly with *Skyrim's* narrative, fantasy, and mechanics without breaking the entertainment value of the game.

3.6.2 DragonMist Lore

My goal was to design DragonMist to blend with the Skyrim narrative and not disrupt the entertainment value of the game. To achieve this, I researched Skyrim lore and wrote a story for the player that unfolds via Bhusari's dialog, the hunter's note to his wife, and lore books scattered around the abandoned temple. Jo'Tsrhni Bhusari is a Khajiit mage and scholar who serves as the quest giver and more knowledgeable other. He follows the player to the abandoned temple and remains in the lab to give the player intuitive clues and explicit instruction to guide the genetics learning (Figure 3.7). The Khajiit are a nomadic race of humanoid cats who are known for their agility, intelligence and trading skills. The prefix to their name indicates their position in life. Jo' means they are a wizard or scholar (masculine honorific). I chose a Khajiit because people of Skyrim seem to distrust them and if you want to trade for something on the shady side, I think a Khajiit would be the merchant of choice to find black market items. It makes sense as a Khajiit scholar and mage, he would be interested in the Dragon Priest's lost research and would be curious about the mysterious abandoned temple where rumors are the Dragon

Priest was conducting strange experiments. The Khajiit would also be expected to be involved with resurrecting powerful dragons who might decide to ally themselves with Mankind and change the course of the war. He tells the player if they can successfully bring back Paarthurnax's bloodline of dragons sympathetic to Mankind, everyone – the Thalmor, the Imperials and the Stormcloaks - will want one.

Figure 3.7. Jo'Tsrhni Bhusari is the more-knowledgeable-other who guides learning.

3.6.4 DragonMist the Quest

Skyrim dragons are large and aggressive and when you encounter one you must fight to kill it, or you die. You can't run because they follow you and you are not allowed to fast travel when they are present. You are forced to fight to the death. Alduin is the ultimate boss in Skyrim and is known as the "World Eater". He wants to destroy all of

Skyrim, and he is resurrecting his dragons to help him. Paarthurnax is Alduin's brother and was his first lieutenant until Paarthurnax took sympathy on Mankind and taught the voice (thu'um) to the Greybeards. The players goal is to resurrect Paarthurnax's bloodline so that these new dragons will be sympathetic to Mankind and help them fight the war. Dragons are technically immortal, so to resurrect a dragon the player must collect dormant souls (dovah sil) from dragons. The player then places one dovah sil in the essence (equivalent to blood) and one into the stone (equivalent of bone). This design decision was implemented to create an intuitive connection to DNA since most middle school and high school students would know that DNA is found in blood and bone. Players then combine two dragon souls to create a new dragon. The genetics content of the quest required that I take some liberty with the true Skyrim lore (e.g. dragon's immortality), but I tried to stay within the game's lore as much as possible.

To complete the DragonMist questline, the player must gain access to the samples and the knowledge required to successfully create a passive dragon from Paarthurnax's bloodline. To do this, they must fight their way through countless draugr who serve the Dragon Priest. When they achieve the boss level, they must defeat the Dragon Priest (see Figure 3.8) and take his research journal which gives them valuable genetics knowledge necessary to complete the quest and gain their reward – a cute friendly baby dragon (see Figure 3.18). The boss level is an expectation of RPG players where they expect an exciting action-filled challenge to earn coveted and rare rewards, in this case the research journals that provide knowledge necessary to breed the baby dragon. I chose a dragon priest for the boss because they are one of the most challenging bosses in *Skyrim* and are known to protect the dragons.

Figure 3.8. Boss level challenge: Defeat dragon priest and take his research journal.

To pique curiosity and spark interest in an academic topic within a game environment, care must be taken to fully integrate the learning content into the game's narrative and quest goals such that successful game play requires acquiring specific knowledge. The quest was designed to make a knowledge-gap salient and to provide the missing knowledge necessary to complete the quest. This learning content is incorporated on three levels; (1) explicit text-book like knowledge written in the dragon priest's research journals and spoken by Bhusari (see Figures 3.9 – 3.11, and Figure 3.19), (2) learning scaffolds provided by a more-knowledgeable-other (Vygotsky, 1978), Bhusari, a scientist mage, who gives ,hints and guidance to the player (see Figure 3.19), and (3) intuitive supports, for example, the structure of and colors in the dragon breeding station match colors in the Punnett squares located in the research journals (see Figures 3.14, Figure 3.11, respectively). Bhusari serves as a teacher in the quest, and was designed to give hints and guidance, mixed with occasional facts, to stimulate curiosity and exploratory behavior. For example, Bhusari may say “red, purple, blue, does that match anything else here?” (see Figure 3.20). Statements such as this may stimulate the player to explore the environment in search of things that are red, blue and purple and as a result find the breeding station and/or the research journal containing the Punnett squares. (see Figures 3.9 – 3.20).

Figures 3.9 – 3.20 show visual representations of the DragonMist quest via game screenshots and illustrate design features that support academic learning and enhancement of curiosity. The first research journal, taken from the Dragon Priest explains how to use the dragon breeding station and introduces the concept of essence (blood) and stone (bone) as well as explaining the concept of Dovah sil (dragon souls). This journal is written in a manner consistent with the lore and fantasy of the game (Figure 3.9).

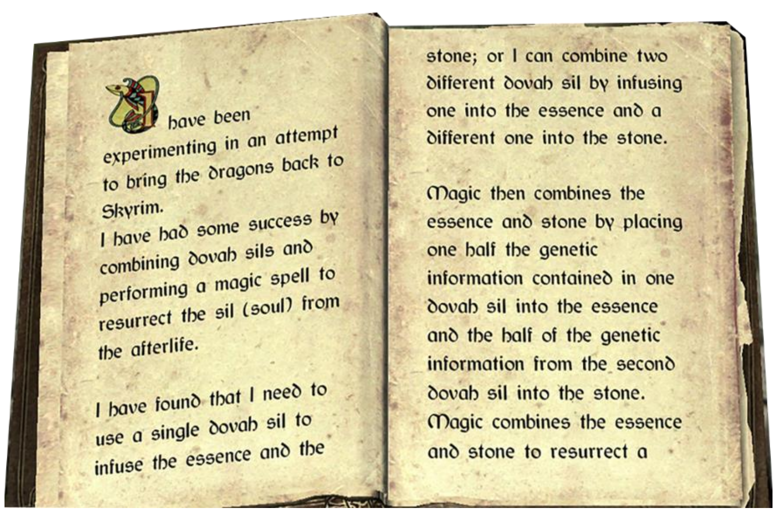


Figure 3.9. Research Journal I: provides instructions necessary to use the breeding station

The first research journal ends by prompting the player to find the second research journal hidden in the library. After the first quest (dominant and recessive traits) is completed successfully, the player is given the Fire and Ice quest and directed to find the third research journal in the library. The second and third research journals provide explicit genetics instruction in an academic textbook fashion (Figure 3.10). Color-coding is used as a visual stimulus to help learners, intuitively, understand genotype notations (ex. purple (Aa) is a mixture of red (A) and blue (a) and the hybrid genotype consists of a dominant and recessive allele, Aa). Both journals include color-coded Punnett squares to illustrate genotypes in an intuitive manner (Figure 3.11). For example, AA genotype is red, aa genotype is blue, and the hybrid genotype, Aa, is purple (mixture of blue and red). Potential offspring that result from the player's chosen parents are presented in the color-coded Punnett square at the dragon breeding station (Figures 3.15-3.17).

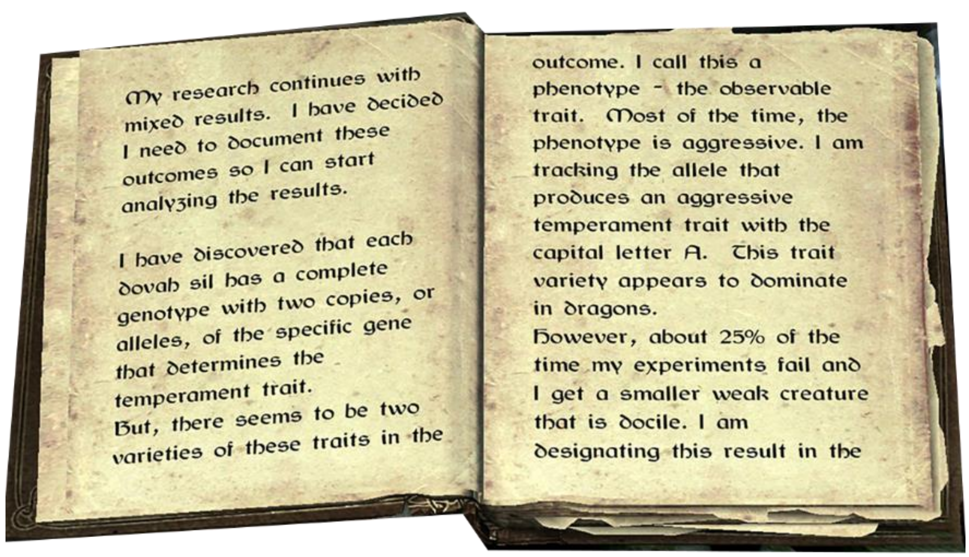


Figure 3.10. Journal II and III give the player explicit genetics knowledge including notation and probabilities

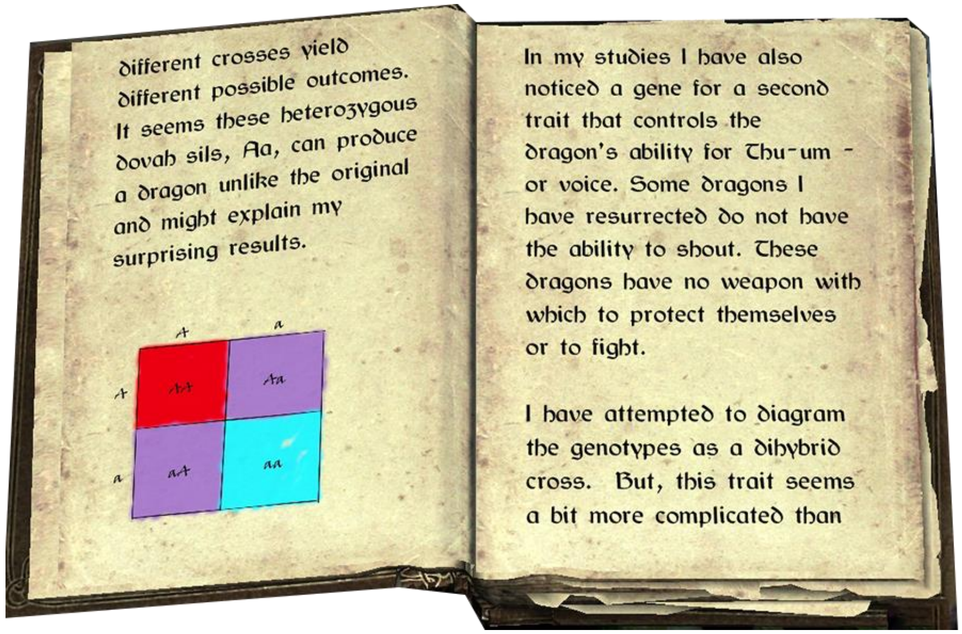


Figure 3.11. Research journals II and III show the color-coded Punnett squares and explain the experimental outcomes

To begin each quest in the DragonMist genetics questline, the player must first find the sample case containing Dovah sil samples (dragon souls) which will serve as parents for breeding a baby dragon. When the player chooses to collect the sample case, a dialog window appears that provides information about the samples and introduces genetics notation (Figure 3.12). One task is marked complete in the player's quest log and the next task is assigned (e.g. take the samples to the dragon breeding station).

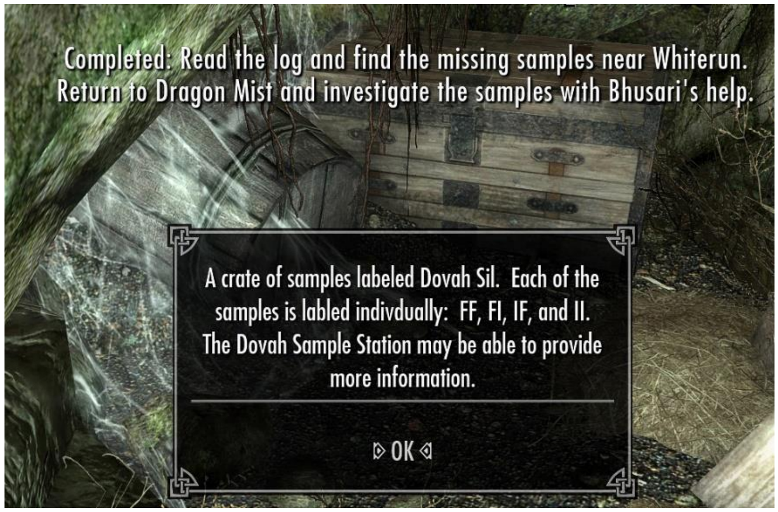


Figure 3.12. The Dovah sil sample case gives the player information about genetics notation.

The player returns to the Dragon Priest's laboratory where Bhusari is continuing the experiments. Bhusari helps the player by providing explicit genetics information and hints or clues to incite curiosity. The player is instructed to take the samples to the dragon breeding station (Figure 3.13). The navigation diamond guides the player into the correct position to see the Punnett square and parents. At the dragon breeding station, the player must use genetics knowledge to choose parent Dovah sil (Figure 3.14). The first quest allows players to create a passive dragon. They must understand that aggression is dominant and that if the capital A is present in the genotype, the dragon will be aggressive. They must choose two parents that have a probability of producing a genotype of two lower case a's (aa) if they want a passive baby dragon. It should be noted that the correct notation for the hybrid is Aa, but to simulate two different parents who could contribute the recessive allele, the sample case holds samples Aa and aA.

Figure 3.13. Visual of the dragon breeding station.

Figure 3.14. Players must choose a parent dragon based on genetics knowledge.

Figure 3.15 illustrates the color-coded animation that displays the player's choice of dragon parents. The colors are matched to the color-coded Punnett square in the research journals to add a level of intuitive learning and incite curiosity. In this game screen shot, the player has chosen correctly. The essence (blood), parent on the left, is purple indicating they chose the hybrid (Aa or aA). The stone (bone), parent on the right, is also purple indicating they chose a hybrid (Aa or aA). This is the only choice that has a probability of producing the recessive genotype (aa) for the passive phenotype, so the player must know they need two hybrid parents for the monohybrid cross.

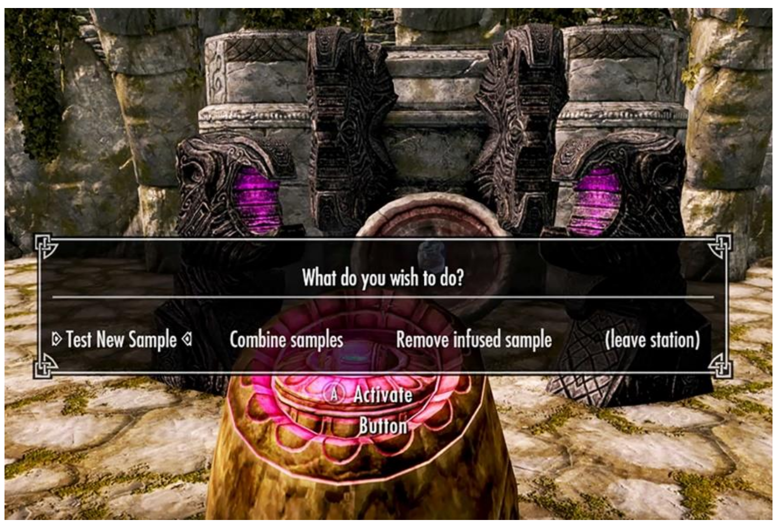


Figure 3.15. Color-coded animation showing chosen parents.

Once the parents are selected, the player is asked to combine the samples. Mendelian genetics is based on probabilities. If the player chose correctly by selecting two hybrid parents, the inheritance pattern would express these probabilities: 25% with genotype aa and expressing the recessive trait of passive (aa / blue); 25% with genotype AA and expressing the dominant trait of aggression (AA / red); and 50% hybrid genotype expressing the dominant trait of aggression (Aa / purple) as shown in table 3.1 and figure 3.16.

Table 3.1

Punnett square for mono-hybrid cross, dominant and recessive inheritance pattern.

	A	a
A	AA (red)	Aa (purple)
a	Aa (purple)	aa (blue)

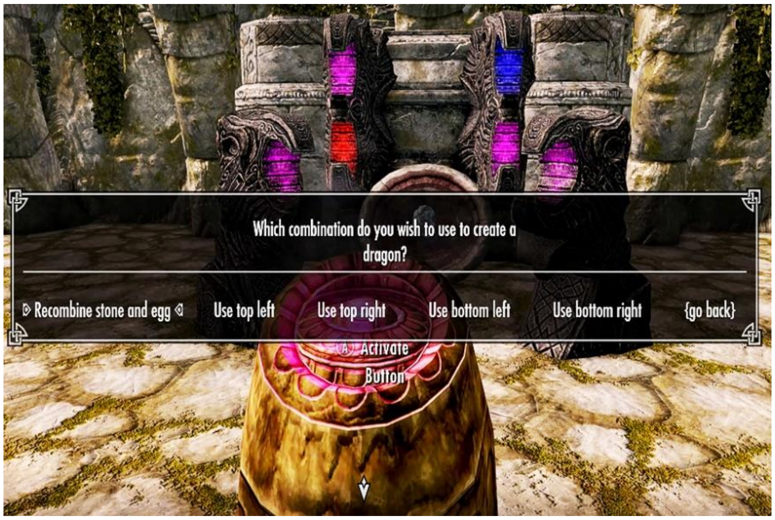


Figure 3.16. Punnett square for dominant/recessive inheritance pattern for monohybrid cross represented by the block of four colors in the center (offspring), two purple (hybrid Aa) parents are visualized on the left and right and the textual menu provides the player with a choice of offspring.

Mendelian genetics are based on probabilities. Therefore, distribution of offspring genotypes rarely matches perfect ratios (1:2:1). DragonMist was designed to reflect real-life outcomes and require players to understand the genetics on a deeper level. The offspring presented in the Punnett squares were based on Mendelian probabilities and could return different outcomes requiring the player to think about genetics and make a decision (Figure 3.17). First, the player must understand if the allele for aggression, represented by the capital A, was present, the dragon would be aggressive (red). They must understand that the allele for passive temperament is recessive thereby requiring two lower-case a's in the genotype (aa / blue). If the Punnett square did not return a blue (aa) offspring, the player must think about their choices and make a decision. If they believe they chose the correct parents, they can recombine the samples to get a different set of offspring. If they feel they chose incorrect parents, they can unload the essence and stone and select new parents. When they choose correctly, the player is rewarded with a cute baby dragon who will follow them and take basic commands (Figure 3.18). It also makes a cute baby noise "Rrrrrr" to generate positive emotion in the player.

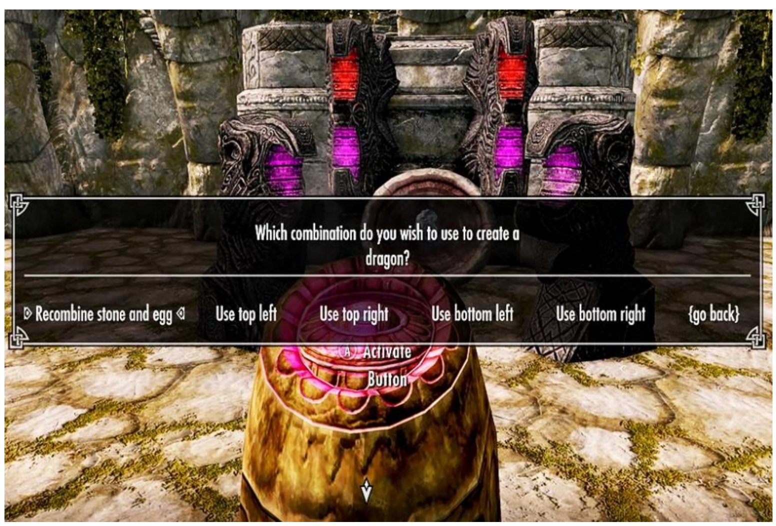


Figure 3.17. Visual of a Punnett square presenting ratio of offspring (red, red, purple, purple Punnett square) based on probability resulting from the parents (two purple lights in front of the Punnett square), the text menu allows the player to choose a baby dragon or recombine samples.

Figure 3.18. The player is rewarded with a cute baby dragon for learning genetics and provides immediate feedback for their genetics knowledge

Throughout the genetics questline, Bhusari works with the player to complete the genetics quest. Bhusari was designed to increase the player's emotional attachment to the game since he proves to be their friend by helping them fight their way through the boss level. He is also designed as quest-giver and a more-knowledgeable-other. His role in the game is to guide the player through the various quests in the genetics questline, answer questions, and give explicit learning knowledge necessary for the player's success (figure 3.19). Additionally, Bhusari was designed to incite curiosity. For example, he makes statements that provide hints or clues such as "This log will require detailed reading. Red, purple, blue. Does that match anything else here?" (Figure 3.20). RPG gamers expect, and appreciate, puzzles and challenges where they must figure something out rather than being told what to do in a linear step-by-step fashion.

Figure 3.19. Bhusari provides explicit feedback for the learning experience

Figure 3.20. Bhusari attempts to incite curiosity by giving hints and clues.

3.7 Pilot Study: DragonMist Alpha Playtesting

Game design is an iterative process (Figure 3.21) (Ubisoft, 2019). I conducted an extensive literature review to investigate game design theory and learning theory. I also relied heavily on many years as an experienced gamer. Prior to designing DragonMist, I purposefully researched and played numerous educational games and many commercial games of various genres. Qian and Clark (2016) conducted a literature review on GBL and identified certain game design features that were prominent in the literature. Findings from this review suggested certain features influenced learning in educational games and highlighted specific learning theories used to design good games. Based upon the literature reviews and my gaming and design experience, I identified certain game design features that I felt were important and targeted these features in the DragonMist design. My goal for DragonMist is a designed play experience where players explore, experiment, discover, act, receive feedback, and eventually gain new knowledge. From this goal, I developed a conceptual model to guide the DragonMist design process. (Figure 3.22).

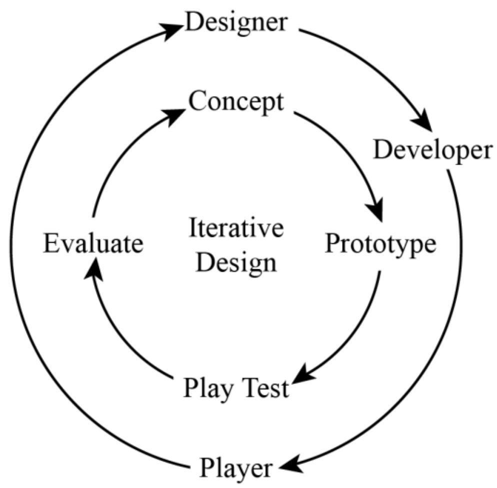


Figure 3.21. Iterative design is the process for game design that cycles between the designer developer and player to improve the game. Source: modified from (Source: Ubisoft, 2019).

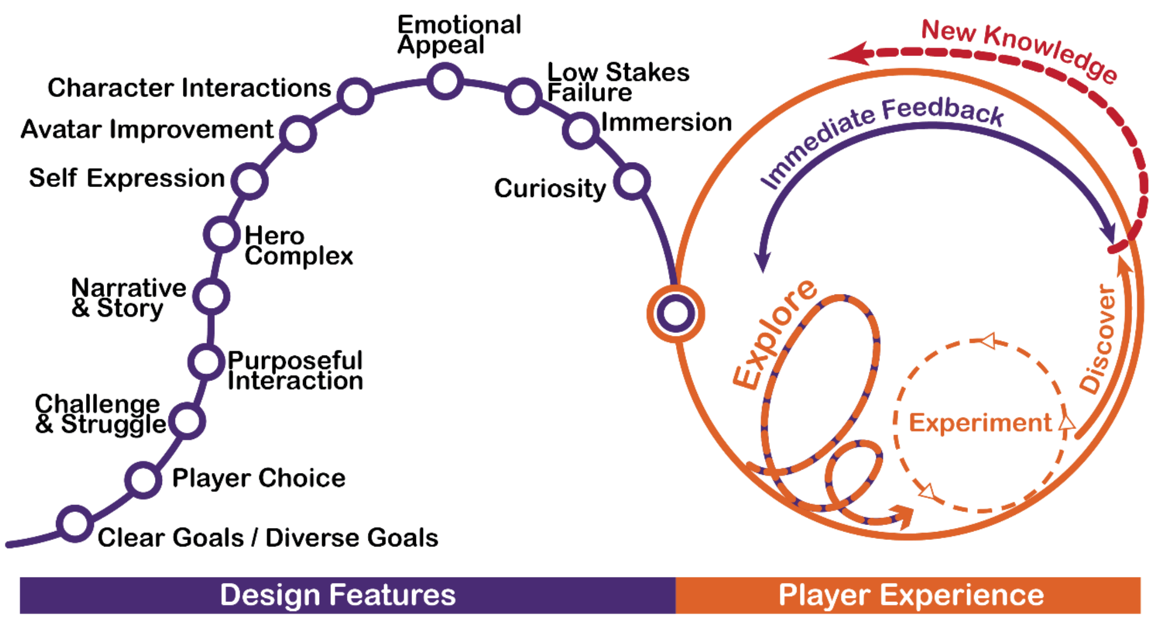


Figure 3.22. DragonMist Conceptual model detailing game design features and player experience deemed important for the DragonMist game.

The design is only half of the process. The game is a designed experience; however, the player-game interaction is required for the experience to become reality. User play testing should be done often while designing a game. The requirements of this research and limitations regarding funding prohibited extensive iterative design. However, a small pilot study was conducted in March 2019 to gain insight on the game design prior to the video game camps conducted in October 2019.

Seven undergraduate education majors (sophomores) volunteered to play-test DragonMist (female, n=5; male, n=2). Six (85.71%) said they were not gamers or seldom played games and only one had played Skyrim previously. The playtesting identified areas of the game that were successful and areas of the game that were glitchy. Primarily, the playtesting confirmed that the entire genetics questline could be completed in approximately two hours and fifteen minutes. This information was helpful for the research timeline.

The pilot study for playtesting was conducted one-on-one in a private office free of distractions. Each play-tester completed the tutorial and DragonMist questline, a short survey and interview. I also observed them closely while they played. Overall, the students were engaged with the game and appeared to have fun while playing. Results from the pilot study confirmed that targeted design features were integrated into DragonMist. The dragon was popular with six participants (85.71%) agreeing that the quest made them want to breed a baby dragon. The goal to create a play experience that encouraged exploration and discovery was supported as six participants (85.71%) said they enjoyed experimenting with stuff to see what would happen. To maintain high levels of motivation and engagement, it is critical to integrate academic knowledge into the game without disrupting the entertainment value. The pilot study confirmed that DragonMist was fun and that it let them do interesting things. Skyrim was created to incite and reward curiosity (Howard, 2016). The pilot study confirmed that DragonMist enhance and rewarded curiosity. Bhusari, the more-knowledgeable-other, is an integral part of the academic content and it was confirmed that he gave the player valuable genetics knowledge necessary to solve the quest. All seven participants stated that they learned genetics, to some degree, while playing the game. DragonMist is in the alpha stage and several glitches / bugs were discovered. I corrected some of the problems prior to the study. However, some of the problems require more advanced solutions and were not correctly. Some of the remaining issues directly block academic content and created a limitation for the study. Finally, to determine time required to complete the Radix genetics questline, three of my friends volunteered to play Radix. It was determined that the entire questline could be completed in approximately two hours and thirty minutes. From the pilot study, I determined that two game play sessions approximately one hour and thirty minutes each, three hours total play time, would be enough for participants to complete the genetics quest for each of the two games. This time frame would also minimize potential problems should a participant finish too early such as disturbing others or cross-contamination issues due to exposure to other games.

3.8 Data Collection

3.8.1 Tasks, Materials and Timeline

Forty-two (N=42) students volunteered for the study. Thirty-one (N=31) students met inclusion criteria and were accepted into the study. These thirty-one students were divided into three groups to participate in one of three week-long video-game camps. All participants played two different games. The control group (ctrl) (n=4) played DragonMist for two days, followed by *Skyrim* for two days. The first experimental group (exp1) played the educational game, Radix, for two days followed by DragonMist. The second experimental group (exp2) played DragonMist for two days followed by Radix.

On day one, to facilitate participants' familiarity with the game operation and mechanics of the game, they were instructed to create their avatar and complete the game's tutorial phase. At this time, participants were assigned the genetics questline for their assigned game. I instructed all participants that their goal for the first two days of the video game camp was to play their assigned game for the purpose of learning genetics. I told them that they would take a post- genetics knowledge survey to assess how successful (or not) the game was in teaching genetics concepts.

On day three, participants switched games. I instructed them to play this game for fun. I told them that their goal was to compare this game to the first game and share experiences about what they liked (disliked) about the games to help designers create more enjoyable educational games. I told them another goal was to consider what they believed they learned in each game and how the games helped them learn.

Participants were given different explicit goals for the first and second game to gain some initial understanding of how their perceptions of the game's purpose might influence their engagement and motivation. The goal for the first game was to learn. The goal for the second game was to have fun. These goals were explicitly stated because some researchers have suggested that changing intrinsically motivated rewards and activities to more extrinsic orientations impact engagement and learning negatively (Deci & Ryan, 1985; Ryan & Deci, 2000). In support of this, Hawlitschek & Joeckel, (2017) investigated student perceptions and learning in an educational history game (*1961*) and found that engagement and learning were decreased when the students were explicitly told that they would be tested on the content when compared to a no-instruction condition where they were instructed to have fun. These instructions make it possible to observe possible behavior changes based on perceived purpose of the game.

Participants played each assigned game for approximately one hour and thirty minutes on each of two days for a total of four days (six hours). I chose the length of time and frequency of game play based on an approximate amount of gameplay needed to complete the quests of the educational game and the DragonMist mod as determined from the pilot study. At the end of each play session, I collected all materials and saved all the games. I then downloaded game log files and made screen shots of the players' games which were saved on an encrypted SSD drive. In the event I changed anything in the participant's game while collecting the data, I reloaded the saved game and made sure it was unchanged. I saved that game, exited Skyrim and logged out of Steam so that no one could access the game until the next game play session. The fifth day of the study was reserved as a make-up day in the event of participant absences and for the focus groups. As incentive to attend the focus group. Participants were told they could choose which game they wanted to play on that day.

Students absent on assessment days received a make-up day prior to game play and as soon after their last game play session as possible. One student failed to make up the post-test for genetics prior to the next game play session and their pre- genetics score was not included in the data analysis. One other student dropped out of the study after day three and had not played the second game, nor did they complete the post-test for genetics. Their curiosity data and game-play experience survey for Radix (the first game played) was used in some of the data analysis.

To protect student's identity, I created a database with unique identifiers, Steam account information, game login for both games and passwords for both games for each participant. The database was populated with pre- /post-test scores as well as data from the surveys. Students chosen avatar names are used as pseudonyms unless the avatar name allowed identification of the student (Appendix N). In that case, an avatar name was created for them. Once the survey and test logins were confirmed to match the actual student, the names were unlinked from the data collected. This data is maintained on an encrypted external SSD and stored in the researcher's office. *MIT*, *Bethesda, Steam* and *Nexus Mods* (server that hosts DragonMist) enforce privacy on their servers as well as established EULAs (end user license agreements). Only researchers approved and named on the IRB (Institutional Review Board) will have access to the raw data. I am the only researcher who conducted observations. No video or photographs were taken. Game screen shots do not identify the player.

Parental consent forms and child consent forms were sent out two weeks prior to the study, All consent forms were completed and returned prior to the game-play sessions. I was available to answer any questions and concerns regarding the study. All concerns were resolved prior to the first game play session. Consent forms are stored in a locked file cabinet in the researcher's office. Table 3.2 outlines the timeline for the study.

Table 3.2

Timeline for Data Collection

Day	Time	Description
Prior to Video Game Camp	30 minutes	Complete the following (under teacher or parent supervision): Consent Form Curiosity pre-survey Demographics survey
Day 1	2 hours	Complete genetics pre-test (30 minutes) Play first game (1.5 hours)
Day 2	2 hours	Play first game (1.5 hours) Complete genetics post-test (30 minutes)
Day 3	2 hours	Complete Game Play Experience survey for game one (20 minutes) Play second game (1 hour 40 minutes)
Day 4	2 hours	Play second game (1 hour 40 minutes) Complete Game Play Experience survey for game two
Day 5	2 hours	Free play the game of their choice (1.5 hours) Focus Group (30 minutes)

3.8.2 Procedures Related to Research Questions

All procedures followed regulations regarding privacy and ethical research standards. All procedures were approved by the University's Institutional Review Board (IRB). Both quantitative and qualitative data were collected simultaneously and independently. Both sets of data are considered to hold equal importance for addressing the research questions. Data were recorded in two separate databases. Each data set was analyzed separately and independently with analytical methods appropriate to the type of data collected. Once initial results were established, the results from both data sets were merged. Initially, direct comparisons of the two data sets were made, a table created for organization and followed by in depth discussion. When necessary, results were transformed in some manner to facilitate data comparisons and additional analysis performed. Finally, interpretation of the data was required to identify in what ways the two sets of results converge or diverge from each other. The combination of the two sets of results serve to create a better understanding in response to the study's research questions. For any results that diverged rather than converged, results were reexamined, quality and accuracy of the databases were investigated, and when required more data collection was considered (Cresswell & Clark, 2018).

3.8.3 Quantitative Data Collection

Procedures for quantitative data collection started by randomly assigning participants to a research condition. This study consisted of two experimental conditions and one control. It should be noted that due to certain restrictions imposed on some participants, the control group was small (n=4) presenting a limitation on generalization of the findings for the control group. For each week-long video game camp, participants were randomly assigned to an experimental or control condition. The control condition (ctrl) was instructed to play DragonMist first followed by Skyrim (DragonMist → Skyrim). The purpose of this control is to compare game play experience between the purely entertainment version of the game (Skyrim) with the modified version containing academic content (DragonMist). This control condition addresses research question two (RQ2); What impact does the integration of learning content into a game design have on player engagement, motivation and learning? Students in the first experimental condition (exp1) played the educational game, The Radix Endeavor (MIT) followed by DragonMist (Radix → DragonMist). Students in the second experimental condition (exp2) played DragonMist followed by The Radix Endeavor (DragonMist → Radix). A cross-over design for group comparison was implemented to minimize bias related to order effects (Figure 3.23). These three conditions distinguish three groups of participants as follows: (a) control condition (ctrl), DragonMist → Skyrim (n=4), (b) experimental condition one (exp1), Radix → DragonMist (n = 14), and (c) experimental condition two (exp2), DragonMist → Radix (n = 12). One participant played Radix only.

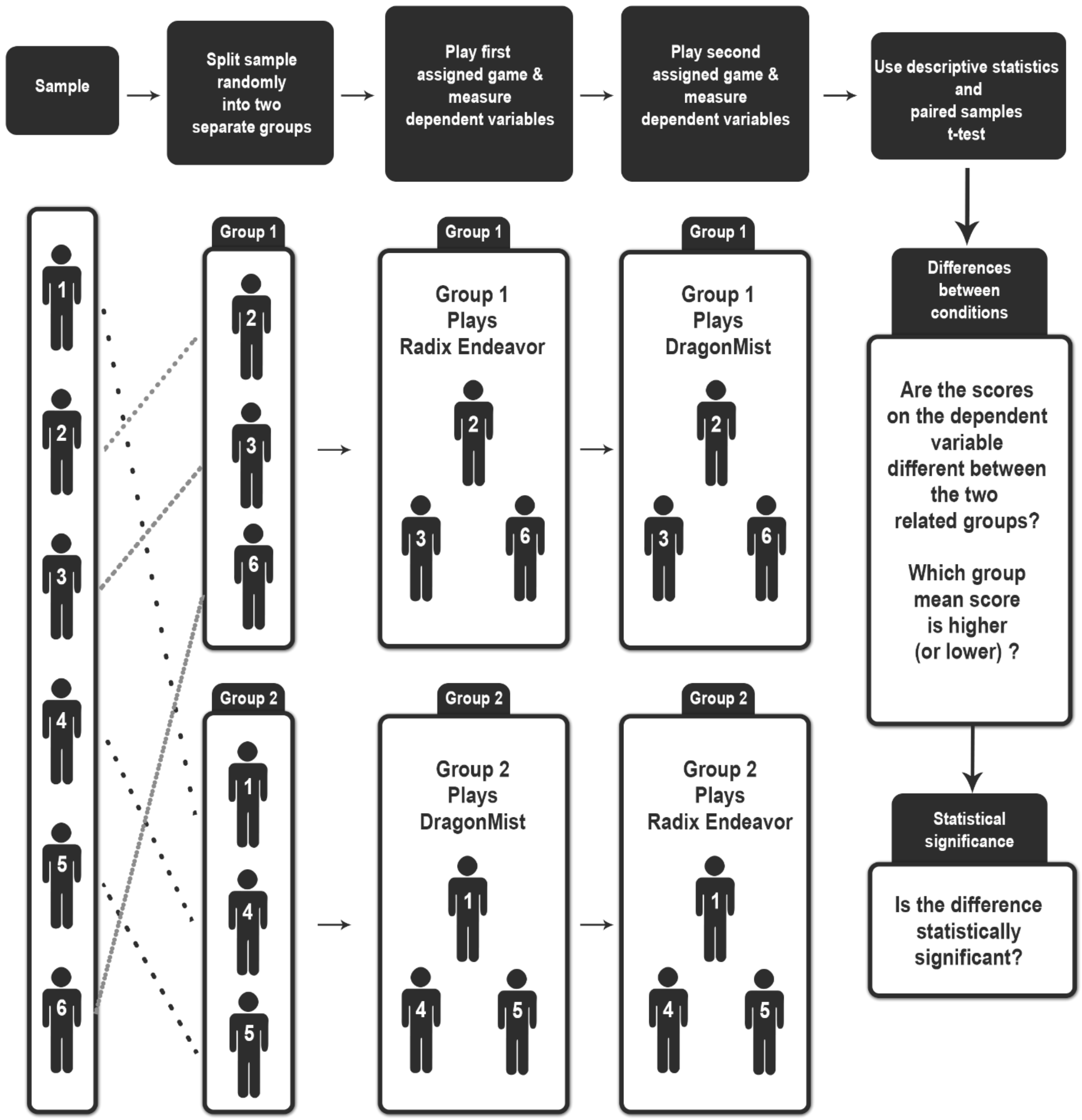


Figure 3.23. Diagram of the cross-over design implemented for group comparisons to minimize bias related to order effects. Source: modified from Laerd Statistical Solutions.

I chose quantitative measures to view the research from a general perspective, identify significant relationships between variables of interest, and test whether the intervention affects outcomes of interest. I collected the following quantitative data:

demographics, pre-/post- test for genetics knowledge, dispositional curiosity survey, scientific curiosity survey, a comprehensive game-play experience survey, and game log files. The survey method is a powerful quantitative method that allows the researcher to collect large quantities of data in a short period of time from a representative sample and make inferences about a larger group (Holton & Burnett, 1997). Game log files were downloaded after each play session and saved to an encrypted SSD drive. Game statistics were used to populate a database to support other data in this study.

Prior to game play, a demographics survey was administered to capture data on key variables known to affect player-game interactions and to assess inclusion criteria for the participant. The demographics survey collected data on age, gender, race/ethnicity, science self-efficacy and general game preferences (Appendix C). The demographics survey was used to distinguish interesting groups for group analysis.

A pre-/post- genetics knowledge test was administered to assess group similarity and academic achievement outcomes. The pre-test for genetics knowledge strengthens the study in three ways. First, it serves to evaluate group similarity. Second, it provides a base-line comparison measure such that potential learning gains can be related to GBL. Finally, some research indicates that curiosity requires some degree of prior knowledge for information gaps to become salient (Loewenstein, 1994). More recent literature on curiosity poses the possibility that curiosity can emerge *de novo* given the appropriate stimuli (Gottlieb et al., 2013). The pre-test will then serve as a foundational reference to identify potential relationships between curiosity and prior knowledge. The post-genetics knowledge test was administered after participants played the first assigned game to assess the intervention's effects on learning outcomes.

At the beginning of the study, prior to game interventions, participants completed a comprehensive curiosity survey (*5CD*; Kashdan et al, 2018) that has been validated against multiple curiosity measures and in tandem with multiple personality measures resulting in a comprehensive set of individual profiles relating curiosity and personality. This quantitative data will address research question five (RQ5): Does an individual's trait curiosity influence how they approach a novel learning environment (GBL) and then influence interactions, engagement and motivation within that environment?

Prior to game play, domain-specific curiosity related to scientific processes was assessed using the *Scientific Curiosity Scale* (*SCILE*; Weible & Zimmerman, 2016). This same measurement was administered immediately after playing each of the two games to answer research question four (RQ4): Can game design features heighten curiosity towards integrated learning content?

A game-play experience survey, that compiles published, and validated measures matched to each structure in the conceptual model (see Figure 2.4), was administered after participants played each of the two assigned games to assess game play experience (engagement) operationalized as perceived flow/immersion, motivation (SDT), and heightened curiosity. The survey also included variables specifically related to game design decisions implemented when creating DragonMist (see Figure 3.22). I constructed these unique items to mirror the wording and content of validated measurement instruments and add study-specific context. The survey items are five-point Likert scale and administered as a pen and paper document. This survey was administered as Game Play Experience Survey I (Appendix G). I instructed participants that they should consider only the game they just played as they answered the questions.

On day three, participants switched games and were instructed to play their assigned games for fun and for the purpose of comparing the two games to help improve educational game design. The participants played the second game for approximately one hour and thirty minutes on each of two days. After they played the second game for the allotted time, they were asked to complete the second game-play experience survey. The second game play experience survey is identical to the first survey (Appendix G). I instructed participants that they should consider only the game they just played while answering the ranked (Likert scale) questions

The two game-play experience surveys differed only by the open-response items. The open response for the first game play experience survey (Appendix G) were designed to solicit participant opinions on the three main topics of interest in this study (engagement, learning, curiosity). Participants were directed to consider only the game they had just played while answering the questions. The second game play experience survey open response questions (Appendix G) were like the first survey except they asked the player to compare both games and discuss their favorite game of the two played in relation to the designated topic (e.g. engagement, learning, curiosity). These quantitative measures are used to answer the following research questions: (a) RQ1: What impact do game design features have on player engagement and motivation in educational games as compared to commercial entertainment games, (b) RQ2: What impact does the integration of learning content into a game design have on player engagement, motivation and learning, and (c) RQ4: Can game design features heighten curiosity towards integrated learning content?

3.8.4 Qualitative Data Collection

A key focus of this study is to consider the research questions from the player's / learner's perspective. Games are a designed experience. However, without the player, the experience does not really exist. The complex dynamic relationship between game and player creates the play experience and impacts the outcome of that experience. Personal preferences certainly influence how, or if, an individual chooses to interact with a certain game. Therefore, qualitative data were also collected each day via observations, field notes, and game screen shots.

Each of the two game-play experience surveys provided open response questions to provide participants opportunity to qualify answers and add comments that may not have been considered in the close-ended items. This combination of questions will allow a greater organization of data, and robust analysis, while preserving free flow of information and ideas via the freedom of response in open-ended questions. I recorded answers entered on the hand-written survey method into NVivo statistical software and a database for research purposes.

All participants were observed during each game play session. An observation protocol was developed to cover key variables of interest identified in the literature review and to support survey concepts (Appendix H). I took the role of participant-observer so that I could record detailed field notes. This role allowed me to observe and record behaviors and interactions with the game and engage in conversations with the participants while they played.

I was the only person who had enough experience with both games to optimally observe the study. Four key strategies increased the quality of my obervations. First, To assist accuracy of observations, the study was divided into three separate video game camps consisting of approximately one-third of the participants in each group. This decision created groups of approximately ten students and made it easier to observe every participant in a detailed manner. Second, my observations were aided by the seating chart and the lab setting. I created a seating chart (Appendix I) to help identify students. All participants playing Radix were on the left side of the lab and all participants playing DragonMist were on the right side of the lab until they switched games. At that time, they remained at their same computers so that logistic interactions remained unchanged while keeping the two games physically dileneated in the lab setting. Third, several university students volunteered to help with classroom management and tech-support. One undergraduate student, who participated in the pilot study, played DragonMist and Radix and volunteered to help with tech-support and game related issues. Two graduate students were present to help keep order and to bring my attention to participants who needed help. These research assistants did not document their observations, but their classroom management and tech-support ensured that I had ample time to interact with the participants and complete field notes. Finally, I created an observation protocol (Appendix H) to ensure that, at a minimum, every variable of interest would be observed for each participant.

Documented observations consisted of a completed observation form (Appendix H) for each participant and field notes that allowed for richer observations and emergent ideas. I observed interactions between the participant and game, participant with classmates, interesting events, emotions, and conversations. As I engaged in participant observation, I wrote notes consisting of key words or phrases that were extended immediately after the game-play session concluded for the day. I also noted direct quotations when I thought they would be useful later to provide information on a particular interaction, emotion, thought process, or motivation. When participants shared game experiences with me, I took mental notes and then immediately wrote key words and phrases to record the experience. As they shared their experiences or asked questions, I also asked questions to clarify their thoughts and emotions. I hand wrote notes while speaking to the participant and drew sketches or took mental notes. When not directly interacting with a participant, I typed up mental notes first. Then, I made additional notes or drew sketches as I observed their game play from a distance. After each game play session, I immediately summarized my observations and expanded key phrases. At the end of the five day study, I took a step back for a few days and then returned to my notes to add in analysis and reflection.

A focus group was held at the end of each of the three video game camps. The focus group was guided by questions designed to cover each of the three main topics of interest to the study (e.g. engagement, curiosity, learning) (Appendix J). The focus group conversations gave participants freedom to discuss ideas and experiences with their peers and with me, so that richer data emerged and validated observations and interpretation of quantitative responses. All participants were encouraged to participate in the focus group. As incentive for attendance on that day, they were told that all surveys were complete and that they would choose the game they wanted to play for fun. As added incentive, they were told they would receive their Amazon gift cards and learning certificates after the focus group. There was some attrition due to scheduling and traffic issues. A total of twenty students participated in one of the three focus groups. Each focus group consisted of six to eight participants. This group size ensured sufficient number for good discussion while maximizing the facilitator's ability to include.

The subjective nature of qualitative data creates a deeper and richer understanding of the numerical data by giving the player a voice to tell their stories. Furthermore, a qualitative approach allows me to draw on my personal experiences and expertise as a gamer, designer, and educator (Creswell & Plano Clark, 2018). Therefore, qualitative methods strengthen this study by providing contextual, detailed, and deeper information from the participant's personal experiences and perspectives as well as the researcher's perspectives. Specifically, the qualitative data addresses research question three (RQ3): How does the game's design influence the game play experience and learning outcomes from the player's perspective when playing an educational game compared to an entertainment game?

3.8.5 Point of Integration

Finally, at the point of integration where results from the two data strands are merged, a more complex understanding of the research problem emerges through the combination of both objective and subjective results. Integration is the process of analyzing interactions and connections between quantitative and qualitative methods (Tashakkori & Teddlie, 1998) Integration can occur as research questions are formulated (Teddlie & Tashakkori, 2003), at an intermediary stage such that the initial research phase informs data collection in the second phase (Ivankova et al., 2006), or at the final interpretation stage (Onwuegbuzie & Teddlie, 2003). For this convergent parallel design study, the quantitative and qualitative results was presented and analyzed independently and results from both data sets were integrated during the final interpretation stage. The final integration is the triangulation of data from both strands of data to interpret the outcomes of this study as a whole. Integration of the two sets of results will answer research question six (RQ6): What game design features enhance (or inhibit) the game-player-learning experience and how do these features influence engagement, motivation, curiosity and learning in a GBL environment from the learners' perspective? I employ an integrative interpretation to address the holistic nature of the research problem. This research design allows me to discuss the results of the study, as a whole, and investigate practical applications related to educational game design and implementation.

In summary, data were collected concurrently, independently and with equal emphasis (QUAN + QUAL) on all participants in accordance with a mixed methods convergent parallel research design (see Figure 3.2). Table 3.3 summarizes how each was collected and for what purpose. Measurements and observation protocols are detailed in *Measurement Strategies* section 3.10 of this chapter.

Table 3.3

Summary of Data Sources to Address Research Questions

Data source	When collected	Connection to research question(s)
Demographics (survey)	Prior to start of game play sessions	Identifies variables known to potentially influence game preferences and learning; distinguishes groups for group comparison and descriptive statistics
Curiosity survey	Prior to first day of game play	**RQ5**. Connects dimensions of dispositional curiosity to participants' approach, acceptance and interactions with GBL
Scientific curiosity survey	Pre-game play, post- game play for each game	**RQ4.** Determines if game design features can heighten scientific curiosity through game play
Genetics knowledge test	Pre-game play, post- game play for the first game played	Determines GBL influence on genetics knowledge. Used for group comparisons between treatment (education or modified entertainment game)
Game-play experience survey	Post- game play for each game played	**RQ1, 2, 4.** Used for group comparisons between game played to assess engagement, curiosity and learning in both games
Game log files	Downloaded after each game play session	**RQ1, 2, 4.** Used for group comparisons between game played and to support other self-reported data
Open response (handwritten as part of survey)	Post- game play for each game played	**RQ3.** Used to enrich quantitative data by giving the participant a voice to tell their story about game play experiences.
Observations (observation protocol, field notes)	Each game play session	**RQ3.** Enriches understanding of the research problem by allowing the researcher to connect what a participant is doing with why they are doing it by engaging in conversation and observing actions, behaviors and emotions.

Table 3.3 (continued)

Summary of Data Sources to Address Research Questions

Data source	When collected	Connection to research question(s)
Game screen shots	End of each game play session	**RQ1, 2, 3, 4.** Game screenshots support qualitative and quantitative data as they illustrate the participants game experience.
Focus groups (audio recordings)	At the end of the game play sessions for each group; 21 participants	**RQ3.** Enriches the data by giving participants opportunity for free expression and promoting emergent ideas as they share play experiences in a group setting.

3.9 Analysis

3.9.1 Quantitative Analysis

The first step taken for quantitative analysis was to prepare the data by populating a database with data from the quantitative measures. Each participant was assigned a unique numerical identifier. New variables were computed for scales comprised of multiple items (e.g. summation, averages). Reverse scored items were inverted and used to populate a new variable. The data were screened for entry errors and missing data. After data were cleaned (e.g. missing data identified, data entry errors identified and corrected), the databases were imported into SPSS 25 for Windows (statistical software) for analysis. Two participants had missing data for the pre- / post- genetics knowledge test. One of these two participants completed all remaining surveys and was used for all data analysis except the genetics knowledge analysis. The other participant dropped out of the study after playing Radix and failed to complete the second game play experience survey. I was able to use his pre- and post- curiosity surveys and game play experience survey I for Radix on independent-samples t-tests; but his data was removed from all paired-samples t-test analysis. Three participants were removed from data analysis for failure to meet the inclusion criteria of the study. One participant had missing data on some of the constructs of the game play experience survey. This participant's data was used for most of the analyses and missing constructs were omitted from analysis. After data screening, twenty-nine (n=29) participants had complete data for the genetics knowledge analysis; thirty (n=30) participants had complete data for game play experience and curiosity, and one participant (n=1) was used for Radix specific analysis but could not be included in paired-samples t-test analyses.

The second step of quantitative analysis was to explore the data for broad trends and to gain an initial understanding of the research problem. Data was visually inspected for general trends and normal distribution. Descriptive statistics (mean, standard deviation, variance, skewness, kurtosis, normality) were analyzed for each major variable to identify proper inferential statistics. The quality of the scores from the survey instruments were examined using procedures to assess their reliability (Cronbach's alpha). Sample size was too small for validity analysis, but this study used previously validated published measures for the surveys. Pre- and post- knowledge tests were analyzed via item analysis to investigate difficulty and discrimination of each test item. Missing data was identified and addressed appropriately for each case.

Inferential statistics were chosen for group comparisons and to identify relationships between variables. Multiple steps were conducted to refine the analysis (e.g.

from interaction effects, to main effects, to post hoc group comparisons). The following inferential statistical tests were selected for data analysis: independent-samples t-tests, paired-samples t-tests, analysis of variance (ANOVA), and hierarchical multiple regression analysis. SPSS 25 for Windows was used to analyze the data for the purpose of answering the research questions and testing hypotheses. Inferential tests were conducted, and effect sizes and confidence intervals were calculated. Statistical results were summarized and significance (*p* value) and practical effects (Cohen's *d*, partial eta squared) were reported in text, tables and figures.

Independent-samples t-tests were used to examine group differences to determine if statistically significant difference exists between the means of two independent groups on continuous dependent variables. Specifically, independent-samples t-tests can be used to: (a) determine differences between two independent groups, (b) determine differences between interventions, and (c) determine differences in change scores. The null hypothesis, (H_0: the population means of the two groups are equal (i.e. $\mu_1 = \mu_2$), is evaluated by the calculated significance level (*p*-value) which is the probability that the sample group means is at least as different as was found in this study, given that the null hypothesis is really true. If the probability is sufficiently small ($p < .05$), I concluded that it is unlikely that the two group means are equal in the population and the null hypothesis was rejected in favor of the alternate hypothesis ($H_{A:}$ the population means of the two groups are not equal (i.e. $\mu_1 \neq \mu_2$). The null hypothesis significance test indicates the group means differences are the same (or different) in the population but does not consider the size of the difference (Laerd Statistics, 2015a). To address this limitation, effect size was calculated to capture the practical significance of the independent variable. Cohen's *d* was calculated (ratio of the standard error of the mean differences) to explain the group means differences (See Equation 3.1) (Cohen, 1988). According to Cohen (1988), the strength of an effect size is as follows: (a) .2 is small, (b) .5 is medium, and (c) .8 is large. Generally, minimum sample size required for independent-samples t-tests is six participants per group. Group sizes exceeded this minimum in this study. All six assumptions were considered prior to conducting the independent-samples t-tests and were reported in the results section (*Chapter Four*).

Equation 3.1

Calculating and reporting effect size for independent-samples t-test

$$d = \frac{|M_1 - M_2|}{S_{pooled}}$$

$$S_{pooled} = \sqrt{\frac{s_1^2(n_1-1)+s_2^2(n_2-1)}{n_1+n_2-2}}$$

Paired-samples t-tests were used to examine mean difference between paired observations and to determine if the difference is statistically significantly different from zero. Paired-samples t-tests were used to compare the same participant tested at two different time points and two different conditions (game played) on the same dependent variables (dimensions of engagement, motivation and curiosity assessed in the *Game Play Experience* post-surveys). The null hypothesis for a paired-samples t-test is that the population mean difference between paired values is zero (i.e. H_0: $\mu_{diff} = 0$). The following were calculated: (a) point estimate and confidence intervals, (b) statistical significance of the difference, and (c) effect size (Laerd Statistics, 2015b). The effect size was calculated (Cohen's d) for the paired-samples t-test by dividing the mean difference (of the two paired groups) by the standard deviation of the difference (Cohen, 1988). All four assumptions were considered and reported in the results (*Chapter Four*).

Two-way mixed ANOVA were used to compare mean differences between groups split on two different independent variables to determine whether there are differences between independent groups over time. The independent variables are considered as between-subjects and within-subjects factors. The within-subjects factor (e.g. time as pre-post intervention) is considered repeated measures (Girden, 1992). For example, this analysis is used to determine if genetics knowledge acquired over time (e.g. pre- post- genetics knowledge scores) changed differently based on the game played (e.g. Radix or DragonMist). For this study, the within-subjects factor is time (pre- post- scores) and the between-subjects factor consists of conditions (game played) or characteristics of the sample (e.g. gender, age, race/ethnicity, or game preferences). There are eight assumptions for two-way mixed ANOVA. All assumptions were considered and reported in results (*Chapter Four*). Multiple steps were conducted to refine the analysis (e.g. from interaction effects, to main effects, to post hoc group comparisons) (Laerd Statistics, 2015c).

Finally, hierarchical multiple regression was used to determine the proportion of variation in the dependent variable that could be explained by the addition of independent variables (Cohen et al.,2003; Gelman & Hill, 2007). Hierarchical multiple regression was used to explore potential influences of dispositional curiosity, considered to be a stable trait, on dimensions of engagement and motivation related to playing DragonMist to learn genetics. Hierarchical multiple regression, like standard multiple regression, allows the researcher to predict a dependent variable based on multiple independent variables. The advantage of hierarchical multiple regression is that the researcher can enter independent variables into the regression equation in the order they choose based on *a priori* knowledge. The advantages are as follows: (a) effects of covariates can be controlled, and (b) possible causal effects of independent variables can be considered when predicting a dependent variable (Cohen et al., 2003; Gelman & Hill, 2007). Data were interpreted and reported in three stages. First, the regression models were evaluated and compared based on the variables entered into the different blocks on the linear regression. Second, hierarchical multiple regression model(s) were examined to determine if the model is a good fit for the data. The differences between models, and their statistical significance, is examined using ANOVA to determine how well the model explains the dependent variable. The statistics considered are: (a) the proportion of variance explained, (b) the change in the R^2 value from the previous model; and (c) statistical significance of the model(s). Finally, the regression coefficients are reported. These coefficients explain the linear relationship between the dependent variable and the independent variables (Laerd Statistics, 2015d). There are eight assumptions that must be met for hierarchical multiple regression (Berry, 1993). All assumptions were considered and reported in the results (*Chapter Four*).

3.9.2 Qualitative Analysis

Qualitative data analysis was performed systematically according to Creswell & Plano Clark (2018) (see Figure 3.24). The first step in qualitative analysis was to create verbatim transcriptions of the focus group conversations. Transcriptions were reviewed for accuracy. All observations, open-response and focus group transcriptions were transcribed into word processing files and organized by data source and participant. All data was reviewed a second time for accuracy. The data files were imported into NVivo qualitative statistical software for further analysis.

The second step was to explore the data overall by reading through all the data and viewing game screen shots to identify broad trends and develop a preliminary understanding of the qualitative database. I used deductive reasoning and existing empirical research to establish an *a priori* code book based on variables of interest in this study (Crabtree & Miller, 1999). The *a priori* codes guided initial coding and were derived from theory, literature review and items on the quantitative measures. As I read through the data, I wrote short memos in the margins to improve *a priori* codes, to identify emergent codes, and to revise the code book. The revised code book, consisting of the *a priori* codes and initial emergent codes, was used to guide the codification of the text.

Coding was used to simplify the data and focus on specific characteristics of the data to move from unstructured information to developed ideas (Morse & Richards, 2002). During the coding process, full and equal attention was given to each data item to identify interesting aspects of the data relevant to answering the research questions (Braun & Clarke, 2006). Important sections of text were identified and coded to group evidence and label ideas and reflect increasingly broader perspectives (Creswell & Plano Clark, 2018). The code book was revised as new codes emerged. Through this inductive process of data analysis, emergent codes revealed new ideas and understandings of the data (Boyatzis, 1998). I coded the first three observation files using the *a priori* code book and updated the code book as codes emerged. I re-coded all three files with the new code book and continued to the next three files. I continued this iterative coding process until all observations had been coded. At each iteration, I collapsed some codes and expanded others. Each time a new code emerged; the code book was updated, and all previous data recoded. The new code book was then used to code the open-response data and finally the focus group data. When emergent codes were identified, all previous data were re-coded for the new codes. Once all text had been coded, I grouped codes under appropriate parent nodes; thus, initiating categories and themes. At each iteration, the new code book facilitated consistency and organization of the coding process. All data were re-coded and re-examined until all relevant data were accurately coded using the final codebook for consistency.

Data were read to identify patterns, make comparisons, identify tensions, produce explanations and build models (Gibbs, 2007). NVivo's visual analysis tools (e.g. word clouds, word trees, cluster analysis, code matrices) were used to see preliminary relationships and search for segments of text containing multiple codes. Coding evidence was then grouped to develop descriptions and categories derived explicitly from participant observations and accounts. Thematic analysis was used to identify, analyze, organize, describe and report themes within the data (Braun & Clarke, 2006). Thematic analysis provides means to examine perspectives of different participants and allows the researcher to highlight similarities and differences which often generates unanticipated insights (Braun & Clarke, 2006). A meticulous thematic analysis also increases trustworthiness of the findings (Braun & Clarke, 2006). Finally, thematic analysis was used to summarize key features of the data set through a structured approach to produce a clear and organized final report (this dissertation) (King, 2004). The flexibility of thematic analysis is both an advantage and disadvantage as the flexibility can lead to inconsistencies when developing themes (Holloway & Todres, 2003). Therefore, a robust, systematic, iterative approach was adopted to improve the quality of the findings (Creswell & Plano Clark, 2018).

Patterns and relationships, derived from the data relevant to the participants' experiences, were identified, analyzed and to combine categories into organizing themes. Organizing themes were combined to form global themes. A systematic process was used to categorize and analyze data representative of research problem and variables of interest (Creswell, 2014). Finally, the data set and derived themes were examined to ensure the themes accurately represented the data (Creswell & Plano Clark, 2018). Themes and larger perspectives are presented as qualitative findings that provide evidence for answering the research questions. Findings are presented as discussions of descriptions, themes, or perspectives. Evidence for themes and/or descriptions are presented as quotes, multiple perspectives, and rich description. Visual models, figures, and tables are used to help represent the data and enhance understanding of relationships in the data.

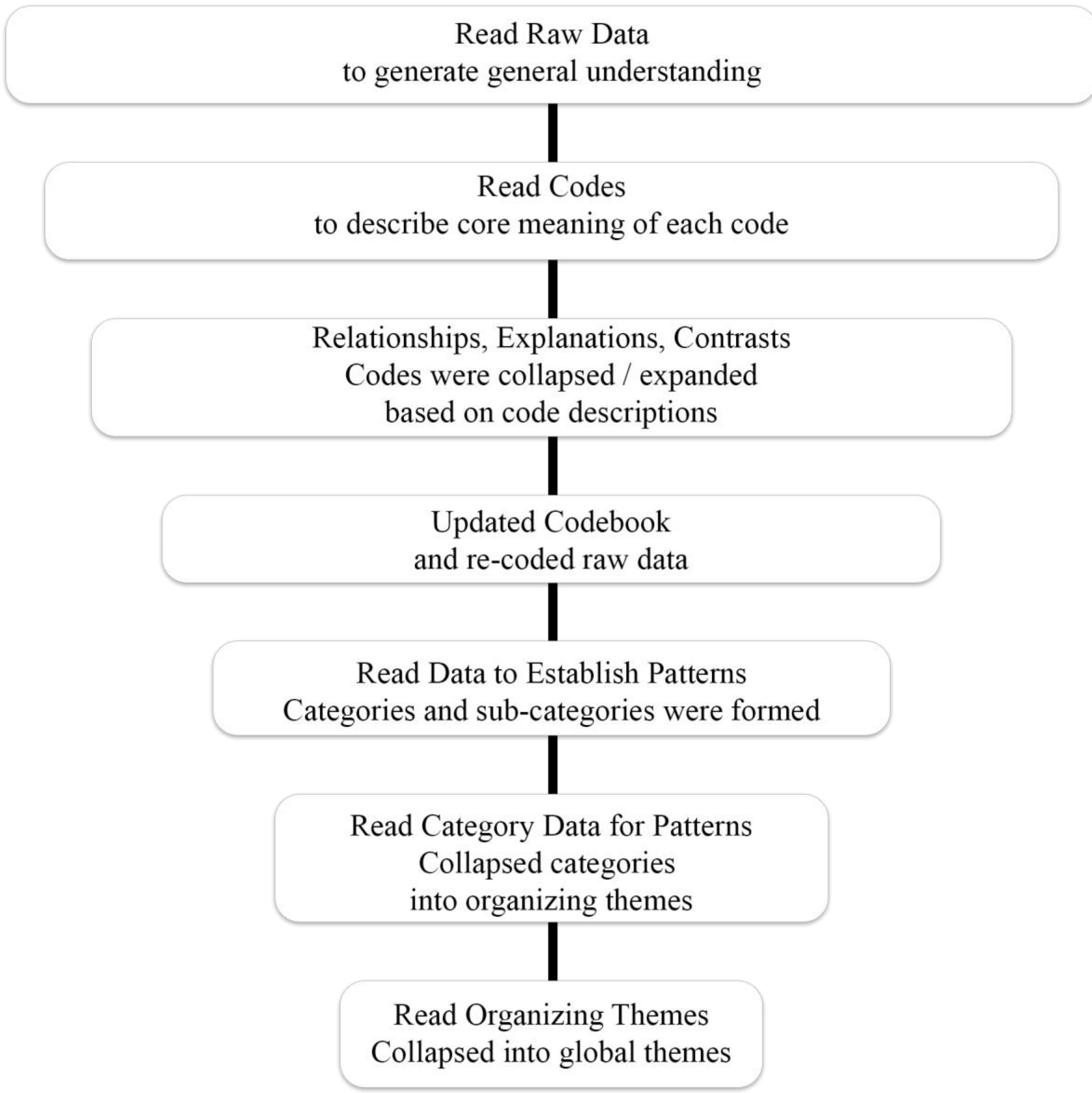


Figure 3.24. Flowchart demonstrating qualitative data analysis as raw data is iteratively reduced to global themes relevant to the research question.

3.9.3 Summary

In summary, this study collected and analyzed both quantitative and qualitative data concurrently and independently to answer the research questions. Procedures, analysis and products are shown in table 3.4.

Table 3.4

Summary of Data Collection Procedures, Analyses and Products for this Study

Procedure and Analysis	Products
Quantitative data collection (surveys, pre-post genetics test, game log data)	Numeric data
Quantitative Analysis (SPSS 25 for Windows) Data cleaning / screening Descriptive statistics Inferential statistics (independent-samples t-tests, paired-samples t-tests ANOVA, hierarchical multiple regression)	Missing data Group comparisons Inferential statistics: mean, variance, standard deviation, significance (p value), practical significance (effect size), predictor coefficients
Qualitative data collection (observations, open response, focus group, game screen shots)	Transcripts (text data) and pictures (game screen shots)
Qualitative Analysis (NVivo 14) 20 cycles of coding Thematic analysis	Codes Categories Themes Visual displays
Integration and Interpretation: Examine both strands of results to analyze for convergence, divergence and to identify relationships and patterns.	Discussion, joint-display tables, visual displays, implications, revised conceptual models, practical implications, future research, limitations

3.10 Measurement Strategies

3.10.1 Demographics Survey

To strengthen understandings of GBL for middle school and high school science and individual attitudes and preferences with respect to games, a demographic survey was administered before the intervention began. This survey was administered using a pen and paper document and data transferred to a database (Appendix C). Questions were designed to establish initial attitudes and perceptions of games and science. Questions were also included to identify game experience (novice – recreational – expert) and game genre preferences. These data allowed the researcher to identify and explore potential relationships between game and player, as well as provided descriptive statistics.

3.10.2 Academic Achievement

Most game-based learning (GBL) researchers agree that learning occurs within game environments. However, there remains much debate about the nature of that learning (e.g. Boyle et al., 2014; Dempsey et al., 1994; Emes, 1997; Randel et al., 1992; Vogel et al., 2006). The genetics knowledge tests were developed by content experts to cover basic genetics concepts and learning goals as outlined in the teacher dashboard provided by the educational game (Radix Endeavor, MIT) and is presented as multiple-choice format. The pre-test consists of fifteen questions as follows: (a) two definition questions, (b) eleven word-problems, and (c) two questions using visuals (Punnett squares) (Appendix D). The design of the genetics knowledge tests followed the revised Bloom's Taxonomy (Krathwohl & Anderson, 2009) on four levels. First, questions one and two were designed to establish a student's definition of genetics. These two questions draw on recall of basic facts (remember). Second, two Punnett square questions require the student to identify, recognize, and select the correct percentage based on a visual image (understand). Finally, the remaining eleven questions were designed as complex word-problems that require the student to use information in new situations (apply) and draw connections between ideas (analyze) (Krathwohl & Anderson, 2009). The pre-test is used to compare group similarity and to establish a baseline for genetics knowledge that can be compared to post- intervention knowledge. This prior knowledge of genetics measure is also relevant to exploring scientific curiosity within the GBL environment. Some researchers suggest prior knowledge is required for an information gap to become salient (Lowenstein, 1994).

For the genetics post-test, questions were structured within three different contexts (generic, Radix specific, and DragonMist specific) to initiate some understanding of potential transfer of academic knowledge between contexts. The post-test consisted of two definition questions identical to the pre-test, two Punnett square questions identical to the pre-test, twenty-two questions designed as context specific word-problems, one question per game context, to match items on the pre-test. The complete post-test consisted of twenty-six questions (Appendix E).

I was concerned that the length and complexity of the post-test would result in missing data due to students' failure to finish and/or fatigue and/or guessing. To address this problem, I divided the post-test into two sections. This division was accomplished by including the two definition questions as question one and two to ease students into the test and enhance confidence. The last two questions on the pre-test covering Punnett squares were included as question fifteen and sixteen on the post-test. Questions three through fourteen (twelve total) questions were then directly matched to the pre-test questions but randomized between game contexts. Question eleven was considered the most difficult item on the pre-test because it covered a dihybrid cross involving dominant/recessive and co-dominance concepts. Therefore, matched questions for both game contexts were included in the first half of the post-test as questions eleven and twelve. Section one of the post-test resulted in sixteen test items that could be directly compared to the pre-test. The remaining ten questions of the post-test were treated as (random) planned missing data for each participant. All participants completed the first sixteen items with no missing data. Four participants failed to complete the remaining ten questions on the post-test.

An example of matched questions follows. The generic question on the pre-test for question six is: Suppose you mated a yellow Labrador retriever with a black Labrador retriever, and all the puppies had black fur. Which of the following statements **best** describes the pattern of fur color inheritance in these Labrador retrievers?" Question twenty on the post-test is Radix specific: You are helping Prunessa learn how to breed Myzle flowers. You found red Myzle flowers and yellow Myzle flowers. You collected one wild red parent plant and one wild yellow parent plant. You took them to a breeding station and crossed the two plants. All the new plants were red. Which of the following statements **best** describe the pattern of inheritance for the color trait in Myzle Flowers? Question six on the post-test is DragonMist specific: Suppose you mated an aggressive dragon with a non-aggressive dragon and all of the offspring were aggressive. Which of the following statements **best** describes the pattern of aggression inheritance in these dragons? Correct answers would be as follows: black fur is dominant, red color is dominant, aggression is dominant (respectively).

These tests were designed to measure participants' understanding of basic Mendelian genetics. The post-test was designed to directly match the pre-test questions but within the specific contexts of the two learning interventions (Radix or DragonMist).

The post-test was designed, in this manner, to gain some initial understanding of transfer of knowledge. Theoretically, if transfer is occurring and the participant is not just randomly guessing, they should be able to answer all three versions of the question correctly independent of game context. Genetics pre- and post- tests are in appendices D and E respectively.

3.10.3 Curiosity Measures

Scholars agree that curiosity is important for learning and general well-being (e.g., Berlyne, 1954; Loewenstein, 1994). Curiosity-based behaviors result in increased knowledge, improved competencies, stronger social relatedness, and increased creativity (von Stumm & Ackerman, 2013). Trait curiosity effects individual capacity to recognize, pursue and explore novel, uncertain, and ambiguous events (Kashdan et al., 2018). Curiosity can be considered from a domain general or domain specific perspective. Both perspectives add value to the research problem. Therefore, two published trait curiosity measures are selected for this study. The *Five-Dimensional Curiosity Scale (5DC)'s* multi-faceted approach aligns well with the holistic perspective of this study. The information provided in this measure can be meaningfully related to gamer preferences, playing styles and resultant behaviors related to trait curiosity.

The idea of domain-specific curiosity is gaining interest in educational research. The focus of this research is GBL within a middle school and high school science context. Therefore, the eight items from the *Science Curiosity in Learning Environments (SCILE)* (Weible & Zimmerman, 2016) enhanced the understanding of curiosity specific to the learning environment.

3.10.3.1 Measurement for General Trait Curiosity (The 5DC). Kashdan et al. (2018) constructed the *Five-Dimensional Curiosity Scale (5DC)*, simultaneously driven by theory and data analysis, that would synthesize curiosity theories and methodologies of prior researchers into one comprehensive measure (Appendix F). This measure provides researchers with the ability to examine the various correlates of curiosity (e.g., personality dimensions, emotional states, and factors of well-being), consequences of curiosity, and interventions for enhancement. The *5DC* was designed to measure both appraisal structures unique to trait curiosity. These two appraisal structures involve the individual's assessment of an event as novel, challenging, surprising, mysterious or unexpected, followed by assessment of the individual's capacity to cope with the stress of interacting with novelty or challenge. This multidimensional approach to curiosity measurement can reveal meaningful subgroups of a heterogenous population for understanding motivation and behavior. The *5CD* has strong convergence with current empirically supported curiosity, personality and emotional scales supporting the accuracy of each dimension's intended measurements. A multi-faceted conceptualization of curiosity was supported by the correlation variations between each dimension and other constructs (Kashdan et al., 2018). The *5DC* (Kashdan et al., 2018) measures informed the research in relation to acceptance of, ability to cope with, and willingness to interact with games as novel, uncertain, and challenging learning environments. Therefore, this measurement may increase understanding as to what degree individuals will embrace games as a learning environment and to what extent curiosity-related behaviors emerge.

3.10.3.2 Measurement of Scientific Curiosity (Domain-Specific Curiosity) (SCILE). Curiosity is an integral part of science. Interest-based behaviors, aligned with curiosity and emerging from prolonged engagement over time, can lead to scientific expertise (Crowley & Jacobs, 2002; Zimmerman, 2012; Zimmerman & Bell, 2014). To address the need to measure curiosity within the context of scientific processes, the *Science Curiosity in Learning Environments (SCILE)* scale was selected for this study (Weible & Zimmerman, 2016).

Weible & Zimmerman (2016), building on the *Curiosity and Exploration Inventory* (Kashdan & Silvia, 2009) and perspectives of the *Children's Science Curiosity Scale* (Harty & Beall, 1984), developed a measurement for scientific curiosity. The *SCILE* measures science curiosity within the guidelines and standards of the *Next Generation Science Standards* (NGSS, National Research Council [NRC], 2013) and the *K-12 Framework* (NRC, 2012). The *SCILE* scale is a valid measure for scientific curiosity, for both boys and girls, for students (elementary, middle school, high school) with reliability based on Cronbach's α of .91. The eight items that assess scientific curiosity were used to investigate GBL and curiosity within the context of genetics (Appendix F).

3.10.3.3 Assessing a Game's Ability to Incite State Curiosity. Researchers still debate curiosity as a stable trait vs. curiosity as an emotional-motivational state and the degree to which either or both can be manipulated. According to Lowenstein (1994), focusing on curiosity as a stable trait risks tracking students based on curiosity (presence or absence) (Loewenstein, 1994). Loewenstein (1994) suggests that curiosity as an emotional-motivational state is more practically valuable such that interventions can be designed to pique curiosity relevant to specific contexts. The difference in assessing curiosity as trait vs state is a matter of general vs specific context (Loewenstein, 1994; Naylor, 1981; Spielberger, 1979). To assess the games' ability to incite state curiosity, the eight items from *SCILE* were modified to be context specific for each game and were included on the post- game play experience surveys (Appendix G). For example, *SCILE* (Appendix F) asks the participant to rate (1- strongly disagree to 5-strongly agree) "I like to make things that no one else has." The study-specific question (Appendix G) asks "While playing this game, I wanted to create something that no one else in the game has (ex. dragon, flowers, bugs). These items will increase understanding of how game design features might heighten curiosity and/or interest in science as a result of game play.

3.10.4 Game Play Experience (Engagement)

Researchers indicate that engagement can be measured via engagement-related attributes (e.g., Flow and affective states) (D'Mello et al., 2007) and student motivation (Johns & Woolf, 2006; de Vicente & Pain, 2002). I used a combination of several published and validated measures for this study to measure engagement, motivation and curiosity on multiple dimensions. Each published measurement was examined for dimensions of interest and those dimensions were used to create one cohesive game play experience survey. When two, or more, published instruments had similar/identical items, the item was included once on the game play experience survey for this study. At time of analysis, the item was considered for each original dimension. Published and validated measures chosen for this study are as follows: (a) *Game Play Questionnaire (GPQ)*

(Ryan et al., 2006), (b) *Perceived Interest Scale* (Schraw, 1997), (c) *Perceived Immersion Scale* (Jennett, 2008), and (d) *User Engagement Scale* (Wiebe et al., 2014). I calculated Cronbach's alpha for each dimension/subscale used in this study and all measurements were aligned with original published reliability measures. The sample size for this study was too small to calculate validity; therefore, relies on the original published instrument's reported validity.

The *Game Play Questionnaire (GPQ)* (Ryan et al., 2006) was adapted to measure player engagement and motivation. The *GPQ* is a subjective measure of gameplay experience based on the theoretical framework of self-regulated learning and self-determination theory (SDT). The measure includes four subscales (autonomy, competence, relatedness, and enjoyment) which were reported as associated with game enjoyment and preference for future play (Ryan et al., 2006). The *autonomy, relatedness* and *competence subscales* of this survey were used to measure motivation and the *enjoyment subscale* was used to measure flow state and intent to play.

Curiosity and interest affect the game play experience. Researchers consider interest, curiosity and engagement to be highly correlated constructs leading to deeper learning (Arnone et al., 2011) and interest is related to intent to engage (Schraw, 1997). The *Perceived Interest Scale* was developed in the context of situational interest and pleasure regarding reading narrative texts (fairy tales, short stories, novels, children's stories). The internal consistencies of the items in the situational interest subscale are Cronbach's α ranging from .69 to .81. The *Perceived Interest Scale* (Schraw, 1997) was adapted to measure perceived interest (as a correlate of curiosity) in the game play experience (Appendix G). For example, the original *Perceived Interest Scale* item, "I thought the story was very interesting (.77)" was adapted to read "I thought this game was very interesting."

Immersion is composed of three phases (engagement, engrossment, and total) (Brown & Cairns, 2004). Total immersion is equivalent to flow state. The *Perceived Immersion Scale* was developed using factors derived from previous work on Flow (Csikszentmihalyi, 1990), cognitive absorption (Agarwal & Karahanna, 2000), and grounded theory of immersion (Brown & Cairn, 2004) with consideration to task factors known to influence whether (or not) immersion is experienced (e.g. attention, challenge, emotional attachment, and motivation) (Jennett, 2008). Factor analysis identified five main factors using Cattell's scree plot method that accounted for 49% of the total variance. The *Perceived Immersion scale* (Jennett et al., 2008) was used to measure both immersion and flow.

Finally, three subscales (*focused attention, perceived usability, and endurability*) were taken from *The User Engagement Scale* (Weibe et al., 2014). The *focused attention subscale* is based on Flow Theory (focused concentration, absorption, temporal dissociation). The *perceived usability subscale* measures both affective (frustration) and cognitive (effortful) aspects of the play experience. Finally, the *endurability subscale* measures a holistic response to the experience to measure a player's intent to play the game.

Several items were included in the survey as context specific items to measure variables of interest specific to the research questions. For example, items were generated to measure information seeking behaviors (e.g., I used resources outside the game to help me understand genetics), state curiosity (e.g., I was curious about how things would turn out in the game), exploratory behavior (e.g., The game made me want to explore and discover things on my own.), aesthetics / emotional attachment (e.g., The story in this game was very important to me), and importance of feedback systems (e.g., Failing in this game gave me a chance to try something new or different).

The game play experience survey also included open response questions. The open response items were designed to cover the three main topics of interest to this study (engagement, learning, curiosity). The open response questions were used to solicit player perceptions about the game designs that could not be adequately captured using Likert-scale items. For example, "Describe 2 (or more) things that you think you learned while playing this game (Appendix G).

3.10.5 Observation Protocol

During each game play sessions, I observed participants for evidence of engagement and curiosity-related behaviors. Engagement is considered an observable measure of intrinsic motivation to learn (Frioland & Oros, 2014). Engagement can be observed as paying attention, expending effort, participation, and persistence (Froiland & Oros, 2014). I also observed participants and talked with them as they shared their game play experiences to identify game design features that influenced their engagement or that caused stress or difficulty. The observation protocol was used to record observations, to ensure all variables of interest are observed and to provide room for field notes (Appendix H).

3.10.6 Focus Groups

Focus group is a qualitative methodology that is often used in social sciences to explore people's experiences, meanings, or ways of understanding of a complex phenomenon (Lunt & Livingstone, 1996). In practice, focus group methodology involves a series of group interviews about a specific topic and guided by a moderator (Lunt & Livingstone, 1996). One major strength of this method is its exploratory nature, allows the researcher to know their target audience in detail, and can stimulate idea generation (Merton, 1987). Focus group sizes normally range from five to eight participants (Morgan, 1998). Given the diversity of gamer's preferences with respect to play styles (Bartle, 1996) and motivations to play digital games (Yee, 2002), focus groups provide deep, contextual insights into specific game play experiences of the different individuals participating in this study.

Focus groups were implemented to allow the participants to respond in their own words while allowing the researcher to target important aspects of the inquiry. General questions were formulated to guide the focus group discussion to ensure all major research topics (engagement, learning, curiosity) were addressed (Appendix I). Focus groups were conducted on the last day of each video game camp. I reserved the lounge area of the Digital Media and Learning lab so that the group could sit in a circular lounge area with soft couches and tables for refreshments. This location created a casual atmosphere that was conducive to relaxed and open conversation free of distractions presented by the computers in the lab. The focus group conversation started with a general introduction to the topic and followed up with questions designed to gently guide participants to more specific areas of the topic. Questions were general and open to prompt the participant to draw their own conclusions. I strived to maintain a neutral but supportive tone to encourage participant honesty. For participants who spoke softly, I did repeat back to them what they said to ensure I understood properly and to ensure that the audio recording picked up their answer. On occasions, when peer pressure influenced answers, I stressed the importance for honestly, support and the value of contrasting opinions. Additional questions were posed to keep everyone on topic, clarify participants' points, increase understanding of comments made by the participants, and maintain required time limits. Each focus group was twenty-five to thirty minutes long. Multiple digital audio recorders were positioned around the circle to maximize audio quality. All audio recordings were transcribed immediately after the focus group concluded.

3.11 Trustworthiness

Trustworthiness ensures rigor and quality of qualitative research (Creswell & Plano Clark, 2018). Criteria for trustworthiness are credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985; Shenton, 2004) which parallel quantitative assessment criteria (reliability and validity). See Table 3.5 for an overview of procedures used to increase trustworthiness of this research.

Table 3.5

Summary of Thematic Analysis Procedures and Implementation of Trustworthiness

Procedure	How Trustworthiness was Attended
Reading all data for general understanding	Prolonged engagement with the data Researcher corroborated evidence from multiple sources of data to validate findings Theoretical and reflective thoughts were documented Records were kept of all data field notes, transcripts, audio files, game logs and screen shots, and reflexive memos
Generating *a priori* code book	A priori codes were derived from the literature review, theoretical foundations, and quantitative measures
Generating emergent codes	Use of a systematic and iterative coding framework, reflexive journaling, audit trail of code generation, archived code books.
Audit Trail	Researcher documented all decisions and activities
Searching for themes	NVivo mind maps, concept maps, cluster analysis, charts and coding matrices to make sense of theme connections. Documenting detailed notes, sketches and diagrams of development of and hierarchies of concepts and themes
Reviewing themes	Returned to raw data for referential adequacy, review of theoretical foundations supporting themes
Defining and naming themes	Reviewed raw data and theoretical foundations in support of themes
Report (Dissertation)	Described process of coding and analysis in sufficient detail, thick descriptions of context, audit trail, reported reasons for theoretical, methodological, and analytical choices throughout the study

Credibility refers to confidence in the accuracy of the findings (Lincoln & Guba, 1985). Techniques to address credibility include activities such as prolonged engagement, persistent observation, and data collection triangulation. One threat to credibility, in this study, is that variations occur in player-game interactions based on the player's daily disposition, interactions in the classroom, and reactions to specific game challenges (levels, problems) at any given time. To attend this threat to credibility, this study was conducted in three independent video game camps consisting of small groups of approximately ten participants, two hours a day for five consecutive days. This design provided opportunity for engagement with each participant and persistent observation of participants each game play session. Thematic analysis produced prolonged engagement with the collected data during the analysis process. Additionally, multiple data sources were used to increase credibility via triangulation (Creswell & Plano Clark, 2018).

Triangulation achieves more accurate and valid qualitative results through careful review of multiple data sources to compare information and determine corroboration of findings (Wiersma, 2000). Data triangulation minimizes weaknesses of single data sources (Guba, 1981). In this study, quantitative surveys, observations, field notes, open response, focus group transcripts and game log data (statistics and pictures) were used to answer the research questions such that deficiencies of each method (e.g. survey fatigue, researcher bias/influence on observations, writing and legibility of open response, peer pressure or personality in focus groups) would approximately average out to reveal a true estimate of a single result (Mark & Shotland, 1987). When complete convergence does not occur, the result is a range of possible estimates that include the true answer (Brinberg & Kidder, 1982). I realize that my own researcher bias could potentially influence participant responses and their responses and behaviors may influence my questioning and interactions (reflexivity) (Creswell & Plano Clark, 2018). Game log data was a valuable source to check biases during interpretation of the data since the game log files objectively reflect game play interactions. Since reflexivity is critical to the audit trail, a self-critical account of the research process was conducted to include internal and external dialog during the study (Tobin & Begley, 2004).

Another possible threat to credibility was related to academic learning outcomes from GBL as related to reflexivity. Participants asked questions about genetics and by answering these questions, learning gains cannot be directly accredited to the game. However, one variable of interest in this study is the game's ability to increase scientific curiosity that prompts the student to seek information and increase understanding by using resources external to the game. Learning gains were assessed via pre- / post-knowledge test to improve the practical implications of this study by establishing learning potential related to GBL. However, many researchers believe much learning, and deeper understanding, from games is external to the game (e.g., Arnone et al., 2011). The game is the catalyst for learning more than the absolute source of learning. The research questions investigated in this study extended the definition of learning to include curiosity related behaviors and learning external to the game. To this end, students were instructed that they could collaborate and/or use any resource available to enhance their learning. Also, to minimize my influence, I did not offer genetics information unless specifically solicited by the participant and all learning resources were available equally for both games.

Transferability relates to the generalizability of the findings to other contexts (Lincoln & Guba, 1985). Analytical generalization was used to corroborate, modify, reject or advance theoretical foundations underpinning this study. Ultimately, it is the responsibility of the reader to determine the extent to which these findings are generalizable to their situation (Creswell & Miller, 2000; Merriam, 1995). A rich, thick description of the context, research design, participant characterization, data collection and analyses are provided in this chapter to provide rationale for theoretical, methodological, and analytical choices throughout this study (Koch, 1994).

Dependability refers to the consistent repeatability of findings (Lincoln & Guba, 1985). Dependability is addressed by conducting a logical, traceable and precisely documented study (Tobin & Begley, 2004). A database was designed to organize and document the data and is maintained in three secure locations (e.g. encrypted SSD drive, my desktop hard drive, and Dropbox). All decisions and processes were detailed and documented throughout the study to establish an audit trail (Lincoln & Guba, 1975). This dissertation serves as presentation of the data that provides adequate evidence and description of the data that supports findings and conclusions. In addition, the dissertation chair and committee members conducted a peer review of the dissertation and adds credibility to my findings (Creswell & Plano Clark, 2018).

Confirmability is the extent to which findings and interpretations are distinctly derived from the data and the researcher demonstrates how conclusions and interpretations were derived (Tobin & Begley, 2004). It should be apparent that findings and interpretations are shaped by the participants rather than by researcher motivation, bias or interests (Lincoln & Guba, 1975). Confirmability is addressed via multiple sources for data collection and chain of evidence (Creswell & Plano Clark, 2018). Chain of evidence is established by citing data sources related to specific findings (e.g. game logs, observation, survey, participant comments) and by including examples of those data as evidence for findings. Additionally, findings and conclusions are situated within existing literature by discussing other research, and theoretical foundations, that supports or contrasts the results of this study. Limitations of the study are discussed as well as recommendations for future research.

CHAPTER FOUR

QUANTITATIVE RESULTS

4.1 Introduction

As described in Chapter Three, this study utilized a convergent parallel mixed methods design. Quantitative data were collected concurrently and independently of qualitative data. Quantitative data were analyzed independently. Quantitative data were derived from demographics survey, genetics knowledge test, curiosity measures, game play experience surveys, and game log files. Quantitative data were collected relevant to four quantitative research questions and are presented in this chapter.

RQ1. What impact do game design features have on player engagement and motivation in educational games as compared to commercial entertainment games?

RQ2. What impact does the integration of learning content into a game design have on player engagement, motivation and learning?

RQ4. Can game design features heighten curiosity towards integrated learning content?

RQ5. Does an individual's trait curiosity influence how they approach a novel learning environment (GBL) and then influence interactions, engagement and motivation within that environment?

4.2 Participant Characteristics

The sample consisted of thirty-one participants (N=31) of whom eight were females (n=8) with a mean age of thirteen years old and twenty-three were males (n=23) with a mean age of thirteen years old. Nineteen participants endorsed white/Caucasian (n=19) and twelve participants endorsed other under-represented race/ethnicities (n=12) (See Table 4.1). Participants were recruited from public middle schools, high schools and after school programs, as well as from home school organizations in three counties in Upstate South Carolina. School-type groups are distinguished as follows: fourteen participants were in the public-school system (n=14), and seventeen participants were home schooled (n=17). Five participants reported diagnosed learning disabilities (two ADHD, one autism, one severe anxiety disorder, and one dyslexia). Table 4.1 reports general demographics as frequencies.

Table 4.1

General Demographics presented as frequencies

Participant Characteristic	Frequency
Gender	74.19% male 25.81% female
Age (years)	9.68% ten years old 19.35% eleven years old 29.03% twelve years old 19.35% thirteen years old 9.68% fourteen years old 6.56% fifteen years old 3.23% sixteen years old 3.23% seventeen years old
Grade	9.68% fifth grade * 22.58% sixth grade 32.26 seventh grade 12.90% eighth grade 9.70% ninth grade 6.45% tenth grade 6.45% eleventh grade
**Race/Ethnicity	9.68% Asian 22.58% Black/African American

	3.23% Hispanic/Latino 61.29% White/Caucasian 3.23% Other 6.45% Prefer not to answer
Group	45.2% Public K12 54.8% Home schooled
Sub-Group	45.16% Public K12 25.81% Homeschool Cohort 1 6.45% Homeschool Cohort 2 16.13% Public K12 Homeschool 6.45% Private Homeschool

Note. Participants (N=31). *Fifth graders were homeschooled at an academic level equivalent to 6th or 7th grade public school curriculum. **Multiple race/ethnicity selections were allowed, accounting for total percentages above 100%

The demographics survey (Appendix C) also collected data on game-play preferences (See Table. 4.2). A total of twenty-nine (n=29, 93.6%) self-endorsed as gamers. Current statistics show that 91% to 97% of middle school and high school adolescents play games (Jenkins, 2013; Reisinger, 2011); therefore, this sample is representative of the population with respect to gamer endorsement. Eighty-one percent (80.65%) of the participants reported that they play video games every day for some period. Only 19.35% of the participants stated that they always prefer playing video games over other activities. More than seventy-five percent (77.42%) of the participants endorsed greater than casual game experience (41.94% frequent player, 35.48% expert player). More than seventy-five percent (77.42%) of the participants endorsed the game console as their favorite device for playing video games. None of the participants had previously played Radix. Eight participants had previously played Skyrim (five were less than level 25, three were over level 25). The games chosen for this research intervention are RPGs. Participant experience with the RPG genre is approximately evenly divided between those endorsing RPG experience (plays sometimes, often, always) (43.39%) as compared to those who have never / rarely played RPGs (51.61%).

Table 4.2

Game Play Preferences Demographics Presented as Frequencies

Game Preference	Participants (n=31)
Self-endorsed as gamer	93.55% gamer 6.45% non-gamer
How often play video games	3.23% Not at all 3.23% About once a month 3.23% A few times a month 9.68% A few times a week 25.81% Every day, less than 1 hour per day 19.35% Every day, 1 to 3 hours per day 35.49% Every day, more than 3 hours per day
Prefer to play video games over other activities	9.68% Never 12.90% Seldom 51.61% Sometimes 6.45% Frequently 19.35% Often/Always
Game play experience	9.68% endorsed "A non-video game player" 6.45% endorsed "A novice video game player" 6.45% endorsed "An occasional video game player" 41.94% endorsed "A frequent video game player" 35.48% endorsed "An expert video game player"
*Device (most frequently used to play games)	25.81% Computer 16.13% Mobile Device 77.42% Game console
RPG player	48.39% Play RPGs sometimes to always 51.61% Play RPGs never to rarely

Note. Participants (N=31). *Multiple devices selections were allowed, accounting for total percentages above 100%

Video games are categorized by their game mechanics. There are numerous video game genres available and many genres contain overlapping mechanics with other genres (ex. RPGs and MMORPGs often have combat mechanics similar to FPS and Fighting genres). Most players chose to play specific game genres most frequently. To gain some insight into the participant's chosen game genres, the demographics survey asked them to rank various genres as to frequency of play. Since, game genres often blend common game mechanics, causing some overlap between genres, a popular example for each genre was listed on the demographics survey (Appendix C). Overall game preferences (N=31) shows that FPS (first-person shooters) were the most popular game genre (average rank 3.42), followed by platformers (average rank 3.16) and RPGs (average rank 2.87) (see Figure 4.1). Game genre preference by gender shows similar distribution for males and females with the exception that females show a greater preference for virtual worlds (ex. The Sims) and puzzle games (ex. candy crush sage, tetras). Males ranked RPGs as their favorite genre about half the time (average rank of 3.04) and females ranked RPGs as their favorite genre between sometimes to half-the-time (average rank of 2.38) (see Figure 4.2). Game genre preference by grade (age) indicates that the youngest group (5th and 6th grade) play RPGs and MMORPGs less frequently than the older groups. This is a reasonable trend since these game genres are often rated M+ for mature content and are known to be challenging games requiring long hours and complex gaming skills (see Figure 4.3).

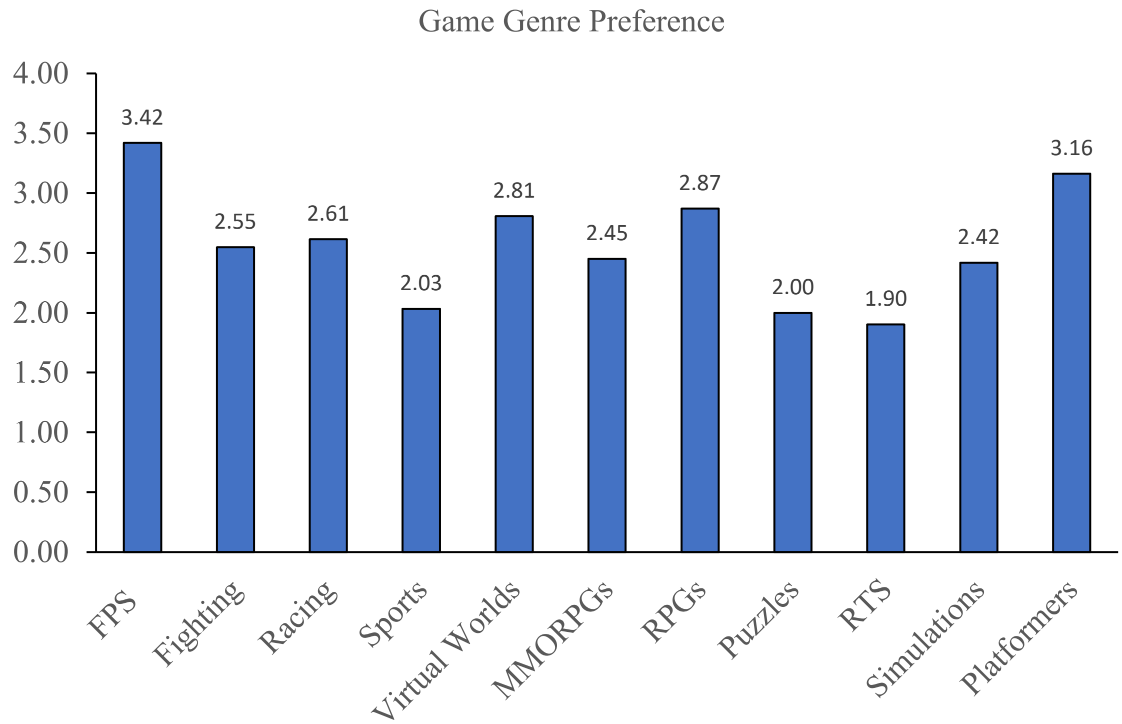


Figure 4.1. Participants' ranked game genre preference (N=31) suggest a preference for first-person shooters (FPS), followed by platformers, RPGs (role-playing games), virtual worlds (specifically Minecraft and The Sims), and MMORPGs (massively multiplayer online role-playing games). RTS is real-time strategy games.

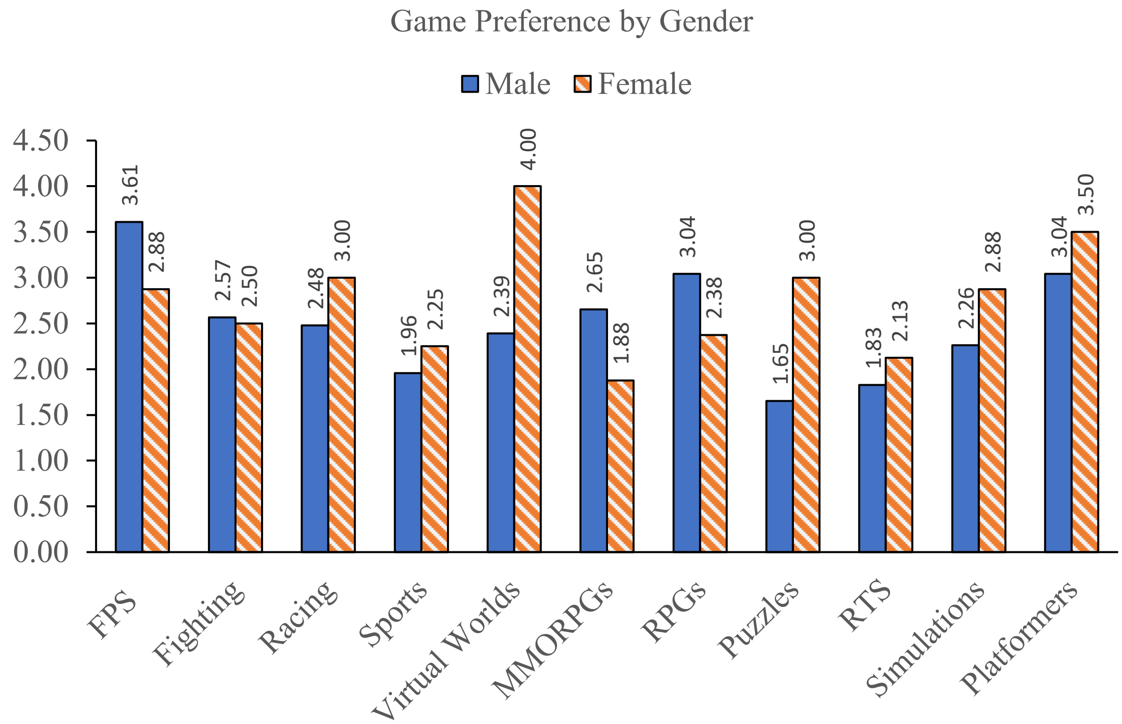


Figure 4.2. Game genre preference by gender indicates that both males and females choose to play RPGs (role-playing games) about half-the-time.

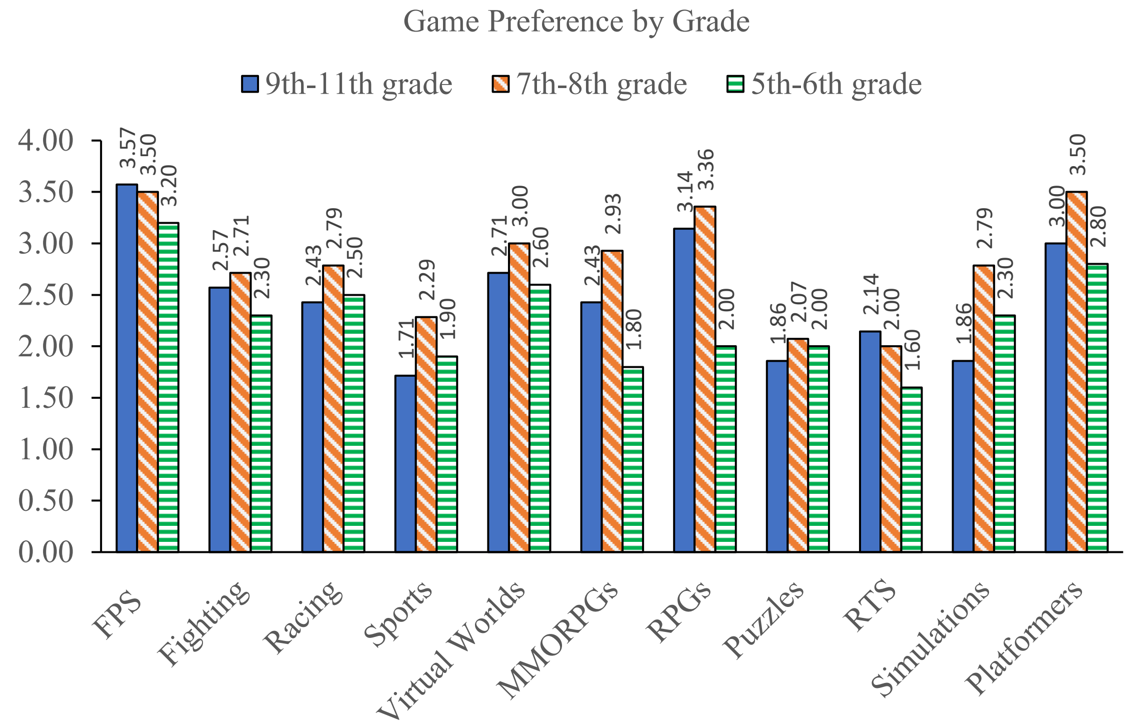


Figure 4.3. Game genre preference by grade indicates the youngest group (5th and 6th grader) chose to play RPGs (role-playing games) and MMORPGs (massively multi-player online role-playing games) less frequently than older participants.

4.3 Quantitative Measurements Reliability

Academic achievement as a result of the GBL intervention was determined via pre-/post- knowledge test for genetics developed by content experts. Item analysis confirmed that item difficulty and discrimination were within acceptable range for all items. Published and validated measures were used to assess multiple dimensions of curiosity and game play experience. Reliability was calculated for each dimension (Table 4.3). All instruments showed reliability consistent with that of the original published measurements and subscales. The sample size of this study was not large enough to conduct independent validity tests; therefore, this research relies on published validity results (See Chapter Three, *Measurement Strategies*).

Table 4.3

Reliability (Cronbach's alpha) for Survey Dimensions

Measurement Survey	Items	Internal Consistency (Cronbach's alpha)
Science self-efficacy	5	0.8
State scientific curiosity	8	0.87
Enjoyment	7	0.96
Autonomy	7	0.9
Competence *	2	0.93
Relatedness	7	0.88
Situational Interest	10	0.95
Perceived Immersion	19	0.94
Information Seeking Behaviors	5	0.84
Exploratory Behaviors	4	0.84
State Curiosity	4	0.9
Aesthetics / Emotional Attachment	9	0.91
Perceived Usefulness	5	0.9
Endurability	3	0.93
Focused Attention	3	0.9
Importance of Feedback	3	0.88

Note: *Competence originally consisted of three questions. One question was deemed as confusing and was deleted to raise the internal validity from 0.5 to 0.931

4.4 Genetics Knowledge Results

Participants were randomly assigned to one of two games to assess the games' potential influence on learning basic genetics concepts. Twenty-nine participants (n=29) completed both the pre- and post- genetics knowledge test. Fourteen participants (n=14) played The Radix Endeavor and fifteen participants (n=15) played DragonMist prior to completing the post genetics test. An independent-samples t-test was used to determine if there were differences in pre-test scores between Radix and DragonMist groups. There were no outliers in the data, as assessed by inspection of a boxplot. Pre-genetics test scores for each level of game played were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$), and there was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .934$). The pre-test score for genetics knowledge was higher for the Radix group ($M = 42.38$, $SD = 14.70$) than the DragonMist group ($M = 36.89$, $SD = 14.224$). The difference in the pre-test groups was not statistically significant, $M = 5.49$, 95% CI [-5.53, 16.51], $t\ (27) = 1.022$, $p = .316$.

A paired-samples t-test was used to determine whether there was a statistically significant mean difference between pre-/post-genetics knowledge scores. Data are mean ± standard deviation, unless otherwise stated. There were no outliers in the data, as assessed by inspection of a boxplot. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test ($p = .735$). The GBL intervention elicited a statistically significant increase in genetics knowledge post-score, $M = 13.942$, 95% CI [8.43, 19.42], $t\ (28) = 5.191$, $p < .001$, $d = .964$. The mean difference was statistically significantly different from zero ($p < .001$), and therefore, we can reject the null hypothesis (H_0: $\mu_{diff} = 0$) and accept the alternative hypothesis (H_a: $\mu_{diff} \neq 0$) suggesting a positive increase in genetics knowledge after playing the genetics quests (see Figure 4.4).

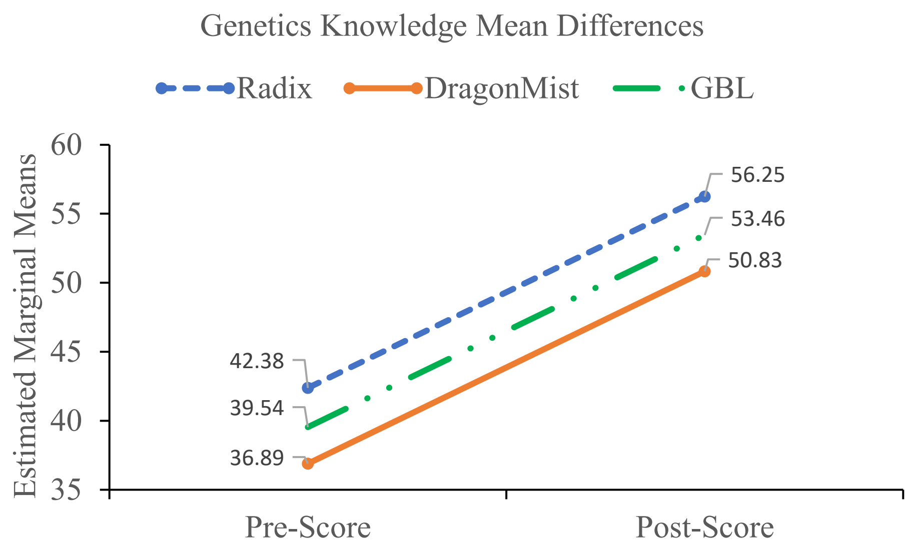


Figure 4.4. Genetics knowledge mean differences show statistically significant learning gains for GBL intervention. Learning gains by condition of game played were not statistically significantly different between games.

Two-way mixed ANOVA was performed to determine possible effects of two different games on genetics knowledge. There were no outliers, as assessed by examination of studentized residuals for values greater than ±3. The data were normally distributed, as assessed by Shapiro-Wilk's test of normality ($p > .05$) and as assessed by Normal Q-Q Plot. There was homogeneity of variances ($p > .05$) and covariances (p =.881), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity was not required for two factors. There was no statistically significant interaction between the game played and time (pre-/post scores) on genetics knowledge, F (1, 27) = .000, p = .994, partial η^2 = .000. The main effect of group (game played) showed that there was no statistically significant difference in mean genetics knowledge scores between intervention groups F (1, 27) = 0.764, p = .390, partial η^2 = .028. The main effect of time (pre-/post scores) showed a statistically significant difference in mean genetics knowledge at the different time points (pre- / post-scores), F (1, 27) = 25.95, p < .001, partial η^2 = .490. These results suggest that, while there is a statistically significant increase in genetics knowledge pre-/post game play, there was no statistical difference between the two games for knowledge gains (see Figure 4.4). Therefore, the intervention group (game played) was collapsed for further analysis.

Two-way mixed ANOVA were performed to determine possible effects of potentially differentiating characteristics endorsed in the demographics survey (e.g. gender, grade/age, gaming experience, experience with RPG games, and race/ethnicity) to determine if the intervention was biased towards any specific group. Unless otherwise stated, there were no outliers, as assessed by examination of studentized residuals for values greater than ±3 and the data was normally distributed as assessed by Shapiro-Wilk's test of normality (p > .05) and by Normal Q-Q Plot.

Gender violated the assumption of normality (male * pre-test time point). These data were moderately positively skewed (skewness = .851). Data was transformed using SQRT (square root) transformation. Data analysis performed with transformed data did not significantly alter results compared to original data. Therefore, original data statistics are reported for gender. There was homogeneity of variances (p > .05) and covariances (p =.263), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity was not required for two factors. There was no statistically significant interaction between gender and time (pre-/post scores) on genetics knowledge, F (1, 27) = 1.406, p = .246, partial η^2 = .05. The main effect of gender showed that there was no statistically significant difference in mean genetics knowledge scores between genders F (1, 27) = 2.199, p = .150, partial η^2 = .075 (Figure 4.5). These results suggest that there was no statistical difference between genders for knowledge gains after GBL intervention. Therefore, the GBL intervention is considered not to be biased towards one gender over the other.

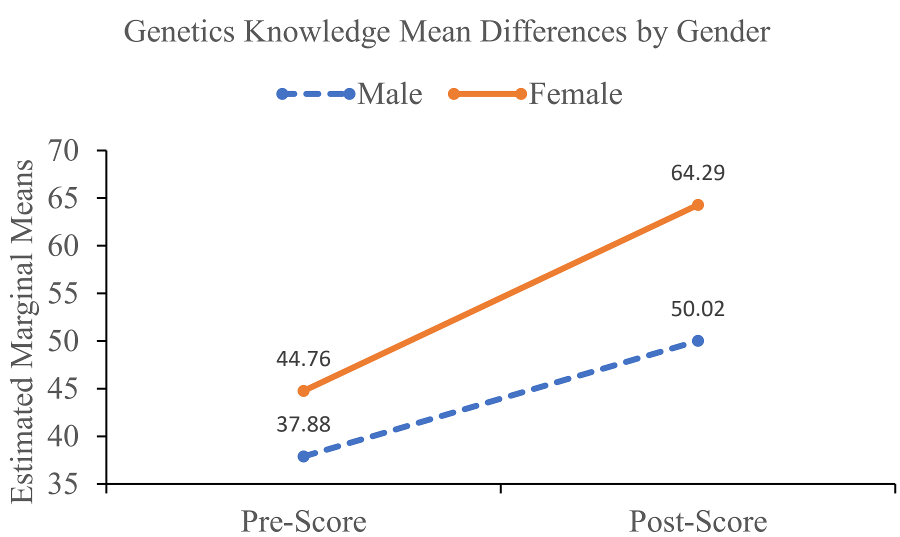


Figure 4.5. Genetics knowledge mean differences by gender. While both groups showed statistically significant learning gains in favor of females, there was no statistically significant difference between genders.

To determine possible effects on learning related to age, grade categories were established as follows: a). 9th, 10th and 11th grade (n=6), b). 7th and 8th grade (n = 14), and c). 5th and 6th grade (n = 9). There were three outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box. Grade violated the assumption of normality (7^{th} and 8^{th} grade group * pre-test time point). These data were moderately positively skewed (skewness = .891). Data was transformed using SQRT (square root) transformation. Transformed data revealed no outliers as assessed by box plot and examination of studentized residuals for values greater than ±3 and was normally distributed, as assessed by Normal Q-Q Plot. There was homogeneity of variances ($p > .05$) and covariances ($p = .719$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity was not required for two within-subjects factors. There was no statistically significant interaction between grade and time (pre-/post scores) on genetics knowledge, F (2, 26) = .732, $p = .491$, partial $\eta^2 = .053$. The main effect of grade showed that there was a statistically significant difference in mean genetics knowledge between academic grade groups F (2, 26) = 6.921, $p = .004$, partial $\eta^2 = .347$. The high school group (9th, 10^{th}, and 11th grades) was associated with a mean genetics knowledge transformed score 1.931, 95% CI[.538, 3.323] and 1.589, 95% CI[.300, 2.879] higher than the 5th and 6th grade group and the 7th and 8th grade group, respectively, a statistically significant difference, $p = .005$ and $p = .012$ respectively. The marginal means for genetics knowledge untransformed scores were 38.939 (SE = 4.613) for 5th and 6th grades, 43.110 (SE = 3.699) for 7th and 8th grades, and 65.764 (SE = 5.650) for 9th, 10th and 11th grades, a statistically significant mean difference of 26.825, 95% CI [8.160, 45.491], $p = .003$ and 22.654, 95% CI[5.373, 39.935], p = .007 for the 5th and 6th grade group and the 7th and 8th grade group, respectively. These results suggest that the knowledge gain for the older group (9^{th}, 10^{th}, and 11^{th} grade) was statistically significantly greater than the younger groups (see Figure 4.6).

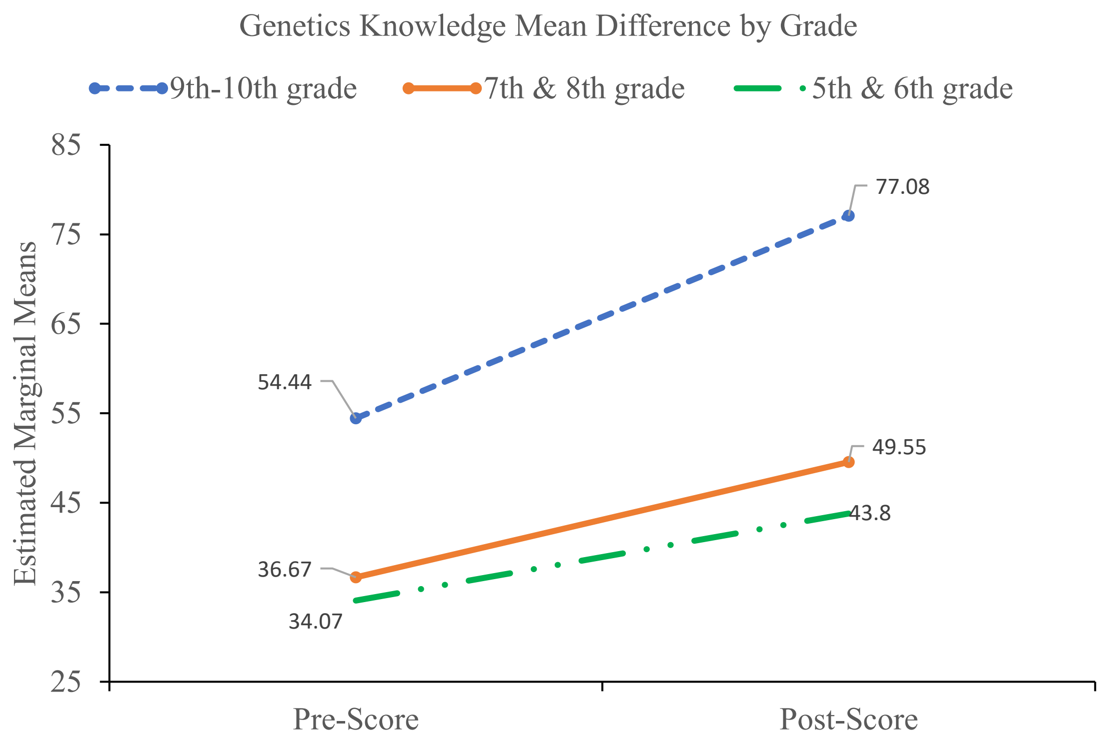


Figure 4.6. Genetics knowledge mean differences by grade category show that all grade categories experienced a statistically significant increase in learning after game-based learning interventions. The high-school group (9^{th}-11^{th} grade) showed a statistically significant higher mean increase over the other two groups.

To determine if experienced RPG players might have an advantage when the educational game genre is RPG, a two-way mixed ANOVA was performed. Estimated marginal means for pre-test scores were 40.00, 95% CI [32.199, 47.801] and 39.048, 95% CI [30.973, 47.122] for RPG players vs non-RPG players, respectively. Estimated marginal means for post-test scores were 56.667, 95% CI [42.265, 68.069] and 50.034, 95% CI [38.232, 61.837] for RPG players and non-RPG players, respectively. Both groups showed increased learning. The RPG players pre- to post- genetics knowledge scores had a greater increase than non-RPG players. Data for pre-test scores by RPG player (Time*RPG) was moderately positively skewed (skewness = .936).

Transformation of the data (SQRT) did not alter the conclusions, therefore untransformed data are used. There was homogeneity of variances ($p > .05$) and covariances ($p = .973$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity was not required for two factors. There was no statistically significant interaction between RPG experience and time (pre-/post scores) on genetics knowledge, $F\,(1, 27) = 1.124$, $p = .298$, partial $\eta^2 = .04$. The main effect of RPG player showed that there was no statistically significant difference in mean genetics knowledge scores between experienced RPG players and non-RPG players $F\,(1, 27) = .362$, $p = .553$, partial $\eta^2 = .013$. These results suggest that, even though experienced RPG players exhibited a greater increase in genetics post scores, there was no statistical difference between groups for knowledge gains after the intervention (see Figure 4.7). Therefore, RPG genre for GBL intervention is considered unbiased with respect to level of experience in RPG games.

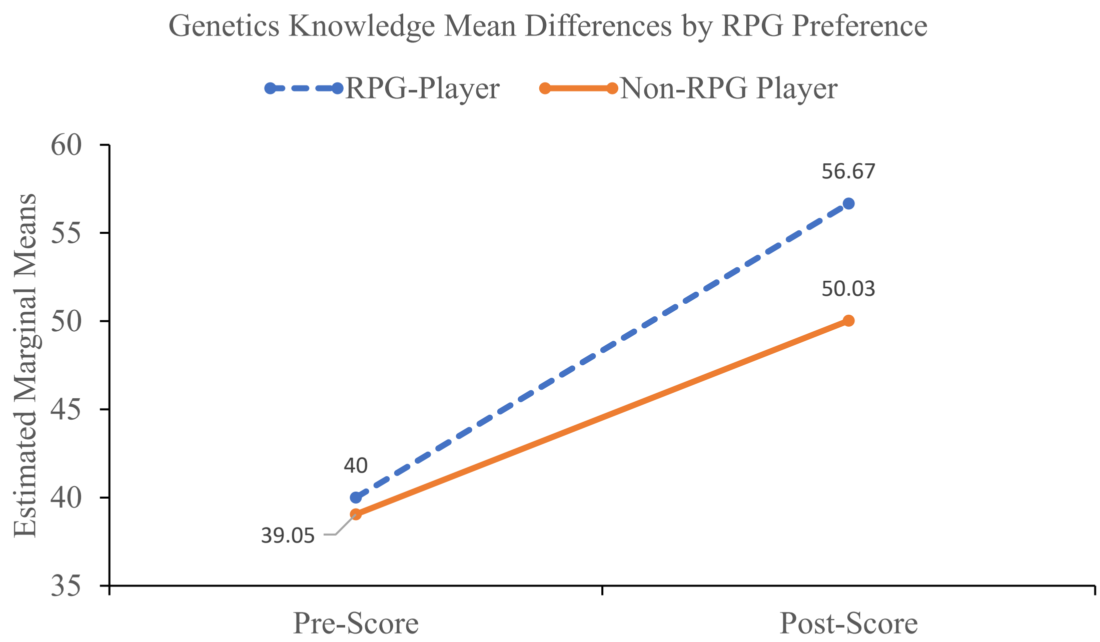


Figure 4.7. Genetics knowledge mean differences by Role-Playing-Game (RPG) preference. Both groups exhibited a statistically significant increase in learning after the game-based learning (GBL) intervention in favor of experienced RPG players. The difference between experienced RPG players and non-experienced RPG players showed a non-statistically significant mean difference.

Two-way mixed ANOVA was performed to determine possible effects of two different groups of students (public school vs home schooled) on genetics knowledge gained as a result of playing games. There were no outliers, as assessed by examination of studentized residuals for values greater than ±3. The data was normally distributed, as assessed by Shapiro-Wilk's test of normality (p > .05) and as assessed by Normal Q-Q Plot. The assumption of homogeneity of variances was violated so data was transformed using SQUAREROOT (SQRT). Transformed data met homogeneity of variances (p > .05) and covariances (p =.797), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity was not required for two factors. There was no statistically significant interaction between the group (school type) and time (pre-/post scores) on genetics knowledge, F (1, 27) = .05, p = .825, partial η^2 = .002. The main effect of group (school type) showed that there was a statistically significant difference in mean genetics knowledge scores between groups F (1, 27) = 7.805, p = .009, partial η^2 = .224. Independent-samples t-test shows mean increase in genetics score (pre-/post) 11.955 (SD = 13.46) and 15.525 (SD = 15.444) for public school group and home-schooled group, respectively (see Figure 4.8). These results suggest that the home-schooled group performed better on the post-test for genetics concepts after playing the games.

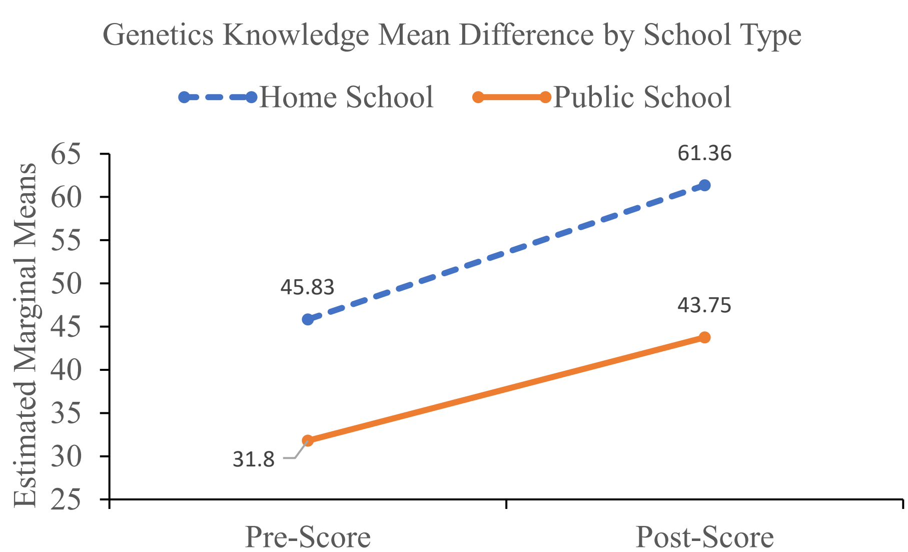


Figure 4.8. Genetics knowledge mean difference by school type. Both groups showed statistically significant increases in learning post game-based learning intervention. The difference between groups is statistically significant in favor of the home-school group.

Two-way mixed ANOVA was performed to determine possible effects of two different groups of students (White/Caucasian vs Non-white/Under-represented) on genetics knowledge gained as a result of playing games. There was one outlier in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box and as assessed by examination of studentized residuals for values greater than ±3. Raw data were inspected for possible data entry error and determined to be accurate. It was determined that this participant was a unique case and data was removed from the analysis. The data violated the assumption of normality for the pre-test scores on the Under-represented group, as assessed by Shapiro-Wilk's test of normality ($p < .05$) and as assessed by Normal Q-Q Plot. Data was transformed using SQUAREROOT (SQRT). Transformed data analysis did not change the results; therefore, non-transformed data are reported. There was homogeneity of variances ($p > .05$) and covariances (p =.809), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity was not required for two factors. There was no statistically significant interaction between the group (race/ethnicity) and time (pre-/post scores) on genetics knowledge, F (1, 26) = .08, p = .78, partial η^2 = .003. The main effect of group (race/ethnicity) showed that there was a non-statistically significant difference in mean genetics knowledge scores between groups F (1, 26) = .05, p = .83, partial η^2 = .002. (see Figure 4.9). These results suggest that the GBL intervention was not biased towards any group based on race/ethnicity.

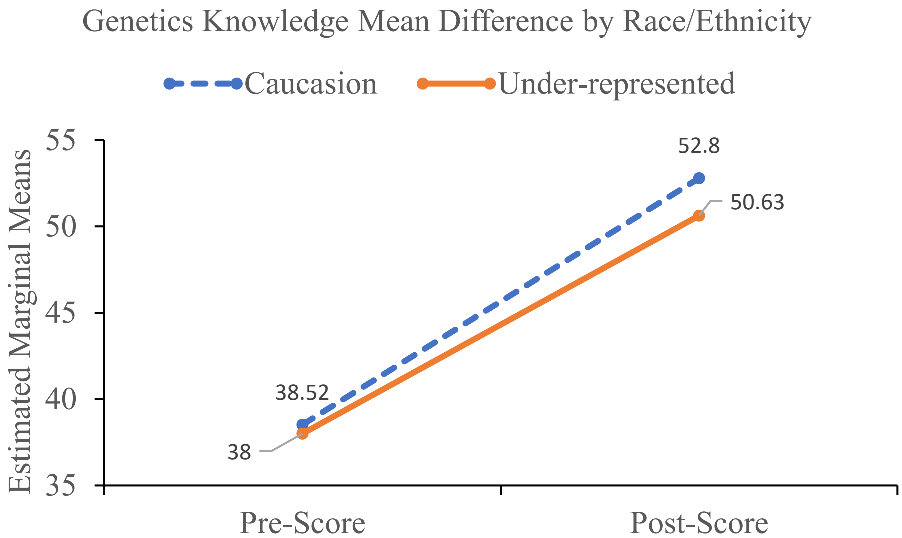


Figure 4.9. Genetics knowledge mean difference by race/ethnicity shows that while both groups exhibited statistically significant increase in knowledge post game-based learning intervention, the difference between groups was non statistically significant.

Finally, the genetics knowledge test was purposefully designed to gain an initial understanding of transferability of academic content learned from GBL. Pre-test items were re-written for the post-test as equivalent contextual items based on each of the two games (Radix and DragonMist). The post-test consisted of four generic questions, eleven DragonMist specific and eleven matched Radix specific questions. Twenty-five participants (n=25) completed the full twenty-six item post-test without missing data. Paired-samples t-tests were conducted to explore mean differences between the number of Radix content-specific items correctly answered with those of DragonMist content-specific items correctly answered. The analysis results show no statistically significant difference for either game independently or combined (GBL, as a whole). Paired-samples t-test for GBL, overall, compared number of correct DragonMist answers (M = 6.16, SD 2.89) to number of correct Radix answers (M = 5.76, SD 3.09). Results show that the mean group difference is not statistically significant (p = .412, 95% CI [-.590, 1.39]). These data suggest participants were able to transfer knowledge gained in one game to other contexts.

4.5 Game Play Experience

Paired-samples t-tests were used to explore each game's influence on dimensions of engagement, motivation and curiosity as well as to gain initial understanding of specific game design features on the player's game play experience. Paired-samples t-tests explored group mean differences between the *Game Play Experience* survey for the first game played with the *Game Play Experience* survey for the second game played. To minimize order effects bias, a cross-over design was implemented for the participants playing Radix and DragonMist (see Figure 3.23). The twenty-six participants (n=26), who played both Radix and DragonMist, distinguish two experimental groups as follows: Exp1 (Radix → DragonMist) (n = 15) and Exp2 (DragonMist → Radix) (n = 11). The control group (n=4) played DragonMist followed by Skyrim to determine the success (or failure) of inserting educational content into an entertainment game. One participant did not play both games and data could not be used for paired-samples t-test analysis.

Paired-samples t-tests were conducted for each dimension of the *Game Play Experience* survey to compare mean differences between Radix and DragonMist. Twenty-six (n=26) participants played both Radix and DragonMist. All dimensions had complete data except for *information seeking, situated interest, competence, enjoyment* and *perceived usefulness* (denoted with an * in Table 4.4). These five dimensions were analyzed based on twenty-five participants (n=25). For all paired-samples t-test analyses on all dimensions, there were no outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box and all data were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$) All dimensions were statistically significantly higher for DragonMist as compared to Radix (Table 4.4). These results suggest that DragonMist is more engaging and incited more curiosity than Radix on all measures for game play experience (see Figures 4.10 and 4.11 respectively).

Table 4.4

Game Play Experience Paired-samples t-tests Statistics for DragonMist Compared to Radix

Player Experience	Game	Mean	SD	Skew	Kurtosis	Shaprio Wilk's	t	d
State Curiosity	DM	14.5	4.28	-.5	.04	.25	4.48**	.88
	Radix	9.95	3.63					
Information Seeking [a]	DM	17.32	4.37	-.11	-.42	.92	4.92**	.98
	Radix	13.2	3.94					
Exploratory Behaviors	DM	14.04	4.12	-.37	-.14	.61	4.23**	.83
	Radix	9.19	2.84					
Situated Interest [a]	DM	38.36	9.38	-.25	-.62	.66	5.65**	1.13
	Radix	22.68	8.29					
Autonomy	DM	28.39	5.99	-.31	.14	.51	3.85**	.76
	Radix	20.73	6.68					
Competence [a]	DM	8.0	1.73	.74	-.02	.05	2.56*	.51
	Radix	6.84	1.7					
Relatedness	DM	23.54	6.6	.16	.4	.78	5.26**	1.03
	Radix	15.39	4.09					

Table 4.4 (continued)

Game Play Experience Paired-samples t-tests Statistics for DragonMist Compared to Radix

Player Experience	Game	Mean	SD	Skew	Kurtosis	Shaprio Wilk's	t	d
Enjoyment [a]	DM	23.84	6.06	-.53	-.41	.09	4.68**	.94
	Radix	13.88	6.41					
Immersion	DM	68.96	15.65	-.17	-.61	.68	4.59**	.9
	Radix	48.31	12.57					
Aesthetics / emotional attachment	DM	30.73	8.84	-.3	-.44	.89	4.82**	.95
	Radix	19.92	5.26					
Feedback Value	DM	22.0	6.12	.58	.49	.29	2.95*	.58
	Radix	17.23	4.69					
Perceived Usefulness [a]	DM	18.72	4.19	.27	-.21	.18	4.96**	.99
	Radix	12.8	4.11					
Endurability	DM	11.23	3.57	-.83	.55	.08	3.8**	.75
	Radix	6.69	3.38					
Focused Attention	DM	23.15	5.58	.08	-1.45	.06	4.96**	.97
	Radix	13.89	5.74					

Note: Paired-samples t-tests for player experience dimensions by game played DragonMist (DM) and The Radix Endeavor (Radix) (n=26); [a] one participant had missing data for these dimensions (n=25); * p < .05; ** p < .001

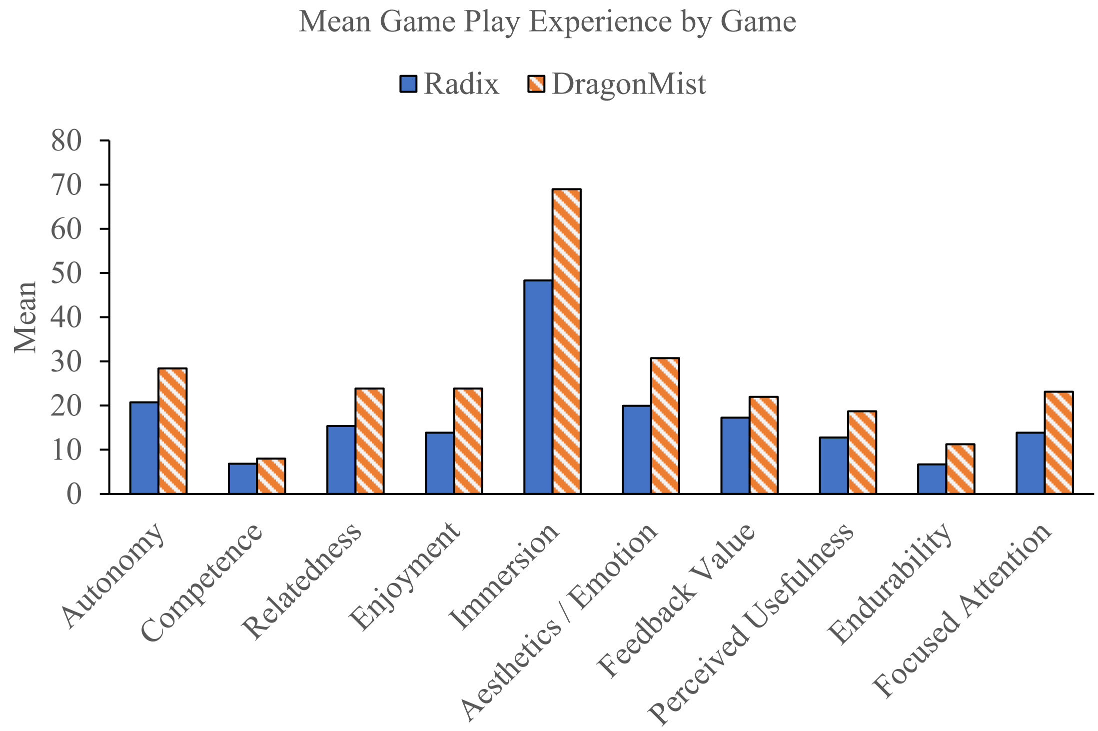


Figure 4.10. Game play experience measures of engagement and motivation, on all dimensions, were statistically significantly higher for DragonMist when compared to Radix.

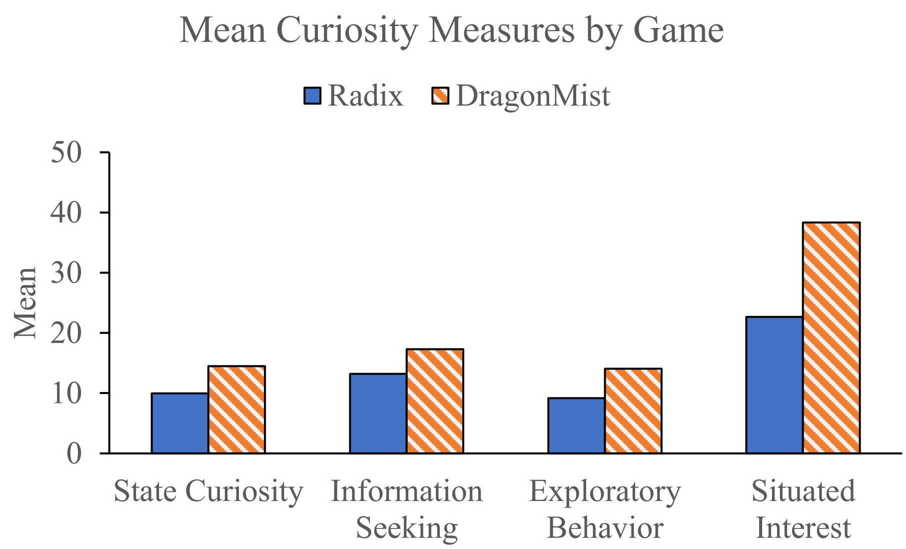


Figure 4.11 Game play experience measures for curiosity and related behaviors are statistically significantly higher on all measures for DragonMist compared to Radix.

Paired-samples t-tests were conducted for each dimension of the *Game Play Experience* survey to compare mean differences between DragonMist and Skyrim. Four (n=4) participants played both DragonMist and Skyrim. All dimensions had complete data. For all paired-samples t-test analyses on all dimensions, there were no outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box and all data were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$) unless otherwise stated. Two dimensions (*competence* and *relatedness*) violated the assumption of normality as identified by Shaprio-Wilks for small sample size, ($p < .05$). Due to the small sample size, transformation of data did not normalize the data. Wilcoxon Signed Rank test and non-parametric Sign test confirmed non-statistically significant differences for these two dimensions and untransformed data were reported. All dimensions were non-statistically significantly different for the two games suggesting that academic content was successfully integrated into DragonMist without significantly disrupting the entertainment value of the unmodded game (Table 4.5).

Table 4.5
Game Play Experience Paired-samples t-tests Statistics for DragonMist Compared to Skyrim

Player Experience	Game	Mean	SD	Skew	Kurtosis	Shaprio-Wilk's	t	d
State Curiosity	Skyrim	16.5	4.36	.71	1.79	.57	.24	.12
	DM	16.75	5.63					
Information Seeking	Skyrim	21.0	4.69	-1.13	2.23	.41	.39	.2
	DM	20.25	7.09					
Exploratory Behaviors	Skyrim	16.25	4.35	.71	1.79	.57	.24	.12
	DM	16.5	4.73					
Situated Interest	Skyrim	44.0	4.89	-1.19	1.5	.58	.93	.46
	DM	42.0	8.64					
Autonomy	Skyrim	30.5	5.46	-1.81	3.48	.06	.74	.37
	DM	29.5	7.55					
Competence [a]	Skyrim	9.0	.82	-2.0	4.0	.001	1.0	.39
	DM	8.5	1.73					
Relatedness [a]	Skyrim	28.5	3.69	2.0	4.0	.001	.5	.25
	DM	27.5	6.14					
Enjoyment	Skyrim	27.5	4.36	.86	-1.29	.27	1.57	.78
	DM	26.0	4.97					
Immersion	Skyrim	79.25	9.43	-.96	-3.42	.25	.59	.29
	DM	76.5	17.06					
Aesthetics / Emotional Attachment	Skyrim	37.25	6.19	1.19	1.5	.58	.46	.23

	DM	36.25	8.54					
Feedback Value	Skyrim	25.25	4.66	.00	-3.9	.99	.48	.24
	DM	24.75	6.39					
Perceived Usefulness	Skyrim	20.75	2.87	-1.66	2.62	.09	.26	.13
	DM	20.25	4.86					
Endurability	Skyrim	13.75	1.89	-1.19	1.5	.58	.93	.46
	DM	12.75	2.63					
Focused Attention	Skyrim	21.0	3.27	.76	1.5	.78	1.6	.8
	DM	24.0	6.16					

Note: Paired-samples t tests for player experience dimensions by game played, Skyrim or DragonMist (DM) (n=4). [a] Competence and Relatedness were non-normal; Wilcoxon Signed Rank test and non-parametric Sign test confirmed non-statistical significance. All mean differences were non-statistically significant ($p > .05$).

The holistic nature of this investigation examines these game design features as a complex network of relationships rather than isolated variables. To understand the potential interactions between different game design features, Pearson's product-moment correlation was run to determine the strength and direction of the association between the various dimensions of game play experience (N=60; game play experience survey for Radix (n=30) and game play experience survey for DragonMist (n=30)). All five assumptions for Pearson's product-moment correlation were considered and met. There was a statistically significant, moderate to strong positive correlation between all game play experience variables except for competence (See Table 4.6). There was a non-statistically significant small positive correlation between competence and autonomy, competence and focused attention and competence and aesthetics (affect).

Table 4.6

Pearson's product-moment Correlations for Game Play Experience Variables

	SciC	IS	EB	SC	SI	Au	Co	Re	Enj	FB	FA	IM	Ae	En
IS	.71**													
EB	.76**	.74**												
SC	.81**	.89**	.86**											
SI	.73**	.79**	.88**	.87**										
Au	.79**	.73**	.89**	.87**	.84**									
Co	.34**	.38**	.32*	.34**	.34**	0.25								
Re	.70**	.75**	.90**	.85**	.83**	.79**	.27*							
Enj	.74**	.74**	.87**	.84**	.97**	.86**	.29*	.81**						
FB	.70**	.75**	.81**	.83**	.75**	.76**	.39**	.84**	.71**					
FA	.68**	.70**	.85**	.81**	.91**	.85**	0.19	.79**	.91**	.72**				
IM	.76**	.77**	.90**	.89**	.94**	.89**	.33**	.88**	.93**	.80**	.95**			
Ae	.65**	.71**	.87**	.83**	.84**	.78**	0.24	.94**	.83**	.78**	.86**	.90**		
En	.71**	.73**	.87**	.82**	.97**	.83**	.29*	.82**	.98**	.71**	.91**	.93**	.85**	
PU	.71**	.83**	.84**	.87**	.95**	.78**	.38**	.83**	.88**	.81**	.83**	.88**	.79**	.9**

Note: SciC-scientific curiosity, IS-information seeking, EB-exploratory behavior, SC-state curiosity, SI-situated interest, Au-autonomy, Co-competence, Re-relatedness, Enj-enjoyment, FB-feedback, FA-focused attention, IM-immersion, Ae-aesthetics (affect), En-endurability, and PU-perceived usability (N=60). ** $p < .01$; * $p < .05$

4.6 Scientific Curiosity (Trait and State)

To see if the game could incite domain specific curiosity (state scientific curiosity), a pre-survey was administered to examine dispositional scientific curiosity (*SCILE)* (Weible & Zimmerman, 2016). The difference between testing for trait and state curiosity is context (Lowenstein, 1994). Therefore, the eight items for scientific curiosity on the pre-survey were reworded as context specific to test for trait curiosity and administered via the Game Play Experience survey I and II after each game. Paired-samples t-tests were conducted for each game to explore the game's influence on scientific curiosity. An independent-samples t-test was then conducted to determine the differential effects on scientific curiosity between games.

A paired-samples t-test was used to determine whether there was a statistically significant mean difference between trait scientific curiosity prior to game play and state scientific curiosity after participants played DragonMist to investigate the game's ability to incite scientific curiosity. No outliers were detected that were more than 1.5 box-lengths from the edge of the box in a boxplot. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test ($p = .715$). Participants exhibited more scientific curiosity after playing DragonMist ($M = 30.55$, $SD = 5.84$) as opposed to the pre- scientific curiosity measure ($M = 28.03$, $SD = 6.23$), a statistically significant mean increase of 2.52, 95% CI [0.04, 4.99], $t(28) = 2.08$, $p = .047$, $d = .39$.

A paired-samples t-test was used to determine whether there was a statistically significant mean difference between trait scientific curiosity prior to game play and state scientific curiosity after participants played The Radix Endeavor to investigate the game's ability to incite scientific curiosity. No outliers were detected that were more than 1.5 box-lengths from the edge of the box in a boxplot. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test (p = .512). Participants exhibited less scientific curiosity after playing Radix (M = 21.54, SD = 5.67) as opposed to the pre-scientific curiosity measure (M = 26.77, SD = 5.97), a statistically significant mean decrease of 5.23, 95% CI [2.35, 8.12], $t(25)$ = 2.08, p = .001, d = .73.

Finally, an independent-samples t-test was conducted to compare DragonMist and Radix with respect to the game's ability to incite scientific curiosity. A Welch t-test was run to determine if there were differences in the game's influence on scientific curiosity between DragonMist and Radix due to the assumption of homogeneity of variances being violated, as assessed by Levene's test for equality of variances ($p < .05$). There were no outliers in the data, as assessed by inspection of a boxplot, and scientific curiosity scores for each level of gamer were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). DragonMist increased scientific curiosity pre- to post- difference score (M = 2.52, SD = 6.51) while Radix decreased scientific curiosity pre- to post- difference score (M = -5.0 SD = 7.34), a statistically significant difference, M = 7.52, 95% CI [3.74, 11.29], $t(50.338)$ = 7.517, $p < .001$, d = 1.09 (see Figure 4.12).

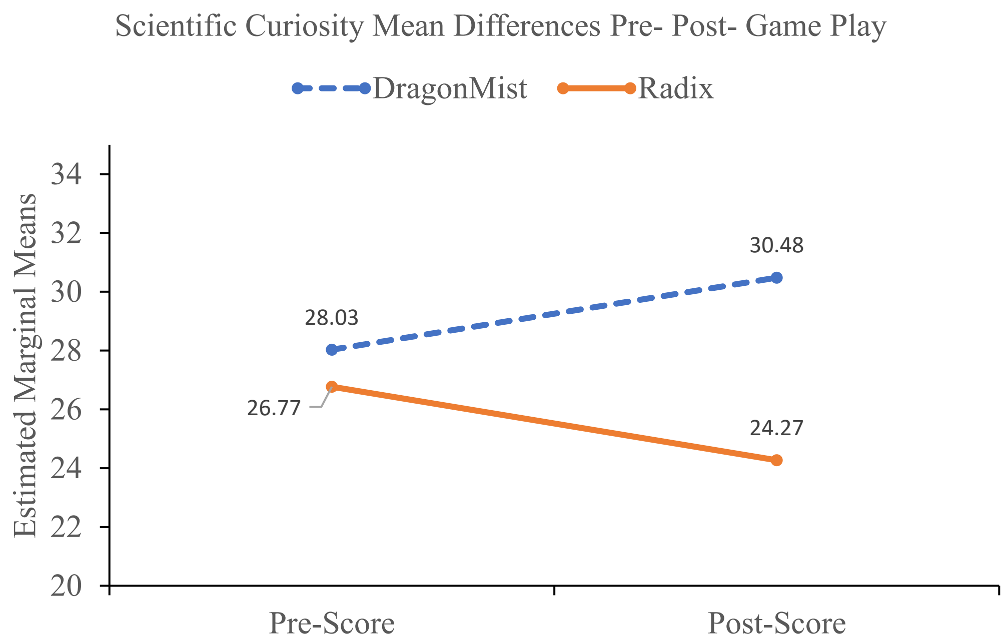


Figure 4.12. Scientific curiosity group mean differences pre- post- game play for DragonMist compared to Radix. Scientific curiosity statistically significantly increased after playing DragonMist and statistically significantly decreased after playing Radix. The mean difference between the two games is statistically significant.

4.7 Dispositional Curiosity (Personality) Influences on Game Play Experience

Some researchers believe that dispositional curiosity is a stable trait that influences how people approach, accept, and interact with novel environments and /or information gaps (e.g., Naylor, 1981; Maw & Maw, 1972; Zuckerman, 1964). Kashdan et al. (2018) found evidence of five distinct factors related to dispositional curiosity: *Joyous Exploration (JE), Deprivation Sensitivity (DS), Stress Tolerance (ST), Social Curiosity (SoC)* and *Thrill Seeking (TS)*. The *5DC* was used in this study to explore intervention strategies to enhance curiosity. JE is considered the archetype of curiosity as a motivational drive and captures a preference for new experiences and reward seeking. JE is also associated with high levels of pleasure, grit and openness. DS is associated with epistemic curiosity and need for cognition. DS is associated with tension that drives the need to resolve an information gap and is an aversion or avoidance motivation. ST is necessary for an individual to cope with conflict or novel, uncertain, complex situations. TS is related to risk taking and danger. People with high TS scores actively seek novel, complex and intense experiences. Finally, SoC is associated with interpersonal relationships and relates to interest in what other people are doing or thinking (Kashdan et al., 2018). These five dimensions of the curiosity profile are explored in relation to certain game play experience outcomes.

Hierarchical multiple regression was used to explore each of the five dimensions of curiosity to determine how much extra variation in the dependent variable (game play experience) is explained by adding one or more independent variables (dimensions of dispositional curiosity) (Laerd Statistics, 2015d). The advantage of hierarchical multiple regression is that the researcher can enter independent variables into the regression equation in the order they choose based on *a priori* knowledge. The advantages are as follows: (a) effects of covariates can be controlled, and (b) possible causal effects of independent variables can be considered when predicting a dependent variable.

There are eight assumptions that must be met for hierarchical multiple regression (Berry, 1993). All assumptions were met unless otherwise stated. There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistic of approximately 2.0. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values.

There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ±3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met, as assessed by Q-Q Plot.

4.7.1 Enjoyment and Dispositional Curiosity

Of the five dimensions of curiosity measured on the pre- survey, JE and TS would be expected to influence enjoyment derived from playing DragonMist. Preliminary exploration of the data (Pearson’s correlation) indicates that JE and TS were positively correlated with enjoyment (r = .537, r = .524, respectively). Independent variables were added to the hierarchical multiple regression model based on anticipated influence on the dependent variable (enjoyment) as follows: JE, TS, ST, DS, and SC. A hierarchical multiple regression was run to determine if the addition of ST and then of DS and finally SC improved the prediction of enjoyment over and above JE and TS alone.

The full model of JE, TS, ST, DS, and SC to predict enjoyment was statistically significant, R^2 = .388, $F(5, 24)$ = 3.04 p = .029; adjusted R^2 = .26. Model 1 of JE to predict enjoyment was statistically significant, R^2 = .288, $F(1, 28)$ = 11.33 p = .002; adjusted R^2 = .263. The addition of TS to the prediction of enjoyment by JE (Model 2) led to a non-statistically significant increase in R^2 of .075, $F(1, 27)$ = 3.198, p = .085 (See Table 4.7).. The addition of ST, DS and SC to the prediction of enjoyment (Model 3, 4, and 5, respectively) led to non-statistically significant increases in R^2 of Model 2. The full model of JE, TS, ST, DS, and SC explains 38.8% of the variance in the dependent variable (enjoyment) when playing DragonMist.

Table 4.7

Hierarchical Multiple Regression Predicting Enjoyment from Joyous Exploration and Thrill seeking

	Enjoyment			
	Model 1		Model 2	
Variable	B	β	B	β
Constant	11.946**		8.258	
JE	.734**	.537*	.487	.356
TS			.471	.329
R^2	.288		.364	
F	11.333**		7.710**	
ΔR^2	.288		.075	
ΔF	11.333**		3.198	

Note. N=30. * p < .05, ** p < .01, *** p < .001

4.7.2 Motivation (Autonomy, Relatedness, Competence) and Dispositional Curiosity

According to SDT (Ryan & Deci, 2000), intrinsic motivation is described as satisfaction of three basic needs (autonomy, relatedness and competence). According to Kashdan et al. (2018), JE was highly correlated with satisfaction of basic needs, TS was highly correlated with pleasure, and SC was inversely correlated to the autonomy aspect of SDT. Initial correlation analysis confirmed that TS (r = .462) and JE (r = .330) were positively correlated with intrinsic motivation while playing DragonMist. Independent variables were added to the hierarchical multiple regression model based on anticipated influence on the dependent variable (intrinsic motivation) as follows: TS, JE, ST, DS, and SC. A hierarchical multiple regression was run to determine if the addition of ST and then of DS and finally SC improved the prediction of intrinsic motivation over and above TS and JE alone. Only Model 1 (TS) and Model 2 (TS + JE) were statistically significant according to ANOVA (p =.009 and p=.03, respectively).

Model 1 of TS to predict intrinsic motivation was statistically significant, R^2 = .219, F(1, 28) = 7.86 p = .009; adjusted R^2 = .191. The addition of JE to the prediction of intrinsic motivation by TS (Model 2) led to a non-statistically significant increase in R^2 of .009, F(1, 27) = .3, p = .59 (See Table 4.8). Model 2 indicates the dimensions of curiosity, TS and JE, explain 22.8% of the variance in the dependent variable (intrinsic motivation) when playing DragonMist (See Table 4.8).

Table 4.8

Hierarchical Multiple Regression Predicting Intrinsic Motivation from Thrill Seeking and Joyous Exploration

	Intrinsic Motivation			
	Model 1		Model 2	
Variable	B	β	B	β
Constant	42.62***		40.494***	
TS	1.299**	.468	1.13*	.407
JE			.294	.111
R^2	.219		.228	
F	7.862**		3.983*	
ΔR^2	.219		.009	
ΔF	7.862**		0.3	

Note. N=30. * p < .05, ** p < .01, *** p < .001

4.7.3 Immersion and Dispositional Curiosity

Initial correlation analysis confirmed that JE (r = .58) and TS (r = .462) were positively correlated with perceived immersion while playing DragonMist. Independent variables were added to the hierarchical multiple regression model based on anticipated influence on the dependent variable (immersion) as follows: JE, TS, ST, DS, and SC. A hierarchical multiple regression was run to determine if the addition of ST and then of DS and finally SC improved the prediction of perceived immersion over and above JE and

TS alone. The full model of JE, TS, ST, DS, and SC to predict immersion was statistically significant, $R^2 = .412$, $F(5, 24) = 3.36$ $p = .019$; adjusted $R^2 = .29$. The model of JE to predict perceived immersion (Model 1) was statistically significant, $R^2 = .257$, $F(1, 28) = 9.688$, $p = .004$; adjusted $R^2 = .231$. The addition of TS to the prediction of perceived immersion (Model 2) led to a statistically significant increase in R^2 of .136, $F(1, 27) = 6.06$, $p = .02$; adjusted $R^2 = .348$ (See Table 4.9). The addition of ST, DS and SC to the prediction of perceived immersion (Model 3, 4, and 5, respectively) led to non-statistically significant increases in R^2 of Model 2. Model 2 indicates the dimensions of curiosity, JE and TS, explain 39.3% of the variance in the dependent variable (perceived immersion) when playing DragonMist.

Table 4.9

Hierarchical Multiple Regression Predicting Perceived Immersion from Joyous Exploration and Thrill Seeking

	Perceived Immersion			
	Model 1		Model 2	
Variable	B	β	B	β
Constant	42.6846***		30.789**	
Joyous Exploration	1.686**	.507**	.879	.264
Thrill Seeking			1.539*	.442*
R^2	.257		.393	
F	9.688**		8.75***	
ΔR^2	.257		.136	
ΔF	9.688**		6.061*	

Note. N=30. * p < .05, ** p < .01, *** p < .001

4.7.4 Situated Interest and Dispositional Curiosity

Initial correlation analysis confirmed that JE (r = .46) and TS (r = .498) were positively correlated with situated interest while playing DragonMist. Independent variables were added to the hierarchical multiple regression model based on anticipated influence on the dependent variable (situated interest) as follows: TS, JE, ST, DS, and SC. The full model of JE, TS, ST, DS, and SC to predict situated interest was statistically significant, R^2 = .371, F(5, 24) = 2.83 p = .038; adjusted R^2 = .24. The model of TS to predict situated interest (Model 1) was statistically significant, R^2 = .295, F(1, 28) = 11.71, p = .002; adjusted R^2 = .27. The addition of JE to the prediction of situated interest (Model 2) led to a non-statistically significant increase in R^2 of .06, F(1, 27) = 2.507, p = .125; adjusted R^2 = .307 (See Table 4.10). The addition of ST, DS and SC to the prediction of situated interest (Model 3, 4, and 5, respectively) led to non-statistically significant increases in R^2 of Model 2. Model 2 indicates the dimensions of curiosity, thrill seeking and joyous exploration, explain approximately thirty-six (35.5%) of the variance in the dependent variable (situated interest) when playing DragonMist.

Table 4.10

Hierarchical Multiple Regression Predicting Situated Interest from Thrill Seeking and Joyous Exploration

	Situated Interest			
	Model 1		Model 2	
Variable	B	β	B	β
Constant	18.914**		14.443*	
TS	1.199**	.543	.844*	.382
JE			.618	.293
R^2	.295		.355	
F	11.712**		7.425**	
ΔR^2	.295		.06	
ΔF	11.712**		2.507	

Note. N=30. * p < .05, ** p < .01, *** p < .001

4.7.5 Focused Attention and Dispositional Curiosity

Initial correlation analysis confirmed that TS (r = .482) and JE (r = .324) were positively correlated with focused attention while playing DragonMist. Independent variables were added to the hierarchical multiple regression model based on anticipated influence on the dependent variable (focused attention) as follows: TS, JE, ST, DS, and SC. Four of the five Models were statistically significant as assessed via ANOVA (p < .05), the complete Model was not statistically significant after social curiosity was added as assessed by ANOVA (p = 0.58). However, Model 1 (TS) and Model 2 (TS + JE) were the best fit for the data and were statistically significant according to ANOVA (p = .003, p = .011, respectively).

The model of TS to predict focused attention (Model 1) was statistically significant, $R^2 = .277$, $F(1, 28) = 10.708$, $p = .003$; adjusted $R^2 = .251$. The addition of JE to the prediction of focused attention (Model 2) led to a non-statistically significant increase in R^2 of .007, $F(1, 27) = .269$, $p = .608$; adjusted $R^2 = .231$. Model 2 indicates the dimensions of curiosity, TS and JE, explain approximately twenty-eight (28.4%) of the variance in the dependent variable (focused attention) when playing DragonMist (See Table 4.11).

Table 4.11

Hierarchical Multiple Regression Predicting Focused Attention from Thrill Seeking and Joyous Exploration

	Focused Attention			
	Model 1		Model 2	
Variable	B	β	B	β
Constant	10.708**		5.349*	
Thrill Seeking	.695**	.526	.622*	.470
Joyous Exploration			.128	.101
R^2	.277		.284	
F	10.708**		5.349**	
ΔR^2	.277		.007	
ΔF	10.708**		.269	

Note. N=30. * p < .05, ** p < .01, *** p < .001

4.7.6 Endurability and Dispositional Curiosity

Endurability is an individual's intent to play the game on a voluntary basis. Since both JE and TS are associated with seeking rewards and approach behaviors associated with pleasure and happiness, a positive correlation is expected for endurability. Initial correlation analysis confirmed that JE ($r = .444$) and TS ($r = .414$) were positively correlated with endurability while playing DragonMist. Independent variables were added to the hierarchical multiple regression model based on anticipated influence on the dependent variable (endurability) as follows: JE, TS, ST, DS, and SC. Three of the five

Models were statistically significant as assessed via ANOVA ($p < .05$). Model 4 (addition of DS) and the Model 5 (addition of SC) were not statistically significant as assessed by ANOVA ($p > 0.05$). Model 1 (JE) and Model 2 (JE + TS) were the best fit for the data and were statistically significant according to ANOVA ($p = .006$, $p = .01$, respectively).

The model of JE to predict endurability (Model 1) was statistically significant, $R^2 = .237$, $F(1, 28) = 8.673$, $p = .006$; adjusted $R^2 = .209$. The addition of TS to the prediction of endurability (Model 2) led to a non-statistically significant increase in R^2 of .051, $F(1, 27) = 1.937$, $p = .175$; adjusted $R^2 = .235$. The addition of ST, DS and SC to the prediction of endurability (Model 3, 4, and 5, respectively) led to non-statistically significant increases in R^2 of Model 2. Model 2 indicates the dimensions of curiosity, JE and TS, explain approximately twenty-nine percent (28.8%) of the variance in the dependent variable (endurability) when playing DragonMist (See Table 4.12).

Table 4.12

Hierarchical Multiple Regression Predicting Endurability from Joyous Exploration and Thrill Seeking

	Endurability			
	Model 1		Model 2	
Variable	B	β	B	β
Constant	5.845**		4.256	
Joyous Exploration	.348**	.486	.241	.338
Thrill Seeking			.203	.271
R^2	.237		.284	
F	8.673**		5.45**	
ΔR^2	.237		.051	
ΔF	8.673**		1.937	

Note. N=30. * p < .05, ** p < .01, *** p < .001

4.7.7 Information Seeking and Dispositional Curiosity

Information seeking was determined via self-report on the *Game Play Experience* survey post- game play as well as calculating game log statistics related to seeking information in the game (e.g. number of books read, increased speech skills, spell and skill books read). Speaking to NPCs for information is not a game statistic available to download and could not be included. There was one extreme outlier in the data. When that case was removed, all required assumptions were met. Initial correlation analysis suggested the strongest positive correlation between curiosity dimension and information seeking were ST (r = .385) and DS (r = .318). Independent variables were added to the hierarchical multiple regression model based on anticipated influence on the dependent variable (information seeking) as follows: ST, DS, TS, JE, and SC. The full model of ST, DS, JE, TS, and SC to predict information seeking was statistically significant, R^2 = .364, F(5,23) = 2.638, p = .05. Model 2 (ST + DS) was the best fit for the data and was statistically significant according to ANOVA (p = .014).

The model of ST to predict information seeking (Model 1) was statistically significant, R^2 = .182, F(1, 27) = 5.99, p = .021; adjusted R^2 = .151. The addition of DS to the prediction of information seeking (Model 2) led to a non-statistically significant increase in R^2 of .098, F(1, 26) = 3.529, p = .072; adjusted R^2 = .224. The addition of TS, JE and SC to the prediction of information seeking (Model 3, 4, and 5, respectively) led to non-statistically significant increases in R^2 of Model 2. Model 2 indicates the dimensions of curiosity, ST and DS, explain approximately twenty-eight percent (27.9%)

of the variance in the dependent variable (information seeking) when playing DragonMist (See Table 4.13).

Table 4.13

Hierarchical Multiple Regression Predicting Information Seeking from Stress Tolerance and Deprivation Sensitivity

	Information Seeking			
	Model 1		Model 2	
Variable	B	β	B	β
Constant	26.483**		14.756	
ST	1.217*	.426	1.126*	.394
DS			.852	.314
R^2	.182		.279	
F	5.99*		5.04*	
ΔR^2	.182		.098	
ΔF	5.99*		3.529	

Note. N=30. * p < .05, ** p < .01, *** p < .001

4.7.8 Exploratory Behaviors and Dispositional Curiosity

Exploratory behavior was determined via self-report on the *Game Play Experience* survey post- game play as well as calculating game log statistics related to exploratory behaviors in the game (e.g. locations visited, chests looted, special items collected). There was one extreme outlier in the data. When that case was removed, all assumptions were met. Initial correlation analysis suggested the strongest positive correlation between curiosity dimension and exploratory behavior were ST (r = .385) and DS (r = .318). Independent variables were added to the hierarchical multiple regression model based on anticipated influence on the dependent variable (exploratory behavior) as follows: ST, DS, TS, JE, and SC. The full model of ST, DS, JE, TS, and SC to predict exploratory behavior was statistically significant, $R^2 = .418$, $F(5,23) = 3.299$, $p = .022$.

The full model for all five dimensions of curiosity explains 41.8% of the variance in the dependent variable (exploratory behavior) when playing DragonMist.

4.7.9 State Curiosity and Dispositional Curiosity

Finally, some research indicates that curiosity requires some degree of prior knowledge for information gaps to become salient (Loewenstein, 1994). More recent literature on curiosity poses the possibility that curiosity can emerge *de novo* given the appropriate stimuli (Gottlieb et al., 2013). A linear regression was run to understand the effect of students' prior genetics knowledge on state scientific curiosity. To assess linearity a scatterplot of state scientific curiosity against genetics pre-test scores with superimposed regression line was plotted. Visual inspection of these two plots indicated a linear relationship between the variables. There was homoscedasticity and normality of residuals. One participant was an outlier and was removed from the analysis due to not representing the target population. No statistically significant relationship was found between prior genetics knowledge and state scientific curiosity ($r = .14$). This finding suggests DragonMist was able to incite scientific curiosity independent of prior knowledge and supports previous research findings that curiosity can emerge *de novo* (Gottlieb et. al, 2013).

4.7.10 Dispositional Curiosity Profiles

Kashdan et al. (2018) developed the 5DC as a way to explore curiosity profiles rather than considering curiosity as simply present or absent. The study mapped the dimensions of curiosity to various published curiosity measures such as the Big Five personality measure (N=2996). The authors explored types of curious people via cluster analysis and found four clusters related to different daily life activities. The four personality clusters were as follows: (a) The Fascinated (archetype of highly curious person) possess psychological strength that enables them to explore and develop passionate interests, (b) Problem Solvers (distinguished by high deprivation sensitivity and stress tolerance) exhibit obsessive interest in solving problems and seek information, (c) Empathizers (high level of social curiosity and relatively low thrill seeking) are more likely to be female and frequently feel stressed, and (d) Avoiders (lowest on all curiosity dimensions) report the least amount of passions and the highest levels of stress. Curiosity profiles were developed for all participants in this study. Six profiles were extreme, three matching the Fascinated profile and there matching the Avoider profile. However, most profiles were not clearly delineated and exhibited subtle variations with more moderate dimensional scores. Therefore, the small sample size (N=31) prohibited cluster analysis to discern distinct curiosity profiles matched to the four personality types distinguished in Kashdan et al. (2018). Notably, the six extreme curiosity profiles matched specific extreme behaviors in this study and will be discussed in chapter eight where the results are integrated.

4.8 Game Log Files

The Radix Endeavor provides graphical logs of class progress as an assessment tool for teachers. Figure 4.13 shows the combined graphical output for the three Radix classrooms set up for this study. DragonMist does not provide a graphical output of class progress but numerical data was downloaded to determine which tasks were completed in the genetics questline. These numerical data were used to create a graphical output like the one provided by Radix (see Figure 4.14). Data from these graphs indicate that 34.22% of genetics tasks were completed for Radix (see Figure 4.13) as compared to 58.77% for DragonMist (see Figure 4.14). The Radix game log data indicate that participants completed 36.74% of genetics tasks when instructed to play to learn as compared to 32.03% when instructed to play for fun. The DragonMist game log data indicate that participants completed 65.19% of genetics tasks when instructed to play to learn compared to 52.1% when instructed to play for fun.

Figure 4.13 Radix game log data as graphical output indicates, on average, 34.22% of the genetics tasks were completed.

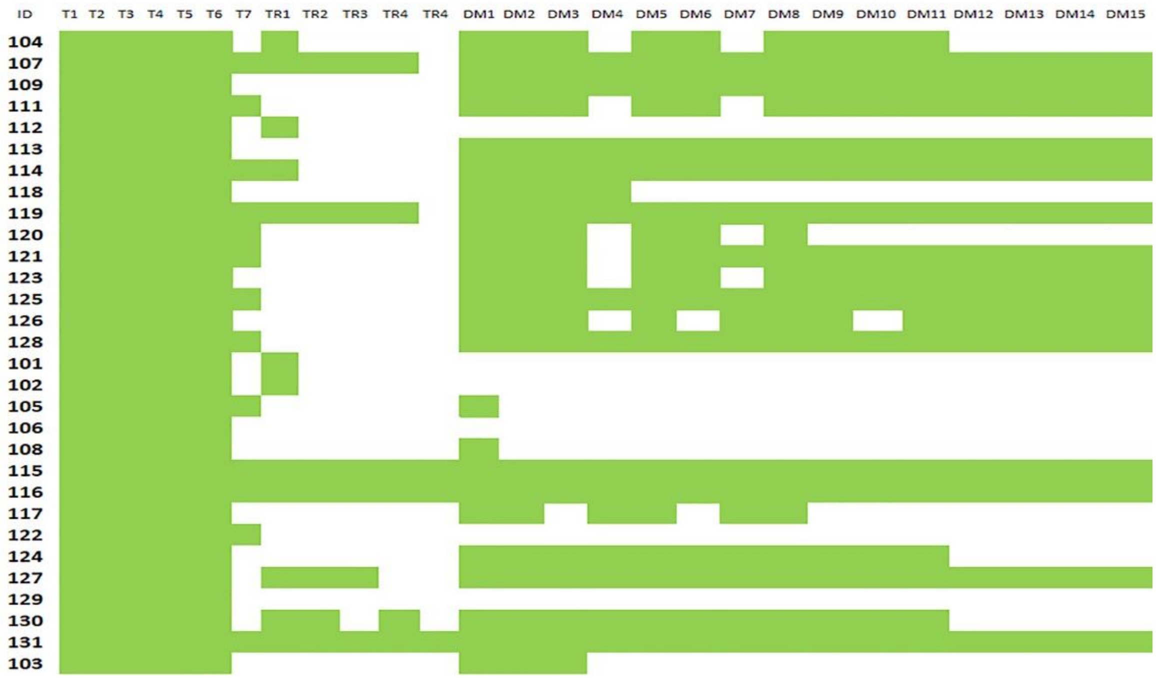


Figure 4.14. DragonMist game log data as graphical output indicates, on average, 58.77% of the genetics tasks were completed.

Avatar customization was calculated by considering the time spent creating the avatar and the number of customizations completed compared to the default character. A rubric was developed, for consistency, based on visible avatar differences that were obvious and easily documented. Pearson's correlation shows that overall engagement (considers all dimensions of the game play experience survey) is moderately correlated to avatar customization (r = .316). A linear regression was run to understand the effect of average degree of avatar customization on overall engagement. To assess linearity a scatterplot of engagement against average degree of avatar customization with superimposed regression line was plotted. Visual inspection of this plot indicated a linear relationship between the variables. There was homoscedasticity and normality of the residuals. There were no outliers. Average degrees of avatar customization statistically significantly predicted overall engagement, $F(1, 54) = 5.825$, $p = .019$, accounting for 9.7% of the variation in overall engagement with adjusted $R^2 = .081$.

To strengthen the findings of self-reported survey data, game log data were downloaded after each day of game play to understand participants' interactions with the game. Log files were examined for evidence of engagement, curiosity, and learning. The game logs are used as support for game play experience survey self-reports. Averages based on absolute counts and ranges are shown for Radix and DragonMist (Appendix L). When possible, relative frequencies are reported (Appendix L). These data will be discussed more in Chapter Eight.

4.9 Summary of Quantitative Results

In summary, these results demonstrate statistically significant learning gains from both games, Radix and DragonMist while engagement and curiosity (and related behaviors) were significantly statistically higher for DragonMist on all dimensions. Results show a statistically significant increase in scientific curiosity after playing DragonMist and a statistically significant decrease in scientific curiosity after playing Radix. Results demonstrate a non-statistically significant group mean difference on all game play experience dimensions for Skyrim and DragonMist. Dimensions of dispositional curiosity statistically significantly predict player engagement with DragonMist. Pearson's product-moment correlations show significant moderate to strong positive correlations between all game play experience dimensions except for competence. Game log data show players completed more than half of the genetics tasks for DragonMist and approximately one-third of the genetics tasks for Radix. Game log data show a significant moderate positive correlation between avatar customization and overall engagement. Detailed game log data, for DragonMist, support player engagement with DragonMist. These results and implications are discussed in Chapter Five.

CHAPTER FIVE

DISCUSSION OF QUANTITATIVE RESULTS

GBL offers engaging learning environments for science education (Lester et al., 2014). However, the challenge is that the academic content must be integrated into the game in a manner that does not disrupt motivation, engagement, flow and immersion. Another goal for educational game designers is to create games that stimulate and reward curiosity. This study investigated game design features, from the player's perspective, that enhance (or hinder) learning outcomes, curiosity, motivation and engagement. The findings of this study suggest several theoretical and practical implications for educational game design purposed for combining academic science content with engaging interactive game play.

5.1 Leaning Science Through Engaging Game Play

The results, relevant to **RQ2** (What impact does the integration of learning content into a game design have on player engagement, motivation and learning?), demonstrated the games' potential to enhance academic science knowledge, specifically basic Mendelian genetics concepts. The results reported suggest genetics knowledge acquisition occurred from a three to four-hour exposure to the genetics questlines in Radix or DragonMist as assessed by pre-/ post- knowledge test. The observed learning gain was of large effect size (Cohen's d = .964). Each game was analyzed independently and the main effect of group (game played) showed no statistically significant difference in mean genetics knowledge scores between intervention groups (p = .390; partial η^2 = .028). Therefore, the results suggest that the mod (DragonMist) enhanced student genetics knowledge equal to the purely educational game (Radix) and learning gains were statistically significant ($p < .001$; partial $\eta^2 = .49$). This finding supports the ability to design an educational quest for an existing commercial game and integrate the academic science content into the game such that successful learning outcomes are comparable to games designed solely for education.

A well-designed educational game should present equal learning opportunities for a diverse student population. Groups were analyzed on endorsed demographics to determine potential bias of the GBL intervention towards any specific group. Twenty-nine participants self-endorsed as gamers (n=29, 93.55%) which aligns with current statistics that show 91% to 97% of middle school to high school aged youths play games (Jenkins, 2013; Resinger, 2011). Game practices and preferences of the participants in this study (See Chapter Three: *Participant Characteristics*) align with other current GBL research. Fraser (2014) reported demographics (n = 1502; average age 18 yrs.) that indicated favorite device for game play is a game console (72%), played daily (57.3%), half (48.4%) endorsed intermediate skills and one-third (33,45%) endorsed expert skills. Therefore, it is a reasonable conclusion that the gaming experience and preferences of the participants in this study represent the larger population. Race/ethnicity was nearly equally distributed between white/Caucasian and under-represented groups (nineteen participants endorsed white/Caucasian (61%)). Participant age ranged from ten to sixteen years old with a mean age of thirteen. One limitation of this study is the small number of female participants (n=8). Approximately one-fourth of the total participants in this study were female, which is slightly lower than other game preference and engagement studies whose reported demographics show one-third of the participants as females (e.g., Poels et al., 2007). Group mean learning gains are summarized in Figure 5.1.

All groups showed statistically significant learning gains. There was no statistically significant difference in mean learning gains between males and females, white/Caucasian and under-represented, or gaming experience defined as experience with the RPG game genre. Statistically significant differences in mean learning scores were reported for the group *Grade Category* and for the group *School Type*. While all grades showed statistically significant increase in learning scores, the older group (high school: 9^{th}, 10^{th}, and 11^{th} grades) was statistically significantly different from the two younger groups. One explanation for this result is the reading comprehension level of the genetics knowledge tests. Two questions were simple definition questions and two questions were visuals. But the remaining questions were complex word problems designed to require deeper understandings of the content via analysis and synthesis. Younger students may have had difficulty with the lengthy complex questions and may have experienced test fatigue as evidenced by several participants' request for extra time to complete the test and three who were unable to finish.

Reported results revealed a statistically significant difference in mean learning gains between the public-school group and the home school group in favor of the home school group. This result may be explained by observations of game play and the verbalized goals of the home-schooled students who participated in the study. Home-school parents and co-op directors indicated some form of documentation was required as evidence that the students were participating in science-related activities as opposed to playing games for entertainment. Thus, a certificate of learning was provided upon completion of the genetics questlines for students who were required to show proof of science activities. All participants from the home-school groups requested the certificate, while none of the public-school participants requested the learning certificates. Home-schooled participants were observed to be more focused on the learning content rather than game play until they completed the genetics quests (ex. several were observed taking notes, and drawing out Punnett squares). This difference in motivation may have influenced their efforts and focus in favor of genetics concepts as opposed to the game play.

Overall, the findings support potential for GBL to significantly enhance academic science learning for middle school and high school students of varying game play experience levels and game habit preferences. These findings corroborate existing literature supporting GBL environments in the classroom (e.g., as reviewed by Qian & Clark, 2016; Wouters et al., 2013). A key finding is that both games showed statistically significant learning gains for both genders and despite initial gaming experience or genre preferences. This result, supports emerging trends in GBL research that suggests students (both genders) show learning gains in gaming environments (Fraser, 2014; Papastergiou, 2009) and that games, under teacher-led conditions, can produce significant learning gains in a diverse student population (Lester et al., 2014).

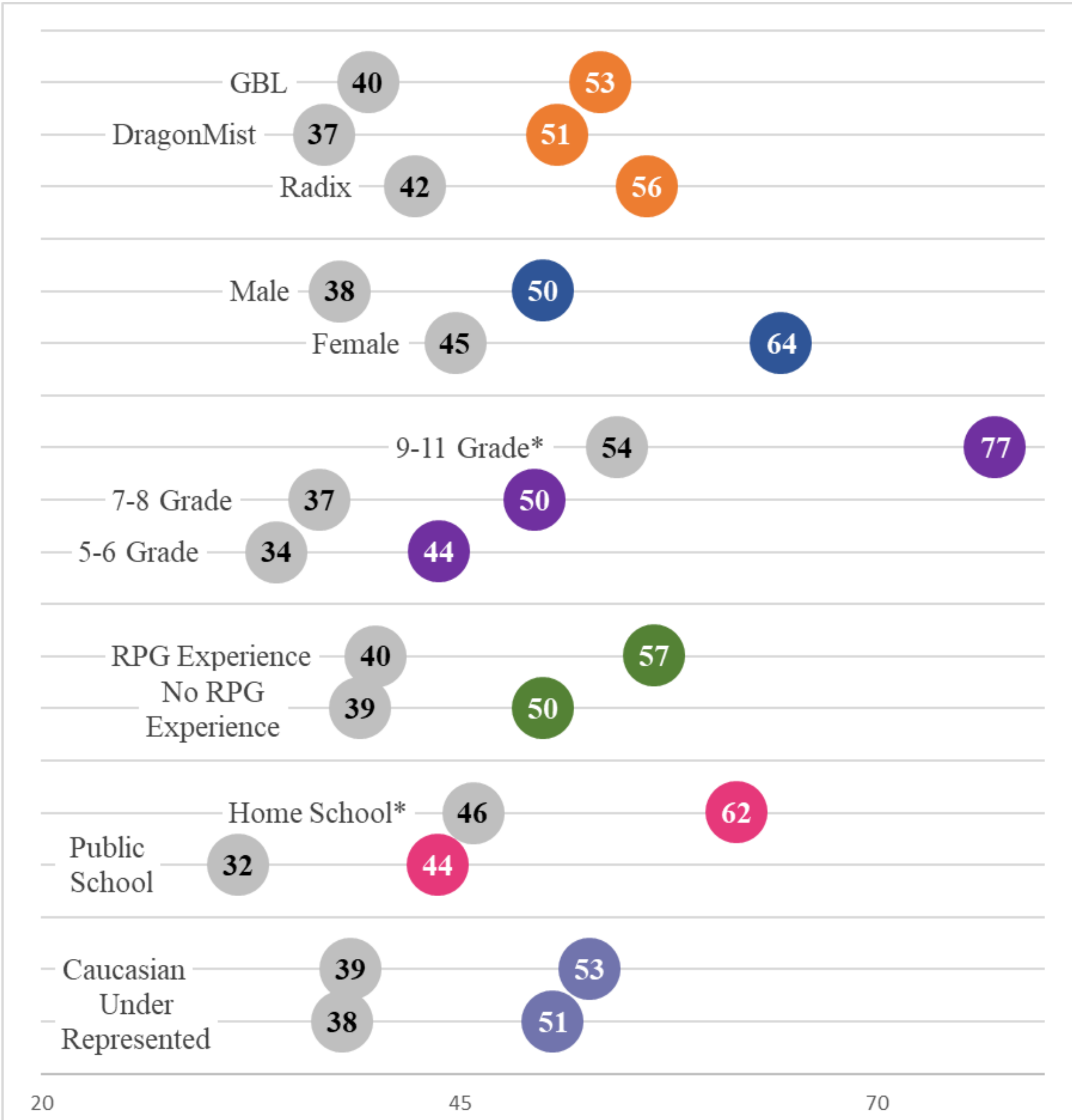


Figure 5.1. Summary of quantitative statistics for genetics pre- post- knowledge mean scores by endorsed demographics (N=29). Knowledge gains after game-based learning (for both games) was statistically significant. All endorsed groups were non-statistically different except for High School (grades 9-11) mean post- scores were higher than the younger groups and the home school group's mean post score was higher than the public-school group.

5.2 Game Design Features Influence Engagement and Learning in Games

5.2.1 Overview and Research Questions Revisited

Educational researchers generally agree that some form of learning occurs while playing games (e.g., Durkin, 2010; Giannakos, 2013; Habgood & Ainsworth, 2009; Spence & Feng, 2010; Young et al., 2012). The effectiveness of GBL depends on the nature of the learning outcomes fostered and the game's features (e.g., Clark et al., 2011; Clark et al., 2016; Hays, 2005; Vogel et al., 2006). Therefore, more research is needed to isolate specific game design features that are relevant to student engagement (Lester et al., 2014). This study investigated game design features that enhanced, or blocked, engagement in educational games by comparing three games (educational, entertainment, modified entertainment) to answer the following research questions.

RQ1. What impact do game design features have on player engagement and motivation in educational games as compared to commercial entertainment games?

RQ2. What impact does the integration of learning content into a game design have on player engagement, motivation and learning?

Relevant to **RQ1** and **RQ2**, an academic quest was designed and developed for a popular commercial game such that a direct comparison to an educational game could be analyzed. The goal of the comparison study was to determine integration of academic content's effect on entertainment value of the commercial game and to identify game design features that could be targeted to improve engagement and motivation in educational games. DragonMist was designed, developed and iteratively refined through extensive play testing and a pilot study. The commercial game, Skyrim, was played numerous times with various character builds to gain extensive familiarity with the game's narrative and mechanics. The Skyrim lore and gamer expectations of Skyrim were researched via online communities, wikis and fandom sites. Dragon lore and avatar race characteristics and naming conventions were researched. This research and extensive connection to Skyrim was necessary such that the genetics quest could be designed to seamlessly integrate academic content into the parent game's mechanics and narrative.

5.2.2 Skyrim, DragonMist and Radix Overall Comparison

The results of the control group (DragonMist → Skyrim) suggest that the academic content was successfully integrated into the commercial game without disrupting the original entertainment value of the commercial game. Reported results demonstrated a non-statistically significant difference in group means for all dimensions of the *Game Play Experience* survey between the two games (Skyrim and DragonMist). With respect to **RQ2**, findings support successful integration of genetics content into an entertainment game that resulted in statistically significant learning gains while maintaining an engagement level comparable to the commercial game. A limitation to generalization of this finding results from the small control group (n=4). However, three participants in the experimental groups were high level Skyrim players (level 86, and levels 50). These three participants were interviewed, informally, after the game play sessions concluded to solicit information about the mod design (DragonMist) and to strengthen the control group findings. All three participants had designed mods for Skyrim and provided insightful comments supporting the successful integration of genetics into Skyrim*'s* mechanics. All three felt that the mod stayed true to Skyrim*'s* narrative and mechanics, and conveyed genetics in an interesting manner. The only suggestion offered was regarding the baby dragon's physics (i.e., the hitbox is too large) causing the game graphics to be glitchy and disrupted immersion of the game.

With respect to **RQ1**, findings show a statistically significant difference between the educational game and the modded commercial game (Radix vs DragonMist) for all dimensions of game play experience. While both games showed significant learning gains and mean learning gains were not statistically significantly different between games; player motivation and engagement were markedly different for the two games. Furthermore, significant associations were found between all game play experience dimensions (except competence). These results suggest that choice of game design features require considerable attention when designing an educational game and are discussed in detail next.

5.2.3 Complex Network of Game Design Interactions

Pearson product-moment correlation was conducted to determine the strength and direction of linear relationships between the dimensions of game play experience as continuous variables. Cohen (1988) provides guidelines for interpreting the strength of the association. The closer the coefficient is to ±1 signifies a stronger association while a coefficient of zero indicates no association between the two variables. A correlation coefficient of 0.10 is small, 0.30 is medium, and 0.50 is large (Cohen, 1988). Determining the strength and direction of the linear relationship in the sample (r = sample coefficient) is the first step. The second step is to determine whether the Pearson's correlation coefficient value is statistically significant. A statistically significant coefficient allows the researcher to reject the null hypothesis and accept the alternate hypothesis that there exists a real association between the population variables.

Pearson correlation coefficients reported in Table 4. 6 demonstrate statistically significant moderate to strong positive correlations between all game play experience except competence. These results support the complex interactive nature of game design. Overall, these results suggest the complex challenge related to combining game design features to create an engaging motivating game that supports academic learning. Significant moderate to strong positive associations between the dimensions of game play experience indicate higher values of one variable are associated with greater levels of the other variables. Competence showed significant small to moderate positive associations with scientific curiosity, state curiosity, information seeking, exploration, situated interest, enjoyment, feedback, immersion, endurability, relatedness and perceived usefulness of the game. The small positive association between competence and autonomy, focused attention and aesthetics (affect) was not statistically significant meaning the linear relationship cannot be generalized to the population (i.e., the *r* value for the association is not statistically significantly different from zero in the population). It is a reasonable finding that aesthetics (graphics, sound, narrative, fantasy, things that elicit emotion in the player) may not increase or decrease as competence changes. However, given the fact that competence is one basic human need required for intrinsic motivation, along with autonomy and relatedness, it is a surprising finding that competence is not associated with autonomy. Focused attention is a component of flow and is considered important to learning and engagement in games (Csikszentmihalyi, 1990). It is also surprising that focused attention was not found to be associated with fluctuations in competence. One explanation for this finding is that only three items on the game play experience survey addressed competence. Future research should investigate competence more thoroughly.

5.2.4 Comparing Game Play Experience Between DragonMist and Radix

Paired-samples t-tests from a cross-over design (see Figure 3.23) were conducted to investigate the game play experience of the two games (education vs modified entertainment) in this comparative study. A Likert scale survey, that probed multiple components of game experience, was used to measure how participants feel after they stopped playing the game on the following dimensions: state curiosity, information seeking behavior, exploratory behavior, situated interest, autonomy, competence, relatedness, enjoyment, immersion, aesthetics (affect), feedback value, perceived usefulness, endurability, and focused attention. All dimensions of motivation, engagement and curiosity were statistically significantly higher for the experimental groups (DragonMist → Radix and Radix → DragonMist) in favor of *DragonMist*. Reported effect sizes for these differences ranged from Cohen's $d = .51$ to 1.13 and provide practical meaning for the results.

Most differences in game play experience reported large effect sizes. Effect size measures the size of associations between variables or the sizes of differences between group means. In other words, significance indicates how likely it is that the difference is due to chance while effect size measures the magnitude of the experimenter effect (how substantially different the two variables or mean differences are). Guidelines for interpreting effect size are according to Cohen (1988). The thresholds for standardized mean difference (i.e., Cohen's *d*) are 0.20 small, 0.50 medium, and 0.80 large. For partial eta-squared, the thresholds for small, moderate and large are 0.01, 0.06, and 0.14 (Cohen, 1988, Miles & Shevlin, 2001).

The dimensions of *Autonomy*, *Competence* and *Relatedness* comprise intrinsic motivation as defined by SDT (Ryan & Deci, 2000). The findings show that motivation was statistically significantly higher for DragonMist than Radix. Autonomy and competence group mean differences were significantly higher for DragonMist with moderate effect size (d = .76 and .51, respectively), and relatedness statistically higher with large effect size (d = 1.03). *Endurability* (intent to play and persistence) was also statistically significantly higher for DragonMist with a moderate effect size (d = .75). These findings support extant literature which suggests players prefer games that offer more freedom, choice and control compared to educational games that maintain student focus on educational objectives by constraining freedom and choice (e.g., Kilmmt et al., 2007; Ryan et al.,2006). Therefore, it was expected that players would also enjoy playing DragonMist more than Radix. This expectation was confirmed as the dimension of *Enjoyment* was also statistically significantly higher for DragonMist compared to Radix and reported a large effect size (d = .94). The correlation between competence with enjoyment and competence with endurability was significant, moderate and positive (r = .3). The correlation between autonomy with enjoyment and endurability was significant, strong and positive (r = .9, r = .8, respectively). Finally, relatedness was significantly, strongly, positively correlated with both enjoyment and endurability (r = .8). Together these findings support a game design that strives to increase intrinsic motivation. When a game is designed to support these three basic psychological needs (autonomy, competence, and relatedness), intrinsic motivation increases, enjoyment increases, and gamers voluntarily spend more time playing the game (endurability).

Intrinsic motivation overlaps with two other important concepts to enhance engagement. Flow and immersion are powerful game design features that are interrelated and complex. Flow theory presents nine components (clear goals, focused attention, loss of self-awareness, temporal distortion, substantive immediate feedback, challenge balanced with skill, sense of control, absorption, and autotelic activity) (Csikszentmihalyi, 1990) and is considered to support intrinsic motivation. Immersion transcends cognitive theories of flow, cognitive absorption and presence (Jennett, 2008). Lower levels of immersion (engagement and engrossment) are sustainable and can be obtained without obtaining total immersion (or Flow,) which is transitory (Jennett, 2009). Flow and immersion are both important considerations when designing engaging games to support learning. Many game design features enhance immersion (e.g., avatar customization, realistic game environment, graphics, sound, fantasy and story, etc.).

All dimensions, related to flow and immersion, were statistically significantly higher for DragonMist, compared to Radix*,* indicating participants obtained higher levels of immersion (engagement, engrossment and/or flow) for DragonMist. Game Play Experience survey dimensions (enjoyment, immersion, aesthetics (affect), feedback value, perceived usefulness, focused attention, and endurability) showed statistically significant higher mean differences in favor of DragonMist with moderate to strong effect sizes (ranging from *d* = .58 for feedback value to *d* = .99 for perceived usefulness). Dimensions of flow and immersion showed significant positive strong associations with large effect sizes ranging from *r* = .65 to *r* = .98. These strong associations confirm the overlap between flow and immersion since increasing one variable is associated with greater levels of the other variables. These results support other literature that indicates games are known to be intrinsically motivating and successfully engaging when they facilitate the flow experience (Kiili, 2005; Salen & Zimmerman, 2004). Additionally, the results reported significant learning gains along with significant levels of flow and immersion which supports other research that found that flow has a positive impact on academic achievement, exploratory behavior, persistence and players' attitudes (Hamari, et al., 2016; Webster et al., 1993). DragonMist was designed specifically to relate learning tasks to the game quest (breed a baby dragon). The goal (baby dragon) was intricately threaded into the Skyrim lore to maintain the flow and immersion of the commercial game. The results reported in this study supports current literature that argues that a major goal for educational game designers is to create games such that the challenges are related to learning tasks and such that flow experience is possible (Kiili, 2005).

5.2.5 Game Log Data

Survey findings are supported by game log data. As seen in figures 4.13 and 4.14, participants completed 34.22% of required genetics tasks for Radix compared to 58.77% of required genetics tasks completed in DragonMist. Other game log data indicates engagement and interaction with DragonMist (Appendix L). Game log data provided by

Radix is geared towards academic assessment, as a tool for teachers; however, these data provide measures of player interactions with the game. Together, these results (self-report survey items and game log files) indicate students were more engaged with and enjoyed playing DragonMist more than Radix while exhibiting non-statistically significant differences in mean learning gains.

Radix is purely educational and presents a greater degree of explicit academic content than DragonMist. It was expected that participants would show larger learning gains for the educational game. However, lack of engagement and reduced endurability with Radix is visualized in Figure 4.13. Radix inserts academic content that breaks flow and immersion by asking players to take in-game quizzes or complete tedious drag and drop assignments (e.g., building Punnett squares). Mean learning gain increases were statistically significant for Radix, but according to the game logs, many participants avoided the learning content altogether.

To maintain flow and immersion, DragonMist elected not to add similar explicit learning tasks to the game play. Rather, DragonMist relied on intuitive learning and curiosity more than explicit text-book style content. The alpha version of DragonMist has several issues known to directly block access to some of the learning content. Despite less explicit academic content and known barriers to some learning objectives, game features that supported motivation, flow and immersion kept participants engaged with the learning content such that they completed more than half of the learning objectives.

These results indicate well-designed games, that support curiosity, flow and immersion, support learning by increasing endurability (intent to play and time spent interacting with the game). Increased endurability then results in greater interactions with the academic content and more meaningful learning. In other words, Radix had more academic content, but the game was not engaging. Therefore, less educational objectives were completed. DragonMist had less educational content but supported flow and immersion such that players persisted in the game environment and more educational objectives were completed.

A key game design feature that supports immersion and emotional attachment to the game; thereby, increasing endurability is the avatar. The avatar is the virtual self and is the players conduit to the game world. One of the most obvious differences between Radix and DragonMist (Skyrim) is the degree to which a player can customize their avatar. Avatar customization is one venue for creativity and self-expression and players often form emotional attachments to their avatar resulting in greater engagement and loyalty to the game. The Game Play Experience dimensions of relatedness and aesthetics/affect both had items related to importance of customization and emotional attachment to the avatar. Relatedness and Aesthetics/Affect were statistically significantly higher for DragonMist over Radix, and with large effect size (d = 1.03 and d = .95, respectively). Pearson's product-moment correlation shows significant positive association between Relatedness and Aesthetics/Affect to all the other game play experience dimensions except competence and with large effect size (range: r = .65 to .98). A rubric, outlining obvious customization points, was used to calculate degree of avatar customization from game screenshots of player avatars as compared to the default avatars in both games. These data, along with time spent creating the avatar, were combined to create a new continuous variable; avatar customization. Pearson's product-moment correlation for Avatar Customization with overall Game Play Experience (engagement) indicates a significant moderate and positive association (r = .316). Linear regression results show that avatar customization accounts for approximately 10% of the variability in overall engagement for both games. Avatar customization is important to overall engagement with the game. Participants played the games in this study for approximately three hours. Longer play time, more interaction with their virtual self, would create greater empathy and emotional attachment to the avatar and the game itself. The player's relationship with the avatar can satisfy the basic psychological need for relatedness and increase positive emotions which are conducive to learning. Additionally, connection to the avatar increases endurability (intent to play) and enjoyment in the game resulting in more exposure to academic content to support successful learning outcomes.

5.3 Game Design, Curiosity and Learning

5.3.1 Overview

The *Zone of Curiosity* is the ideal condition where optimal experience and learning occurs (Day, 1968). Curiosity should be encouraged and supported to enhance learning processes (Spielberger & Starr, 1994). Curiosity is important to educational game design on three levels. First, research indicates dimensions of curiosity impact tendencies to approach, accept and interact with novel, uncertain, or conflicted environments (e.g., Naylor, 1981; Maw & Maw, 1972; Zuckerman, 1964). Dispositional curiosity traits can determine how a person controls, or reacts, to stressful situations, risk and danger. Some dimensions of curiosity increase tension and stress and are considered aversive while other dimensions of curiosity are approach oriented and associated with pleasure, grit, reward seeking and risk taking (Appendix A). Second, curiosity can be considered as a state. State curiosity can be stimulated and supported to increase curiosity related behaviors such as information seeking, exploration, and persistence (Berlyne, 1967). Finally, some research indicates curiosity can be domain specific (James (1890) 1950; Weible & Zimmerman, 2016). Domain specific curiosity is correlated with situated interest as people tend to exhibit curiosity about specific topics that interest them (Peterson & Seligman, 2004). The degree to which dispositional curiosity influences students' acceptance of GBL as a novel learning environment and the degree to which state and domain specific curiosity can be manipulated are not well documented in current GBL literature.

5.3.2 Can Games Heighten Curiosity?

Some research states prior knowledge is required to incite curiosity (Loewenstein, 1994). Results of linear regression analysis between pre-genetics knowledge scores and reported state scientific curiosity post game play suggests the two variables are not associated. Therefore, these findings corroborate Gottlieb et al. (2013) findings that suggest curiosity, given appropriate stimuli, can be evoked without prior knowledge. Key findings of this study, related to **RQ4** (Can game design features heighten curiosity towards integrated learning content?), support the notion that games can incite state curiosity and lead to increased information seeking and exploratory behaviors as well as increased persistence. After playing DragonMist, participants showed statistically significant increases in situated interest, general state curiosity, domain specific scientific curiosity, information seeking behaviors and exploratory behaviors.

Another key finding is that participants showed significant increases in state scientific curiosity after playing DragonMist compared to pre-curiosity scores ($d = .39$) while participants showed significant decreases in state scientific curiosity after playing Radix compared to pre-curiosity scores ($d = .73$). The mean difference in the game's effect on scientific curiosity between DragonMist and Radix was statistically significant with a large effect size ($d = 1.09$). This result supports the importance of game design features related to interest and domain specific curiosity. DragonMist was designed to directly match the learning objectives provided in the teacher dashboard for Radix. Therefore, the difference between the two games was how the academic content was presented. DragonMist was designed to ensure the academic knowledge was directly connected to, and necessary for, quest completion (breed a baby dragon). Academic content was seamlessly integrated into the narrative and mechanics of the commercial game in a manner that did not disrupt the original entertainment value as demonstrated by the control group results. DragonMist did not present academic content as an interruption to the game play (e.g., quizzes and purely academic tasks); thereby, maintaining flow and immersion. Additionally, DragonMist was designed to provide intuitive learning supported by a more-knowledgeable-other designed to evoke and reward curiosity.

These findings suggest the game's design features are critical to, not only player motivation and engagement, but for learning and scientific curiosity as well. Increased scientific curiosity and sustained interest leads to exploration and information seeking in peer-level online communities external to the game, resulting in deeper more meaningful learning (Arnone et al., 2011). Successful commercial games use design features that incite, support and reward curiosity to increase player loyalty and endurability (Howard, 2016). In other words, the commercial game industry wants the players to keep playing so they keep spending money. Educational games should focus on evoking and rewarding curiosity to enhance learning. A well-designed educational game can extend academic learning beyond mere memorization of academic facts to develop higher order thinking skills that support curiosity and deeper learning.

5.3.3 Does Personality Matter? Examining Dispositional Curiosity.

For GBL to be effectively used in classrooms, game designers must understand how to design engaging games that support learning. However, effective intervention strategies are equally important. Therefore, educators should understand how a diverse student population tends to approach and accept novel uncertain learning environments such as games. With respect to **RQ5** (Does an individual's trait curiosity influence how they approach a novel learning environment (GBL) and then influence interactions, engagement and motivation within that environment?), results indicated significant moderate positive associations between certain dispositional curiosity traits and variables of game play experience (see Figure 5.2).

Hierarchical multiple regression allows the researcher to predict a dependent variable based on multiple independent variables and answers the question "how much extra variation in the dependent variable can be explained by the addition of one or more independent variables?" usually expressed as the increase in R^2 and the change in R^2 (i.e., added unique variation in the dependent variable) (Laerd Statistics, 2016). First, models were compared and evaluated to determine the best fit for the data (i.e., proportion of variance explained, change in R^2 from previous model, and statistical significance). Next, coefficients of the regression model were interpreted and reported. The goal of this study was to understand the proportion of variance explained by adding independent variables. Therefore, R^2, as an explanation for variability in the dependent variables (dimensions of game play experience) associated with factors of dispositional curiosity, will be discussed here.

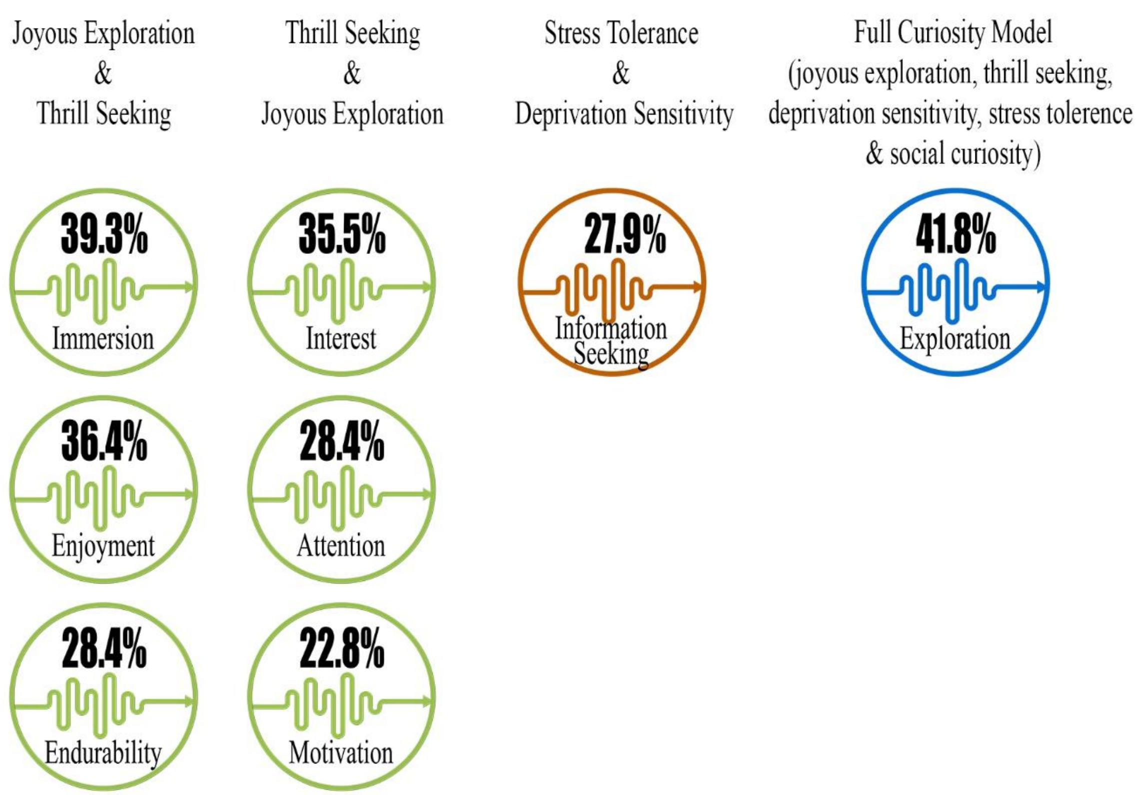


Figure 5.2. Hierarchical Multiple Regression Results Demonstrate the Amount of Variance in Engagement Explained by Dispositional Curiosity.

It was expected that persons with high dispositional tendencies towards *Joyous Exploration* and *Thrill Seeking* would demonstrate higher levels of engagement with the games in this study. Joyous Exploration (JE) is the dictionary definition of curiosity and is strongly correlated to motivation to seek out knowledge and new experiences. Reward seeking is inherent to JE (Kashdan et al., 2018). Thrill Seeking (TS) is strongly correlated with willingness to tolerate volatility, uncertainty, ambiguity and sensation seeking (Kashdan et al., 2018). Both, joyous exploration and thrill seeking are associated with approach tendencies and increased grit and feelings of pleasure (Kashdan et al., 2018).

Game play experience dimensions of enjoyment, motivation (autonomy, competence, relatedness), immersion, situated interest, focused attention, and endurability, were moderately to strongly, positively significantly associated with joyous exploration and thrill seeking, accounting for between 22% to 39% of the variability in engagement (see Figure 5.2). Game design features that enhance immersion and flow (e.g., rewards, aesthetics/affect, realistic 3D environments, complexity, interesting quests, challenge and goals) would naturally appeal to individuals high in joyous exploration and thrill-seeking tendencies. Since joyous exploration and thrill seeking are both associated with grit and pleasure, it follows that endurability and enjoyment are associated with these dispositional curiosity factors. JE accounted for most of the variability in immersion, enjoyment and endurability. Immersion and enjoyment were shown to be significantly positively correlated with large effect size (r = .93). Endurability and enjoyment were significantly positively correlated with large effect size (r = .98). Therefore, individuals with high levels of joyous exploration would naturally engage with immersive games and experience the related outcomes of positive emotions and increased interactions with the game.

Thrill seeking accounted for most of the variability in situated interest, focused attention and motivation (see Figure 5.1). Intrinsic motivation, interest and focused attention are all components of flow state. Results show a significant positive correlation between motivation and situated interest as well as motivation and focused attention with large effect size ($r = .94$ and $r = .95$, respectively). Thrill seeking tendencies to approach and willingly interact with uncertainty and ambiguity supports player engagement with the novel situations and uncertain outcomes that make games fun.

The archetype of a highly curious person, high JE and TS and ST, possess psychological strengths that enables exploration, discovery and passionate interests (Kashdan et al., 2004; Mussel, 2013; Silvia, 2008). In support of that literature, the findings in this study suggest an individual's dispositional JE and TS influences their tendency to adopt and/or engage with an educational game as well as the player-game interaction and outcomes. The factors of engagement (immersion, enjoyment, endurability, interest, attention and motivation) that are associated with dispositional curiosity tendencies (joyous exploration and thrill seeking) are strongly correlated. These findings demonstrate the complex relationship between game design features, curiosity, personal preferences and personality. However, other factors also contribute to the game-player experience. In other words, a naturally curious student may approach and engage with a novel learning environment more readily than less curious students to some degree. Other factors that contribute to the game play experience may be personality traits, unrelated to curiosity, such as preferred learning styles and game play motivations as well as goal orientation and perceived purpose of the game itself. Educators could increase engagement with the game by supporting various learning styles and student goals. Game designs could support varying levels of joyous exploration and thrill seeking by providing a variety of rewards and goals that are directly associated with the learning content, as well as designing quests with different degrees of perceived danger and risk.

Deprivation sensitivity (DS) is strongly correlated to epistemic curiosity and is positively associated with both adaptive and maladaptive outcomes. DS is about seeking information to escape tension of an information gap and is strongly correlated with anxiety (Berlyne, 1954; Kashdan, et al., 2018). Stress tolerance (ST) is strongly correlated, inversely, with need for closure and strongly associated, inversely, with maladaptive outcomes such as experiential avoidance, distress tolerance and psychological inflexibility (Kashdan et al., 2018). Information seeking, was moderately, positively significantly associated with deprivation sensitivity and stress tolerance, accounting for 28% of the variability in information seeking behaviors. These findings suggest an individual's DS and ST may influence their tendency to engage in curiosity related behaviors while playing educational games to some degree. Individuals high in deprivation sensitivity place importance on epistemic curiosity. These students engage in information seeking behaviors to escape the tension of not knowing (Berlyne, 1954). Kashdan et al. (2018) aligns high DS with problem solvers. Individuals high in stress tolerance can cope with the anxiety and stress related to the uncertain ambiguous nature of games and will persist in information seeking behaviors to resolve information gaps and resolve conflicts.

Students with high deprivation sensitivity and/or low stress tolerance may experience increased tensions and anxiety and exhibit maladaptive outcomes of inflexibility, distress and avoidance. DS and ST accounted for 28% of the variability in information seeking in DragonMist. For educational games, students may target learning goals more so than game related goals and may perceive higher stakes related to failure when learning is the intended purpose of game play. Therefore, information seeking may be prompted by epistemic curiosity and aversion approach (reduce anxiety of not knowing) in educational games. Games are uncertain environments that contain risk, ambiguity and complex problems which may increase the associated tensions of deprivation sensitivity and maladaptive outcomes related to low stress tolerance. In practice, students known to have low stress tolerance or high deprivation sensitivity tendencies should be supported in a manner that relieves stress and anxiety by emphasizing low stakes failure inherent to games and unexpected in a typical classroom. Practitioners could minimize stressful outcomes from uncertain novel learning environments by providing scaffolds and tutorial phases to reduce the stress related to unfamiliarity or low confidence with game play or by encouraging collaborative play such that these individuals have extra support. Often, games encourage tinkering, experimentation and trial and error using low-stakes failure scenarios to add fun, value and encourage creative problem solving. Students focused on relieving anxiety of gaps in their information (high DS) or those with low ST, may enjoy more clearly defined goals and problems with more explicit scaffolding to support learning.

The full model for dispositional curiosity (JE, TS, DS, ST, & SC) accounted for 42% of the variability in exploration. This finding is reasonable because DragonMist was specifically designed to encourage and support exploration and curiosity. DragonMist is a quest within Skyrim which is an extremely open world designed to evoke and reward curiosity. The lead designer, Todd Howard, created Skyrim to be “the most open of open worlds” to encourage exploration and discovery and “stimulate and reward curiosity in every way possible” (Howard, 2016).

Finally, social Curiosity (SoC) is strongly correlated with the tendency to gossip and is positively associated with both adaptive and maladaptive outcomes and inversely associated with autonomy. SoC has only recently been seriously considered as a factor of curiosity (Litman & Pezzo, 2007) and downstream consequences are unknown (Kashdan et al., 2018). SoC was not significantly correlated with any of the game play experience dimensions except for *Exploratory Behavior* where the full model (JE, TS, DS, ST, and SoC) accounted for 42% of the variability. This finding suggests that social curiosity is not a primary consideration when designing educational games. However, a student known to have tendencies towards high social curiosity, and inverse associations with autonomy, may have lower motivation to interact with GBL environments unless collaboration and/or a multiplayer version of the game is available. More research is needed to determine if dispositional social curiosity is relevant to GBL.

5.3.4 Conclusions

In conclusion, regardless of the exact nature of expected learning outcomes, the ability for any educational tool to produce improved learning is dependent upon student motivation and engagement (Sabourin and Lester, 2014). However, some researcher perspectives indicate learning and engagement are opposed outcomes in games; increasing learning decreases engagement and increasing engagement decreases learning (Cheng et al., 2014; McNamara et al., 2009; Rai et al., 2009). In contrast to this perspective, the results of this study indicate it is possible to design a game that can educate and entertain simultaneously. Moreover, when the targeted learning outcome is defined as curiosity and related behaviors (information seeking, exploration, and persistence), games support deeper understanding and learning by inciting, supporting and rewarding state and domain specific curiosity.

For successful implementation of GBL into the classroom, well-designed games must be available. Complex games require large budgets and many years to produce. Often, these games are not engaging, and students do not voluntarily interact with the games. It is important to identify game design features that either enhance or inhibit learning, curiosity and engagement in educational games to produce good games while maintaining reasonable budgets and time frames. In support of previous research that showed positive learning outcomes and increased engagement from a mod designed to teach History (Charsky & Mims, 2008; Squire, 2004), the results of this study suggest that modding an existing commercial game is a viable option. Mods can be created relatively quickly and on minimum budgets because they build on a more powerful successful model. DragonMist demonstrates a promising first step towards successful integration of academic content into an existing commercial game. The results indicate students' learning gains were equivalent to those gained from a grant-funded, team designed educational game. Additionally, DragonMist showed statistically significant gains in scientific curiosity. Finally, all dimensions of motivation and engagement (flow and immersion) were statistically significantly higher for DragonMist compared to Radix. Increased immersion and flow are positively correlated with greater endurability (persistence and intent to play), which in turn results in more exposure to the educational content and potential for learning.

The quantitative results present valuable insight into key game design features that should be considered to create well-designed educational games that elicit voluntary play and support learning. One limitation to the study's findings results from the time constraints of the study. Most gamers, who enjoy RPGs and/or MMORPGs, spend countless hours, over months and years, engaging with the game while this study limited play time to three hours. Some behaviors and game play experiences may be strengthened, or weakened, with more time interacting with the game. For example, greater time spent in the game would strengthen emotional attachment and may lead to greater information seeking, exploration and even greater persistence in the game. However, as the novelty effect wears off, some players may become less interested and move on to unexplored activities. Qualitative results enrich these quantitative findings and are presented in the next chapter.

CHAPTER SIX

PRESENTATION OF QUALITATIVE DATA

6.1 Qualitative Data Analysis

Qualitative data were collected via observations and field notes, open response questions, and focus groups (audio recordings) to answer the following qualitative research question: (**RQ3**) How does the game's design influence the game play experience and learning outcomes from the player's perspective when playing an educational game compared to an entertainment game?

Data were coded on two contextual dimensions (DragonMist, Radix) using a systematic, iterative approach until all files were exhaustively coded and accurate (Creswell & Plano Clark, 2018). Thematic analysis identified five themes (intrinsic motivation, flow/immersion, curiosity, learning, and popular game design features). A taxonomy was created for each theme to show dimensions (organizing themes) of the theme and codes used as evidence for that theme. Thematic data were analyzed for GBL and then independently for each game (DragonMist, Radix) to explore relationships and contrasts related to players' interactions with each game.

6.2 Theme One: Intrinsic Motivation:

6.2.1 Introduction and Overview of Intrinsic Motivation Theme

One intent of this study is to explore the characteristics of the games that participants perceived as motivating. Self-determination Theory (SDT) is based on positive psychology and describes human motivation (intrinsic and extrinsic). SDT also relates the innate tendency to satisfy three basic needs (autonomy, competence and relatedness) for well-being and positive emotions conducive to intrinsic motivation (Ryan and Deci, 2000). Individual preferences and personality influence how, or if, they interact with certain games. However, when the game design satisfies basic human psychological needs for well-being and happiness (autonomy, competence, and relatedness), player intrinsic motivation and positive emotions are enhanced. The theme of *Intrinsic Motivation* consists of three dimensions (autonomy, competence, and relatedness) (see Figure 6.1). Overall, intrinsic motivation for the game-based learning intervention shows that all three dimensions of motivation were expressed by the participants. Table 6.1 lists examples of data evidence that supports the intrinsic motivation theme perceived as autonomy, competence and relatedness.

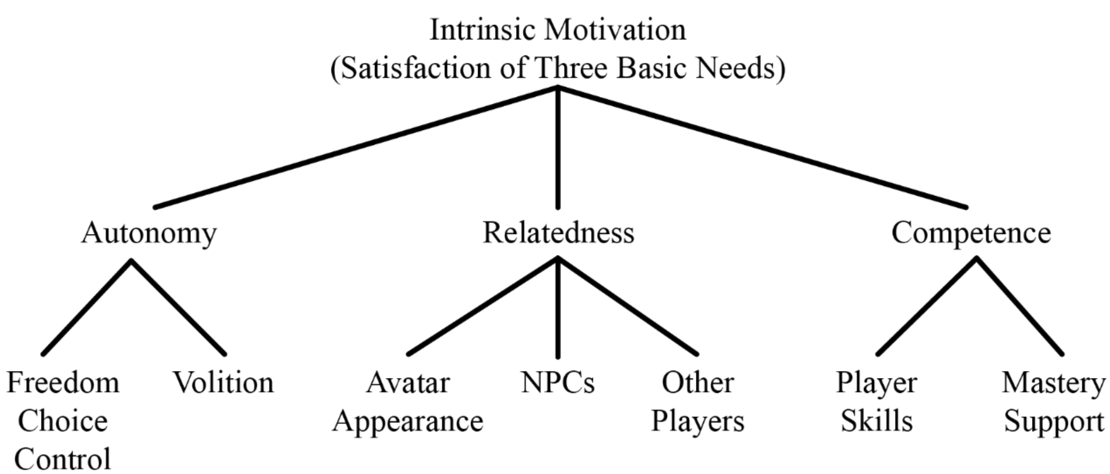


Figure 6.1. Taxonomy of Intrinsic Motivation Theme with three dimensions (autonomy, competence, relatedness).

Table 6.1

Intrinsic Motivation Theme: Autonomy, Competence and Relatedness Dimensions.

Autonomy: freedom, control, choice, volition

(positive sentiment: DragonMist)

"How can I get back to the temple, I want another fire dragon" (Gulum-Mere)

(negative sentiment: DragonMist)

"I could not go everywhere I wanted because there were people there who wanted to kill me."
(Syncette)

Competence: Clear goals, instruction & direction, opportunity for mastery, skills

(positive observation: Radix)

She started the quest and spent a lot of time reading the NPCs' dialog and used the internet to look up genetics (YeeHaw)

(negative sentiment: Radix)

"I am not sure what this lady wants, she told me to breed flowers but that is confusing because you don't breed flowers, do you?" (Zayna)

Table 6.1

Intrinsic Motivation Theme: Autonomy, Competence and Relatedness Dimensions.

Relatedness: Care for, help, belong, you are important, hero's journey

(positive sentiment: DragonMist)

"I did not want to be human because the lizard is way cooler and I could use so many colors. Look at my head, I have yellow feathers. I look silly" (Tslez'k)

(negative sentiment: Radix)

"I don't like that there are no realistic skin tones to choose from, I want dark skin like mine"
(Ahendria)

Figure 6.2 shows player's perceptions of intrinsic motivation (autonomy, competence, and relatedness) for DragonMist and Radix. Four students in the control group (IDs 111, 112, 123, & 126) did not play Radix and are represented as missing data. Other missing data indicates no participant response and no observation for that participant for that code. Participants moods, attitudes and perceptions vary and game situations and challenges vary. This variation, in game and player, results in some mixed sentiment and is represented as mixed data in Figure 6.2. Results of each dimension of intrinsic motivation (autonomy, competence, and relatedness) are presented next.

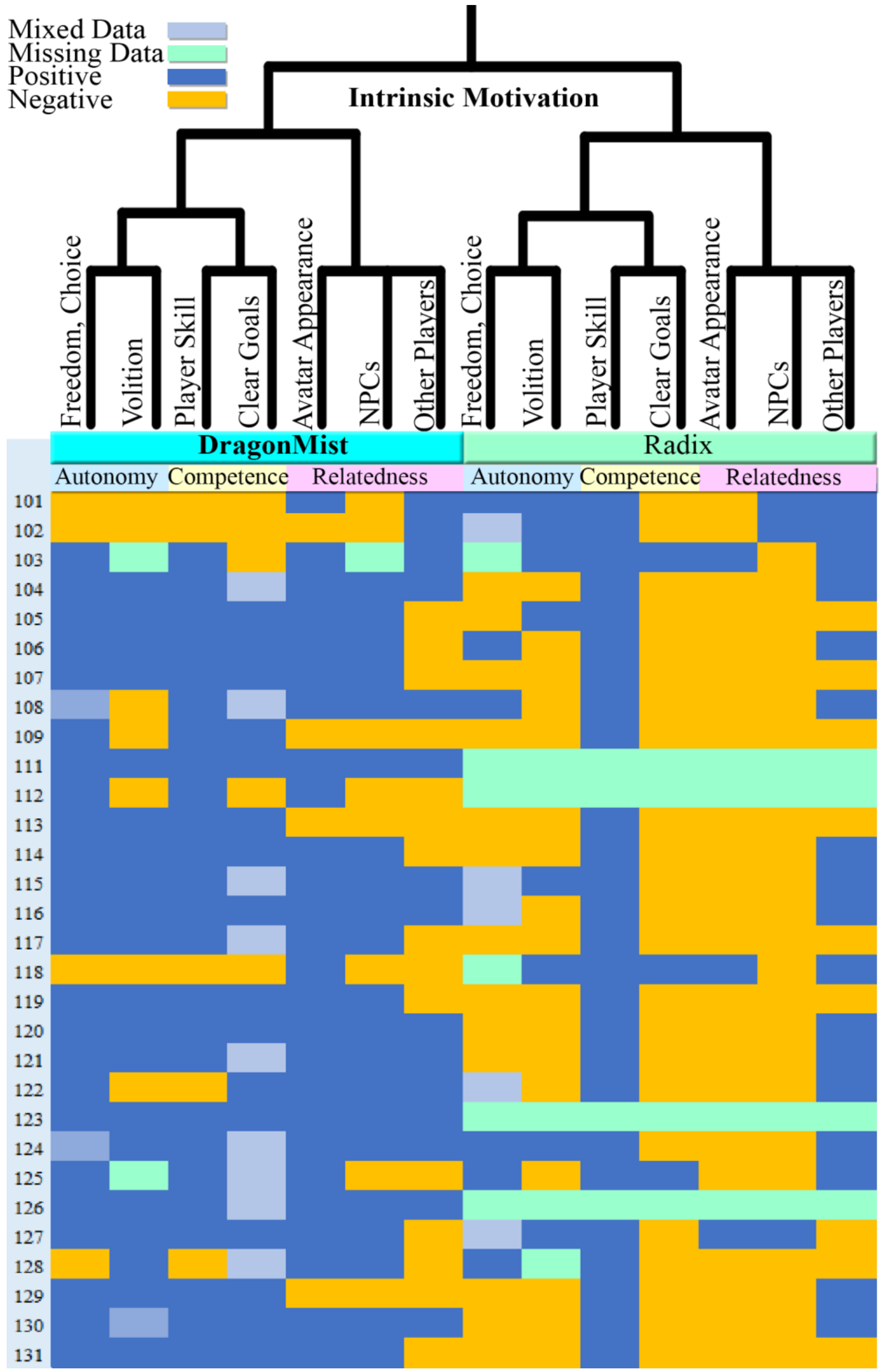


Figure 6.2 Heatmap Visualization of Intrinsic Motivation, autonomy, competence, relatedness, is one theme that emerged from the data for DragonMist and Radix.

6.2.2 Autonomy

Autonomy refers to “regulating one’s own behavior and experience and governing the initiation and direction of action” (Ryan & Powelson, 1991, P. 52). Provision of the *paradox of control* is important to motivation in the uncertain environment of games (Csikszentmihalyi, 1990, p. 58). In other words, learners need to perceive that they have control over the environment and that they have meaningful choices. Educational game designs that constrain freedom and choice negatively impact autonomy.

Qualitative data were coded for expressions of perceived autonomy described as feelings of freedom, choice and control and/or volition (self-determined actions *vs*. required actions). Both positive and negative sentiments regarding autonomy were documented for both games (see Figure 6.2). Freedom, choice and control were often listed when participants were asked what they liked most about the game they played. Most participants perceived freedom, choice and control while playing DragonMist: “I liked creating dragons, being able to freely go through quests, and customizing” (Dundi). Participants expressing negative freedom, choice and control often expressed their desire to avoid violence but believed they had no choice or control to do so: “I was going to leave the wolf alone, but my guide killed it, why did he do that?” (Ancosa). Most of the participants did not perceive autonomy while playing Radix. Much of the negative sentiment derived from lack of travel options and numerous load screens. NPCs ask the player to travel to locations to pick flowers and return to them. This game mechanic creates repetitive travel to and from the same locations with numerous load screens: “The load screens are too slow; I wish there was a way I could just fast travel” (Mukmog).

Several other participants indicated lack of choice of quests: “I don’t have any freedom to do what I want to do you just collect animals or do educational stuff there is nothing else to do” (Teela). Negative sentiments for volition were also prominent in Radix where participants indicated (verbally or behaviorally) they would prefer to engage in a different activity. Overall, most participants perceived more autonomy, on both levels (freedom, choice, control and volition) for DragonMist while expressing negative autonomy on both levels for Radix.

6.2.3 Competence

In addition to autonomy, intrinsic motivation requires a “sense of accomplishment and effectance” (Ryan & Powelson, 1991, p. 52). Players must believe they can move towards mastery. In other words, they must perceive clear attainable goals which requires adequate instruction, direction and support from the game. Flow requires attainable challenges, based on player skills, with uncertainty of outcomes (Csikszentmihalyi, 1990). Therefore, there is some overlap between competence and flow. To explain the data, efforts were made to separate these two concepts as much as possible while building the themes. Competence was described as evidence of ability to navigate the game successfully (player skill) and perceived ability to achieve mastery (mastery goals) supported by clear instructions, directions and scaffolds for required tasks (usability of the game).

Figure 6.2 shows perceptions of competence for the two games. With respect to player skills in DragonMist, most players successfully navigated the game world except for technology difficulties due to controller sensitivity. The five participants who expressed negative perceptions of competency in DragonMist primarily focused on low skill required to defeat enemies which is often required for progress: "I am not good at fighting games, but I want a pet dragon" (Vallinalda). Many of the participants had mixed perceptions of competence in DragonMist regarding mastery goals and clear instructions. Some participants perceived low competence early in the game and as they gained experience, they perceived more competence. For example, Stryker asked how to use the dragon breeding station because he didn't understand the menus (user interface). Later in the game play session, Stryker called me over to say:

> Now that I have more experience with the dragons, I understand the pet dragon better. I think I would like it better if I could have done the Whiterun dragon quest first and read more of the dragon lore and then start breeding dragons, it would have made more sense.

Observations for competence in Radix showed primarily positive sentiment related to player skills required for the simple game mechanics. Low competence, in Radix, resulted from confusion or frustration due to lack of instruction, direction and/or few opportunities for mastery. For example, during the focus group in response to "describe what you did not like about your least favorite game", Ching-Chong replied "ah its ah Radix and how there is barely anything to do and ahm I … ah… its **NOT FUN,** all it is is its just like there's **NOTHING"** (threw his hands up in the air and made a face).

In summary, most participants were confident in their skills to play DragonMist but expressed mixed feelings regarding ability to achieve mastery or perception of clear instructions or scaffolds to do so. Lack of fighting skills and controller sensitivity negatively influenced perception of competence for DragonMist. All participants perceived high competence regarding player skill in Radix. This results from the simple game mechanics that primarily require walking, talking to NPCs and collecting items. However, most participants expressed low competence regarding mastery. Most participants were confused due to lack of clear instruction and lack of purpose: "I got confused and didn't know how to complete a quest" (Stryker).

6.2.4 Relatedness

Self-determination theory defines relatedness as the importance of building positive interpersonal relationships, the feeling of belonging, acceptance and support (Ryan & Deci, 2000). In games, the concept of relatedness is extended to include relationships among players (Ryan, et al., 2006) and virtual relationships inside the game (NPCs, avatar) (Bachen et al., 2012, Yee, 2006). Relatedness, in games, can be promoted by a popular game design feature, the hero's journey, that creates a feeling of belonging and fulfils the need for altruism (helping others). The avatar and NPCs in the game influence perceptions of relatedness. Avatar customization emerged as a popular game feature and relates to several themes in this study (Appendix N). The player's relationship with their avatar is a complex interaction influenced by multiple motivations (Yee, 2006; Yee, Bailenson & Ducheneaut, 2009). Detailed understanding of player motivations regarding avatar customization is beyond the scope of this investigation, but certain key patterns surfaced in the data with respect to relatedness and flow/immersion. Evidence that the avatar's appearance (physical features) and abilities (strategic customization) are coded for the *Intrinsic Motivation: Relatedness* theme. Interactions with the avatar that increase immersion and flow, will be discussed in greater detail in the *Flow/Immersion* theme.

Evidence of relatedness in the data results from in-game play (the player specifically wanted to help NPCs, hero's journey), identifying with the avatar (caring about the avatar's appearance and skills, customization), or from relationships external to the game (classmates, teachers, researcher). DragonMist is a single player game, but participants were encouraged to collaborate with classmates if they chose to. Approximately half of the participants played, physically, with a classmate. Others chose to play solo. During the focus group, in response to "how would you improve the game?", the desire for a multiplayer option was expressed: "It would have been nice if DragonMist had been multiplayer" (BeastMode), "Yeah, because it is hard to fight off… like when you are bad at combat" (Vallinalda), "yeah, you could have helped each other like fight people because it is kind of hard as a solo" (BeastMode).

Radix is a MMOG (massively multiplayer online game) and relatedness was a prominent motivator for the Radix game. Nine participants chose to play Radix solo, and the other participants chose to play in groups. Radix provides in-game chat and email and the players' avatars can interact to solve quests together. This game feature was popular in Radix but was associated with two opposing outcomes related to learning. Some participants used the multiplayer function to increase learning and understanding: Glum-Mere and Talen-Zaw were observed using the chat and email functions to give each other resources, discuss how to use the tools, where to find things and the genetics concepts. On the other hand, the social aspect of Radix often led to off-task behavior that was a barrier to learning. For example, Dragonia announced to the class "hey everyone, I am the guy in blue, if you want to play together" Soon after, four participants were observed laughing, talking and enjoying the game. However, closer observations revealed they were using chat and email to "spam f" and to poke fun at each other, "where are you going bot?" Additionally, they were observed avoiding the genetics quests in leu of playing *hide and seek* in the game environment.

Players also perceive relatedness internal to the game via NPC interactions. Most participants expressed feelings of importance (hero's journey) or altruism (desire to help the NPCs) in DragonMist: "I can't get out [of the cage] and my friend who I was supposed to help is going to die because he has to fight all the bad guys by himself" (Nedthroth). However, some participants did not feel related to the NPCs or chose to ignore them: "Faralda is NOT telling me anything useful so I decided to light her up with my flames (laughing)" (Tslez'k). Most of the participants chose to ignore NPCs in Radix except for required interactions for the learning tasks. However, in the focus group, in response to "What did you like about the game", one participant expressed positive sentiment for NPC relatedness in Radix: "I liked that I could help the people" (Yee Haw).

Also, during focus group, in response to "What did you dislike about the game", one participant responded: "I didn't like that the people are so needy, and they can't do anything for themselves" (Katniss). Even though Katniss did not like the neediness of the people, it shows relatedness to the NPCs.

Finally, avatar customization emerged as important when players were asked to describe features that they liked most about the game and during observations of the game play sessions. Avatar customization provides players with a creative method for self-expression as they participate in games. The avatar-player relationship influences emotions, behaviors, engagement, and learning in games (Yee, 2006; Yee, Bailenson & Ducheneaut, 2009). The degree of importance attributed to the avatar across several themes requires a detailed presentation of the data.

Participants took between five and ten minutes to create their avatar for Radix. None of the participants discussed the customization with their classmates or with me. Most of the participants accepted the assigned default character name. Therefore, the table uses their chosen DragonMist avatar names. Figure 6.2 shows that most participants did not perceive a sense of relatedness attributed to avatar appearance while playing Radix. The avatar customization window, along with default avatar, for Radix is shown in Figure 6.3. Only three participants indicated that avatar appearance was important. Two of these participants expressed dissatisfaction with avatar customization. Table 6.2 shows examples of data coded for relatedness connected to avatar appearance customization in Radix.

Figure 6.3. Avatar customization and default avatar for Radix.

Table 6.2

Player Avatar Customization and Perceived Relatedness for Radix

Default Avatar	Player Avatar	Player Perceptions
		In response to the open response question: Describe three things that you liked most about the game. "I liked that I could customize my avatar" (Yee Haw)
		During the game play session, Lareia complained that the skin tones were not realistic, and she could not make the avatar look like her. Ahendria, was playing Radix with Lareia and she also complained about the unrealistic skin tones.

Participants took fifteen to seventy-five minutes to create their DragonMist avatars. Avatar creation was the impetus for lively conversation and showing off (sharing their avatar with classmates and with me). Many participants discussed avatar skills and traits and wanted to show me their avatar at each stage of customization. Figure 6.2 shows that all but four participants (who chose the default avatar, or the only customization point was race) assigned importance to avatar customization and perception of relatedness via avatar appearance and/or skillsets while playing DragonMist. Figure 6.4 shows the DragonMist (Skyrim) avatar customization menus with the default avatar. There were two Nords, two Redguards, three Orcs, two Khajiit, two Imperials, two Dark Elves, three High Elves, three Breton, and eleven Argonian playing DragonMist during the three video game camps. Table 6.3 shows examples of data coded for relatedness connected to avatar appearance in DragonMist.

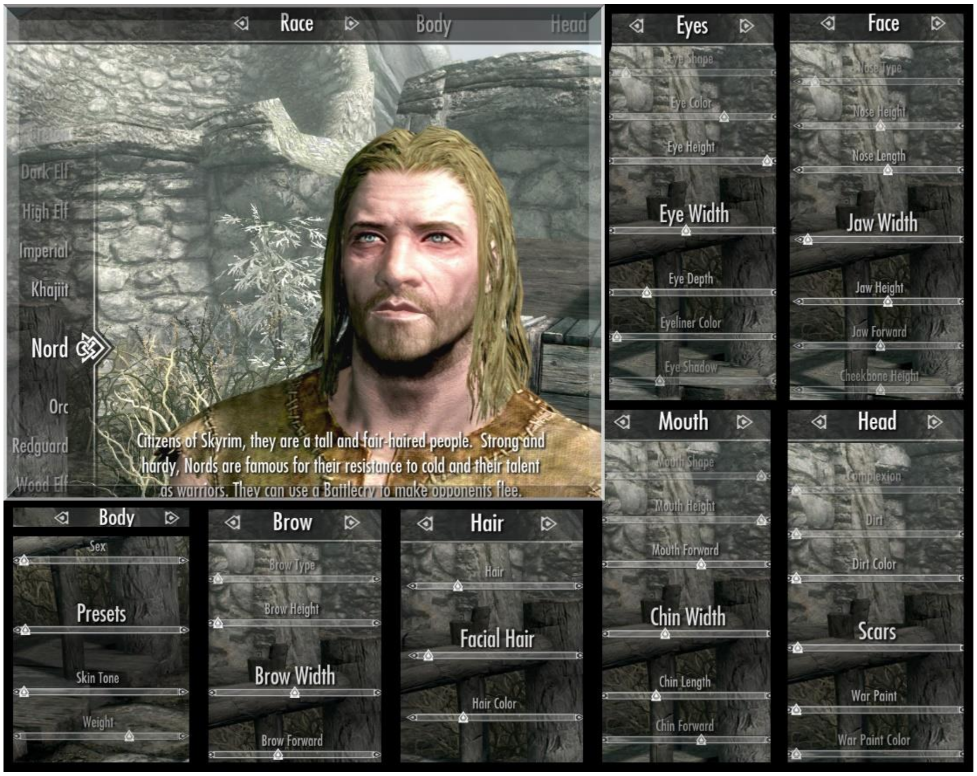


Figure 6.4. Avatar customization menus for Skyrim / DragonMist showing default avatar.

Table 6.3

Player Avatar Customization and Perceived Relatedness for DragonMist

Default Avatar	**Player Avatar**	**Player Perceptions**
 Default Redguard		Dundi called me over to show me his avatar. He said "I like him, he is really cool. I really like that I can customize him to look like me" Open Response Question: Describe what you liked about the game: "I liked that I could customize my avatar"

Default Argonian

"Look at all the colors I can use. See the feathers, aren't they cool? I am a *cool lizard thing* and I am going to make him really fat and strong" [*participant emphasis*] (Dragonia)

Default Imperial

Dill Pickles called me over to show me his avatar. He said "I named my guy Dill Pickles, that is *really funny* – right? [*participant emphasis*]

Open Response Question: Describe what you liked about the game:
"I liked that I could customize my avatar"

Default High Elf

Vallinalda spent over an hour on her avatar and the hair style is much like her real hair. She said "I am sorry I am taking so long to create her but there are so many choices and I want her to look just like me"

Default Dark Elf

Rytoth was interested in the appearance of the avatar and the race specific skills. He called me over to tell me "I like the dark elf because he has ancestor's wrath – he can surround himself with fire and anyone who gets close will be destroyed"

Default Argonian

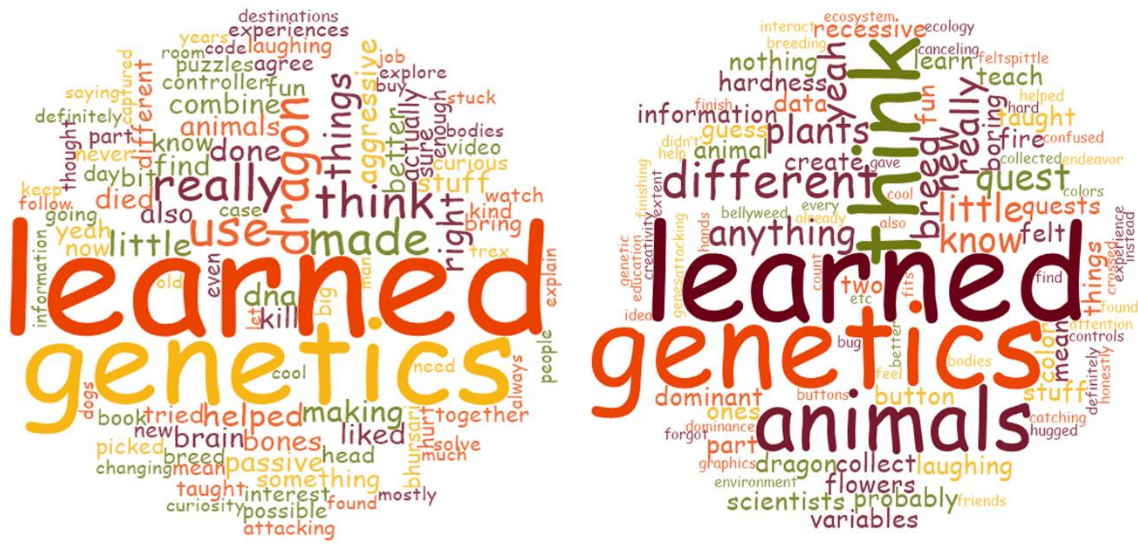
"I always play Argonian because you get a lot more skills and you level up faster. Look at his strengths – this is why I choose him" (Asdolufiene)

In summary, relatedness was perceived in both games, but the source of relatedness was different. In Radix, which is a multiplayer game, most participants chose to play in the game with other students. For Radix, most of the participants did not relate to the NPCs in the game beyond required genetics information and only three participants indicated the appearance of the avatar was important. Conversely, in DragonMist all but four participants indicated avatar customization and the NPCs were important to their game play experience. DragonMist is a single player game, but about half of the participants chose to play (physically) with each other. Several others, who were physically separated from others in the computer lab, indicated their preference for multiplayer options.

6.3 Theme Two: Learning in Games

Most researchers agree that commercial games are naturally engaging and motivational, and that learning occurs in game play (e.g., Gee, 2007; Squire, 2011). Educational researchers generally agree that some form of learning occurs while playing games (e.g., Durkin, 2010; Gee, 2008; Giannakos, 2013; Habgood & Ainsworth, 2009; Young et al., 2012). The effectiveness of GBL depends on the nature of the learning outcomes fostered and the game's features (Clark et al., 2011; Clark, Tanner-Smith, & Killingsworth, 2016).

Participants were asked to describe what they thought they learned while playing the games in this study (open response and focus group). Player's perceived learning from the two games is shown in Figure 6.5. During the open response and focus groups, participants were asked to describe what they thought they learned from the games, and which game taught them more about genetics. Participants' perception of learning varied greatly according to their responses. Perceptions of learning for both games included: nothing, how to play the game, genetics, problem solving, and other areas of interest representing transfer of knowledge to other contexts.



Perceived Learning DragonMist   Perceived Learning Radix

Figure 6.5. Word clouds showing perceived learning for DragonMist and Radix

Responses varied among the participants for Radix. Ryker, Jaeger and Talen-Zaw felt like they learned how to play the game (e.g., "I learned how to play the two games and the controls" Talen-Zaw). However, most of the participants believed they learned genetics to some degree while playing Radix. For example:

> For Radix I felt a lot of learning, I learned that there is a lot of genetic variables and I learned what recessive and dominant was and what helped to create what you want... what variables create new things (Zayna)

YeeHaw said "In Radix I learned about how data is collected on a kind of animal, how to find out how the animal fits into the ecosystem, and how animals in the environment interact with each other (note, this was the ecology questline after she had completed the genetics questline). Ancosa states "About genetics like the hardness, colors, etc. about plants." And Katniss states "it taught me a little about genetics". Stryker and Jaegar said they learned new vocabulary in Radix. Asdolufiene said "I've already taken genetics, but this gave me hands on experience to some degree."

Others perceived that they learned in Radix but did not enjoy playing the game. For example, Asdolufiene states:

> Radix taught it really well but it made it to where it was *too boring* so nobody would want to stay in it too long to learn anything so I would say Skyrim did a better job – uh DragonMist did (Asdolufiene) [*participant emphasis*]

Other participants shared this perception. Mukmog states "I probably learned more in Radix, it was all genetics, but it was too boring and tedious … so it was not fun to play." Tslez'k said "In Radix it was some genetics, but it was too boring to pay attention." Finally, some participants felt that Radix did not teach them anything. Teela states "I really did not learn anything." Dragonia says "nothing really." Gargel The Third states "I was just confused most of the time."

Perception of learning also varied in DragonMist. A few participants believed they did not learn. For example, Dill Pickles states "I didn't get straight to the DragonMist but I got a little bit far into it – ah –so I wasn't that interested – I am not going to lie – but the game itself – DragonMist – the whole idea was really cool"

Others believed it taught them mostly how to play the game. For instance, Ahendria says "How to use the xbox controller better and that some games are built different or created." Ching-Chong states "I learned not to kill chickens in the city." Talen-Zaw states "I learned not to kill people in Riverwood and also about genetics." Katniss says "DragonMist made me curious about how the game will end, but I am not sure I learned much." Katniss also states, "I learned that if you kill or hurt that guide, then he will hurt you back, so violence is never the answer." And, Theha said "It taught me how to pick a lock." Some participants perceived that they learned about academic topics other than genetics. Nedthroth called me over to ask if DragonMist was based on Norse Mythology. The draugr in the temple made him curious and he had googled them and found a connection to Norse Mythology. In reply to "describe what you think you learned while playing the game", Dill Pickles wrote he learned about Medieval architecture and

Jaegar wrote that he learned about physics and how the game worked. Most of the participants indicated that DragonMist helped them learn Genetics to various degrees (See Table 6.4).

Table 6.4

Participants Perceived Learning in DragonMist

	Nedthroth "I learned how ah what outcomes of genetics are and the genetics table and like aa, and I think I also learned how to use uhm just in my mind I think I learned how to use um ah genetics using three? IS that a thing?"
	Pajzara (open response): "genetics and medieval architecture." (focus group) "uhm – in DragonMist – at the beginning I didn't really know anything about genetics and learning like the 'A' uh – the capital A and the little case a and like the dominant and recessive– (*laughed*) I didn't know about that before"
	Vallinalda (open response) "DragonMist made things more *enjoyable* learning genetics making it easier to learn." [*participant emphasis*]
	Dundi (open response) "The aggression and passive, being Aa."

Table 6.4

Participants Perceived Learning in DragonMist

	BeastMode (focus group) “By breeding the dragon it helped me with learning about genetics and to use your brain to solve puzzles.” (open response) “DragonMist definitely, it helped me learn more about genetics because you had to breed the *right* dragon that would not kill you, and it helped me on strategy. [*participant emphasis*]
	Gulum-Mere (focus group) “I learned about genetics and temperament.” (open response) “DragonMist helped me with genetics by applying it to a reward with the dragon.”
	Gargel The Third (open response) “Radix was just mostly confusing, but DragonMist made me want to explore the world and learn.” But later (focus group) he said: “I didn’t really learn anything, but DragonMist was fun.”

A key finding in this learning theme was evidence of knowledge transfer to other contexts. Flexible transfer is a qualitative aspect of learning (Bransford et al., 1999). Bransford et al. (1999) suggests a key aspect of transfer is the speed at which concepts are applied to new contexts. Environments that encourage learners to explore multiple solutions and perspectives of a complex problem can facilitate flexible transfer (Bransford et al., 1999). Environments that provide opportunities to create products and use new skills and knowledge are particularly motivating (Bransford et al., 1999). While they learned in both games, DragonMist stimulated their curiosity and encouraged transfer of knowledge to other context. For example, while Tslez'k was playing DragonMist the following interaction occurred:

Tslez'k got several aggressive dragons and asked Dundi how he got the pet dragon. They discussed the genetics and how to get a pet dragon, but Tslez'k got another aggressive dragon. He called me over and said: "I keep making dragons but Bhusari keeps attacking them – why does he keep killing them?" I asked: "did you make a passive dragon?" He said: "I don't know – I just keep making them and he keeps killing them and look they are all piled up here [laughing]." I said: "you need to make the *right dragon* [*participant emphasis*] and then he will not attack." He said: "how do I get the right dragon I have tried everything." We got the Dragon Priest's research journals and looked at the dominant and recessive traits. I told him: **"**the capital A is aggressive and if that is present it will always win, and the dragon will be aggressive**."** He said: "Ok I get it - these colors mean something – if it is red it is going to be mean and Bhusari will kill it. If it has a large 'A' and a small 'a' it will be purple, but the large 'A' still wins, and the dragon is still mean?" I said yes. He said "OH I GET IT now (excitedly). So, I need two little a's and that will be blue and that will be the right dragon!"

The next day Tslez'k's mother emailed me to tell me that he had been applying what he learned, and she was impressed that he was so excited about genetics. When they arrived for the game play session that night, his mother said "Tslez'k tell her what you told me this morning when we were walking the dogs.". Tslez'k said: "oh yeah, I told her that I understand why the dogs act the way they do. Beau is large 'A' large 'A' so that wins, and he is always mean – he is the boss. But Molly is little ‘a’ little ‘a’ and she is passive.” Other examples of knowledge transfer exhibited during the first and third focus groups are described in Figures 6.6 and 6.7, respectively.

Ok now that we defined genetics – did either game make you curious about genetics or make you want to learn more about genetics?

it kinda made me compare customization in video games to genetics like changing the eye color or changing body weight or something is like how genetics works (Dill Pickles)

it made me curious because I have seen videos on youtube about like snake genetics but I never really watch them because I thought they would be boring, but now I kind of want to watch them because I think they will be interesting. (Pajzara)

we COULD make a dragon if we wanted to (Nedthroth)

yes – see… its already been done… (Talen-Zaw)

It has already been done with a sheep but also they need dna from animals, it has been done with other animals – they can bring back a wooly mammoth with its fur even If it died out — if the DNA has not died out – but animals' dna 100 million years old can bring them back if they died out. (Shrek)

it is possible because there's this one man that was trapped in ice for like 3 years but still survived with little brain damage, they could bring him back (Dill Pickles)

Honestly if I were going to create a dragon I would combine ---- I say that combine the dna of a reptile like a lizard and a bird (Nedthroth)

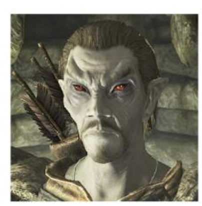


Figure 6.6. Focus Group One: Conversation about genetics after playing DragonMist

Ok now that we defined genetics – did either game make you curious about genetics or make you want to learn more about genetics?

I wonder if there's any like possibility to actually breed a dragon in real life like if we could find old DNA or something (Syncette)

I think you can from bones because there is DNA in bones so like if you find enough bones you **can** actually make a TRex – they can actually make a TRex if they find enough bones but they have not found enough bones yet (Ching-Chong)

So you are all nodding yes,
Do you think that is real?
I mean you could do something like that?

well I can say I watched a video on it and yeah and its actually possible (Ching-Chong)

Yes, I can say I think it is possible, I agree - yes (Dundi)

Yes, I agree too (Tslez'k)

yes, because I found a book in Dragonmist that could teach you about genetics (Syncette)

Figure 6.7. Focus group 3 conversation about genetics after playing DragonMist.

In summary, when asked which game they liked best for learning genetics, overall, some participants perceived more genetics learning in Radix because of the prominence of academic content in the game. Eseryel, et al. (2014) observed students playing an educational MMOG (*McLarin's Adventures*) started playing with great enthusiasm but soon started complaining "this is not a game!" when their expectations of a game environment were violated. This same phenomenon occurred during this video game camp where many of the participants started complaining and going off-task while playing Radix. On the other hand, they thought DragonMist was the better educational game because it offered more than just education and the reward (the dragon) was better. It was more fun to play, they stayed on task longer and engaged with the learning content longer because they wanted a pet dragon. In contrast, three females and one male never completed the DragonMist quest due to the violence in the game. One male was unable to complete the DragonMist quest due to technical issues with the computer and believed he learned more in Radix. Syncette had difficulty with DragonMist on the first day because she has never played games. However, she asked if she could go through the website (DragonMist.org/game) after the session and come back the next day and try again. On the second day, she successfully completed the DragonMist quest. During the focus group, in response to the question "which game do you feel taught genetics better?", Syncette expressed that DragonMist taught the genetics concepts better than Radix (see Figure 6.8).

Figure 6.8. In Focus Group Syncette expressed that she learned more in DragonMist because the game was more interesting.

6.4 Theme Three: Curiosity in Game-based Learning

6.4.1 Introduction to Curiosity in Games and Learning: The Curiosity Theme

This study examined the relationship between game design features, curiosity, and the resultant behaviors that increase meaningful learning inside the game and external to it. Figure 6.9 is a visualization of the interactions between the variables in this study. Individuals tend to be curious about specific things that interest them, so it is important to understand if games can incite curiosity about academic topics that educators expect students to learn. Like hyperlinks on a webpage, our curiosity expands as questions lead to more questions. Commercial game designers capitalize on this natural human tendency to create games that increase player engagement and loyalty (Howard, 2016). Curiosity is critical for educational game design because "to predict, or even control, curiosity would be to teach more efficiently, to entertain more consistently, and life would be endlessly interesting (St. George, 2016, p 7)."

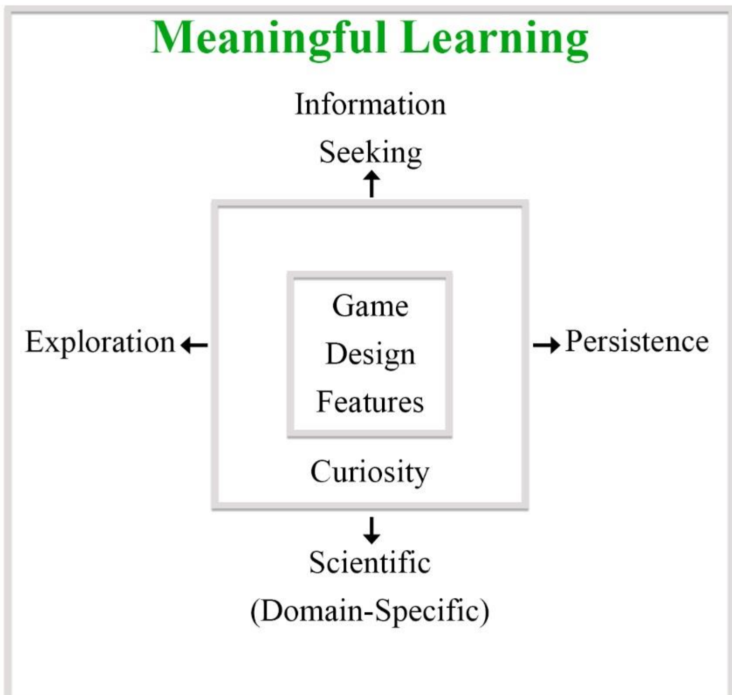


Figure 6.9. Visualization of the Relationship to Learning Between the Variables in this Study (game design features, curiosity and related behaviors).

The theme of *Curiosity* consists of four dimensions (information seeking, exploration, domain specific (scientific) curiosity and persistence) (see Figure 6.10). Results show that a variety of game design features incited, supported and/or rewarded different types of curiosity or behaviors and in varying degrees. Table 6.5 lists examples of coding evidence that supports the *curiosity* theme defined as information seeking, exploratory behaviors, scientific curiosity and persistence.

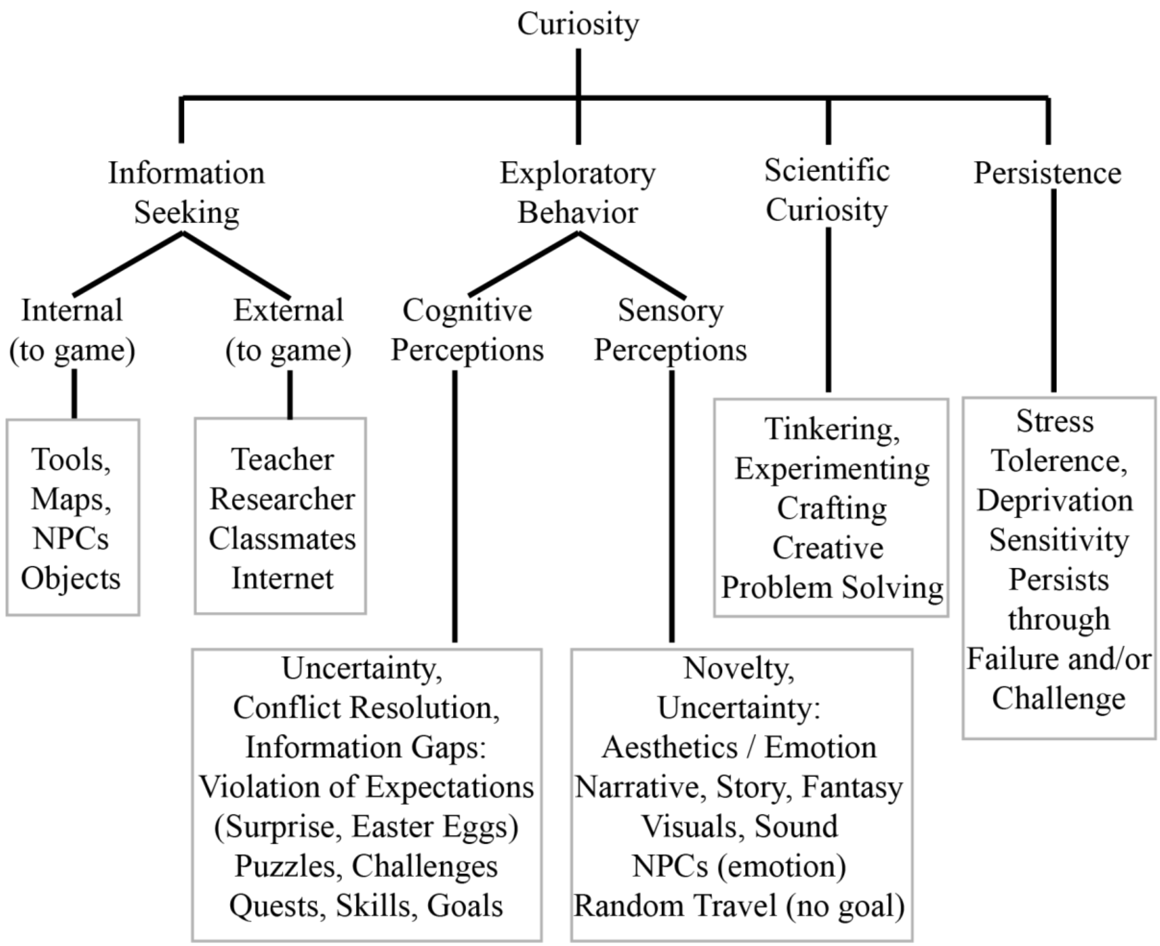


Figure 6.10. Taxonomy of Curiosity Theme and Identified Dimensions of Curiosity

Table 6.5

Excerpt from Code Book Showing Coding Evidence for Curiosity

	Description	Examples
Information Seeking		
Internal to the game: Game Objects	Tools, objects, maps, books. Evidence that players seek knowledge via game objects	She read the books in DragonMist, she got off the horse to read the road signs
Internal to the game: NPCs	Evidence that players speak to the NPCs to gain knowledge that helps them solve the quest	She talked to the NPCs (in game) and followed their instructions.
External Resources	Asks researcher questions, talks to classmates to gain knowledge or help, seeks information on the internet	he asked – I think I need that blue/green color for ice dragon – right?
Exploratory Behavior		
Cognitive perception	Curiosity arises out of uncertainty, violation of expectations, surprise, and information gaps. Evidence that players act on their curiosity to resolve the information gap, resolve uncertainty. Examples: Search for Easter eggs, enjoy solving glitches, work to solve puzzles and challenges	Dundi said hey look "I just stole a 600-gold necklace! I tried to sell it, but they will not give me but 100 gold. It is worth 600 gold why is he only going to give me 100?" When he decided on a quest – he would consult the map. He would then hire a carriage to get him as close as possible rather than walk
Sensory perception	Curiosity arises out of novelty and uncertainty and is supported/prompted by aesthetics and emotions. Ex. story, fantasy, NPCs, sounds, visuals (graphics).	Zayna saw Asdolufiene's game (beside her) where Bhusari was helping him fight the draugr in the temple. She said oh he is cool; can I have more magic like he has?
Scientific Curiosity		
	Evidence of tinkering, experimenting, crafting and creative problem solving	Kusold the Burly - if something didn't work (like a locked door) he would back track look for clues, try different things until he solved the challenge

Data was coded and results were used to create a visualization of curiosity and associated behaviors or game features (see Figure 6.11). Low levels (participant had one observation, response, or comment) are shown as light blue. Moderate levels (participant had two to five observations, responses or comments) are shown in medium blue. High levels (participant had greater than five observations, responses or comments) are in dark blue. Orange signifies an absence of this variable in the qualitative data as coded by the final code book (See Table 6.5). Red was used to show negative behaviors related to seeking information on the internet. It was decided to specifically identify this behavior since seeking information unrelated to the learning objectives of the game resulted in off-task behavior, disruptive behavior and was a barrier to learning. Persistence was simply visualized as present (dark blue) or absent (orange) and has some overlap with the Flow / Immersion theme and will be discussed more in chapter seven.

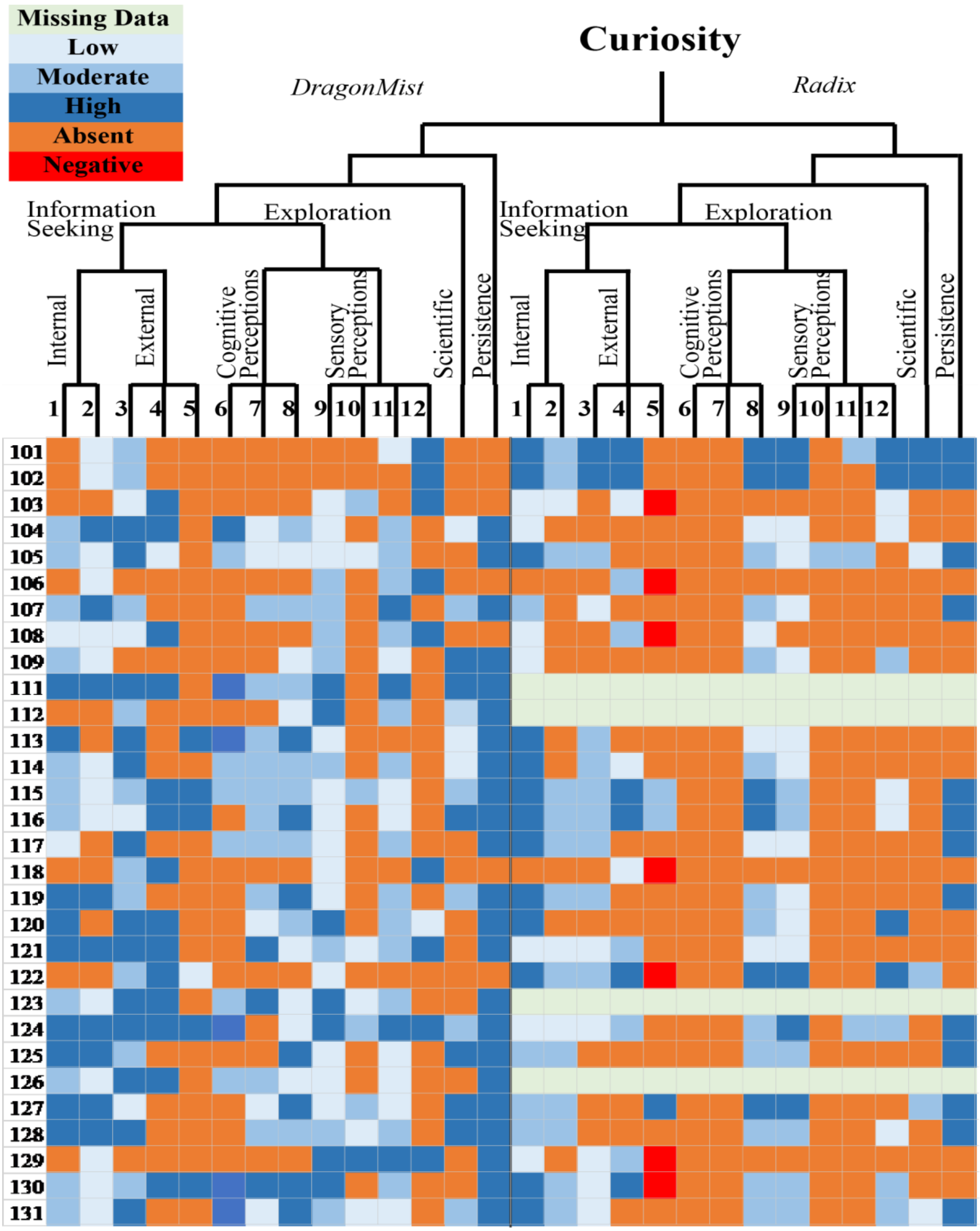


Figure 6.11. Heatmap Visualizing Curiosity for DragonMist and Radix. 1-maps, tools; 2-NPCs, 3-teacher, 4-classmate, 5-internet; 6-violation of expectations, 7-puzzles, challenge, 8-quests, skills, goals; 9-visuals, 10-story, fantasy, 11-NPCs; 12-no goal, random travel. (missing data due to control group (n=4) did not play Radix.)

6.4.2 Information Seeking Behaviors

Overall, participants exhibited more curiosity and curiosity related behaviors while playing DragonMist compared to Radix. Curiosity and behaviors were greatly varied among participants, especially for DragonMist. Most participants exhibited information seeking behaviors in both games. While playing DragonMist, information seeking behaviors were equally observed for use of game objects (e.g., maps, books, tools) and NPCs (e.g., auditory dialog and subtitles), internal to the game. For example, in response to the focus group question "how did the game help you learn?", Syncette replied "I found a book in DragonMist that could teach you about genetics." And Zayna was observed using local and world maps to make decisions about where to go and how to get there. NPCs were also important in-game sources of information. For example, Shrek and Ryker were observed speaking to every NPC they encountered and acting on their instructions. Information seeking, external to the game, showed a strong preference for teacher/researcher over classmates or internet for DragonMist. Most probable explanation for this preference of information seeking is accessibility since DragonMist is a single player game and it is full screen (requires closing the game to access the internet).

Most participants also exhibited information seeking behaviors for Radix. For internal resources, there is a slight preference for game objects (e.g., maps and tools) over NPCs dialog. All but two of the participants were observed using the maps to find quest locations. Only four participants failed to use the in-game tools that provided genetics information. Most of the participants interacted with the NPCs for information with mixed feelings about the usefulness of that information. Ryker was observed reading all of the NPCs' dialogs and acting on the instructions in a step-by-step linear fashion, Ching-Chong states "I talked to that woman you pointed out but she really didn't tell me what to do … she told me to find Dr. Shalimar, but she didn't tell me WHERE to find him." Fewer participants sought information or help from me while playing Radix in favor of seeking information from classmates (physically or using in-game chat and email). Radix is browser based and tabbed making internet access quick and easy. More participants used the internet while playing Radix, compared to DragonMist, but primarily these activities were off-task and unrelated to Radix. For example, YeeHaw was observed copying NPC dialog and pasting into Google to seek information about genetics and other educational quests in Radix. In contrast, seven participants used the internet to stay off task. For example, Ching-Chong and Dragonia started looking for game cheats for Radix but were soon searching for arcade games to play. When asked to return to the genetics quest in Radix, they would both quickly switch tabs back to Radix when I approached the back of the room. I told them they could use the internet to search for help with genetics and Ching-Chong replied:

> Well it [Radix] does not have any rewards so we play Radix for a bit then we do a barrel roll as a reward for playing the Radix game – we play a bit then we reward ourselves by Googling Easter eggs and stuff. (Ching-Chong)

6.4.3 Exploratory Behaviors

A pattern emerged regarding exploratory behaviors. Some exploration was motivated by goals, skills and quests, puzzles and challenge, and violations of expectations. I called this code *Cognitive Perceptions* because it was primarily motivated by learning, understanding, problem solving and closing an information gap. This type of curiosity was most closely related to uncertainty, conflict resolution and information gaps. Violations of expectations is one powerful way to incite curiosity (Hunt, 1963, 1965; Jirout & Klahr, 2012; Piaget, 1952, 1969). When a person's expectation is violated, it creates an uncomfortable tension that must be resolved. Violations of expectation includes elements of surprise. For example, Easter eggs are a popular game technique where players find surprising rare valuable items at random. These Easter eggs keep players continuously exploring in hopes of getting the sense of accomplishment, pleasure and specialness related to the rare item. Games use this technique to keep players exploring the game world and to increase engagement and endurability with the game. Violation of expectations and other types of curiosity related exploration were prominent in DragonMist as illustrated in Table 6.6.

Table 6.6

Examples of Exploratory Behaviors from a Cognitive Perception for DragonMist

Violation of Expectations

Stryker called me over to ask about dragon lore. He said "In Skyrim dragons are evil and you kill them, and the Dragon Priest brought back aggressive dragons, but you want me to create a friendly dragon? This does not make sense." The violation of expectation "dragons should be aggressive" resulted in exploration of the dragon lore in Skyrim and the genetics books in DragonMist as well as question-asking.

Ching-Chong observed Syncette using the ebony fire sword provided as an Easter egg in DragonMist. Ching-Chong said "Wow, where did you find that? Syncette replied "In the DragonMist temple". Ching-Chong then said, "I didn't do that quest, but that is a great Easter egg, I am going to go back and get that." The result of this Easter egg is that the player, who had skipped the genetics quest, was willing to go back and play the genetics quest to find the cool sword.

Puzzles and Challenges

(Open response to "how did the game help you learn?") BeastMode wrote "DragonMist made you use your brain to conquer puzzles so you could get to your other destinations"

The puzzles in Skyrim/DragonMist often occur at locked doors where a puzzle must be solved to gain entrance. Players then explore the area looking for clues or necessary items to solve the puzzle and progress to the next level.

Pajzara preferred to steal and pickpocket items rather than to barter for them. He said, "it is a challenge to pickpocket and get away with it, and it is fun to pickpocket and then run."

The challenge led to Pajzara exploring the world and interacting with NPCs looking for valuable items he wanted to take. It also led to exploration and problem-solving when he went to jail and rather than pay the fine, he explored and strategized until he found a secret passage so he could escape.

Table 6.6

Examples of Exploratory Behaviors from a Cognitive Perception for DragonMist

<u>Quests, Skills & Goals</u>	
	Zayna, focus group response to "Describe what you liked about your favorite game" replies: "I like that you can have some other things to do like jobs for the people who need your help and you can fight bad guys so it is not ALL learning, you can have some action and fun." Zayna enjoyed finding and completing quests and building her skills which enhanced her exploratory behaviors in the game.
	Mukmog noticed navigation markers on his compass and would go explore. He noticed a cave and finished that quest; he noticed the necromancer quest "ancestral worship" on his way to Windhelm and completed that quest. Mukmog's written response to "How does the game make you want to explore more?" was "Markers on the map get bright when close so I wanted to see what was there and what monsters I could fight and loot"
	Jaegar wrote in response to "How does the game make you want to explore more?": "Making the dragons made me want to explore more."

The only type of cognitive perception related curiosity in Radix was for goals and quests. I included evidence of collecting, as a goal, since this was a prominent activity in Radix. Violation of expectation and puzzles/challenges were absent for Radix. Goals related to collecting items resulted in the greatest degree of exploratory behaviors in Radix. Examples are illustrated in Table 6.7.

Table 6.7

Examples of Exploratory Behaviors from a Cognitive Perception in Radix

	Katniss (observed game play): every animal and flower she came to she would examine it with the tools in the toolbox and collect the animal Katniss's desire to collect animals in the game, encouraged exploratory behaviors as well as using the tools that provide genetics information.
	Ancossa (observed game play): called me over to show me the blue stripped Zebra she found and showed me how many she had collected.
	Dundi called me over to show me something he collected. He said: "I found some kind of dinosaur, what can I do with it?" The desire to interact with the animal he found in the game led to question-asking and use of the genetics related tools in the game (the critter catcher).
	Dragonia was curious about the animals "All I want to know is why all of these monsters are crawling around". This led to exploration in the world to find more, but also to creativity as he designed a game inside the game with a goal "I created a game inside this game to find as many different monsters as possible as a race, everybody who is playing my game raise your hands"

The second dimension of exploration identified in the data was labeled *Sensory Perceptions* and is related to novelty and uncertainty. This dimension focuses on aesthetics/affect and curiosity is stimulated by game objects (visuals, graphics, tools, maps), story and fantasy, interactions with NPCs (e.g., emotional interactions with the NPCs as opposed to seeking knowledge from the NPC), and finally random exploration without an obvious goal. The results indicate that story and fantasy were not as important to DragonMist players as the visuals and the NPCs. Additionally, in DragonMist participants exhibited minimal preference for random wandering around the world in favor of more goal/progress-oriented exploration (cognitive perception). In contrast, Radix players exhibited more curiosity regarding visuals (graphics) followed by a preference for random wandering around the world without an expressed purpose. Only one participant mentioned story/fantasy for Radix and only three exhibited curiosity related to NPC interactions. The curiosity generated by the graphics was most likely related to the preference for collecting (cognitive perceptions exploration) since the visual differences in the various game items created the desire to collect unique items. Examples of sensory perception inspired exploratory behaviors for DragonMist, and Radix are illustrated in Tables 6.8 and 6.9 respectively.

Table 6.8

Examples of Exploratory Behaviors from a Sensory Perception in DragonMist.

Visuals, Graphics, Game Objects (tools, maps)

(Focus Group: How did the game make you want to explore?)

"I always wanted to go into the castles and see if I could find treasures like a brown door or like a chest or something laying around and stuff"

Dill Pickles

I observed Ahendria notice the horse at Riverwood. She got the horse and seemed to enjoy riding through the country exploring the world.

Story & Fantasy

Asdolufiene said "I think it would make more sense if you followed the original quest line [Skyrim] until you get all the lore on dragons and Paarthurnax in the Whiterun and Voice quests. If you had time to get the lore on the dragons and understand what they are doing I think it would make more sense to want one for a pet [in DragonMist].

(Focus Group: What made your favorite game more enjoyable to play?).
"DragonMist I was able to do more and create more. There was reward of creating the dragon. The fantasy was very important because the dragon was more interesting than the plants and bugs in Radix and the dragon made the game a lot more interesting and fun. The story in DragonMist is more interesting and I would like to play longer to learn more of the story." Syncette

Table 6.8

Examples of Exploratory Behaviors from a Sensory Perception in DragonMist.

(Focus Group: What made your favorite game more enjoyable to play?)
I enjoyed playing DragonMist more because I felt that the overall concept of it was more engaging. I was certain that I had made progress in DragonMist which definitely wasn't the case in the other game [Radix]. I liked the fantasy aspect of DragonMist and how you could breed a dragon. YeeHaw

NPC Interactions That Increased Curiosity

(Focus Group: How did the game make you curious?)

"I accidentally hit my guide he didn't make a big deal out of it so I asked myself (*whispering*) "What if I killed him" (**everyone laughing**) and then he started attacking me and then he kept on attacking me until I died." Katniss

Talen-zaw spoke to Bhusari and left Sleeping Giant Inn to start the quest and raised his hand to ask "Look, he is following me, is he supposed to do that?" and later when Bhusari helped fight the draugr in the temple, Talen-Zaw said "Look, he helps me fight too – he has sparks … where can I get sparks too?"
(note: Bhusari's 'sparks' were a point of curiosity and stimulus for exploration for a number of participants).

Random Exploration – No Goals

Theha didn't complete any quests, he just seemed to enjoy wandering around exploring and talking to the NPCs (out loud and in the game).

Table 6.8

Examples of Exploratory Behaviors from a Sensory Perception in DragonMist.

	Teela didn't seem focused on getting or completing quests, he just enjoyed wandering around and looking at things.

Table 6.9

Examples of Exploratory Behaviors from a Sensory Perception in Radix.

<u>Visuals, Graphics, Game Objects (tools, maps)</u>	
	Ryker used the maps to find locations and determine how to get there.
	Dragonia "Can I make a pet out of any of these monsters crawling around?"
<u>Story & Fantasy</u>	

Table 6.9

Examples of Exploratory Behaviors from a Sensory Perception in Radix.

(Open response to Describe how the game made you want to explore)

"NPCs, Graphics and Storyline" Zayna

NPC Interactions That Increased Curiosity

(Open response Describe how the game made you want to explore).

"The other in-game characters" Syncette

Random Exploration – No Goals

Kusold the Burley called me over to ask: "What can I do in this game?" I showed him how to start the genetics quest. Kusold the Burley said: "No thanks, I will just wander around."

Table 6.9

Examples of Exploratory Behaviors from a Sensory Perception in Radix.

	I observed Tslez'k playing Radix. He ignored the NPCs and just wandered around collecting things. He and Dundi would discuss where to go and were following each other around laughing and talking.
	(Open response: What did you like most about the game) Ching-Chong "I liked discovering new places"

6.4.3 Scientific Curiosity

Scientific curiosity was defined as evidence of tinkering, experimenting, crafting and creative problem solving. About half of the participants exhibited scientific curiosity in DragonMist. For example, Kusold the Burley played in a systematic linear fashion. He would look around at things – and if something didn't work (like a locked door) he would back track and read books and look for clues, then go back to the original room and try different things until it worked. Nedthroth loved mixing things together to create items in the game. He collected ingredients and played around at the alchemy table to create potions and poisons and he wandered around Skyrim looking for mines so he could get ores and make armor and weapons. And Tslez'k told me "I like mixing things together to make the dragons, can I make more different kinds?" Scientific curiosity was much lower for Radix. About one-fourth of the participants exhibited scientific curiosity in Radix. Both Syncette and YeeHaw were extremely focused and strategic about their interactions with the genetics quest. They would draw out Punnett squares and review information in the game and decide on a course of action to complete the quest (in both games).

6.4.4 Persistence Through Failure and Challenge

Persistence was also markedly different between the two games. All but seven participants persisted through failure and challenge while playing DragonMist. These seven participants also exhibited low competence with the game. In contrast, half of the participants persisted through failure and challenge in Radix. All participants who did not persist in the game, complained that the game was boring and went off task. These results would indicate lack of persistence in DragonMist is most likely related to low stress tolerance (one of the five dimensions of dispositional curiosity) while lack of persistence in Radix is most likely related to deprivation sensitivity due to tensions related to poor guidance and lack of goals. The lack of persistence in Radix may also be related to low motivation (autonomy – no choice or control, and/or competence – no mastery goals).

In summary, results demonstrate that participants described and exhibited curiosity in both games. However, participants who played DragonMist exhibited more curiosity related behaviors across a variety of dimensions. Participants exhibited more scientific curiosity related behaviors and more persistence while playing DragonMist compared to Radix. Finally, results illustrate a few key curiosity dimensions that were completely absent for participants who played Radix. This result indicates that certain game design features, known to elicit and support curiosity, are important considerations for games designed to add entertainment value and support learning.

6.5 Theme Four: Engagement (Flow and Immersion)

6.5.1 Introduction to the Engagement (Flow and Immersion) Theme

Flow, immersion and motivation are overlapping concepts in the literature. Flow has been described as a state of immersion experienced when engaged with enjoyable valuable activities that induces feelings of fun, enjoyment and creates lasting memories (Csikszentmihalyi, 1990; 2014). Flow experience enhances learning by incrementally adjusting challenge difficulty such that knowledge and skills increase (Csikszentmihalyi, 1997). Immersion enhances engagement and motivation and is enhanced when the game feels real. Immersion is evident when the player feels like they are experiencing the game world rather than doing an activity. Immersion and flow are supported when players perceive their choices are meaningful in the game world, in other words, their actions have consequences. Emotional attachment to and empathy for avatar and the NPCs increases immersion. Players often speak to, or about, the avatar and NPCs as if they are real people with real lives. Immersed players enjoy challenging goals, progress (e.g., gaining skills, completing quests, gaining status). Feedback is critical in immersive games, and to flow experience, and is provided in multiple forms (e.g., progress bars, rewards, and fun failure). Recently, the flow structure was expanded to include curiosity and immersion (engagement, engrossment, and total/flow) (Agarwal & Karahana, 2000;

Brown and Cairns, 2004). Results of this study indicate several key factors that contribute to flow and immersion as follows: (a) avatars and NPCs increased realism and emotion in the game, (b) challenging goals increased engagement and flow, and (c) feedback and rewards were important to flow and immersion (see Figure 6.12).

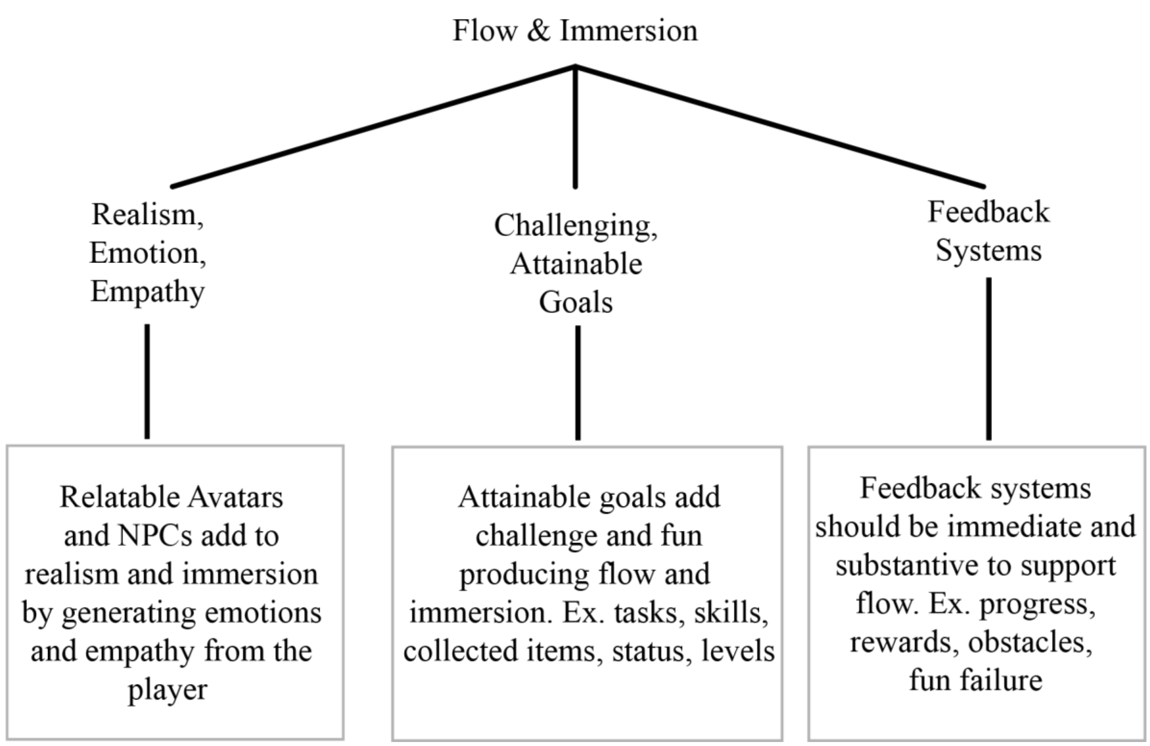


Figure 6.12. Flow & Immersion Theme Showing Three Dimensions: Realism, Goals, and Feedback Systems that Enhance Flow and Immersion.

Evidence of flow and immersion theme was dramatically higher for DragonMist compared to Radix (see Figure 6.13). Most participants reported flow experience and feelings of immersion in DragonMist, supported by relatable avatars and NPCs, goals and challenges, and valuable feedback systems (rewards, obstacles, progress, fun failure). Most participants reported low levels of flow and immersion after playing Radix.

Participants failed to relate to the avatar or the NPCs, failed to perceive challenge and goals, and complained about lack of rewards, no progress and inadequate feedback while playing Radix (see Figure 6.13). These concepts will be discussed next.

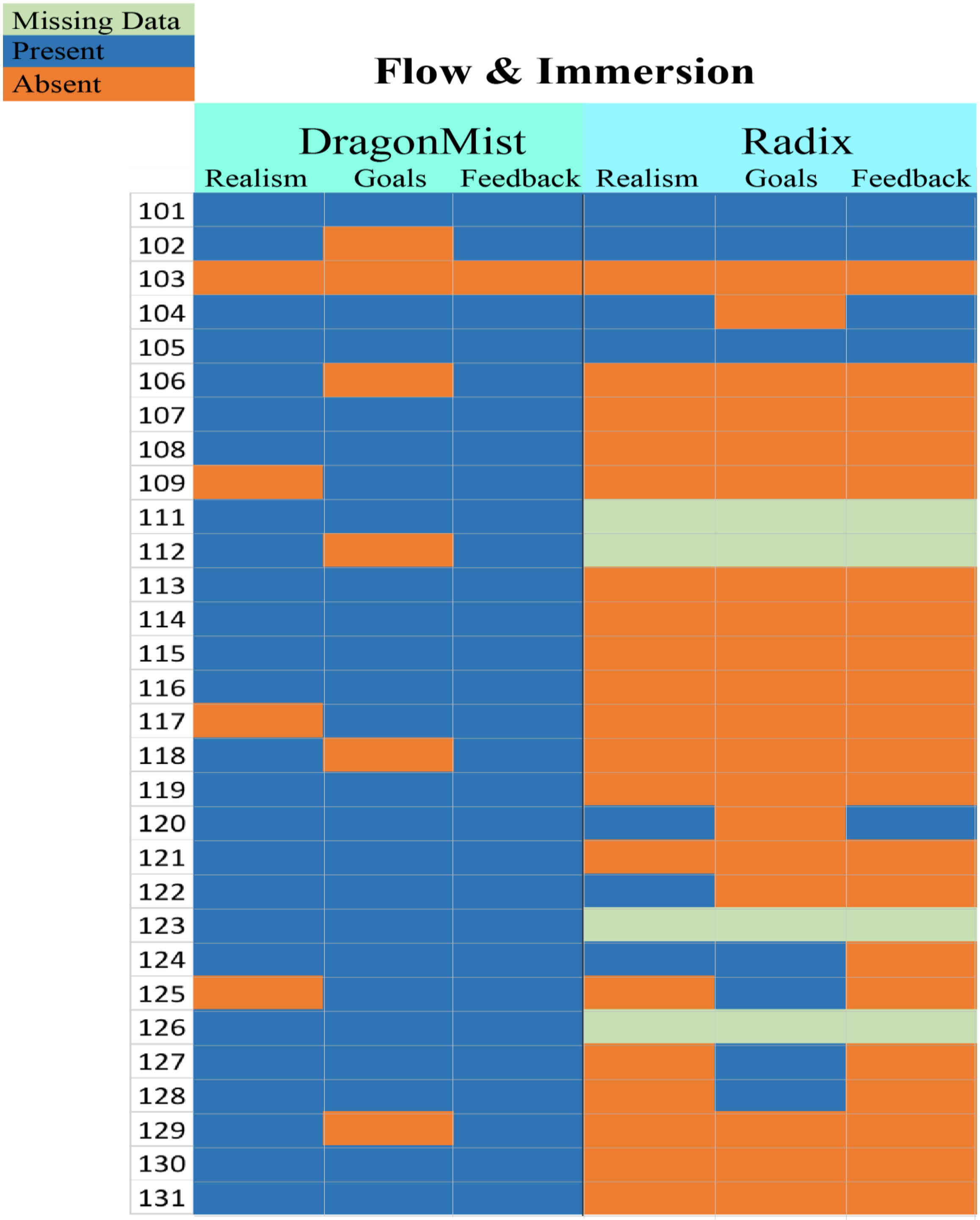


Figure 6.13. Visual Illustrating Presence or Absence of Dimensions of Flow and Immersion: Realism, Goals, Feedback.

6.5.2 Realism Enhances Flow and Immersion

Relatable avatars and NPCs proved to be a powerful game feature that increased realism and immersion in DragonMist. Many of the participants expressed empathy and emotion related to their avatar and to the other NPCs in the game. The avatar and/or NPCs were real enough that the participant exhibited concern for them when they were in danger or had failed. For example, Lareia asked how to get to the DragonMist Temple. When I pointed to it, she said: "It looks like I have to go over there, across the river – can I swim? Or will I drown?" (Lareia). When Tslez'k was fighting the draugr at the DragonMist temple, he called me over for help. He said; "I was just turning around to look at something and I accidentally hit Bhusari with my sword and he started throwing sparks at me. I told him I was sorry, but he still will not quit" (Tslez'k). Synette voiced concern for her avatar by saying "oh gosh I am barefoot – how did that happen – I need shoes don't I?" (Syncette). Later at the Fire & Ice cave, she found the blind man and asked; "Do I have to kill this blind man?" I told her no she could ignore him. She said, "oh good, cause he is old and blind and I don't want to kill him" (Syncette).

The realism of the NPCs increased curiosity and exploration. For example, Nedthroth was speaking to Bhusari, "why don't you just tell me how to use this breeding station?" Zayna noticed Bhusari using magic and wanted 'sparks' like him. I directed her to the vendor in Riverwood who sells magical spells. She called me over to ask, "why does he charge me so much; I have not made any money yet …Why don't these people pay me to do things for them when they ask for help?" (Zayna). And BeastMode was fighting the dragon in the Dragon Reach quest and called me over to ask questions (see

Figure 6.14). His connection with the baby dragon led him to explore more about Skyrim's dragon lore and he eventually asked to go back to the DragonMist quest to create more dragons with different voice weapons to see if they would fight more effectively.

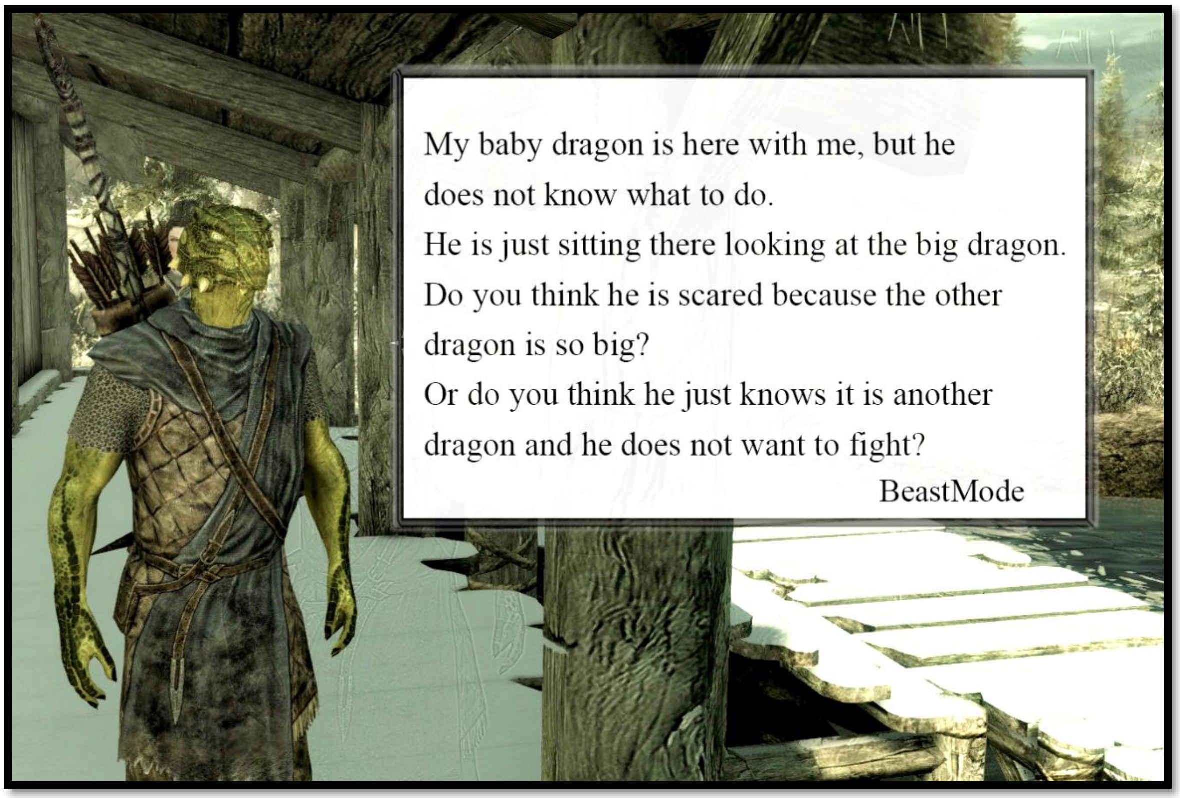


Figure 6.14. Relatable Avatars and NPCs Led to Exploration and Question-Asking.

Relatable avatars, NPCs and fantasy in the game also support the hero's journey, a plot structure used to increase immersion in games. Feelings of being a hero relates to the need to help others or perform altruistic act. During the focus group, Ching-Chong indicated he was proud of killing an evil dragon because it helped the people of Whiterun. He said "the king needed my help because he didn't know what to do with this dragon. I helped the king jarl guy kill that dragon cause no one else could and he gave me this cool weapon" (Ching-Chong).

In contrast, only a few participants indicated their desire to help the NPCs in Radix. “I liked that I could help the people” (Yee Haw). And during focus group, in response to “What did you dislike about the game”, Katniss responded: “I didn’t like that the people are so needy, and they can’t do anything for themselves” (Katniss). A few participants made comments associated with the hero’s journey concept. For example, Syncette said “Prunessa needs me to find these lumabells to cure some sort of disease.” Many of the participants ignored the NPCs on a relatable level and only utilized them as an informational tool when they needed information to complete or start a quest or ignored them altogether. For example, Dundi and Tslez’k played Radix together and wandered around randomly. I never observed them interacting with the NPCs and they never accepted or completed any quests.

6.5.3 Goals and Challenges Are Fun and Produce Flow and Immersion

Most participants placed importance on challenges and goals related to engagement (flow and immersion) with the game. Mastery goals, perception of ability to achieve mastery, and clear directions were considered as competence (motivation theme). For flow and immersion, general goals and progress are considered. For example, goals to make progress, gain status, level up, complete a challenge, quest or puzzle. Flow is a zone of optimal experience where challenge is slightly more difficult than the player’s skill or knowledge such that improvement occurs. When players are in the flow state, they enjoy the activity. Examples of flow state related to goals and challenge were observed while participants played DragonMist. For example, Jaegar and Stryker were discussing their games, talking and laughing and showing each other their accomplishments. Another example, Shrek and Nedthroth were discussing the dragon breeding station and both had created aggressive dragons at first. Nedthroth finally got a passive dragon and got excited. He exclaimed "I got a pet dragon and he will carry stuff, what else does he do – can he fight?" (Nedthroth). And Drago and Ching-Chong played DragonMist together. They were animated, laughing, discussing strategy and working on the quests together. When challenges are too difficult, anxiety and frustration occur. For example, Lareia was having difficulty navigating the 3D world in DragonMist and I could tell she was frustrated. Katniss sighed heavily and said: "I accidentally hit one of them, now they are all being mean to me and I don't know what to do" (Katniss). And I observed Vallinalda staring at the monitor and appeared frustrated. I asked if she needed help. She said, "I am just resting, I am not good at fighting games and the dragon priest keeps killing me and I have to start over and fight all these monsters just to get killed again" (Vallinalda). When challenges are too easy, boredom occurs. For DragonMist, lack of flow was primarily evidenced as frustration and anxiety rather than boredom or apathy.

In contrast, participants indicated confusion related to the game's purpose while playing Radix. For example, in answer to "Describe what you <u>disliked</u> about your least favorite game", Gargel the Third wrote "Radix was just mostly confusing." Evidence of boredom and annoyance indicated participants did not feel challenged in Radix and they did not feel like the game had goals. During the first focus group the following conversation occurred. “There was no point in playing it” (Dragonia). “Yeah, like there was nothing to do, so I just wandered around” (Tslez’k). “I agree, I mean if you can’t fail in a game – ah – its like a game for six-year olds” (Ching-Chong). “yeah, like you need to make it have some kind of conflict or something” (Drago). While playing the game, Beastmode called me over and asked if he could stop playing. He said, “this game is not a game, it is boring and there is no point to it” (Beastmode). Theha and Teela constantly complained of boredom and stayed off task by playing games on their phone and Googling arcade games. A few participants exhibited concentration and focused attention, evidence of flow state, on quest goals in Radix. YeeHaw and Vallinalda completed the genetics quest quickly and move on to other educational questlines. They both made written notes and put a lot of thought into completing the learning tasks. Kusold the Burley and Ryker were quiet and focused on the game and finished the genetics questline quickly.

6.5.4 Feedback Systems: Rewards, Obstacles and Fun Failure

Feedback is critical for learning. Games are a cyclic process of player action, game response, game feedback, new player action (see Figure 3.1). Feedback is necessary for flow and immersion and should be substantive and immediate. Player progress, rewards, and obstacles are forms of feedback. Fun failure is a popular game feature that gives failure feedback in a humorous manner that keeps players playing. For flow and immersion to occur, players must feel that their choices in the game matter. In other words, it is critical that their actions have consequences. As seen in Figure 6.13, all but one participant expressed feedback experiences were valuable for DragonMist. Most participants had negative sentiments towards the feedback in Radix.

Rewards and obstacles were favorite feedback mechanics in DragonMist. The baby dragon was a popular reward in the genetics quest. Zayna said, "I really liked that you get a dragon when you do the genetics correct, that is a better reward than the other game" (Zayna). Gargel the Third said "This is more fun and I want to get the pet dragon". When Syncette created her pet dragon and talked to it. When the baby dragon made his "grrrrr" noise, she said "awe he is so cute, can I have more of them?" (Syncette). The rewards also increase curiosity. For example, Gulum-Mere wrote "DragonMist made me curious about genetics, my curiosity was rewarded by a pet dragon". And Rytoth wrote "DragonMist more fun because it has rewards; you can find stuff and buy stuff and fight enemies; you get a pet dragon." Others, like YeeHaw, felt like they were rewarded just by obstacles (consequences of their actions) and these rewards/obstacles increased positive emotions in the player (see Figure 6.15). An interesting pattern emerged in the data regarding actions having consequences. When the participant felt that they chose their action, the emotion associated with the consequence was positive (see Figure 6.15). In focus group, Dundi laughingly said "when you attack people or something you get to go to jail and stuff, that was fun." Also in focus group, Drago was laughing and said "don't hit a guard (*laughing*) they will put you in jail and then once you get out of jail (laughing) and once you get **OUT** of jail don't hit the guard in the head again because they will attack you." However, when the participant felt out of control or that they had no choice, then the consequence was perceived as harsh and/or unfair and caused negative emotions. For example, while Drago thought it was funny to go to jail after choosing to hit the guard in the head, expressed a different sentiment when the action that solicited consequences was an accident. "I accidentally stole something and the guard – he started attacking me – and I can't do anything because everyone is so mean. I just want to quit and go home" (Drago). And, Dill Pickles was fighting the thief on the way to Riverwood and accidentally hit his guide. When he arrived at Riverwood the citizens started attacking him. Dill Pickles said, "I didn't mean to hit my guide, now everyone attacks me, this is an awful game, I just want to play Minecraft" (Dill Pickles).

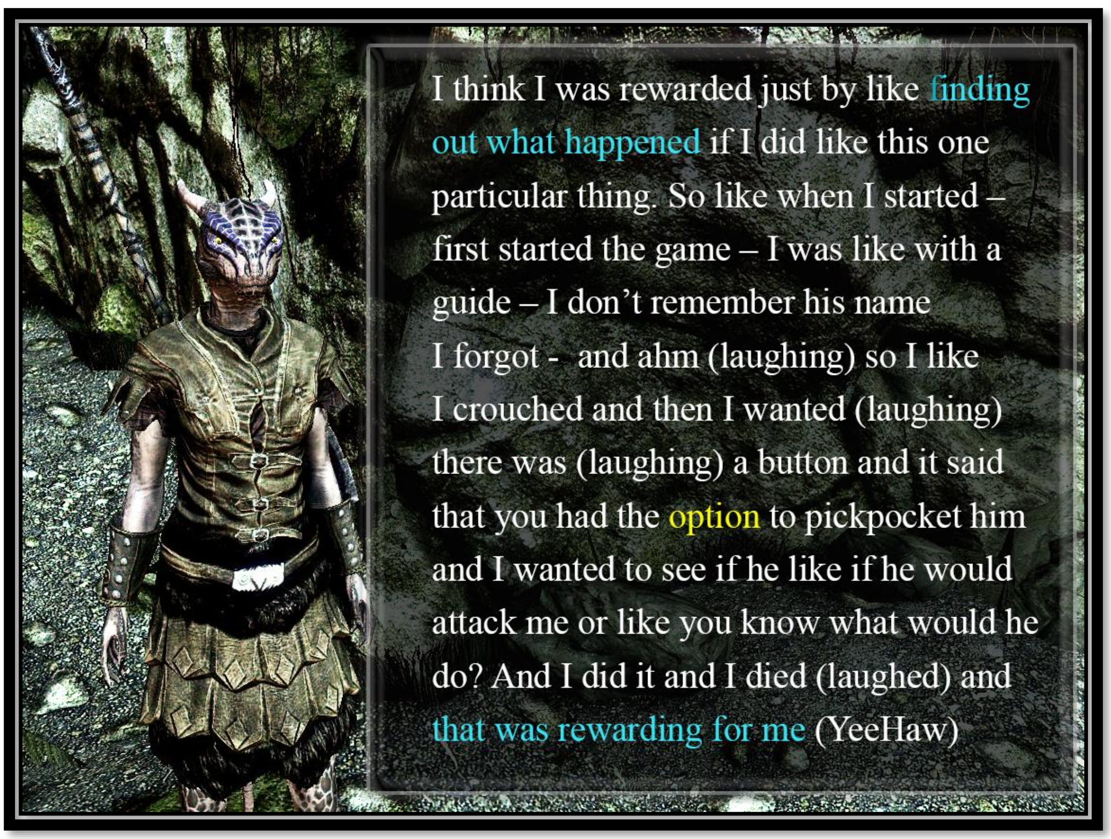


Figure 6.15. Example of Rewards that Increase Positive Emotion and Curiosity

These negative emotions evoked from action consequences in the game are often redirected by fun failure feedback. Games use humorous animations and failure scenarios to stimulate positive reactions to failure feedback and to encourage players to try new things rather than give up (e.g. promotes creative problem solving). For example, Tslez'k asked for my help after making several aggressive dragons and said:

> it was fun making all of them and watching Bhusari kill them and it was *funny* because they are all just piled up on top of each other - look at all of them that is *just so funny!* But I am glad I finally got the pet dragon. (Tslez'k). [*participant emphasis*]

Another extremely popular fun failure scenario was the giant that sends the player flying with one blow (see Figure 6.16). Several players enjoyed this failure situation so much they attacked the giant over and over and laughed and shared the experience with others. I heard Pajzara laughing and talking to Gulum-Mere. Pajzara said “"he hit me **ONCE** and I went flying, how am I supposed to deal with that?" Talen-Zaw called me over and said, “This is too funny, watch me fly through the air” and he walked up and hit the giant to show me what happens. Participants found other failure scenarios funny. I heard Dundi laughing and he said, “I stole this guy's necklace and he chased me down saying ‘get your thieving hands off that'” (Dundi).

Figure 6.16. Giant sends me flying is a popular fun failure scenario that kept participants engaged.

Most participants in Radix did not feel that their actions had consequences and they felt the rewards were not good rewards. In focus group, Dragonia said “you can’t really – you can’t really FAIL in Radix … you can only get lost.” In response, Dundi replied “I didn’t know what to do to HAVE consequences in Radix.” And Syncette replied “yeah there was like there was nothing bad happen to you in Radix … there was no rewards there was no consequences.” And Asdolufiene said “Radix is not a fun game, it is just a lot of forced useless grinding, it is pointless repetition, … with no consequences or useful rewards - you just grind it out”. In contrast, a few participants felt that Radix gave valuable feedback. For example, in response to “Describe what you liked best about this game” Gargel the Third wrote “I just wanted to complete the quests to progress” and Stryker wrote “It saved progress and let me choose what to do”. Others expressed some confusion related to the feedback. Ancosa and Katniss were playing Radix together and called me over because Prunessa would not accept the lumabell they were turning in. Katniss said, “why do these flowers look the same in my inventory, they looked different when I picked them, but now they are the same and I can’t tell which is the one she want?”

In summary, Figure 6.13 shows a dramatic difference in game play experience regarding flow and immersion between the two games. Participants did not relate to the avatar and NPCs in Radix as well as they did in DragonMist which decreased the enjoyment of the game. Most participants exhibited positive emotions signifying flow state with respect to challenge and skill in DragonMist. However, a few exhibited frustration and anxiety when they perceived the challenges were too difficult or that they had no control and choice. Participants in Radix seemed to have the opposite response, exhibiting boredom and low persistence due to lack of challenge and goals indicating flow state was not achieved. Most participants enjoyed the rewards, obstacles and other feedback mechanisms in DragonMist while most participants felt their actions were meaningless and received no consequence when playing Radix. As with challenge and goals, failure scenarios were met with joy and pleasure when the actions were of the participant's choosing. However, when the player perceived a lack of choice and control, consequences to their actions resulted in negative emotions (frustration, anxiety, and low persistence).

6.6 Theme Five: Popular Game Features

6.6.1 Overview of Player Perception of the Game Designs

The game-player relationship is a complex network of dynamic components. The designer designs the game with an experience in mind, but the experience is not reality without the player. Therefore, each player's experience in a game is unique. This study explores game design features, from the player's perspective, that influence motivation, engagement, curiosity and learning. NVivo's visual analysis tools and cluster analysis tools were used, on all transcribed qualitative data, to gain an initial understanding of prominent game features players perceived as important to their DragonMist game play experience (see Figure 6.17). Prominent concepts were then investigated to determine context and relationships to game mechanics, learning and curiosity. Some of the most interesting game features will be introduced here and discussed in relation to the other four themes to initiate a holistic meaningful understanding of the research problem in the final two chapters (Chapter 7 and 8).

Figure 6.17. Visual Representation of Prominent Game Features Participants Perceived as Important to Their DragonMist Game Play Experience

6.6.2 Perceptions of DragonMist

The dragon was the most popular topic related to DragonMist and was discussed in various contexts. The dragon increased curiosity. In response to the focus group question, which game made you more curious and how did it make you curious. Asdolufiene said, “DragonMist and what types of dragon outcomes there could have been or that could be created …I made like 4 or 5 different dragons." The dragon stimulated lively conversation in all three focus groups where evidence of learning and transfer to other context was evident. "The ability to customize the dragon, like the color of the dragon and there's three separate colors and like the underbelly and claws and stuff like that – that would be like genetics" (Pajzara). Syncette said "I wonder if there's any like possibility to actually breed a dragon in real life – like if we could find DNA or something" which then stimulated a lively conversation for the group moving from dragons to dinosaurs to snakes, sheep, mammoths and humans. Open responses confirmed the relationship between the dragon and curiosity. For example, in response to "How did the game make you curious?" Dundi wrote "DragonMist made me more curious, I was curious about going through the cave and the genetics quest. I like how it taught me about how to make the dragon passive or aggressive." Mukmog wrote "how to get a pet dragon", Tslez'k wrote "I want to learn more about dragons", and Nedthroth wrote "genetics and dragons a LOT!"

The choice of dragons prompted more engagement with the genetics quest and learning. Several participants asked if they could return to DragonMist and create more dragons or different dragons. Gulum-Mere chose a ice dragon first and later asked if he could return to the temple to make a fire dragon. Beastmode originally skipped the fire and ice quest and went on to Skyrim quests with his first pet dragon (no voice weapon). When he was fighting the dragon in the Dragon Reach quest, he called me over to tell me his baby dragon was just watching (see Figure 6.14). After he completed the Dragon Reach quest, he wanted a different dragon that would fight better, and this prompted him to return to DragonMist and complete the Fire & Ice quest on co-dominance to get a fire dragon.

When asked "Which game would you talk to your friends about and what experience would you describe for them?" "I would tell them about DragonMist because a log of my friends like Skyrim and there's not like a pet dragon in it I don't think, and I think a lot of my friends would probably like to have a pet dragon" (Nedthroth). And, YeeHaw said "I would tell my friends I got to have a pet dragon." Overall, the dragon made DragonMist more fun to play and created more interest in genetics: "DragonMist sparked my attention in genetics more because not only does it look great; but it is fun and had dragons! I mean what more could there be?" (Ching-Chong).

The horse at Riverwood was another popular game feature. Syncette and Lareia loved riding the horse because they ride horses in real life. The horse added to the immersion and relatedness in the game. I heard Syncette "Oh no my horsey is behind the waterfall, will he drown? Oh he is okay here he comes, he is ok." Others used the horses for an efficient and engaging means of travel. For example, I saw Ryker check his quest log and then his map. He walked up to the stable and talked to the stablemaster to buy a horse. He told him, never mind, because he didn't have enough gold. Ryker checked his map again, walked around a bit and then jumped on the horse and took off running. I also saw YeeHaw check her quest log and map, ride her horse out of Riverwood, check the road signs and head off to Whiterun. The maps and fast travel were also used extensively. Players would consult the maps and the nav markers to decide where to go and the best way to get there. Additionally, several participants mentioned that the red moving dots on the navigation bar/compass made them curious and helped them track enemies. The glowing icons for locations nearby also got the players attention and many participants mentioned this feature as helpful and increasing their desire to explore. Mukmog wrote, “compass had map markers that made me want to see what was there.”

Magic was high on the list for entertainment value. Players noticed Bhursari, or other NPCs, using magic and started exploring and seeking information as to how to acquire magical skills. Gargel the Third said, “I saw this guy using sparks and I searched him but all he has is armor and swords.” And Zayna said “Oh Bhusari has sparks, I want those too, where can I find them?”

Quests, challenge, puzzles and goals were discussed a lot. Several participants were focused on quests and goals and would methodically work through them until completion without deviating to things that caught their attention (YeeHaw, Vallinalda, Beastmode, Jaegar, Rythoth, Kusold the Burly and others). Beastmode said in focus group and wrote on open response, as one of his favorite things about the game, “more genetics in the game, it also made you use your brain to conquer puzzles to get to your other destinations.”

The topic of rewards, obstacles, consequences, and failure was another frequently discussed and observed concept and revealed complicated contexts. Rewards are part of feedback and includes loot, weapons, armor, special items, gold, advancement, consequences, fun failure, obstacles, surprise, and even information. Basically, feedback and/or rewards substantiate the player’s importance in the game (their actions matter) and provides means for the game’s response to player choices and actions in the world.

Several players felt rewarded by information. They were curious about why something happened, what would happen, where things would lead, and they felt rewarded when the game responded to their chosen actions (see Figure 6.15). For others, rewards were fun failure. The giant was a popular source of this type of feedback (see Figure 6.16). The aggressive dragon as feedback for incorrect genotype choices at the breeding station was also a fun failure. “I keep making them and Bhusari keeps killing them, this is so funny.” (Tselz’k). Most all the participants enjoyed finding special items (Easter eggs), gold, and other collectibles. For example, Nedthroth said loudly ““WOW, look at THIS! I got an ebony sword of fire, this is AWESOME, you can’t get one of these until like level 50 – this is a great Easter egg!” These Easter eggs prompted students, who had originally skipped the genetics quest, to seek it out and complete DragonMist to get the sword.

The avatar, NPCs and customization features were important to the players. The avatars and NPCs increased engagement and immersion and all of the participants were talkative and actively engaged while customizing the avatars for DragonMist. During focus group when asked “How did the game make you curious”, Dill Pickles said “DragonMist game the details of the game and how you could go, how the people were, their face, and their lives , how the NPCs say things and their story.” Many of the others wrote “customizing my avatar” in response to “Describe things that you liked about your favorite game.” And a few participants connected customization to genetics “it kinda made me compare customization in video games to genetics … like changing the eye color or changing body weight or something is like how genetics works” (Dill Pickles).

Violence emerged as a dual edged sword and complicated topic of discussion. For example, when the focus groups were discussing which game would be better for the classroom, the topic of blood and violence came up in all three focus groups. Most of the participants believed violence (e.g., boss fights, combat, random attacks) added to the fun and challenge of the game. However, they also agreed that DragonMist was too violent for schools. Most expressed that DragonMist would be less fun without the action and fighting. "I would not make it ***LESS*** violent because then its just not as **FUN** … it just becomes Radix and you are just running around doing nothing" (Syncette). A few felt the blood and violence in the game should not be a concern because it was so fake. For example, one conversation in focus group went as follows.

> Dragonia: don't get me wrong I liked the violence because I play super smash brothers at home, but I don't like blood and everything
>
> Syncette: I agree I didn't like it when the sword got blood on it and everything … but I liked when the skeletons explode (laughing)
>
> Ching-Chong: That was so cool, it's like how long is this Gallagher monster?
>
> Rebecca: What? What is a Gallagher monster?
>
> Ching-Chong: well it's like blood in video games is basically just colored Gallagher monsters … well cause uhm everything yeah every games– ah you know its like a monster from Gallagher cause every things made of

pixels so yeah … it is just a Gallagher monster getting its head chopped off. (Everyone laughing)

Other game features were mentioned or observed less frequently. Sound effects (e.g., footsteps, breathing) and music were important to several participants, “the dragon’s breathing is too loud, I can’t hear people sneaking up on me” (Shrek). A few wrote that the 3D environment made the game feel real or like a real-life adventure. All participants were observed switching between first- and third-person point of view (POV). Most participants commented, positively, about graphics and animations in the game. Specifically, they enjoyed, and exhibited positive emotions (laughing, talking, sharing), with the fun failure animations in the game (see Figure 6.16). They often called me over to repeat the action that resulted in the animation because it was unique and funny. For example, Tslez’k said “Look what I did. I ran off the cliff and the horse died; this is so funny!” He started running and ran off the cliff and the horse and his avatar rolled down the cliff to the bottom and died. He was laughing and said, “See I ran right off the cliff and we both died!” (Tslez’k).

Several talked about the fantasy and lore as well as ability to make or create (crafting, creating, alchemy, dragons). Hidden areas that require players to search and explore increased engagement and enjoyment for the game. Most players discussed movement (flags, fox, wolves, rabbits) as a key game feature that incited curiosity and prompted them to explore the game world or ask questions which led to discovery of random, surprising rewards such as Easter eggs or new locations (see Figure 6.18).

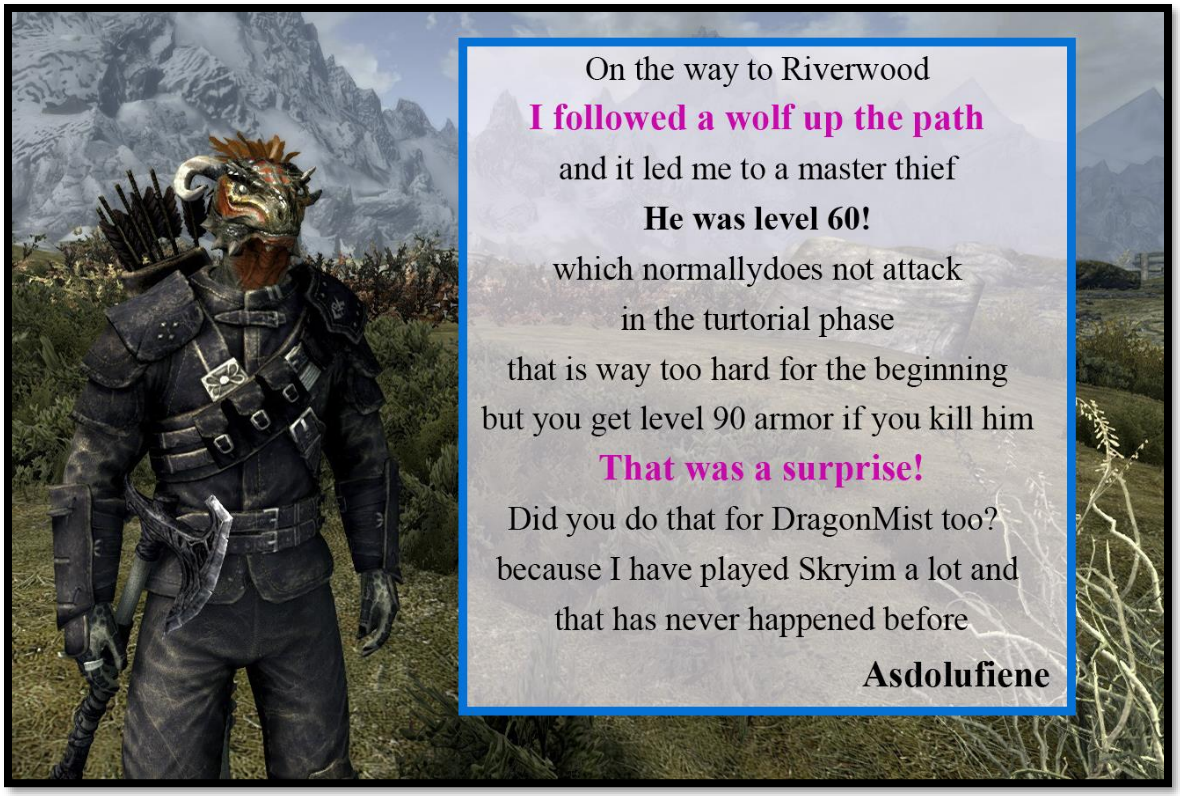


Figure 6.18. Movement Incited Curiosity in DragonMist. Wolves, foxes, waving flags, grabs the player's attention and encourages them to explore hidden areas of the game.

6.6.3 Perceptions of Radix

Many of the same game features were observed and/or discussed in relation to Radix as well. Many of the participants believed they learned more genetics in Radix than in DragonMist. However, the general sentiment was that there was too much education and no choice for any other game play options (See Table 6.10).

Table 6.10

Student Perceptions of Academic Learning in Radix

	Focus group response to "describe what you disliked about your least favorite game" "All you do in Radix; you just catch animals and (pause) and ah measure their feces" (everyone laughing) (Ching-Chong)
	Focus group response to "describe what you disliked about your least favorite game" "Radix just seemed like they just put – ah – wait – ah – they just put – ah (sighs) – wait – like they just put like the biological stuff in it and it didn't seem like there was no quest there that was not about genetics" (Dragonia)
	Focus group response to "describe what you disliked about your least favorite game" "Radix was just – like – was just 100% learning and – ah – just no game play" (everyone nodding in agreement and saying yes) (Drago)

Table 6.10

Student Perceptions of Academic Learning in Radix

	Open response to "Describe what you disliked about your least favorite game" "I liked Radix and I learned a lot in Radix, but it was all educational and there was no action and you didn't really get good rewards when you worked so hard on doing what the people asked you to do" (Zayna)
	Open response to "Describe what you disliked about your least favorite game" "I disliked only one thing and it was how extremely genetics based the game was. I like educational games but sometimes you gotta take a break" (Syncette)
	Open response to "Describe what you disliked about your least favorite game" "No action, just adventure, everything was about genetics and it was boring." (Gargel the Third)

Teela wrote "Radix is interesting, but it is not **FUN**!" Most participants seemed to agree with Teela. Some participants were focused and methodical about playing the game, but when they completed the genetics quest, as instructed, they asked if they could switch games and/or they went off task in favor of other activities. Those who continued to play Radix, roamed around collecting things or created games inside the Radix game where they could play as a group (e.g., race to find and collect a new animal, hide-n-seek.) A few participants completed the genetics quests and started other academic quests. The Human Body Systems and Ecology questlines seemed to be popular. Primarily, the complaint about Radix was that it was 'not a game' (Rytoth, Gargel the Third, Asdolufiene) and it was all education (See Table 6.10) which lowered perception of choice, control and freedom. In focus group, Dundi and Tslez'k said "we mostly followed each other around." "We were **TRYING** to have fun, but it wasn't really that fun, we didn't have anything to do (laughing)…" (Tslez'k); "yes like just trying to make the ***best*** of a **bad** situation" (Dundi).

Another feature that most players complained about in Radix was travel options. Most of the participants wanted the ability to fast travel or 'teleport' (e.g., Beastmode, Stryker, Syncette and Jaegar). Most of the participants complained about repetitious tasks and perceived the game as tedious and boring. For example, Jaegar asked, "Why do you have to do so many steps to use a tool? That is so much work to do one simple task." And Mukmog states:

> This is *tedious*, … he sends you way over there to collect a flower … and you wait for load screens, then you have to go back to him [to turn it in], then he sends you *right back to the same place to get the same flowers!* Why didn't he just tell me to get them while I was there? (Mukmog). [*participant emphasis*]

Some liked that Radix was easy to learn and not hard to master as far as player skills was concerned. However, this simplicity often created a lack of challenge or sense of purpose in the game. For example, in response to focus group question "Describe an experience that you disliked in your least favorite game", Ching-Chong replies "Ah Radix and how there is barely anything to do and ah it's NOT fun! … like there's ***NOTHING*!"** ***[participant emphasis*]**

The most frequently discussed game features, related to enjoyment and engagement, were collecting and playing with friends. The colorful fantastical animals were a favorite game feature for all participants playing Radix. For example, Katniss said "I liked seeing how many animals or something that I could get by breeding it, so like the most that I got was like 99,000 of them … I bred like shimmer flies." However, most agreed that collecting was not enough to make the game fun and that the animals should be tied to some type of reward beyond turning them in to an NPC to complete a quest. For example, Dragonia said "Maybe when you catch a monster then you could like bring it out and like walk with it or something or ride it.". and he wrote on open response:

“[Radix] Kind of boring. I mean I think that because collecting stuff ***can*** be fun but in this game it just wasn’t. but… it was fun to play with friends.” Most participants perceived a lack of rewards, consequences, and opportunities to fail in Radix. For example, Syncette said “I didn’t know what to do to ***HAVE*** consequences in Radix.” Most participants liked the multiplayer options – chat, email, avatar multiplayer except for a few who chose to play as single player. The multiplayer option both increased and decreased learning dependent upon the individual student.

Other game features mentioned were lack of immersion and increased confusion due to the cluttered user interface, not having an option to play full-screen, not having a way to turn on / off quests, lack of nav markers on the map unless you performed multiple steps to create one, and confusing educational vocabular (e.g. NPCs asked the player to ‘breed’ flowers).

6.6.4 Participant Ideas for Improvement

During focus group, all three groups were asked to imagine themselves as game designers and to give input on improvement for both games. All participants had good thoughtful suggestions (See Table 6.11). They were amazingly unbiased and helpful with their suggestions and seemed interested in creating better educational games. Chapter Seven will discuss all five themes and begin to develop an overall understanding of the complex relationship between game – player – and learning.

Table 6.11

Participants Suggestions for Improving DragonMist and Radix

DragonMist	
Education	If used for education, maybe use it with a teacher who could help, or have areas with questions to guide the learning like Kahoot, and maybe less violence (Dill Pickles) Add more journals (Nedtroth)
Genetics	Add ability to customize the dragon, like different colors, scales, different decorations like a funny hat, different skills (Dill Pickles, Pajzara, Asdolufiene, Ching-Chog, Talen-Zaw, Gargel the Third, Shrek, Nedtroth, Syncette) "It would be cool to create fire dragons that glow, where everything glowed like bright orange or something" (Talen-Zaw) "It would be cool to make the ice dragon kind of – like it has frost around you and at night you see blue and during the day it would be kind of white like frost" (Pajzara) Dundi & Tslez'k wanted ability to make glowing dragons of different flame colors as genotype choices
Engagement	Fix the dragon's hit box (multiple responses)
Freedom, Choice and Control	Several participants said they would prefer to just randomly find the quest and do it by choice rather than being told to do it. They felt that the narrative was a bit confusing without any background lore on dragons and the war (Rytoth, Jaegar, Stryker, Asdolufience, Nedtroth, Mukmog, Beastmode and Dundi) In contrast, others thought for schools, it would be best to skip the Skyrim tutorial and only do the DragonMist quest due to the violence and bad language (Dragonia, Drago, Syncette, Katniss, Ahendria, Lariea, Ancosa, Dill Pickles)
Radix	
Education	"to make it more educational, allow you to fail more" (Zayna) "It should actually teach instead of just provide information" (Syncette) It was educational but too boring to pay attention (multiple responses) "I would recommend it for STEM class, but it gets boring because all you do is collect stuff and turn it in and nothing happens" (Dragonia)
Engagement	Make general stores so you can buy and sell stuff (Ching-Chong) Make it 3D and fix the environment – one place had multiple exits that all went to the same place which was annoying (Dragonia)

Table 6.11

Participants Suggestions for Improving DragonMist and Radix

	Make it so your actions matter. Let you fail. Give rewards, have obstacles, make rewards do something or useful (multiple responses) Put in conflict. Let you do spells, more action (Drago, Syncette, Zayna, Jaegar, Stryker, Talen-Zaw) Less repetition and grinding (Asdolufience, Ryker, Rytoth, Gulum-mere, Jaegar, Stryker and others). More goals, more challenge (multiple responses) "Add mini-games and puzzles to make it more fun" (Zayna)
Freedom, Choice and Control	Make the avatar customization better, like give an option to not be human, make the skin tones more realistic, make it "less ugly" (Lareia, Ahendria, Katniss, Ancosa, Ching-Chong, Dragonia, Drago, and others). "Give it a point", "don't just put you in there" "tell you how to start" "Give it a main theme" "let me turn on quests", "let me skip steps I already know" (multiple responses) Allow you to teleport (multiple responses)

CHAPTER SEVEN

DISCUSSION OF QUALITATIVE FINDINGS

7.1 Overview and Revised Model

Qualitative data were examined and five themes emerged that address the following research question: (**RQ3**) How does the game's design influence the game play experience and learning outcomes from the player's perspective when playing an educational game compared to an entertainment game? Findings reveal large variations in player perceptions and interactions with the games in this study, confirming the complex nature of the research problem. The results were used to revise the game design model to illustrate relationships between the five themes (see Figure 7.1). This chapter will situate the findings in current literature and discuss the complex network of interactions found in the data.

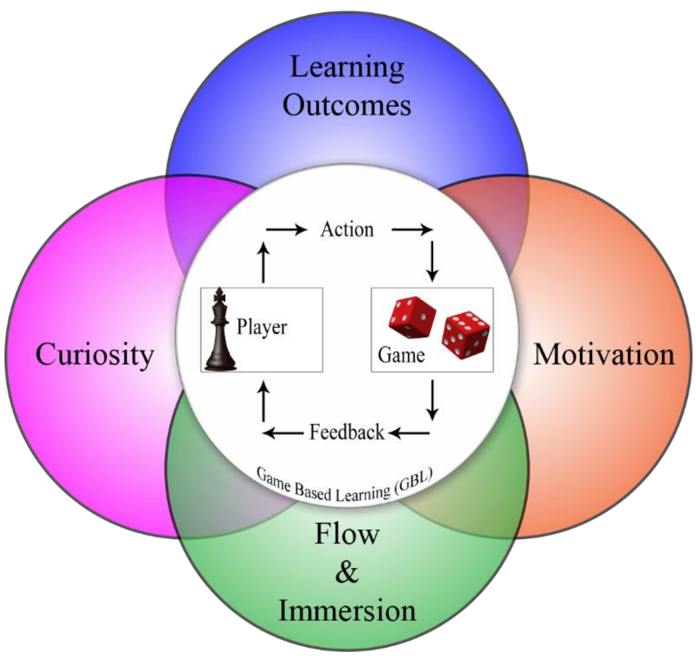


Figure 7.1. Revised GBL Model Based on the Five Themes that Emerged from the Data.

7.2 How Does the Game's Design Influence Learning Outcomes?

Results confirm the complexity of the game-player dynamic that produces the game play experience (e.g., McGonigal, 2011; Schell, 2015). However, despite personal preferences, gaming experience and science attitudes, most players perceived that they learned genetics to some degree for both games. More importantly, after playing DragonMist, players exhibited interest and curiosity which led to conversations of genetics and DNA in other contexts. Stimulation of curiosity prior to learning creates more effective learning experiences and curiosity enhances incidental learning (Gruber et al., 2014). Curiosity related exploratory behaviors and information seeking activates the dopaminergic reward center in the brain which enhances memory (Kang,2009). Therefore, DragonMist was designed to convey some explicit academic content, but the primary goal was to stimulate curiosity and related behaviors to encourage exploration and information seeking as well as to enhance incidental learning. Therefore, learning was evident on two levels for DragonMist, explicit academic content from the game and curiosity related transfer.

Researchers question the degree to which knowledge gained from game play transfers to other contexts (e.g., Fraser, Shane-Simpson, & Asbell-Clarke, 2014; Hou, 2015). Transfer refers to quality of learning and is defined as "ability to extend what has been learned in one context to new contexts" (Byrnes, 1996, p. 54). Evidence that students began connecting the genetics taught in DragonMist to other real-life contexts supports previous research that suggests academic content presented in games creates familiarity with domain knowledge and transfers to other contexts (Squire, 2004; 2012).

Moreover, evidence that the game's design, which encouraged creative problem solving, exploration and discovery, sparked curiosity and facilitated transfer corroborates Bransford et al. (1999) who found that environments which encourage learners to explore multiple solutions and perspectives of a complex problem can facilitate flexible transfer (Bransford et al., 1999). Additionally, evidence that students enjoyed mixing things together to create dragons as well as reported high levels of motivation supports findings that suggest environments that provide opportunities to create products and use new skills and knowledge are particularly motivating (Bransford et al., 1999). Finally, participants reported increased curiosity about genetics and dragons which stimulated information seeking and exploration external to the game as evidenced by collaboration with classmates, question-asking, and use of internet. This finding supports previous claims that games spark curiosity and interest about a topic which then generates information seeking resulting in deeper understanding and transfer (Arnone et al., 2011).

During the focus groups, participants continuously returned to DragonMist as the topic of conversation. The dragon stimulated more curiosity and interest compared to the flowers and bugs in the genetics quest for Radix. The "monsters" (i.e., animals) in Radix were more interesting to the participants than the flowers and bugs. However, the animals were not part of the genetics questline and acted as a deterrent to the genetics questline through off-task behaviors instigated by interest in the animals. Despite evidence of increased interest in breeding dragons compared to crossing flowers, several participants reported they thought they learned more about genetics in Radix. This perception was most likely influenced by the amount of explicit academic content in Radix and that all quests were educational. However, another explanation may be related to the feel of the game. Participants were more immersed and engaged with DragonMist and the game matched their expectations of an entertainment game which may have influenced their goals and interactions with the game. In contrast, Radix felt more like school and participants indicated it was all learning and "not a game."

7.2.1 The Dragon as a Reward and Fun Failure Increased Persistence

The dragon proved to be important for curiosity and interest, but also proved to be important across all of the five themes. The dragons were tied to the original commercial games' fantasy and lore which enabled the mod to integrate seamlessly with the entertainment game. Since Skyrim dragons are powerful and evil, when a Skyrim player encounters a dragon, a fight to the death ensues. This challenge adds to engagement and enjoyment. The uniqueness of the baby dragon added value to the reward which increased persistence in the genetics quest since the only way to have a pet dragon in Skyrim is to breed one. Feedback for correct genotype choices for the passive dragon was designed to resemble fun failure scenarios in the original game. Reported results indicate players were engaged, rather than frustrated, when their incorrect choice produced the wrong dragon that was aggressive and attacked. In addition to the increased action fighting the dragon, the player gained experience points in the game towards level-ups and could collect valuable loot and gold. This fun failure feedback design then minimized the stakes related to an incorrect choice and encouraged exploration of the genetics concepts further. Results confirmed that players persisted until they got the correct parents to provide the correct genotype to produce the correct phenotype (passive dragon). This fun failure provides immediate feedback to the player, in a supportive and engaging manner, so that they revisited the genetics concepts and learning was enhanced. After breeding an aggressive dragon, players asked questions, discussed the genetics with classmates, consulted the Dragon Priest's research journals, or consulted the DragonMist website for help. All participants persisted in the learning quest until they got the baby dragon. These findings support existing literature regarding failure in games. Evidence from this research supports the concept that failure becomes a learning experience through increased efforts and opportunity to experiment with different strategies and solutions (Annetta, 2010). DragonMist was designed to provide hints and clues that stimulate curiosity and encourage exploration and discovery. The Dragon Priest could have been experimenting to breed a passive dragon thereby providing explicit knowledge and ensured success. However, the Dragon Priest's success (an aggressive dragon) was the player's failure which created a problem for them to solve as they experimented and discovered the correct genotype for a passive dragon. The results document increased motivation and persistence in the quest which supports Annetta (2010). If an obvious simple solution exists and immediate success occurs, players will not invest effort to consider alternatives (Annetta, 2010). Low-stakes failure, exploration and discovery in games can provide realistic problem-solving experiences that traditional classroom cannot replicate (Annetta, 2010).

7.2.2 Comparing Rewards and Feedback in Radix to DragonMist

A key finding in this study is evidence of the complex nature of rewards and feedback in games. Surprisingly, one of the main complaints regarding Radix was the inability to fail. Nearly all participants indicated they wanted to fail more in the game but it was impossible to do so. Participants perceived persistence in the face of failure as more valuable accomplishment or winning and supports Annetta, (2010) regarding negative effects of simple solutions. Participants reported that failure (in games) provided opportunity to try different things, be creative and increase their skills and knowledge. However, they also expressed that the value of the reward had to match the challenge such that the reward was worth their hard work. Many participants reported that the baby dragon was a better reward for their efforts, and they reported they enjoyed mixing things together to get the right dragon. However, the results indicated that most participants perceived a lack of reward for their efforts in Radix which led to boredom and confusion.

Failure feedback in Radix consisted of the NPC refusing to accept the submitted item and minimal feedback was given (e.g. NPC says "Hmm not quite, I need a feltspittle flower. You can find them in Bladed Plains."). The feedback was perceived as less than helpful and created annoyance, frustration and/or confusion for many of the participants as evidenced by questions of "what does she want me to do, I don't understand this game at all" (Syncette). Most participants complained about the number of steps required to use a tool as well as being required to walk across several locations to collect an item which required numerous load screens. Therefore, the effort required to succeed (NPC accepts the item and assigns the next task) was perceived as exceeding the value of the reward. The repetitive simple game mechanics failed to challenge most students and they reported that Radix taught genetics well, but it was "not fun" (e.g., Syncette, Dragonia, Dundi) or "so boring it did not keep my attention (e.g. Ching Chong, Beastmode)." Some participants set a goal to complete a required genetics quest and since they believed Radix did not reward them for their efforts, they rewarded themselves by "doing a barrel roll" external to the game. Others avoided the game altogether in favor of different activities. The inadequate feedback and rewards hindered learning in that many participants perceived that they learned how to play the game or that they learned nothing. In contrast, most participants reported positive perceptions of the feedback (aggressive dragon and Bhusari's responses) in DragonMist. Bhusari was designed to act as a scaffold for learning as well as to support novice players. Bhusari helped the player fight; thereby provided balance between challenge and skill to promote flow. Several novice gamers expressed the success of this design choice as evidenced by describing Bhusari as a friend. Bhusari's status as a friend increased relatedness and allowed him to become an effective learning scaffold. Players would seek Bhusari's help when they bred aggressive dragons. Bhusari would help fight the aggressive dragon and then explain what went wrong, provide additional genetics knowledge and encourage the player to try again.

Visual clues were reported as important feedback by most participants and support learning. While playing DragonMist, all participants were observed investigating the visual feedback and/or discussing the meaning with classmates. Bhusari's comment "red, purple, blue, does that match anything else here?" (see Figure 3.20) prompted participants to explore the laboratory for those colors. The visual feedback used a consistent color scheme to support learning. People tend to group things based on color and intuit a relationship between items of the same color. Bhusari incites about these color and exploration reveals the meaning as players discover the colored Punnett squares in the Dragon Priest's journals and the colored animations in the breeding station. These visual clues stimulated questions and discussion between the players and helped the players make intuitive connections between the abstract genetics notation and colors associated with genotypes of the dragons. Non-experienced RPG players sometimes failed to make connections to some of the visual feedback clues that come natural to RPG players. For example, most RPG players intuitively knew to position their avatar like Bhusari who was there as a visual clue. Participants who did not intuit this correct position, could not make the correct associations between the colors in the Punnett square animation with dragon genotypes. When incorrectly positioned, players resorted to randomly choosing an offspring genotype which seemingly produced random phenotypes for the baby dragon. Therefore, the colors became confusing and frustrating to the player when they were not positioned correctly at the breeding station because part of the feedback information was blocked from view. Participants reported similar confusion regarding visual feedback in Radix. Radix used visual clues in the game by making the flowers different colors. However, once the flowers were collected (placed into the player's inventory), the icons used to represent the flowers were all the same. This lack of visual consistency created confusion and annoyance in the player which in turn lowered motivation. Participants also reported confusion related to inaccurate use of genetics vocabulary in Radix. Many of the players questioned the NPCs' instructions to "breed flowers". Player response to these instructions ranged from annoyance as they lost respect for the game's authority on genetics knowledge to confusion and questioning.

These findings support the importance of feedback in games. However, findings show that confusion, rather than understanding, occurs when the feedback is inconsistent or misleading. These findings support current literature that suggests learning environments that are problem-based and provide immediate feedback promote effective learning (Boyle et al., 2011).

Feedback can provide rewards or obstacles, or can be delivered as consequences to one's actions in the game. This type of feedback is powerful for increasing immersion and relatedness because players are immediately validated as their actions in the game makes a tangible difference. The hero's journey is a common game narrative archetype used to increase immersion by making the player believe they are unique and important. For the player to truly believe they are a hero, they must first perceive consequences to their actions. In other words, the game must respond to their chosen actions and provide feedback (see Figure 7.1).

A key finding in this research demonstrated action consequences were important to flow and immersion as well as motivation (autonomy, competence and relatedness). Curiosity was incited as the player wanted to see what happens if they perform a certain action. When players believed there was no consequence for their actions and choices, their relatedness with the game was inhibited because they perceived their presence in the game did not make a difference. Their curiosity was inhibited because "I do what the NPC asks and nothing happens!" (Jaegar referring to Radix). In other words, the game was not responding to them, so they were not important. This perception led to increased off task behaviors and low motivation and engagement with Radix. Most participants expressed the desire for opportunities to fail in the game so that they could feel important and learn more because they could try new things.

All participants expressed perception of consequences for their actions while playing DragonMist. Most participants indicated their actions had no consequences while playing Radix. Participants indicated Radix was not a game since it had no conflict to resolve and no consequences, so they perceived that their presence in the game did not matter despite the NPCs dialog that tries to set them up as a hero. Only one participant gave any indication of a perceived hero's journey in Radix while most participants wanted to help the NPCs in DragonMist. Therefore, a key finding is that narrative alone is not enough to establish the literary device of a hero's journey used to increase immersion and emotion in games. The game must also hold the player accountable for their actions such that the player believes they have an impact on the world.

7.3 How Does the Game's Design Features Influence Motivation

Before players will interact with an educational game, they must first be motivated to do so. Findings of this study supports previous research that indicates player motivation determines engagement while playing games and both motivation and engagement are greatly influenced by the game's design (Eseryel et al., 2014). In agreement with Ryan and Deci (2000), this study confirms that GBL environments designed to enhance player motivation engage players longer such that they complete more tasks and perceive greater competence. Figure 6.2 indicates DragonMist provided more motivation for players to engage with the game by supporting the three basic psychological needs of autonomy, competence and relatedness. Increased motivation and engagement resulted in greater persistence and greater evidence for voluntary interaction with the game (see Figure 7.2). Results of this study confirm the complexity of interactions between player preference and outcomes which increases the challenge for educational game designers. However, satisfaction of three basic psychological needs (*autonomy*, *competence*, and *relatedness)* determines the nature and quality of motivation (Ryan & Deci, 2000). The results of this study support evidence that intrinsic motivation (interest) enhances greater engagement and quality learning (Ryan & Deci, 2000). This is a key finding with practical implications. Personal preferences and personality influence gamer's interaction with and choice of games creating a complex challenge for educational game designers. However, autonomy, competence, and relatedness are basic psychological needs, inherent to all humans, and when met increase positive emotions and intrinsic motivation in GBL. Participants exhibited greater persistence in DragonMist and greater evidence of voluntary play as 25 chose to play DragonMist on free-choice Friday. Three female participants, who had previously expressed a preference to play with each other inside the Radix game, wanted to continue playing together and chose Radix (Lareia, Katniss, Ancosa). All three of these females also exhibited frustration with the game controller and fighting competence in DragonMist. Two male participants did not want to play DragonMist or Radix on free-choice Friday. One student who exhibited frustration with DragonMist due to violence and low fighting skills, and also exhibited extreme boredom and lack of interest with Radix, chose to play Minecraft on Friday (Dragonia). One participant asked to leave early because he only played platformers and did not enjoy playing other games (Kusold the Burley).

Figure 7.2. Most participants persisted through challenge and failure while playing DragonMist. Half the participants persisted in Radix while half stopped playing due to boredom. Given a choice, 25 of 30 participants chose to play DragonMist, three chose to play Radix, and two did not want to play either game.

Curiosity is also an intrinsic motivator (Berlyne, 1967). This study provides evidence that increased motivation to learn and play in the game, supported by increased flow and immersion, generated curiosity and enhanced learning. Players who perceived higher intrinsic motivation voluntarily interacted with the game and for longer periods of time (see Figure 7.2). Key findings in this study initiate evidence of game features that increased curiosity and led to exploration, information seeking and preliminary evidence of transfer of knowledge to other contexts. Therefore, this study adds to current literature by demonstrating that games can be designed to solicit, support and reward curiosity to support intrinsic motivation and stimulate curiosity such that persistence and other curiosity related behaviors conducive to learning arise. Practical implications from this research relates to the complex challenge of integrating academic content into a game while maintaining high levels of motivation and engagement. It is often difficult to insert explicit academic content into games. However, it is relatively easy to incite curiosity. The findings indicate that educational games can take advantage of curiosity to increase persistence and motivation in the game like the commercial game industry does (Howard, 2016). Educational game designers should focus on domain specific curiosity such that players seek and form their own knowledge about an academic topic rather than being spoon fed explicit facts to memorize. Evidence from this study suggest games can generate curiosity and encourage learners to tinker, explore, experiment, discover and form their own conclusions supported by substantive and immediate feedback. In other words, well-designed games that support curiosity can add value to traditional education by going beyond explicit academic content to encourage information seeking and exploration and self-regulated learning.

7.4 How Does the Game's Design Features Influence Flow and Immersion?

Flow, immersion, and intrinsic motivation are complex concepts with many components in common. Participants discussed many game features relative to flow and immersion that also influenced motivation, curiosity and learning. Further complexity became evident as participants perceptions of a given game feature varied based on other influencing factors as evidenced by mood and behaviors. The results support flow theory and SDT with relation to positive and negative affect (Csikszentmihalyi, 1990; Ryan & Deci, 2000). Notably, perceptions of violence emerged from the data and revealed complex interactions between the game and player. For example, most players expressed that violence in the game added to the entertainment and engagement value by adding action and humor. However, when the player perceived low competence or low choice and control in violent situations, affect shifted to negative emotions (e.g. anxiety and frustration). Negative affect reported for DragonMist referred to experiences of low game skills or inability to avoid fighting required for progression or low tolerance for violence. Specifically, five of the eight females and two males expressed negative emotions related to violence in the game. All seven of these participants indicated they never (n=6) / rarely (n=1) played RPG games. Two of the females changed their perception of violence after a few hours of play time as they gained experience in the RPG game genre (Syncette & Vallinalda). Both females later stated that they would not advise removing the violence and action because the game would then become boring. Specifically, when these two females gained enough skill to navigate the game and avoid violence when they chose to (e.g., neither wanted to kill animals), their attitudes towards the game changed and they exhibited laughter and active engagement with the game, persisted through challenge and chose to play the game on the free choice day. Another female initially enjoyed DragonMist and actively engaged in fight scenes until another participant started laughing at her. As a result of this peer interaction, she became embarrassed about her skill in the game and perceived low competence with respect to fighting skills. After this negative interaction with the other participant, this girl's attitude changed towards both games and remained negative (apathetic and derisive) for the remainder of the study. The remaining two females played Radix first and enjoyed playing together. Due to technology issues with the computers, when they switched to DragonMist they were physically separated in the lab. Both had difficulty in the fighting scenarios, perceived absolute failure and gave up. If they had been next to each other so that they could have supported each other, their attitudes may have been different. One male was observed intentionally attacking friendly civilians and was laughing about it with a classmate. However, once the game responded by reciprocal violence against his avatar he got upset and wanted to quit. After resetting his game prior to his attacks, he repeated his violent behavior against the friendly NPCs and reaped the same consequence. This second time, he got upset because he didn't want to start over and watch the bloody part of the opening tutorial again. He told me he wanted to quit because watching the violent animation upset him. The last male also voluntarily attacked guards and civilians and was laughing about it until the guards put him in jail. The guards took his stuff and he lost the horse he had stolen. At this point he told me he wanted to stop playing and go home because the violence bothered him. While he was talking to me, another participant got his game reset and told him "I got your horse back and got your stuff back and the guards are leaving you alone" (Ching-Chong). Drago then started smiling and said, "you got my horse back?" and he was happy with the game again and told me "the violence is fun I just didn't want to lose my stuff."

Notably, these findings introduced yet another level of complexity to the challenge of educational game design. This study investigated multiple variables contributing to a network of interactions between the player, the game and the outcomes. However, this study did not consider variability in a single person's perception of a single game based on time and context. Nor did this study investigate the complexity stemming from social networks and/or peer interactions. But overall, reported evidence indicates when players lacked gaming skills to navigate their avatar away from violence (run away from the wolf) or necessary to progress (kill the draugr to get to the science lab), they became frustrated, anxious and exhibited low persistence. In contrast, when players developed game skills necessary to avoid violence or to defeat enemies, their mood improved and they exhibited positive emotions (laughter, active engagement and sharing experiences with their classmates) and persistence increased. Therefore, it is conceivable that violence was not at the foundation of the discomfort with the game. Rather, it seems that low competence was the real cause for anxiety and frustration. However, all the participants, including the ones who reported violence added to fun and action in the game, reported that the level of blood and violence in DragonMist would be an issue for teachers and some parents if used in the classroom. Participants all agreed, that even though they thought the game was boring, Radix did teach genetics concepts well and was the better choice for a classroom. In contrast, when asked which game they would voluntarily play at home or discuss with their friends, all but three replied that it would be DragonMist and several had already discussed DragonMist with friends.

Flow state is considered as one of the three levels of immersion (Brown & Cairns, 2004) and consists of nine components (Csikszentmihalyi, 1990). Two components necessary for flow state are clear goals and challenge that is attainable but slightly more difficulty that the players current skill or knowledge (Csikszentmihalyi, 1990). Results provided evidence that players, who perceived no purpose or goals and/or their skill exceeded the challenge, exhibited boredom and apathy which also led to low persistence, avoidance and off-task behaviors. Participants reported more goal focused activity and perceived challenge and accomplishment and/or mastery for DragonMist which in turn enhanced motivation (competence), flow and immersion. Most participants complained that Radix had no goals, no purpose, no challenge or failure and perceived it as boring. Results of this study indicates that DragonMist was more motivating and more engaging, and supported flow and immersion better than Radix. Figures 6.2 and 6.10 supports the greater entertainment value of DragonMist over Radix. However, this result does not present a full understanding of motivation, flow and immersion in GBL.

Participants who expressed boredom while playing Radix responded in a variety of ways. Several players became disruptive and continuously vocalized their displeasure with Radix, remained off-task and/or refused to play. Others played through the genetics rapidly and moved on to other activities quietly. Others engaged in the genetics questline with focused attention in a methodical linear manner, writing notes and studying the content and did not complain or go off task. However, during focus group and open response, these same participants, who appeared to be engaged with Radix, reported that Radix was tedious and boring because it was not challenging, had no goals, no failure and no rewards. One participant wrote “Radix is interesting, but it is NOT FUN!” (Teela).

Participants who exhibited positive emotions and active engagement while playing DragonMist also responded to the game in a variety of ways. Some participants played DragonMist with focused attention and methodical approach playing through each quest in a step-by-step linear fashion. Others played the genetics quests with focused attention and then moved on to randomly explore Skyrim without accepting any other quests. While, others approached the genetics quests with the same playstyle as the rest of Skyrim. Some participants exhibiting frustration or anxiety early in the game later exhibited laughter, enjoyment and confidence in the game. For example, observations showed one participant avoiding conflict whenever possible early in the game and seeking it out later. One participant tried to avoid failure of any capacity while playing the genetics quests but intentionally set the avatar up for failure (e.g., riding the horse off of high cliffs to watch them roll down the mountain and die) in non-genetics related quests.

Another complexity was illustrated by observing two participants in particular. These two participants, diagnosed with ADHD, exhibited similar learning behaviors and outcomes, but different motivations for and responses to the two games providing a nuanced understanding of the game – player interaction. Both participants avoided playing Radix, dramatically expressed boredom with the game, and despite constant prompting to return to Radix, remained on their phone or engaged with activities on the internet and/or moved around the lab in search of other games to play. In response to "Describe what you learned while playing this game", one wrote "nothing" and the other wrote "I really did not learn anything." These same two participants were completely focused and immersed in DragonMist evidenced by complete unawareness of surrounding activity and lack of acknowledgement when I addressed them. However, their avatar actions inside the game were as unfocused and random as their physical actions while playing Radix. Both participants were totally immersed in exploring the game and interacting with NPCs, but failed to focus on goal completion of any quest including the genetics quest despite constant prompting to do so. Their responses to the question "Describe what you think you learned while playing this game" were "It taught me how to pick a lock" and "I really didn't know anything, sorry ☹ (drew a frowny face)."

Overall, participants who failed to persist in DragonMist exhibited anxiety and frustration due to low gaming skills (low competence) which was perceived as low autonomy (lack of freedom, choice and control). In contrast, participants who failed to persist in Radix exhibited boredom, apathy, frustration and confusion related to lack of challenge which blocked flow and immersion, and inadequate support or feedback which undermined competence (ability to achieve mastery, clear goals) and blocked flow (balance of skill to challenge). Therefore, evidence of motivation, flow and immersion (or lack of) did not necessarily produce the same interaction with the games. Notably, other influences on motivation were obvious in these reported results. This variation in player motivation, specifically as it relates to flow and immersion, for both games indicates motivation is a complex phenomenon in GBL, especially related to learning objectives, and requires further research. However, results provide evidence that support of basic psychological needs (autonomy, competence, and relatedness) increased positive affect, persistence and voluntary interactions with learning objectives and the game overall. Other motivational supports may improve GBL further. The variations in participant perceptions, behaviors and outcomes in this study confirm the extreme challenge related to good educational game design and illuminate the extremely complex network of interactions between game and player that results in variable outcomes produced by these relationships.

Other game features were discussed as important to flow and immersion as well as motivation. Travel options increased immersion for DragonMist. Players enjoyed riding horses and hiring carriages for travel. The horse, as a travel option, especially appealed to the participants who loved to explore and who enjoyed the environment and graphics. Others, who were quest, advancement and/or mastery oriented, utilized the fast travel frequently. Participants expressed frustration related to the travel in Radix. The only game mechanic was walking from one location to another. While a few participants expressed pleasure from seeing new locations, most wanted to complete the genetics quest efficiently and lengthy travel requirements and multiple load screens caused negative affect and low persistence. Evidence suggests travel options in DragonMist enhanced immersion but also increased perception of autonomy by increased choice.

Quest options were frequently mentioned as engaging motivating game features that incited curiosity. Players noticed side quests via the glowing nav markers on the DragonMist compass which in turn encouraged exploration. While it might be suspected that these diversions would decrease learning, they increased perception of autonomy (freedom, choice, and control) as well as immersion (real-life adventure) and increased positive perceptions of the game overall. Several players who chose Skyrim quests over DragonMist initially, returned to DragonMist later in the game play sessions out of curiosity or desire for the rare and valued pet dragon or for various Easter eggs hidden in the DragonMist temple. In contrast, players felt that their freedom, choice and control in Radix was hindered because their only choice in the game was educational quests. Because players felt they were forced to play the educational quests (low volition), many expressed negative opinions about the game or stated that “this is not a game.” A few participants believed Radix did provide a choice and said they liked the fact that the game offered “more quests than I could do”. Participants reported issues with the Radix user interface which created frustration. The quest log does not allow the player to turn on/off quests which was perceived as limiting to their autonomy and added to frustration and confusion in the game. In contrast, DragonMist also presents the player with numerous quests, but the player can turn them on / off and a marker for the selected quest is visible on the HUD (heads up display) compass. The difference in presentation of quests (user interface) between the two games changed the player’s perception of freedom, choice and control for the game. It is understandable under the time constraints of a classroom; quest order and options must be controlled. However, if the game is designed to motivate and engage players to voluntarily interact with the game, they have the luxury of randomly discovering an educational quest, and then choosing to complete it, would support intrinsic motivation and engagement.

One of the most observed and discussed game features in this study was customization of the avatar. Evidence confirms other research that identifies the importance of avatar customization to motivation, flow experience and game loyalty (Liao, Cheng & Teng, 2019; Yee, 2006, 2009). In support of these previous research studies, avatar customization increased relatedness and made the game feel more real as players exhibited empathy for and relatedness to the avatar and NPCs in the game. Initially, the appearance was important. For more experienced RPG players, skill and perk customization was a strategic choice for avatar customization. In DragonMist, the player's relationship with the avatar (and NPCs) and the immersion with the game increased as players interacted with and related more to their virtual presence in the game. Participants reported increased perceptions of their avatar and other NPCs as seemingly real-life personalities as the game responded to the player's action by imposing consequences to their actions. Players often were observed speaking out loud to the NPCs in the game as if they were real people, referring to their avatar as "I", and exhibiting concern when the avatar was in peril or empathy when the avatar failed. Additionally, many participants expressed altruistic intention and desire to help the NPCs in the game. Only a few participants expressed this degree of relatedness and immersion for Radix.

Evidence that increased relatedness to the avatar and NPCs in the game stimulated curiosity and enhanced learning was observed and reported. Players interacted with the educational content because they wanted to help the NPCs ("I am trying to help Bhusari breed this dragon but he keeps killing them" Tslez'k), or they visited locations in the games and accepted quests in the game "because my guide in blue told me to go to Solitude… I have to go even though it is so far away" (Nedthroth). One example, from Radix, was seen when Syncette didn't want to travel all the way across the world (and she sighed and held her hands up really far apart to show distance) but "I have to help Prunessa find these lumabells to cure some disease." Results support customization as a game feature that increases motivation, specifically relatedness, and immersion which then increased learning in the game. Participants indicated they wanted to speak to Bhusari (the more-knowledgeable-other) after each experiment, act on his instructions and help him with his genetics research which increased interactions with the educational content in the game.

Finally, a game feature that increased engagement with the game, but not specifically related to flow or immersion, was the multiplayer option. Radix offers in-game interactions with the avatars as well as chat and email functions. DragonMist is single player and many participants chose to play physically together, discussing strategy and sharing accomplishments, but others expressed the desire for multiplayer options to help them succeed in the game. Related to learning, multiplayer options that encouraged collaboration and discussion were positively influential to learning gains. Players were seen discussing educational goals and genetics concepts for both games. Radix players would follow each other in the game and work on quests together, share resources and information, and help each other with genetics tool use. However, for participants who felt unchallenged or unengaged with the game, they used the in-game features of Radix to remain off task as well as disrupt others who wanted to complete the genetics quest. The chat function became a popular feature to poke fun at other players and the game itself. While, for the most part, this humor was perceived kindly and as added fun, a few players felt bullied and actions were required to remove the multiplayer option for the remainder of the study. When these multiplayer tools were constrained, most of the participants started complaining that Radix was boring and tedious, and they went off task rather than continue the game. In practice, multiplayer options should positively enhance collaborative learning, increase player confidence, and support learning and curiosity in games as players discuss creative ways to solve each task. However, constant teacher facilitation may be required to keep the interactions on topic and conducive to a safe educational environment.

To summarize, all five themes overlapped confirming the complex interactions between game, player and outcomes (learning, curiosity, experience). For all themes, I found both similarities and differences between player perceptions of DragonMist compared to Radix. First, participants reported perceived learning, ranging from how to play to the game to genetics, for both games. However, DragonMist was evidenced to incite more scientific curiosity leading to transfer of knowledge. Participants referred to similar game features that enhanced motivation, flow and immersion for both games. Also, participants indicated both games had features that increased curiosity. Notably, only a few participants reported high levels of flow and immersion for Radix as opposed to high levels of flow and immersion for DragonMist. Additionally, more players reported elements that increased motivation for DragonMist over a more varied set of game features. Results indicate some key game features known to support motivation and curiosity are absent in Radix such as violation of expectation which is a confirmed method to incite curiosity in theory (curiosity (Hunt, 1963, 1965; Jirout & Klahr, 2012; Piaget, 1952, 1969) and in the commercial game industry (Howard, 2016). Nuanced understandings were gained related to player response to similar game features at different play times and/or under different context. All participants reported experiences like fun, enjoyment, concentration, immersion, learning and curiosity. Nevertheless, participants more explicitly reported motivation, flow and immersion, and curiosity related to DragonMist. More specifically, negative emotions (e.g., frustration, confusion, boredom and apathy) were more frequent and stronger for participants reported and observed interactions with Radix. Participants frequently reported boredom and apathy towards Radix in relation to absence of goals, rewards and consequences and frustration occurred as a result of lack of direction and repetitious tedious simplistic game mechanics. Participants did not report feelings of boredom while playing DragonMist. However, several participants reported or exhibited anxiety and frustration related to low competence and aversion to violence. Overall, participants perception of learning ranged from nothing, to how to play the game, to genetics for both games.

CHAPTER EIGHT

INTEGRATION AND INTERPRETATION OF RESULTS

8.1 Connections to Research Question

This study asked middle school and high school students to play three different games to investigate learning outcomes related to basic genetics concepts and asks the players to share their perceptions of the games to improve educational game design. Curiosity was explored as a personality trait that influences how students in a diverse student population may approach and interact with novel learning environments as well as considering curiosity related behaviors as a learning outcome. Quantitative and Qualitative results are integrated and discussed in this chapter.

Results of both quantitative and qualitative data strands are integrated to explore convergence (or divergence) and enhanced understanding of the research problem to answer the following mixed methods question:

RQ6: What game design features enhance (or inhibit) the game-player-learning experience and how do these features influence engagement, motivation, curiosity and learning in a GBL environment from the learners' perspective?

This chapter integrates research results and will show what game features were perceived to influence motivation, engagement (flow and immersion), learning and curiosity. Radix and DragonMist game features will be compared and illustrated via game screenshots to enhance understanding of the game features identified in this research as important to the player. The goal of this chapter is to illustrate various game design choices that designers can implement to improve educational games and to inform educators on GBL implementation in the classroom or as supplemental learning tools external to the classroom

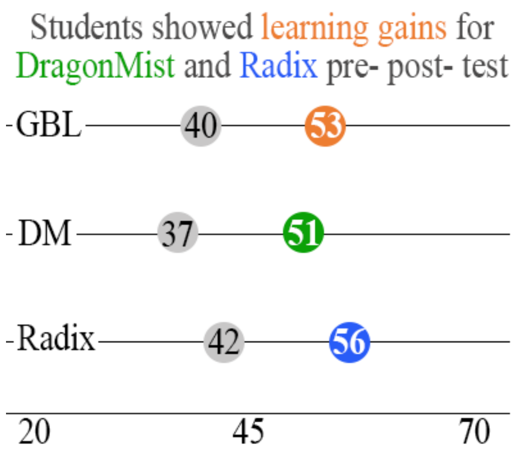
8.2 Learning in Games

Participants showed statistically significant genetics learning gains pre- post- test for both games. There was no statistically significant difference in learning gains in Radix as compared to DragonMist. Students' correct responses for matched Radix specific and DragonMist specific questions were compared as an initial understanding of knowledge transfer in GBL. Results showed no statistically significant difference in group means for correctly answered context specific questions. Open response and focus group discussions asked participants to describe what they thought they learned in each game and to explain how the game supported that learning (or not). Although participants expressed various perceptions of learning (nothing, how to play the game, genetics), overall, participants reported they learned genetics to some degree. In addition, focus group conversations provided evidence of transfer after playing DragonMist as the dragon stimulated curiosity about DNA and the ability to create dragons in real-life which lead to discussion of dinosaurs, wooly mammoth, snakes, cloned sheep, and retrieving DNA from a man who had been suspended in ice. Evidence provides support of previous research that indicates learning occurs in games (e.g., Gee, 2007; Squire, 2011). Current research questions the degree to which knowledge gained from game play transfers to other contexts (e.g., Fraser, Shane-Simpson, & Asbell-Clarke, 2014; Hou, 2015). Results of this study provide preliminary support for transfer of knowledge gained in game play to other contexts. A summary of the qualitative and quantitative findings for genetics learning is provided in Table 8.1.

Table 8.1

Evidence of Learning Summary for Radix and DragonMist

Pre- Post- Genetics Test



Learning gains were significant ($p < .001$) with large effect size ($d = .964$)

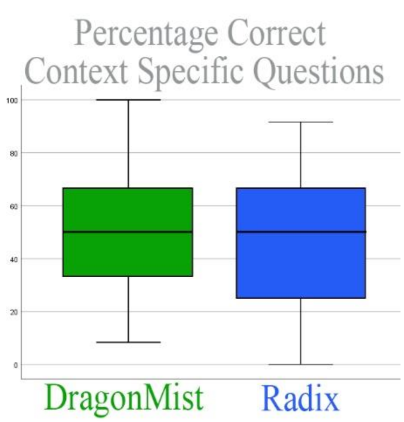
Game Logs

Perceived Learning

"I didn't know anything about genetics, and learning like the capital A and the little case a and like the dominant & recessive" (Pajzara)

"I felt a lot of learning. I learned that there is a lot of genetic variables & I learned what recessive & dominant was" (Zayna)

Evidence of Transfer Between Contexts



Non-statistical significance ($p = .417$)
Note. Should be interpreted with limitations due to large standard deviations

Perceived Learning

"I understand why the dogs act the way they do. Beau is large 'A' large 'A' so that wins, and he is always mean – he is the boss. But Molly is little 'a' little 'a' and she is passive." (Tslez'k)

"It has already been done with a sheep but also they need DNA, … but animals' DNA 100 million years old can bring them back if they died out" (Shrek)

8.3 Dispositional Curiosity in GBL

Humans and animals are biologically wired for exploratory behavior and information seeking as is evidenced by the dopaminergic system in the brain (reward system) that is activated by curiosity stimulation (Kang, 2009) Epistemic curiosity activates the reward center and enhances memory (Kang,2009). Day (1968) defined curiosity as a Zone of Curiosity where optimum experience and learning occur, a zone between the zone of frustration and anxiety and the zone of boredom. Higher dispositional curiosity increases tendency and desire to seek out opportunities to be curious, interact with novel environments, or seek new knowledge (Litman & Silvia, 2006) and leads to higher probability of pleasure (Peterson et al., 2007). Other perspectives do not agree that curiosity exists as a stable trait (Coie, 1974). A pre-curiosity personality survey (5DC, Kashdan et al, 2018) was used in this study to determine what degree a person's trait curiosity might influence their acceptance of and interaction with games as novel uncertain learning environments. Kashdan et al., 2018 distinguishes five distinct factors related to dispositional curiosity: *Joyous Exploration (JE), Deprivation Sensitivity (DS), Stress Tolerance (ST), Social Curiosity (SoC)* and *Thrill Seeking (TS)*. Hierarchical multiple regression analysis suggests dispositional curiosity (specifically JE and TS) account for between 23% to 39% of the variability in dimensions of game play experience (i.e., immersion, enjoyment, endurability, interest, attention, and motivation) (see Figure 5.2). ST and DS accounted for 28% of the variability in information seeking and the full curiosity model (JE, TS, DS, ST, and SoC) accounted for 42% of the variability in exploration (see Figure 5.2).

Observations and participant perceptions verify that dispositional curiosity has some degree of influence on a person's response to GBL. To examine these results from a qualitative perspective, two specific cases will be discussed (See Table 8.2). As seen in Table 8.2, Syncette's overall dispositional curiosity is high (87%). Her JE and TS were also high (96%, 80%, respectively) which was shown to predict immersion, enjoyment, endurability, interest, attention and motivation). Overall, Syncette's related game play experience dimensions were high ranging from 60% to 90%. Syncette's DS was 100% and her ST was 60% which was shown to predict information seeking behaviors. Syncette's information seeking behaviors were 88%. Observations of her interactions with the game confirmed that she persisted through stress and frustration while learning how to navigate the game and exhibited a change in behaviors the second day. She was observed actively engaged with the game, highly focused on the learning content and demonstrated information seeking behaviors via consulting the DragonMist website and asking questions.

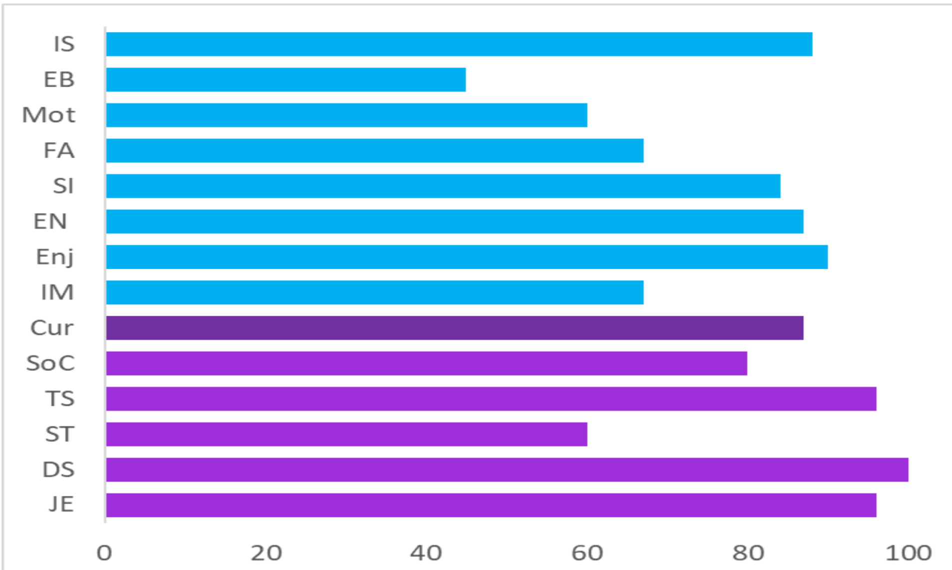
In contrast, Drago reported moderate curiosity overall (42%) and game play experience dimensions were much lower than Syncette. Drago's JE was low (32%) and his TS was moderate (60%) which is associated with his low scores for endurability (40%) and enjoyment (37%). Moreover, his ST is low (28%) and observations confirmed that any failure or challenge in the game caused him to shut down and stop playing. Drago's DS (associated with epistemic curiosity) was also low (20%). DS creates a tension related to information gaps and is considered an avoidance approach as a person is driven to relieve tensions by gaining missing information (Lowenstein, 1994). Drago's low need to resolve gaps in his information along with his low stress tolerance supports observations of his game play (e.g., quit in the face of failure or challenge).

Quantitative results show that curiosity factors explain a portion of the variability in game play experience variables investigated in this study. Three participants similar to Syncette and three similar to Drago provide deeper understanding by exploring extreme cases. These cases provide support of the curiosity profiles defined by Kashan et al. (2018). Practical applications for intervention strategies to enhance learning in games should consider the diversity related to individual preferences and personality. The integrated results of this study demonstrate that students in a diverse academic population will react differently to the same stimuli. Low deprivation sensitivity (DS) and low stress tolerance (ST) may inhibit student learning in games. Low drive to resolve the tension of not-knowing (DS) combined with inability to deal with the stress of a novel uncertain game environment (ST) resulted in lower endurability and lower engagement with the learning activities. On the other hand, participants high in dispositional curiosity, overall, will persist through difficult learning curves and/or uncertainty in games. High DS (drive to learn) increases endurability such that information gaps are resolved. However, dispositional curiosity accounts for less than half of the variance in the game play experience and outcomes. There are limitations to generalization of these results due to small sample size (N=31) which prohibited cluster analysis to discern distinct dispositional curiosity patterns in the non-extreme cases. Most participants had more moderate curiosity measures across the five factors. More research is needed to fully understand dispositional curiosity influences on GBL.

Table 8.2

Dispositional Curiosity Personality Profile and Interactions with GBL Intervention

Legend: IS-information seeking; EB-exploratory behaviors; Mot- motivation (autonomy, competence and relatedness); FA-focused attention; SI-situated interest; EN-endurability; Enj-enjoyment; IM-immersion; Cur-total curiosity scale; SoC-social curiosity, TS-thrill seeking; ST-stress tolerence; DS-deprivation sensitivity; JE-joyous exporation



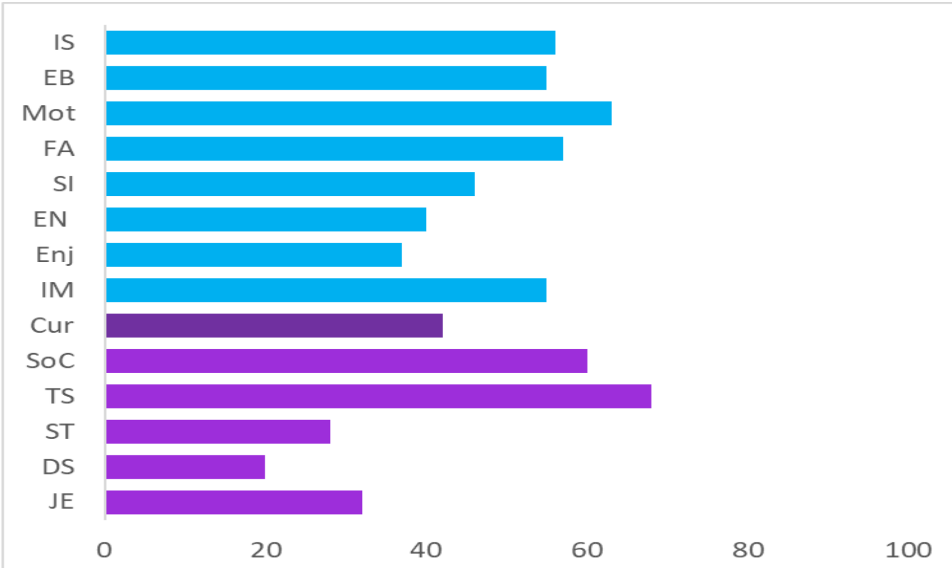
Syncette (5th grade, Female, Non-Gamer)

Syncette originally did not think she could participate in the study because she had never played games and she was in the 5th grade. However, she was on a 7th grade science curriculum and loves science, so I told her she could join the study. On day one, I noticed she had stopped playing DragonMist. She complained of a headache and said she didn't understand the game's connection to genetics. She was having difficulty with the fighting required to progress to the science lab and did not want to kill animals. She asked if she could quit and read a book. She then asked if she could just watch the videos on the DragonMist website.

The next day Syncette returned and said she wanted to try again after watching the videos. She played, exhibiting active engagement – laughing and sharing her game experience. She said "I love hitting these skeletons and watching their heads explode". When she reached the science lab, she asked a lot of thoughtful questions about genetics, she read the research journals, she drew out the Punnett squares on her name card and created her dragon. She accepted the Fire & Ice quest and continued in the game. On the free-play day, Syncette chose to continue playing DragonMist

Table 8.2

Dispositional Curiosity Personality Profile and Interactions with GBL Intervention



Drago (7th grade, Male, game preference First-Person Shooters (FPS)

Drago started playing DragonMist and was having a lot of fun playing with a group of classmates by discussing their avatar creation and showing each other things they found in the game. Drago tended to follow along with some of the others and when they discussed and decided to assult a civilian, Drago did likewise. When the citizens started attacking him, he got frustrated and stopped playing. I helped reset his game to a time prior to his assult and he started over. He was now behind his friends in the questline to complete DragonMist so he avoided the genetics quest and headed to Whiterun instead. He attacked a guard and when they put him in jail and took his stuff, including the horse he has stolen, Drago got really upset and asked me if he could stop playing and go home. The next day he started playing again but when a classmate got upset with the violence in the game, Drago told me he did not like the violence and wanted to stop playing. His mother told him "tell the truth". He then said, "the violence is fun, but I lost all my stuff and I want to stop playing". The other participant had become disruptive and was keeping Drago upset, so I separated them (physically) in the lab and Ching-Chong helped Drago get his horse back and Drago was happy and played the game quietly the rest of the game session. However he never went back to the DragonMist quest to complete all of the learning tasks.

8.4 State Curiosity and Domain Specific Curiosity in GBL

Individuals tend to be curious about specific things that interest them, so it is important to understand if games can incite curiosity about academic topics that educators expect students to learn. Curiosity is critical for educational game design because "to predict, or even control, curiosity would be to teach more efficiently, to entertain more consistently, and life would be endlessly interesting (St. George, 2016, p 7)." Berlyne (1954) described curiosity as an intrinsic motivator resulting in an appetitive tendency to explore or investigate novel environments. Gottlieb et al. (2013) described curiosity as a cognitive structure and ability to reason that makes extraordinary advances possible and as an insatiable need to learn and understand. Some researchers question the ability to incite curiosity *de novo* stating prior knowledge makes an information gap become salient, and then a person is driven to relieve the tension of not knowing by searching for information (e.g., Lowenstein, 1994; Olson & Camp, 1984). Early perspectives of "a curious person, suggests curiosity is either present or absent (e.g., Maw & Magoon, 1972). More recently, Spielberger (1979) distinguished two types of curiosity as trait (i.e., a stable personality trait that determines the frequency an individual experience curiosity) and state (i.e., intensity of feelings of curiosity at a specific time). Other researchers state that curiosity can also be domain specific (e.g., scientific curiosity) (James (1890) 1983; Weible & Zimmerman, 2016). Scientific curiosity is defined as curiosity about science and scientific processes (James (1890) 1983). Therefore, scientific curiosity is identified as a way of thinking (e.g., tinkers, experiments, forms hypotheses and conclusions, and discovers) (Weible & Zimmerman, 2016). The results of this study support evidence of both trait and state curiosity and supports ability to evoke curiosity, *de novo*, given correct stimuli (Gottlieb et al., 2013).

Linear regression results indicated a non-statistically significant relationship between pre-genetics knowledge, as identified by pre-test scores, with state curiosity measures post-game play ($r = .14$). The Game Play Experience surveys were completed after playing each of the games. Paired-samples t-tests were used to compare state curiosity generated by each game. DragonMist incited more curiosity than Radix with large effect size ($p < .001$; $d = .88$).

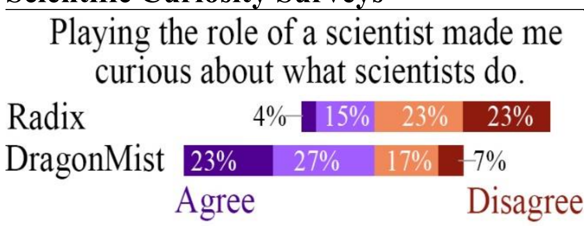
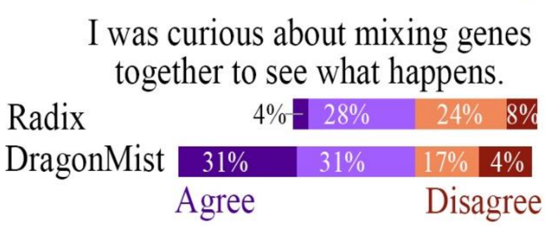
The difference between testing for trait and state curiosity is context (Lowenstein, 1994). A pre-survey was administered to examine trait scientific curiosity (*SCILE*, Weible & Zimmerman, 2016). These eight Likert scale items were revised to be context specific and re-administered post- game play to examine the games' ability to incite domain specific curiosity. Scientific curiosity was significantly enhanced ($p = .05$), and with moderate effect size ($d = .39$) after playing DragonMist. Scientific curiosity was significantly reduced ($p = .001$), and with moderate effect size ($d = .73$) after playing Radix. The mean group change in scientific curiosity between DragonMist and Radix was statistically significant ($p < .002$) with large effect size ($d = 1.09$) in favor of DragonMist.

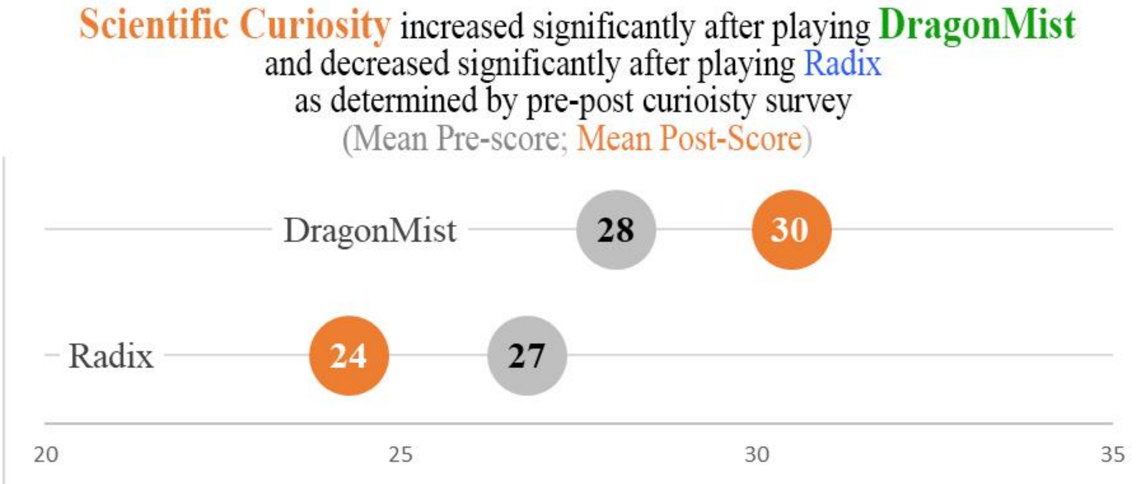
These quantitative results provide evidence that a difference exists and that DragonMist more successfully incited general and scientific curiosity. Qualitative results converge to add meaning by explaining how DragonMist evoked more curiosity. Participants were asked to respond to the question "Which game made you more curious?

Describe how the game made you curious" in open response and focus group. As seen in Figure 6.11 shows that participants were more curious in DragonMist than Radix and the game stimulated that curiosity in a more diverse manner. Participants indicated they used maps and tools, internal to the game, for both DragonMist and Radix. NPCs were a source of information for participants in both games. However, NPCs in Radix failed to stimulate curiosity in the player while participants indicated they were highly curious about NPCs in DragonMist. Where DragonMist excelled, and Radix failed, is seen under the cognitive perception's category, specifically violation of expectations, and puzzles and challenges. Participants exhibited and/or discussed scientific curiosity in DragonMist more often than for Radix. All perceptions of the game, combined, influenced degree of persistence in the game which was much higher for DragonMist. A sample of questions, and summary of the results are shown in Table 8.3.

Table 8.3

Sample Curiosity Survey Questions and Evidence of Curiosity in the Games

Sample Questions from the State and Scientific Curiosity Surveys	**Participant Responses and Observations**
  	"I like mixing things together to make the dragons, can I make more different kinds?" (Tslez'k) Nedthroth loved mixing things together to create items in the game. He showed me ingredients he combined to make potions and ores he collected and how he mixed them together to craft weapons.



Note: sample questions were picked at random from the survey. Percentage of students selecting “I don’t know” was not displayed on the graph. The graph was normalized such that Agree and Disagree are represented on 100% scales to reduce visual bias.

Quantitative results of paired-samples t-tests indicated that players experienced significantly higher (with moderate to large effect size) game play experience on all dimensions of engagement and curiosity behaviors in favor of DragonMist (See Table 4.4). Qualitative results converged and provided support of these findings to enrich understanding of the research problem by identifying game features that supported curiosity. The primary goal of this research is to provide insight into better educational game design. Some game design features, shown in the results to stimulate and support curiosity, are recommended as relatively simple considerations. Some other game design features are more costly and time consuming and inclusion would have to be balanced between value to learning outcomes and difficulty of implementation. The game features that support curiosity which are relatively easy to design should be implemented in educational games to enhance learning as well as increase persistence and voluntary interactions with the game. Three game features that would be easily implemented are recommended for educational games as follows.

First, violations of a person's expectations are known to evoke curiosity (Hunt, 1963, 1965; Jirout & Klahr, 2012; Piaget, 1952, 1969). This concept is closely related to randomness and surprise in games. Commercial games provide players an engaging experience with uncertain outcomes. Successful games often increase curiosity by violating the players expectations, providing random and surprising events, and the popular Easter egg. Evidence that DragonMist used violation of expectation combined with an Easter egg to improve learning is seen in the interaction between Syncette and Ching-Chong. Ching-Chong initially wanted to play Skyrim and avoided the DragonMist genetics quest. He observed Syncette using her ebony fire sword and became intrigued. Seeing a participant, who admittedly had never played games, wielding a high-level sword violated his expectations of the game (i.e., this is a powerful weapon normally unavailable to a player of such low experience level). His desire to find this rare and valuable Easter egg prompted his return to the genetics quest in search of this sword; thereby, completed the genetics quest. Violating a player's expectations and/or hiding rare valuable items for them to find increase curiosity and engagement with the game. As evidenced in DragonMist, this method does not have to be directly tied to academic content to increase interaction with the learning concepts. The only violation of expectation observed in Radix was the misleading use of academic vocabulary. When the NPCs continually asked the players to breed flowers and players expected the word breeding to refer to animals and expected that flowers would be crossed or seeds would be planted, it prompted question asking. However, this violation of expectation created frustration, annoyance, and mistrust of the game’s authority on genetics rather than increasing curiosity about learning the genetics concepts (see Figure 8.1). This method to increase curiosity should be utilized to incite curiosity and related learning behaviors and only requires creative thinking on the designer’s part.

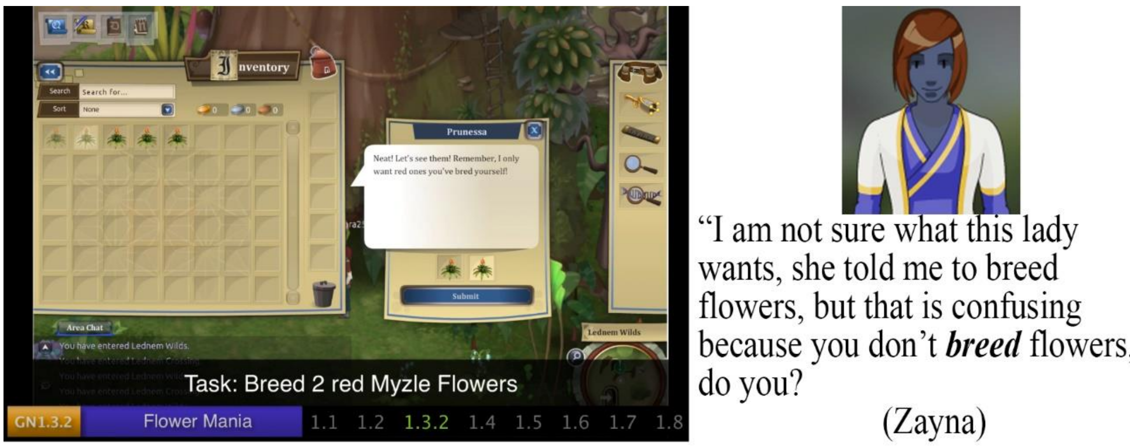


Figure 8.1. Teacher Dashboard and game screenshot showing that Radix NPCs tell the student to breed flowers which caused confusion for several participants in this study.

Second, RPGs have quests within quests so that the player has opportunity to choose their game play experience as they progress towards the main goal, or boss fight. Players in Skyrim are often presented with puzzles for which they must search for clues and then solve to gain access to hidden or prohibited locations. This technique adds challenge and mystery to the game which in turn supports curiosity. Searching is a primary game mechanic used in games to incite curiosity and promote engagement and persistence in the game. In DragonMist the player must search for research journals hidden in the library to gain necessary genetics knowledge to breed a dragon.

The NPCs in Radix tell the player “go to Lednam Wilds and collect a lumabell of each color, there are two colors”. The game mechanics require the player to walk to Lednam Wilds, pick the flower and return to Prunessa. The flowers are always in the same location and there are no obstacles or puzzles blocking access; therefore, there is no mystery and no challenge to the task. The player walks to the identified location, picks a blue and a white lumabell and upon return to Prunessa, the player is told to go back to Lednam Wilds and pick a blinking lumabell. This simple unchallenging game mechanic created boredom and annoyance in the player and resulted in low persistence in the game. In other words, Radix was much like a game of fetch while DragonMist is more like a scavenger hunt.

Participants indicated that puzzles and challenge increased their enjoyment of DragonMist and believed adding puzzles or min-games to Radix would improve that game (see Figure 8.2). Again, these mini-quests and/or puzzles do not have to be directly linked to learning content. In fact, it increases a player’s sense of choice and control if they can choose goals in the game unrelated to required academic task completion. For example: “I disliked only one thing and it was how extremely genetics based the game [Radix] was. I like educational games but sometimes you gotta take a break” (Syncette) and “No action, no adventure, everything was about genetics and it was boring” (Gargel the Third) referring to Radix.

Figure 8.2. Players believed that adding mini-quests and puzzles to the game would improve the overall enjoyment of the game.

Finally, the NPCs were important to learning and immersion in the games. The NPCs were often used as sources of information or as quest givers. On a more immersive level, the NPCs were a source of curiosity in the game and enhanced engagement in the game experience. It is not a difficult task to provide NPCs with the power to incite curiosity and increase immersion. The designer just has to provide a purpose for the NPC beyond simple directives and explicit information. A dump of information is not teaching and not conducive to learning as evidenced by Syncette's comments in focus group (see

Figure 6.8). The NPCs in Skyrim are designed to increase curiosity, player autonomy (freedom and choice), and immersion by conversing with the player in a realistic manner. For example, on the way to Riverwood with your guide, he will tell you of his childhood adventures. As you round a bend in the road, he draws the players attention to Bleakfalls Barrow and says "look up on that mountain, that is Bleakfalls Barrow, strange things happen there, I avoided it as a child." This conversation then piques the player's curiosity about Bleakfalls Barrow – "why do strange things happen there?" "Why does my guide avoid this place, maybe I should go check this place out". Bhusari was designed to pique curiosity rather than always give explicit information. When you first meet Bhusari at Sleeping Giant Inn, he talks of the dragons of Skyrim and the war. He tells the player of rumors regarding a Dragon Priest trying to resurrect his dragon gods of old and mentions that a hunter he hired to find the secret temple had not returned. This prompts the player to take on the DragonMist quest. In contrast, the NPCs in Radix tell the player "Go to Lednam Wilds and pick a lumabell of each color. There are two colors". These explicit directives do not encourage curiosity or player choice. Therefore, participants indicated they primarily used Radix NPCs as information givers or out of necessity to complete an assigned task, whereas they indicated emotional attachment and curiosity regarding the NPCs in DragonMist. Because of this realism and attachment to the DragonMist NPCS, the players wanted to help them and followed their instructions, which increased learning. For example, "I am trying to help Bhusari breed this dragon, but he keeps killing them" (Tslez'k) or "my guide in blue told me to go to Solitude … I have to go even though it is so far away" (Nedthroth).

8.5 Participants Identified Game Design Features that Improved Game Play Experience and Learning

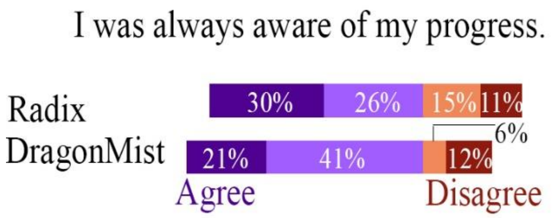
8.5.1 Feedback Systems: Rewards, Consequences & Failure

Participants indicated that both games, overall, provided progress feedback. However, participants revealed important differences in the manner in which the two games handled rewards, consequences and failure. This type of feedback is critical for motivation, flow and immersion, curiosity, and learning in a game. The results provide evidence for several game design choices that can impact game play experience and learning outcomes which can easily be implemented in educational games.

Paired-samples t-test results indicated significant differences in the game play experience between the two games in this study. DragonMist showed higher levels of flow, immersion, motivation and curiosity on all dimensions with moderate to large effect sizes (See Table 4.4). Observations, open responses, and focus group transcripts about player preferences and perceptions highlighted the significance of feedback, specifically fun failure, consequences for one's actions and valuable rewards, as components that supported motivation, engagement, and curiosity in the game. Sample questions from the survey, directly related to rewards and feedback, are provided in Table 8.4. Results converged as qualitative results provide evidence that players perceived no rewards, no failure and no consequences in Radix which then decreased their engagement, motivation and desire to play the game (See Table 8.4).

Table 8.4

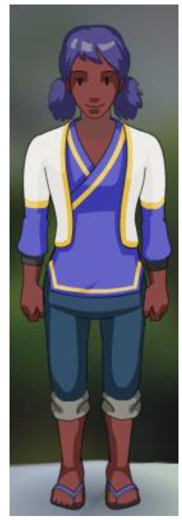
Results of Feedback Dimension of Game Play Experience Survey Compared to Participant Responses

Sample Questions from the Game Play Experience Survey	Participant Observations and Responses
	"It saved my progress and let me choose what to do" (Stryker) I just wanted to complete quests to progress" (Gargel the Third)
	"I didn't know what to do to ***HAVE*** consequence in Radix" (Syncette) "Radix does not have any rewards, so we play Radix for a bit then we do a barrel roll as a reward for playing the Radix game (Ching-Chong) "you can't really ***FAIL*** in Radix … you can only get lost" (Dragonia)

Note: sample question from the feedback dimension of the Game Play Experience survey. Percentage of students selecting "I don't know" was not displayed on the graph. The graph was normalized such that Agree and Disagree are represented on 100% scales to reduce visual bias.

Quantitative measures provide evidence that participants valued the rewards and feedback systems in DragonMist more than the feedback system in Radix. Qualitative results support the quantitative findings and provided a more nuanced understanding of student perceptions of feedback. Observations and participant responses revealed they valued rewards in the game. However, the reward needed to have a perceived value equal to, or exceeding, the amount of perceived effort to accomplish a task. Otherwise, the reward was perceived to be a poor reward and the tasks were perceived as tedious and a lot of effort. Participants indicated rewards should have some value in the game other than just being an item they collected. For example, several participants asked about the coins (flourins) awarded in Radix. For example:

> I don't know what they are called but they were like how good you did, it would show up at the top of what you got and everything but it never showed you how to use them, so it was like you just collected them but you didn't know what to do with them. (Katniss in reference to flourins awarded in Radix)



Several participants indicated the dragon was a better reward and worth working for because it would follow you, talk to you, carry your gear and fight for you. In contrast, they expressed disappointment that the animals collected in Radix would only sit in your inventory and do nothing. Notably, most participants believed the opportunity for failure in the game increased their learning and gave them opportunity to be creative and try new things. Most participants expressed the fact that Radix did not allow failure, had no conflict and as a result was not challenging. Finally, fun failure scenarios in DragonMist (and Skyrim) were popular among the participants and stimulated lively conversation, laughter, sharing of their experience, and repeating the behavior to show others (see Figure 6.16).

These results support the theory of operant conditioning as a behavioral management system to teach relevant actions and behaviors under voluntary conditions

(Skinner, 1971). Gamers expend great effort and countless hours in entertainment games working towards rewards (e.g., points, unlocked levels, virtual stuff (weapons, armor, food, potions, etc.), and status). Rewards provide players with motivation to complete actions in the game and are given throughout the game to influence player behavior. Feedback is necessary for learning, whether that is academic learning or learning to perform better in a game. Following operant conditioning principles, rewards in games are perceived as positive incentives to perform an action or behavior or negatively as a penalty for incorrect actions or behaviors (See Table 8.5). Following these principles, when a player performs the wrong action in DragonMist (i.e., chooses the wrong parents), they are always given an obstacle, albeit a fun one. They get an aggressive dragon and must fight to kill it before moving on (see Figure 8.3). The fun nature of the failure encourages the player to think about what went wrong, form a new strategy and try again. An added benefit to this failure design is increased relatedness and immersion with the game as players relate to Bhusari, who helps them fight, which then increases their interactions with the more-knowledgeable-other such that they engage more with learning concepts (see Figure 8.3). When they choose correctly, they always get a baby dragon as a reward and the baby will talk to them, follow them and carry stuff.

Table 8.5

Feedback and Reward System in Games Should Strive to Support Persistence

Game Response:	**Give Something**	**Remove Something**	**Do Nothing**
Player action:			
Correct Action (Success)	**Positive reinforcement** Player is given a reward "I will do that again"	**Negative reinforcement** An obstacle is taken away "I'll do that again"	**Extinction** Nothing happens "what's the point" "I give up"
Incorrect Action (Failure)	**Positive Punishment** Player is given an obstacle "Let me think - I will try something new"	**Negative punishment** A reward is taken away "Let me think - I will try something new"	**Extinction** Nothing happens "Nothing I do matters; I may as well stop playing"
No Action	**Confusion** Player is given a reward "I don't understand"	**Confusion** A reward is taken away "I don't understand"	**Extinction** Nothing happens "I expected that"

Note: Modified from (de Byl, 2019).

Figure 8.3. Fun Failure Feedback is Presented to the Player via an Aggressive Dragon. The aggressive dragon attacks and the fight scene adds action and challenge that makes failure a less negative experience.

Participants supported the concept of extinction when nothing happens in response to their efforts or when rewards were not clearly connected to the behavior. For example, the flourins awarded in Radix may have been an attempt to increase persistence by using variable rewards (e.g., technique successful for gambling such as slot machines). However, in Radix the design of the reward system caused confusion and perception that the game did not reward them for their efforts. When a player accepts a task and when they complete a task, the same sound effect plays. Intuitively gamers will connect this sound effect with an expected response from the game. In Radix, flourins are awarded when a player accepts a quest, but not always. Other times the flourins are awarded when the player completes a quest, but not always (see Figure 8.4). If the intended behavior was persistence due to variable rewards, the design failed because players expressed confusion and perceived that the game did not reward them. Therefore, reward feedback should be consistent and clearly attached to a behavior. Or, if they are variable (i.e., random, surprise), it should be evident that they are special by a unique sound, graphic or animation.

Participants indicated that Radix did not give rewards, except for the NPC accepting the item and assigning a new quest (for which they may or may not receive florins) (see Figure 8.4). This type of reward was not worth their efforts because the rewards had no further utility in the game. Ching-Chong said that Radix could be improved if the designer would "make general stores so you can buy and sell stuff" and Dragonia said Radix should be improved by "maybe when you catch a monster then you could like bring it out and like walk with it or something or ride it ." Another example in Radix is the experience points awarded (or not) after you complete a set of learning tasks in leaderboard fashion. Syncette is the only participant that noticed this reward "Hey guys I just received some kind of experience points or something." These points are awarded in a subtle manner which often escapes the player's attention, then there is no further utility for them, no way to share with friends as a status, and no clear connection to what must be done to get them. Therefore, they are not valued as feedback.

Figure 8.4. Inconsistent rewards led to confusion and perceptions that the game did not provide rewards.

Another design flaw in Radix related feedback is that the game does not respond to the player's actions. Most participants focused on lack of consequences in Radix and all participants believed their actions had consequences in DragonMist. Not only did they express a desire to fail in the game so that it would help them learn and let them be creative, but they stated that the game had no purpose and "what does it matter? I turned in the item she asked for and nothing happens" (Ryker). Many other participants expressed this perception of lack of consequences therefore their actions in the game made no difference. This perception resulted in low persistence and low relatedness with the game.

Notably, participants revealed a complex relationship between consequences and resultant emotions and behaviors. They did not seem to think of a reward as a consequence. They seemed to **expect** a reward as something given in exchange for their efforts. Valued rewards validated their efforts and increased positive affect and persistence. Lack of reward, or rewards without purpose, function or value; resulted in negative affect and low motivation. However, most of the consequences discussed were perceived as punishment. Participants indicated they enjoyed punishment in the game, if it was a result of actions of their choosing. Therefore, if they perceived high autonomy (volition, choice and control), punishment stimulated increased positive affect and persistence in the game. For example, several participants enjoyed the life of crime. They liked the added challenge and experience of fiero (victory in the face of extreme challenge) when they got away with something they perceived as wrong (observed when they sat back from the monitor, threw their arms up in the air and made some exclamation of accomplishment and pride). Pajzara and Talen-Zaw both enjoyed stealing and pickpocketing because they said they liked the “challenge of getting away with it”. When they went to jail, they accepted that as yet another challenge and took great pride in figuring out a way to escape rather than pay the fine and lose their stuff. Therefore, they enjoyed the punishment (jail) as a reward of extra challenge. Conversely, Drago (and others) exhibited the opposite response. They perceived low autonomy because the crime that placed them in jail was accidental due to low competence with respect to fighting skills or general RPG gaming skills. When these participants ended up in jail, due to an accident, they became anxious, frustrated and wanted to stop playing. Regardless, when Radix did not allow them to fail, it lowered motivation. They commented that Radix did not provide conflict, action or challenge other than educational. Low accountability in the game decreased perception of accomplishment and competence (or mastery) which resulted in boredom, apathy and low persistence in the game.

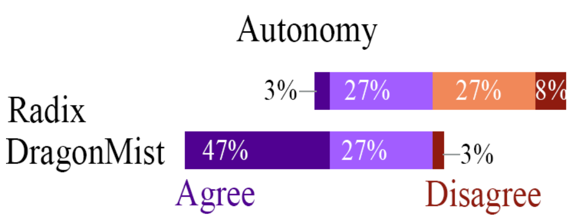
Collectively, these results indicate educational game designers should create feedback systems that go beyond progress feedback. This research provides evidence that progress feedback, alone, is not sufficient to support flow, immersion, motivation or learning in games. The player’s connection with the game, and desire to persist, is supported when they feel their actions have consequences, specifically perceived punishment when perception of autonomy is high. In other words, players want to believe their presence in the world impacts that world; therefore, they matter. In Radix, they perceived no consequences (rewards or otherwise) and expressed confusion evidenced by numerous comments such as "What is the purpose of this game?" and "Nothing I do in the game matters, so what's the point?" The rewards should be as valuable as the perceived effort to obtain them and they should have some utility in the game beyond evidence of a completed learning objective. The results of this study support Ryan and Deci (2000) who indicate providing extrinsic rewards for intrinsically motivated activities lowers the motivation for that activity. Educational game designers should make efforts to attach rewards in the game to some function such that the reward is perceived as valuable and or rare. Not only does this improve motivation and curiosity, it develops skills in resource management as players must decide what to buy and/or sell with coins or which rewards they want to keep or trade. Additionally, immersion and motivation are increased when the game responds to the player and their actions have consequences which can also add challenge to the game.

8.5.3 Game Play Experience Compared for DragonMist and Radix

Quantitative measures provide evidence that DragonMist is more immersive and supports flow more successfully than Radix. Qualitative results provide support for DragonMist's greater engagement (see Figure 6.13) as well as higher intrinsic motivation (see Figure 6.2). Evidence of convergence between the two sets of results are illustrated in Table 8.6 where results of the Game Play Experience Survey are illustrated along with focus group responses when asked to describe their most favorite and/or least favorite game play experience. Feedback systems were found to be important for immersion and flow, as discussed in section 8.5.2. Other concepts important to immersion and flow were realism and goals. Immersion is described as three components (engagement, engrossment and total or flow). Intrinsic motivation is correlated with concepts of flow theory. Therefore, engagement and motivation are often influenced by the same game design feature.

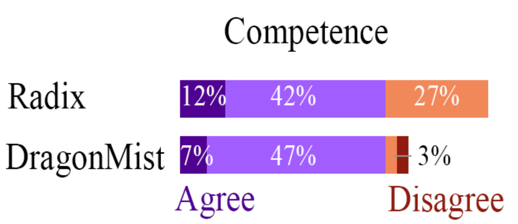
Table 8.6

Dimensions of Game Play Experience and Focus Group Conversations Discussing Experiences from Their Favorite Game Compared to Their Least Favorite Game



I like DragonMist … you could ride a horse … you got basically freedom like to do what you want but if you do something bad then they like make you go to jail (Teela)

I liked DragonMist ... it's a free roam game you can do whatever you want to do – like go do other missions besides the main mission, to where if you don't, uh if you kill someone you get bounty for it, if you steal something you get bounty for it (Shrek)



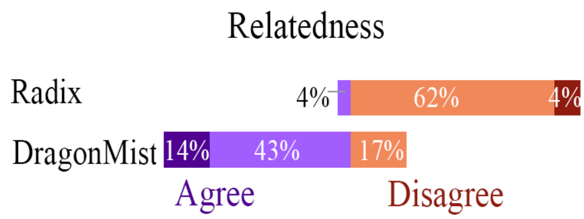
Most participants exhibited competence for both games but the following gives a few examples of perceived low competence in the games:
yea DragonMist– I was failing – failing the entire time (*laughing*) _ I had a lot of good strategies … like at certain points of the game like to get the bad guys I would kind of have to sneak up on them and shoot them with a bow so I could get close and then hit them with a sword (Vallinalda)

Radix was really weird because some of them [the quests] were like 'build this window' or like tag these animals and I didn't know like which one I was supposed to do (Beastmode)

Table 8.6

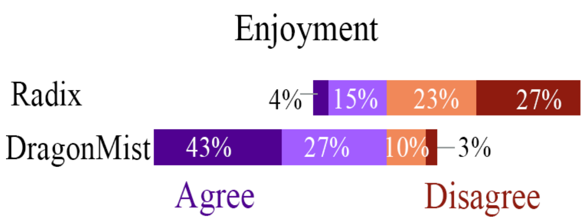
Dimensions of Game Play Experience and Focus Group Conversations Discussing Experiences from Their Favorite Game Compared to Their Least Favorite Game

Well in DragonMist I wish ahm like when you started off I wish you actually knew where to go because I had to get you to help me like when you go to his house and you go out of it I didn't' know where to go (Dundi)



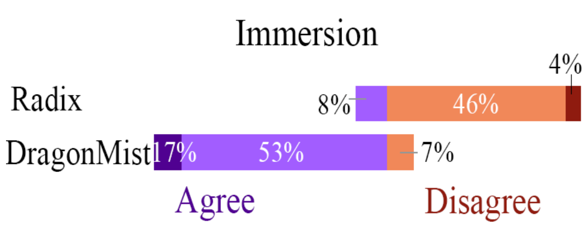
I wanted to explore new things in the game to complete the quests that the NPCs gave me (YeeHaw)

I helped the king jarl kill this dragon because no one else could. He gave me the ax of Whiterun. That's AWESOME! (Ching-Chong)



Radix was too boring so nobody would want to stay in it too long to learn anything (Asdolufiene)

yeah I agree that Radix didn't keep Drago or Dragonia or my interest. Cause just we just all started watching YouTube and ah (*everyone laughing*) – and ah and ah like doing google tricks and like snapping all that …. With google and stuff (Ching-Chong)



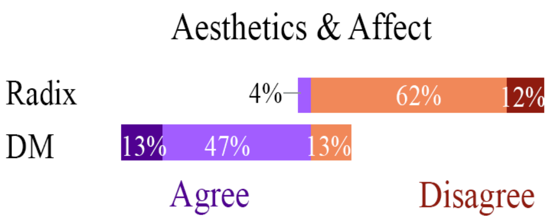
ah at first DragonMist gave me a headache because it was a lot in your face like and I had no clue what to do but like Radix was just – it didn't feel like you are in the game but DragonMist did feel like you are in the game (Syncette)

Yeah cause uhm in DragonMist like when I accidentally hit my guide he didn't make a big deal out of it so I

Table 8.6

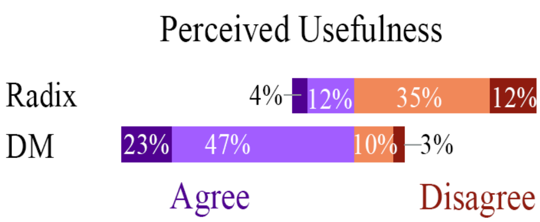
Dimensions of Game Play Experience and Focus Group Conversations Discussing Experiences from Their Favorite Game Compared to Their Least Favorite Game

asked myself (*whispering*) "What if I killed him" (**everyone laughing**) and then he started attacking me and then he kept on attacking me until I died (Ancosa)



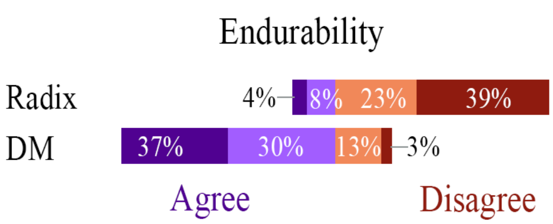
I didn't really like Radix – the 2D in Radix – ah the 2d's – I prefer the 3d's and better graphics (Beastmode).

I liked the characters, story and powers in the game (Talen-Zaw)



that game [Radix] was bugging me because it didn't give me no directions (Teela)

because there wasn't … I mean.. anything that you do there ah like there was supposed to be, like there was nothing ***important*** like you didn't have a goal in Radix but DragonMist you do (Syncette)

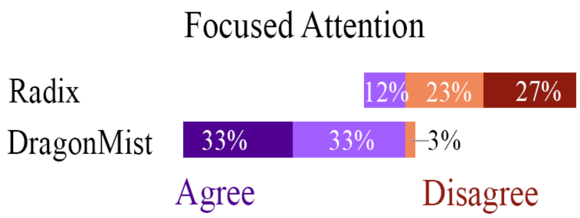
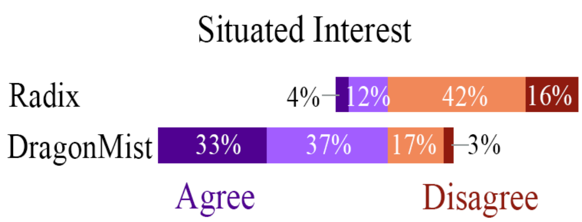


I would tell them [my friends] about DragonMist because of how much I really liked It and how much more action that it had than Radix (Talen-Zaw)

I would tell my friends about DragonMist because its …. Its just really fun. Its like you get to ah ah do quests and you get to help out a king Jarl Barthul.. or whatever you call it but ahm you just like fight dragons and fight draugrs and cast spells (Ching-Chong)

Table 8.6

Dimensions of Game Play Experience and Focus Group Conversations Discussing Experiences from Their Favorite Game Compared to Their Least Favorite Game

	Focused Attention is not a topic that was discussed in focus group. However, I observed several participants completely focused on DragonMist. Syncette, Vallinalda and YeeHaw made notes, drew out Punnett squares. Teela was so focused on DragonMist that he was unaware of others in the room and I had to touch him on the shoulder to get his attention when I spoke to him. When he played Radix, he was up running around the room and being totally disruptive.
	I liked the ability to customize the dragon -like the color of the dragon and there's three separate colors and like the underbelly and claws and stuff like that (Pajzara) I want to see what it does or what I can do to it or you know like how it interacts with other things – like kind of with the dragons – I wanted to see you know like how they interacted with everything else so I kind of like messed around with that (Syncette) it would be cool to create a fire breathing dragon where everything glowed like bright orange or something (Asdolufiene) it just didn't' keep your interest long enough Radix didn't (Dundi)

Note: Percentage of students selecting "I don't know" was not displayed on the graphs. The graphs were normalized such that Agree and Disagree are represented on 100% scales to reduce visual bias.

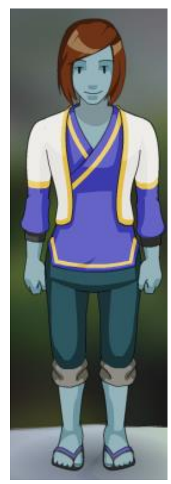
8.5.4 How to Improve Immersion and Autonomy with Travel

Qualitative results improved understanding of autonomy and immersion in the games by providing evidence of game features that were perceived to add realism, choice and freedom to the game. One game feature that was discussed frequently during the game play sessions, in focus group and in open response was travel options. The map function was extensively utilized by all participants in both games. However, the map feature in DragonMist is different than the map in Radix. Both games' maps provided information to the player for locations and directions. However, DragonMist's map feature also incited curiosity because of the compass feature (i.e., navigation bar) (see Figure 8.5). A universal design principle is simplicity (reduce clutter) because every extra piece of information adds to cognitive load and resulting stress (Knaflic, 2015). Gamer's mod games to decrease information on the HUD (heads up display) to increase immersion (e.g., Immersive HUD mod for Skyrim*'s* popularity evidenced by 3,066,321 downloads as of Feb. 25, 2020). DragonMist's map consists of a small nav bar that serves as a compass with quest markers. But it also provides stimulus for curiosity as hidden locations glow on the nav bar when in close proximity, red dots move along the bar to signal danger, and the quest marker acts as directional information. For example, "the compass had map markers that made me want to see what was there" (Mukmog) and "if you look up where that compass thing is there is like a little red dot where it is showing the enemies" (Shrek). The main map (global and local) can be opened using a button on the controller when players need more information (see Figure 8.5).

Figure 8.5. Map and Quest Feedback System for DragonMist/Skyrim. Game screenshots illustrate simple HUD (heads up display) that provides a lot of information while supporting immersion and player choice.

Participants frequently complained about the map in Radix commenting that "Radix is very slow and repetitive, complicated map that required a lot of load screens, travel sequences to move about" (Jaegar). And in response to focus group question "Describe your least favorite experience", Drago said "Radix probably like kind of how tiny the map was and how when you were done with that map like what are you supposed to do." (see Figure 8.6). Ancosa was one of few participants who indicated she liked Radix better than DragonMist, but she also complained about the map feature in Radix and indicates that the map and travel option reduced her autonomy in the game resulting in negative emotions:

> I mean I thought it was *annoying* in Radix if you were like up here (*pointing to ceiling*) on the map and it wanted you to go to a certain place down here (*pointing to floor*) you *couldn't just travel* down there you had to like keep clicking places and then you made it there. (Ancosa) [*participant emphasis*]



The simple compass function in Skyrim provides the player with an active quest marker so they always know what their goal is, glowing icons for hidden locations nearby should the player want to investigate, blue diamond for user-specified locations, and a red moving dot to signify danger. If the player wants to fast travel or if they need more information, they open the world map. In comparison, Radix map function (see Figure 8.6) provides a mini-map with a white dot signifying the players current location, minimal surrounding information, no quest marker, and a yellow flag that signals the next exit to take. However, this yellow flag must be reset manually with every location change (load screen involved).

The map is a source of information that, if designed properly, can increase immersion and autonomy by providing a perception of choice and freedom as well as increase perceived usability of the game when the function is both intuitive and simple. To design a user interface and quest/map feedback system with the utility and complexity of Skyrim for an educational game may not be feasible. However, taking steps to reduce clutter and to increase player autonomy (i.e., add fast travel option), and minimize necessary actions for map use, should be implemented.

The mini-map in the bottom corner, shows a white dot that represents the player's location. Clicking on the magnifying glass, opens the local map where a player can set a yellow flag which tells them the direction of the proper exit. The mini-map shows the yellow flag but gives minimal helpful information because the player cannot see quest markers.

Before a player can choose the correct exit, they must consult the world map. They can find the route needed to get to their destination, but then they have to set a new flag (marking an exit) for each location they have to travel through. The world map will not allow them to set a flag nor does it show quest markers

Figure 8.6. The Radix map function required numerous steps and did not provide helpful information for identifying assigned quests.

Two additional game design features, related to map feedback systems that supported autonomy, competence and immersion, were discussed by participants. The qualitative results support the evidence that participants enjoyed DragonMist more than Radix (See Table 8.6) and provides evidence that travel options were important for the players' enjoyment by supporting autonomy and enhancing immersion. Load screens were discussed relevant to travel options. The participants also indicated the quest log function and associated map feedback provided clear direction (location and active quest) which increased perceived choice, freedom and control as well as supported player goals while playing DragonMist. In contrast, the quest log, travel and map feedback caused confusion and annoyance while playing Radix.

Travel methods in DragonMist support player autonomy as well as immersion as evidenced by the popularity of the horse. Most participants (according to game logs: 26 out of 30) got the horse at Riverwood. Observations confirm that most players rode the Riverwood horse (provided as an owned horse) and/or stole horses to ride. All participants took advantage of fast travel in DragonMist. And, many participants were observed consulting their map, calculating routes to their destination and using multiple travel options to include hiring carriages, walking and riding horses. For example, Ryker and Beastmode were both (independently) observed checking their quest log, activating a quest, then checking their maps and making notes of the best route. They then walked to the nearest stable, hired a carriage to get to the closest hold, tried to buy a horse at that stable, didn't have enough gold, then stole the horse and set off to their destination. In contrast, Radix travel consists of walking to a marker, waiting on a load screen, and walking to the next marker.

In response to "Considering the two games you played, which game did you enjoy most and what made the game more enjoyable to play than the other game", Mukmog wrote:

> DragonMist u could turn on the quest u wanted to do and follow markers and fast travel. Radix was too slow and tedious to travel … it was too boring and tedious. Could not turn off or skip quests so it was *NOT* fun to play. (Mukmog) [*participant emphasis*]

These results provide evidence of importance of user interface design. DragonMist is based on Skyrim's design that combines complicated components of the quest log, map function, navigation bar and travel options in a simplistic intuitive manner that lowers cognitive load and increased understanding (competence), choice (autonomy), immersion and curiosity. The user interface in Radix created frustration and confusion because players perceived low autonomy (no choice of travel options or quest choice), low competence (lack of clear directions and goals), and flow and immersion were hindered by tedious repetitive steps required to travel. For example, in response to "describe what you did not enjoy about the game you just played", YeeHaw expresses low autonomy and competence in Radix:

> I didn't like how I didn't know if I was doing the right thing or the right materials for the quests. I didn't like how there was no fast-travel and I couldn't go straight to the place that I wanted, and how sometimes the directions that the NPCs gave were not specific. (YeeHaw)

Notably, a frequent complaint in Radix was related to the numerous load screens with most of the participants complaining of tedious repetitive tasks that required multiple trips across the Radix world and having to endure multiple load screens. Interestingly, DragonMist also has multiple load screens but not one participant mentioned load screens in DragonMist. Possible explanations for this phenomenon relate to travel options and the nature of the load screen (see Figure 8.7 vs Figure 8.8). Typical game mechanics in Radix involve, speak to an NPC, accept the task, walk to the location, collect the item, return to the quest giver NPC, submit the item, accept the next quest (which often times is to return to the same location from which you just left). This simple game mechanic, that required multiple load screens to complete, was perceived as tedious. For example, "it took a long time to walk to where I wanted to go" (Stryker). Another example; Mukmog called me over while playing Radix to ask if he could fast travel. He said:

I talked to Dr. Salimar and had to walk to another section that required a load screen to get one flower and then Salimar sent me right back to the same section to pick another of the same flower! There are *so many load screens!* (Mukmog). [*participant emphasis*]

Figure 8.7. The only travel option in Radix is walking. Participants expressed the desire for fast travel and less load screens. Numerous load screens that provide no added value made the game tedious and boring.

In contrast, DragonMist uses Skyrim's game engine which provide multiple travel options. For instance, you can walk, you can fast travel to any previously discovered location, you can hire a carriage to take you to major holds and you can ride a horse. On the way to your designated location, you encounter chance encounters and random experiences which adds interest and immersion to the game. Finally, the load screens provide clues and information for the player, so while they are waiting for the next location to load, they are gathering helpful information about the game (see Figure 8.8).

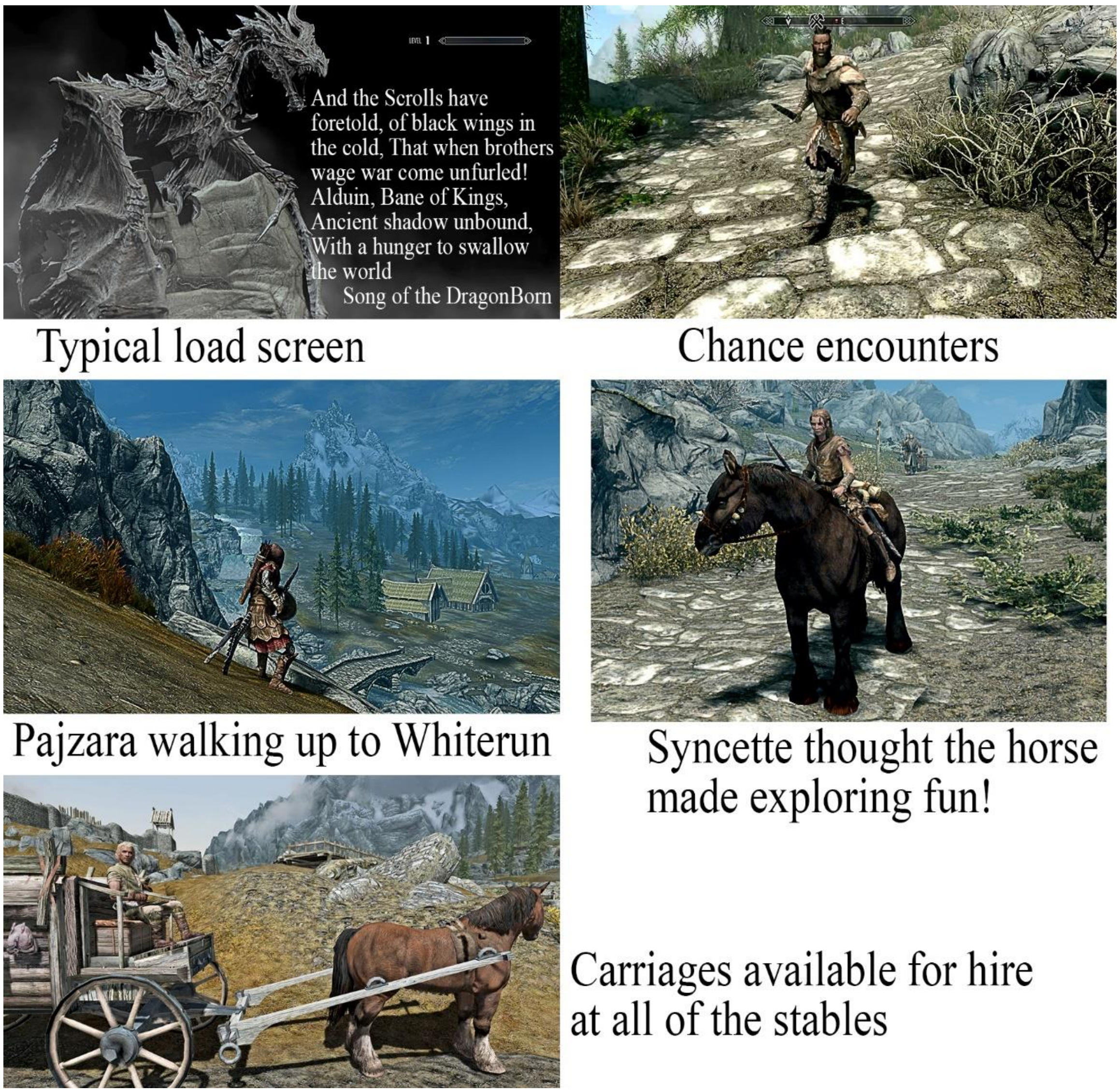


Figure 8.8. Travel in DragonMist supports player autonomy by offering options of fast travel, carriage, horse, or walk. Action and immersion are increased by chance encounters and the 3D environment. Load screens provide information and visuals for interest.

Quests were confusing to many players because they could not select (turn on or off) a quest even though the visual feedback, intuitively, seems that is an option. Even though DragonMist (Skyrim) provides numerous quests in the quest log like Radix, participants only perceived confusion in relation to Radix quests. One explanation for these different perceptions is that players activate a chosen quest in DragonMist and that marker is always visible in the nav bar (see Figure 8.8). In contrast, quests cannot be activated in Radix and no quests markers show unless you are in close proximity (see Figure 8.7). Therefore, all available quests are active and the player must perform multiple steps, going through the quest log, to discern the proper order and/or which quest is related to which overall questline. For example, the opening scene of Radix shows a blue exclamation point which is an optional quest (see Figure 8.9). The green quest marker, assigned genetics quest, is not visible. Several participants perceived low competence due to a lack of clear goals or instruction because they could not select a quest, or turn on (or off) quest markers. This design feature blocked learning because of confusion, frustration and following incorrect quests. Moreover, due to a lack of quest order clarity, students got frustrated. For example, Syncette followed Ching-Chong over to Prunessa and got frustrated when Prunessa would not speak to her. The first two steps are not genetics related, but because she had not done those two tasks, she had to travel back across the Radix world to speak to Dr. Salimar to let him tell her to go to Prunessa. Confusion occurs because quest markers are not visible unless you are near the NPC in the world and the player cannot make an assigned quest active nor does the map show the marker unless the player is in close proximity

Finally, players also asked for the option to turn off menus in the user interface and wanted a full-screen option. As illustrated in Figure 8.9, the Radix user interface is cluttered and made some participants feel blocked. Several participants asked if there was an option to hide the menu bars. Participants indicated the lack of a full-screen option blocked their sense of freedom in the game and hindered immersion in the game. For example, Mukmog asked “can I switch to full screen, I can’t see what I need to see.”. Providing players with a full-screen option is as simple as selecting an option choice in the build settings during publishing. The forced windowed mode for Radix increased the feeling of being blocked as expressed by several participants. The resultant small game window appeared more cluttered due to the numerous menus which could not be hidden. And the extra visual components common to most browser windows increased cognitive load and decreased feelings of immersion in the game (see Figure 8.9).

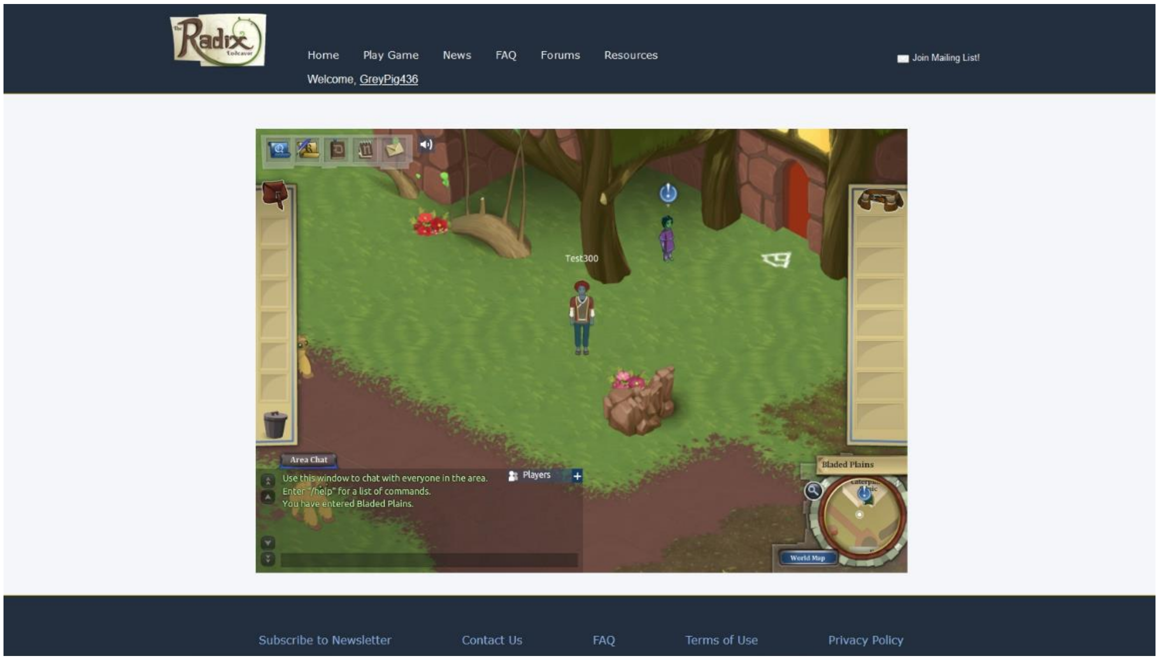


Figure 8.9. Opening scene for Radix shows the browser-based game as the player views it from the monitor. Players complained that there was not a full screen version and inability to close menus. Cognitive load is increased to due non-essential information.

8.5.5 Avatars and NPCs Increased Immersion, Relatedness and Learning

Avatars and NPCs were found to be important for motivation, curiosity, and engagement (immersion & flow). Avatar customization to the degree that Skyrim provides would most likely be an unrealistic goal for educational game design. However, there are several things, identified by participants in this study, that would be easy to implement to increase creative self-expression, motivation and immersion. Research indicates players have multiple motivations for creating their avatars and often form an attachment to them such that they play the same avatar for years (Bachen et al., 2012, Yee, 2006). Participants were not asked to explain their motivations for avatar creation, but many made comments about the avatar appearance. Some created avatars that looked like them, others played non-humans, and others created their avatar based on skills and perks. Avatar customization in DragonMist goes beyond appearance. The choice of avatar impacts the game experience because of the skills and perks in which each race specializes in as well as how the NPCs react to them in the game. Therefore, the avatar choices change the game play experience. Most participants exhibited concern and/or empathy for their avatar while playing. For example, I overheard Syncette exclaim ""OH NO horsey stop sliding please stop sliding you are doing to die and I am going to die and that is never a good thing." Lareia was embarrassed when she realized her avatar was unclothed and asked me to please help her get dressed. During open response and focus group, participants indicated avatar customization was important to them and several indicated that they wanted the option to play a non-human. For example, "you are not a human?" (Ching-Chong). "No I wanted to be this cool lizard thing" (Dragonia). Out of thirty participants, eleven were Argonian, three were Orcs and two were Khajiit.

Examples of the extensive customization choices for avatars in DragonMist compared to Radix are shown in Figures 8.10 and 8.11. The extensive degree of customization provided by Skyrim would be costly and time consuming for educational games. However, providing choices of non-human avatars using 2D artwork similar to the Radix avatars would not be difficult. Players could also be allowed more options such as clothing that related to skills, jobs or status in the game. Several participants indicated a desire for more realistic skins tones, more choices to make the avatar look more like themselves (e.g. Lareia & Ahendria) and the option for non-human (e.g., Dragonia, Drago, Tslez'k) in Radix.

Figure 8.10. Examples of possible avatar customizations in Radix.

Figure 8.11. Examples of possible avatar customizations in DragonMist

Another obvious difference between the two games was how the participants perceived and interacted with NPCs. Participants interacted with the NPCs in a variety of ways. For both games, the NPCS were used as a source of information and as quest givers. Participants often talked out loud to the NPCs while playing DragonMist and often expressed concern and/or a desire to help them. This degree of relatedness to the NPCs in the game increased learning opportunities as the student expended more effort because they felt compelled to follow the NPC's instructions. For example, "I am trying to help Bhusari breed this dragon but he keeps killing them" (Tslez'k). Another example, "I have to help Prunessa find these lumabells to cure some disease" (Syncette). Only a few participants referred to the NPCs in Radix as if they were real people. Most of the participants in DragonMist interacted with the NPCs as if they were real. One explanation for this is the degree of artificial intelligence (AI) designed into the NPCs. AI in games can be complex and programmatically challenging. However, simple AI is easy to accomplish and adds personality to the NPC. For instance, in Radix the NPCs are standing in one spot. They are always in that same spot in the same posture. They are no more interesting than cardboard posters. Skyrim has designed the NPCs to relate to the player in extensive ways. For example, when (if) you decide to be married to an NPC in the game, every NPC who you have ever helped will attend the wedding. This is a surprise that creates a feeling of realism and immersion in the game. This degree of AI is not necessary to add some personality to the NPCs in the game. The NPCs in DragonMist go about their lives. Therefore, the player never knows where the NPC may be. This uncertainty adds to the mystery and challenge of the game and encourages the player to explore. And this degree of AI would be much easier to implement. The NPCs can be used to incite curiosity as discussed in section 8.4. This type of conversational dialog just requires creative thinking during the game design.

Notably, the relatedness to the avatar, and the immersion created by realistic NPCs, is necessary to support the hero's journey so popular in RPGs. However, NPC dialog and story / fantasy are not sufficient. The game must respond to the player. In other words, the player must perceive that their actions have consequences in the game. Dentry (in Radix) tells the player "There are people who believe knowledge is power .. they want that power for themselves … my friends call them the Obfuscati." Dentry goes on to inform the player that the Obfuscati do not support his research and that the player is the only one who can help. This is an attempt to set up the hero's journey for the player and make them feel important. However, the participants indicated that they could not fail in Radix, there were no rewards, and there were no consequences to their actions. According to Dragonia "all you do is collect stuff and turn it in and nothing happens!" In contrast, when Ching-Chong helped Jarl Balgruuf kill the dragon at Dragon Reach, he felt like a hero as evidenced by his comments in focus group, "the king needed my help because he didn't know what to do with this dragon. I helped the king jarl guy kill that dragon cause no one else could and he gave me this cool weapon" (Ching-Chong).

Providing players with options to create more self-expressive avatars (e.g., choice of non-human, more realistic skin tones, customizations that impact the game experience) would increase relatedness and immersion in the game. Providing, at least, simple AI to the NPCs would help bring the story and fantasy alive by making them more responsive, mysterious and personable. Rather than have the NPCs give explicit directions, "Go to Lednam Wilds and collect one lumabell of each color. Lumabells come in two colors", NPCs could provide more curiosity evoking dialog instead. For example, when Bhusari says “red, purple, blue, does that match anything else here?”, it piques the player’s curiosity and prompts exploration to find things that are red, purple and blue and to determine the meaning of the curious statement. Bhusari could have said, “Go to the third shelf in the library and get that journal and look at the last page to see the Punnett square and match those colors to the breeding station.” This direct command would not provide opportunity for curiosity or exploration. Quantitative results support these findings with evidence that DragonMist significantly increased scientific curiosity while Radix significantly decreased scientific curiosity (statistically significant difference, $p < .001$, $d = 1.09$) (see Figure 4.12)

8.5.6 Game Features That Blocked Learning

In summary, game design features were discussed that support motivation, engagement, curiosity and learning in the games. Other game design features were observed to block learning. Predominantly technology issues with the lab computers and equipment hindered learning by adding to frustration and anxiety. The lab computers were not strong enough to run the games resulting in glitchy graphics, locked up games, and monitors that were too dark causing players to strain to see items in the game (especially DragonMist which is dark inside the dungeons). Surprisingly, the headphones were a problem for several participants. The headphones caused headaches, and two participants were afraid of germs. Earbuds were offered (unopened sanitary packaging), but most participants said the earbuds are worse than headphones. Some participants had difficulty with the game controllers (DragonMist), while others had equal difficulty with the keyboard and mouse (Radix). The multiplayer function for Radix enhanced learning for the most part, but also provided evidence of occasional bullying behaviors and off-task behaviors. The repetitive tedious simple game mechanics in Radix caused many participants to complain of boredom and to go off-task. Studies show negative emotions, specifically boredom, leads to disengagement, decreased learning, and strongly influences interactions with computer-based learning environments (Baker et al., 2010; Sabourin et al., 2011). In contrast, the complexity of game mechanics (especially related to fighting skills) caused a few participants to exhibit frustration and go off-task in DragonMist. However, most participants exhibited active engagement and positive emotions (laughing, talking, animated body language) while playing DragonMist. Finally, several bugs in DragonMist were identified that directly blocked learning tasks. For example, the dragon's hit box is too large for inside the DragonMist temple. The baby dragon often blocked player movement and they could not return to Bhusari to hear his explanation of the genetics used in the experiment and could not receive the next quest for Fire and Ice (co-dominance). These observations should be considered when implementing games in the classroom.

8.4 Summary of Integrated Results

Results demonstrate a complicated relationship between the game, the player, learning outcomes and curiosity. The results confirm the difficult challenge for educational game designers regarding well-designed games that entertain and teach. Findings suggest games are promising learning environments that increase motivation to learn and have potential to incite curiosity leading to transfer of knowledge to other contexts when students' interests are stimulated. The findings confirm, in contrast to some research perspectives, games can be designed to be both educational and engaging. Findings also confirm that educational games designed to be highly motivating and engaging lead to increased persistence and voluntary play which in turn increases exposure to the learning concepts. Another key finding is that games can evoke state curiosity as well as domain specific (scientific) curiosity which can prompt information seeking and exploration, and stimulus for more meaningful learning. Integrated results of this study identified several key game design features that can be implemented to improve motivation and engagement in educational games while also supporting learning outcomes.

Comparison of three games in this study indicates areas where some educational games are inferior to successful entertainment games regarding well known primary game mechanics (Appendix M). Play, in general, is an instinctual learning mechanic. Therefore, successful entertainment games often rely on primary game mechanics derived from instinctual human behaviors and abilities that evolved from survival instinct (de Byl, 2019). Games that present challenges that stimulate these primary game mechanics are rewarded by the human brain and increase engagement (Kang, 2009). Appendix M provides a list of commonly used game mechanics along with examples identified in each of the three games used in this study. Several of these commonly used successful game mechanics were not identified in Radix and provides an explanation for the lower motivation and engagement perceived by the participants in this study. Specific game features identified by participants in this study were discussed in section 8.5.

8.3 Research Implications

This research adds to existing literature by conducting a convergent parallel mixed methods approach to examine student perceptions of game-based learning from a holistic perspective. Key findings improve understanding of the opposing theoretical perspectives regarding engagement and learning in games. The findings of this research provide evidence in contraction to researcher perspectives that indicate learning and engagement are opposed outcomes in games; increasing learning decreases engagement and increasing engagement decreases learning (Cheng et al., 2014; McNamara et al., 2009; Rai et al., 2009). Quantitative results provide evidence that motivation (autonomy, competence, and relatedness) and engagement (flow and immersion) were significantly higher for DragonMist (moderate to large effect size on all dimensions of game play experience) when compared to Radix. Results of pre-post genetics knowledge mean scores revealed statistically significant learning gains for both games ($p < .001$, $d = .964$). Notably, two-way mixed ANOVA results indicated the main effect of group (game played) showed that there was no statistically significant difference in mean genetics knowledge scores between intervention groups $F\ (1, 27) = 0.764$, $p = .390$, partial $\eta^2 = .028$. These results are supported by qualitative results. Together, the results of this study provide evidence that a well-designed entertaining game can increase learning and provided a motivating engaging game play experience that supports flow and positive affect. These findings support other research that indicate positive affects (e.g., engagement, concentration, enjoyment, and excitement) can enhance learning via increased persistence and better use of mental resources (e.g., Bless et al., 1996; Raghunathan & Trope, 2002).

This research also adds to existing GBL literature by directly considering curiosity on two levels. First, dispositional curiosity is considered a stable personality trait that influences how a person approaches, accepts and interacts with novel, uncertain, conflicted environments (Litman & Silvia, 2006) as well as information gaps (e.g., Lowenstein, 1994). Games are novel and uncertain learning environments; therefore, it is important to understand how curiosity, as a stable trait, might influence learning from games by a diverse student population. Findings of this study provide evidence that dispositional curiosity does account for a portion of the variability in the game play experience related to motivation, flow and immersion, and curiosity related behaviors emerging from the game. Second, various and opposing perspectives regarding state curiosity exist. One perspective is that curiosity is either present or absent and the environment cannot incite curiosity (e.g., Maw & Magoon, 1972). Another perspective indicates curiosity can be stimulated when an information gap becomes salient but only if preexisting knowledge is present (e.g., Lowenstein, 1994). Others suggest state curiosity can be piqued given proper stimulus (Gottlieb et al., 2013, Spielberger, 1979). Finally, other research perspectives, that agree general curiosity can be stimulated, show that domain specific curiosity can be targeted and evoked as well (James (1890) 1983; Weible & Zimmerman, 2016). In contrast to the perspective that curiosity cannot be stimulated (Maw & Magoon, 1972) and that preexisting knowledge is required (Lowenstein, 1994), the findings of this study corroborate perspectives that curiosity can be stimulated, specifically scientific curiosity (Gottlieb et al., 2013; Weible & Zimmerman, 2016). Key findings of this research provide evidence that games can significantly increase scientific curiosity in addition to general state curiosity. Also, there was no significant association between prior knowledge and state curiosity as determined by pre-knowledge scores compared to post- game play curiosity measures.

Theoretical implications of this research provide evidence for the importance of supporting Flow Theory and Self-Determination Theory in educational game designs to enhance motivation, engagement, curiosity and learning. Results of this study adds to theoretical research regarding curiosity by providing an initial understanding of how dispositional curiosity influences a person's acceptance of and interaction with games as well as how games can be designed to stimulate and reward scientific curiosity. The results of this study also provide support for game theory and practice known to increase motivation, engagement and endurability in games.

Practical implications of this research inform educational game designers and practitioners for design and implantation of games in classrooms and as supplemental educational tools in informal learning environments. This study identified several key design features that should be considered to improve the overall entertainment value of the game while supporting learning outcomes. The designer chooses what experience the game will provide to the player. Open worlds and customization provide more flexibility for player impact on that experience; however, the experience is still constrained to some extent by the game's mechanics and aesthetics. Educational games create another level of control when educators impose goals onto the player, specifically the goal of learning required academic content. Furthermore, imposed goals and related content then reduce intrinsic motivation by lowering autonomy (volition, freedom, choice and control). When poorly-designed, the game also lowers competence and relatedness. For commercial entertainment games, players regain choice and control by choosing which game to play and for how long. When games are used in a classroom, this choice is removed. For these reasons (identified in this study), educational games often fail to engage students to the same degree as commercial games.

Key findings of this research add to the current GBL literature by providing several options for better educational game design and implementation. First, several key game design features were identified that increase engagement and motivation in games to support learning. These game features should be designed into educational games to increase flow, immersion, curiosity, motivation and thereby support and encourage learning outcomes. Educational games should implement these game features when possible to improve the overall play experience for all students, especially features that support autonomy, competence and relatedness. Second, games should be designed to incite domain specific curiosity. Findings of this study demonstrate academic content can be integrated into an entertainment game, in a combined explicit and implicit manner, that stimulated academic curiosity while maintaining the entertainment value of the original game. Commercial games evoke and reward curiosity about the game to keep gamers interested and playing. The findings of this study demonstrate that DragonMist increased scientific curiosity such that students became interested and curious about DNA and genetics, physics, Medieval architecture and Norse Mythology. The findings show that this curiosity and interest led to curiosity related behaviors (information seeking, exploration, persistence) that enhanced learning. After playing DragonMist, participants exhibited initial evidence of transfer of knowledge to other contexts. Finally, in support of other research (Charsky & Mims, 2008; Squire, 2004), results provide evidence that an academic quest can be seamlessly integrated into a popular entertainment game within a reasonable timeframe and minimal budget. Teachers and educators should advocate for gaming publishers to allow for (and support) modded content for commercial games. Bethesda's support for gamer developed content has proven to be a successful design model for the entertainment game that exhibits increased gamer loyalty where creative gamers have opportunities for media creation while also providing new and exciting content for players. The results of this study show that DragonMist, a modded quest for Skyrim, provided learning gains similar to a team-designed, grant supported, educational game with the added benefits of statistically significant enhanced motivation, engagement and flow and was designed and developed with minimal budget and within a year.

Two key findings provide options for GBL implementation. First, when the purpose of the game is to be implemented in a formal educational setting under teacher facilitation, game design features identified in this study should be considered. These game features increased positive affect, known to support learning (e.g., Bless et al., 1996; Raghunathan & Trope, 2002) and persistence in the game. Notably, games require a lot of class time, time that classrooms often do not have. Games can also be designed for the purpose of supplemental education in informal settings. These games should focus on piquing, supporting and rewarding domain specific curiosity such that students explore and seek out information on topics that interest them and transfer the knowledge learned in the game to other contexts. For games of this purpose, it is critical to implement game features identified in this study that increase motivation (autonomy, competence, and relatedness), increase engagement by supporting flow and immersion, and reward curiosity. Games designed as such will stimulate voluntary interactions with the game for long periods of time. Therefore, this study shows potential for these games to encourage self-regulated learning external to a formal classroom setting and potential to generate interest in science for students who may be disengaged with science in formal settings.

8.4 Limitations and Future Research

The findings of this study should be interpreted with limitations. First, the sample selection of the study imposes constraints in generalizing the findings, as it was non-probability voluntary sampling and only thirty-one participants completed the entire study. Another limitation to generalization is the small control group (n=4) to compare the original commercial game to the modded game. Additionally, there were only eight females in the final group of participants. Learning gains must be interpreted with limitations. Learning gains were significant after playing both games. However, the effectiveness of GBL compared to traditional methods cannot be determined since there was no traditional methods control group. Various learning outcomes were investigated in this study. One consideration was potential learning external to the game prompted by curiosity stimulated by the game. Therefore, learning gains cannot be directly attributed to the game content as participants were encouraged to seek-information and explore interests using any available resource. Finally, naturalistic game play may have been influenced by time constraints and physical setting of the video game camp. Time constraints for the study may have minimized motivation, immersion and flow effects as gamers generally exhibit greater emotional attachment to games with greater relatedness and investment over time. Flow state and immersion may have been influenced by the computer lab setting. The nature of flow and immersion means it is difficult to measure as any request for the player to describe their perception of flow and immersion. by necessity, breaks the flow state. Therefore, perceptions of flow and immersion primarily rely on self-report after game play is completed.

Future research should consider in depth case study to explore some of the extreme cases that emerged in this study. For example, one participant (a 5th grade female) had never played games and didn't perceive educational value at first. On the final day of the study she asked me to sign her portfolio/resume so she could send it to her mentor (a scientist, she contacted through NASA's website and with whom she frequently communicates). She had also kept him apprised of her progress during the video game camp and shared the DragonMist website with him. Other interesting cases involve students with learning disabilities. Two diagnosed with ADHD, one with Autism, one with Dyslexia, and one with Severe Anxiety Disorder provided interesting information regarding GBL. These students demonstrated unique behaviors and learning outcomes in this study. Future research should consider GBL within the context of struggling learners and learners with disabilities.

At present, I only distinguished between the two games (educational MMORPG vs modified entertainment RPG). However, there is considerable variation between game genres and within each type of game. Additionally, the only personality trait investigated in this study is dispositional curiosity. Evidence supports correlation between dispositional curiosity and game play experience (to include learning outcomes). However, dispositional curiosity is not the only influence on GBL relative to personality, preferences and motivations. It is recognized that many personality traits and preferences influence interactions with games (e.g., Bachen et al., Bartle, 1996; 2012; Yee, 2002; 2006). This study chose one game genre, RPGs, because current science education research suggests promise for role-playing to build science interest and self-efficacy (Fraser et al., 2014; Lester et al., 2014). Future research should further explore differences in game experiences and outcomes by considering different personality and learning style preferences as well as consider different game genres.

Time constraints of the study restrict naturalistic game play, especially for the RPG and MMORPG genre where players are known to spend years interacting with the game and their favorite avatar (e.g., Yee, 2006). It is a reasonable conclusion that extended time with DragonMist would increase emotional attachment to the game and result in greater endurability due to greater investment in the game. Greater attachment to the game would result in more time spent interacting with learning content and more opportunity to stimulate curiosity. However, novelty effects are also possible such that a player abandons the game when they believe there is nothing new to learn or experience.

A longitudinal study would provide more information about educational games purposed for voluntary play in informal environments.

Finally, it is recognized that there are limitations to generalizability. The reader should take responsibility for determining the degree to which findings of this study may be generalized to each individual situation. Future research should conduct a holistic study like this research and add a traditional education control group to establish effectiveness of GBL compared to traditional teaching as well as aim for a larger sample size such that more robust statistical analyses could be conducted to understand the complex network of relationships between the variables of this study (e.g., Structured Equation Modeling and/or Bayesian Networks).

8.5 Conclusions

This research adds to existing GBL literature by conducting a convergent parallel mixed methods research design to holistically investigate multiple game design features known to support engagement (immersion and flow) and motivation. Few, if any, GBL studies have directly compared an educational game with a successful entertainment game to examine the possibility that games can simultaneously teach and entertain. This research also adds to existing GBL literature by directly examining curiosity both as a stable trait and a dynamic state. Integrated results of this study provide evidence of the complex relationships between the game design, the player, and learning outcomes. These results provide evidence that educational games can be designed to enhance science knowledge (specifically basic genetics) and provide a motivating, engaging experience for the student. The results provide evidence that dispositional curiosity influences students' acceptance and interactions with educational games. Also, evidence was found that games can stimulate scientific curiosity and related behaviors that lead to deeper learning and initial evidence of transfer of knowledge to different contexts. The integrated results identified several key game design features that should be considered when creating well-designed educational games that support learning, incite curiosity and enhance all dimensions of motivation and engagement investigated in this study.

Designing good educational games, that teach and entertain, is a difficult challenge. It is extremely difficult to integrate explicit academic content into an entertainment game and maintain the gameness of the experience. However, games are powerful tools that can stimulate, support and reward curiosity. A key finding of this study is evidence that well-designed games can increase scientific curiosity. Therefore, these games can initiate the player's learning journey which will branch and grow as they follow a trail of information seeking and exploration where questions generate new questions and lifelong learning begins.

APPENDICES

Appendix A

The History of Curiosity

Prior to formal research, Aristotle (Posnock,1991, p 40) and Cicero (1914, p 48) related curiosity as an intrinsic motivation and innate love of learning. Later, Hume ((1777)/1888) portrayed curiosity as emerging from two powerful motivating forces. Good curiosity was related to love of knowledge and scientific inquiry, while bad curiosity was a passionate and insatiable fascination with the actions and circumstances of other people (Hume, (1777)/1888). Curiosity was often compared to intense physiological appetites that caused distressing deprivation feelings when unsatisfied (Blumenberg, (1966)/1983). In its humble beginnings, curiosity was defined as an intrinsic motivator that can both positively and negatively influence human behavior in all life stages (e.g., Stern, 1973; Wohlwill, 1987). Regardless, of curiosity's duality – is curiosity a desired and beneficial trait? Or did it in fact kill the proverbial cat? – researchers began encouraging educators to stimulate curiosity in classrooms (e.g., Tomkins & Tway, 1985; Vidler, 1974). The complex history of curiosity is reviewed in the following table.

First Wave of Curiosity Research: 1910-1960's, Primary Focus: Psychological Underpinnings	
Dewey, 1910	Defines curiosity as three different types: physical curiosity (about the environment), social curiosity and intellectual curiosity
Hull, 1943	Curiosity and motivation to learn considered as a biological drive and as a deprivation state, similar to hunger or thirst
Cohen, Stotland & Wolfe, 1955	Curiosity as '*Need for Cognition*' (need to structure relevant situations in meaningful ways) and widely viewed as a personality trait Sense-making has motivational force, and feelings of tension and frustration arise out of the need for cognition

Hebb, 1949; 1955	Incongruity Theory perspective. Curiosity as a manifestation of a natural tendency towards cognitive processing and the emotional need to make sense of the world
White, 1959	White's perspective is opposed to both drive theory and incongruity theory perspectives. Curiosity results from a motivation to master one's environment. Curiosity described as a competence or effectance motive. (White's perspective was later extended by Edward Deci's Self-Determination Theory).
Ellsberg, 1961	Curiosity as 'Ambiguity Aversion' (avoidance of situations in which one believes there is a lack of information necessary for making decisions), related to sense-making
Hunt, 1963; 1965	Incongruity Theory perspective. Curiosity is an intrinsic motivation triggered by violated expectations and motivated by a desire for positive affect
Fowler, 1965	Curiosity as a homeostatic drive based on boredom
Piaget, 1952; 1969	Curiosity is important to childhood cognitive development Linked curiosity with exploratory behavior as an emotional need to assimilate and accommodate understanding one's world (sense-making) Curiosity is not constant but can be evoked by violated expectations as an inverted-U relationship between evoked curiosity and the extremity of the expectation violation
James, (1890)/1950	Curiosity defined as scientific curiosity; distinguished between curiosity about the environment and curiosity about science or knowledge
Blumenberg, (1966)/1983	Curiosity as an apetitive drive; produces unpleasant feelings as a result of deprivation if not satisfied
Berlyne, 1954; Berlyne, 1960; Berlyne, 1967	Behaviorism: Curiosity as a drive related behavior and powerful intrinsic motivator for observed behaviors (exploratory and information-seeking) Two types of curiosity: perceptual (drive aroused by novel stimulus that attracts attention; continued exposure reduces) Epistemic curiosity (desire for knowledge) Added two factors of curiosity to describe specific (desire for specific information) and diversive (general seeking of stimulation related to boredom) Lead to a 4-way combination of the 2 dimensions: specific-perceptual; specific-epistemic (similar to scientific curiosity), diversive perceptual, diversive epistemic (described as a bored teenager flipping through tv channels seeking novel stimulus) As an emotional-motivational concept, curiosity-related behaviors can be evoked via novelty, complexity, surprise

Zuckerman, 1964	Curiosity measured as a tendency to seek novel sensory stimulation by engaging in social exploratory behaviors ***Sensation-Seeking Scale***
Day, 1968	Defined curiosity as a *Zone of Curiosity* where optimum experience and learning occur (between the zone of frustration & anxiety and the zone of boredom)
Vygotsky, 1978	Linked curiosity with exploratory behavior extends children's cognitive ability
Second Wave of Curiosity Research: 1970's – 1980's: Characterized by Striving to Understand How to Assess Dimensionality & How to Measure Curiosity	
Pearson, 1970	Measured curiosity as the tendency to approach or avoid novel stimuli that activate sensory and cognitive processes ***Novelty-Experiencing Scale***
Day, 1971	***Ontario Test of Intrinsic Motivation*** 110 trait-oriented T/F to measure areas of interest and included diversive and specific curiosity subscales. Validates specific curiosity but questions if diversive is actually curiosity or if it is boredom and related boredom-related behaviors (sensation-seeking)
Maw & Maw, 1964; 1968; 1972	Define behaviors that curious individuals exhibit: (four-part definition of curiosity) person reacts positively to novel, strange, incongruous or mysterious elements by approaching, exploring, or manipulating; expresses desire to know more about themselves and their environment; seeks new experience and scans surroundings; persists in experimentation & exploration to gain knowledge
Maw & Magoon, 1972	Extend previous work to correlate curiosity with personality sub-scales
Kagen, 1972	Define four basic human motivations: motive to resolve uncertainty, sensory stimulus motive, anger & hostility, and motive for mastery. Kagen proposes that uncertainty and curiosity are related but disavows Berlyne's relationship between mastery and curiosity (epistemic curiosity) stating that the underlying motivations differ
Coie, 1974	Focus on psychometric properties and developmental perspectives Linked intelligence and trait curiosity; but speculates that trait curiosity does not exist as a '*stable'* trait
Spielberger, Peters, & Frain, 1976	Focused on curiosity as a trait, positive emotions ***10 item trait curiosity scale***
Berlyne, 1978	Berlyne questions his earlier classification of diversive curiosity saying it might be more closely related to sensation-seeking behaviors stemming from boredom
Spielberger, 1979	State curiosity – intensity of feelings of curiosity at a specific time

	Trait curiosity – frequency at which an individual experiences curiosity ***State-Trait Personality Inventory (STPI)***
Naylor, 1981	Defines dimensionality of curiosity as state and trait State curiosity defined as individual differences in one's response to curiosity-evoking situations Trait curiosity defined as individual differences in tendency to seek out and the capacity to experience curiosity ***Melbourne Curiosity Inventory (State and Trait)*** *Trait: how do you generally feel about (ex. I feel absorbed in things I do)* *State: how do you feel about what you are doing at a particular moment in a specific context (ex. I feel absorbed in math class)*
Malone, 1981	Cognitive curiosity defined as the desire to bring better form to one's knowledge structures
Olson & Camp, 1984	Curiosity as "Need for Cognition"
Deci, 1985	Extends White's theory. Considers curiosity as a motivational state related to competence as a motivating factor
Current Research on Curiosity: 1990's to present	
Gilovich, 1981; 1991	Describes curiosity as stemming from human's predisposition to see order and recognize patterns to make meaning of the world
Goff & Ackerman, 1992	Curiosity related to intelligence and academic performance ***Typical Intellectual Engagement Scale*** (59 Likert items)
Loewenstein, 1994	Focused on the origin of curiosity and extended the concept of epistemic curiosity. Posed an information-gap theory (curiosity as a form of cognitively induced deprivation that arises when a gap in one's knowledge or understanding becomes salient) as the origination of curiosity that places primary importance on the individual's state of knowledge When an information gap is made salient, the individual will become curious and will be motivated to explore and seek out information until this gap is resolved Curiosity becomes stronger as resolution of the information-gap is near creating feelings of pleasure and satisfaction Theorized 4 factors related to curiosity: intensity, transience, impulsivity; and tendency to disappoint when satisfied Questions the existence of curiosity as a stable personality trait Defines state curiosity as momentary curiosity in response to immediate features of the environment
Spielberger & Starr, 1994	Curiosity, in the context of education, is a means to increase and support outcomes and processes of learning

	Specific (to reduce uncertainty) and diversive (seeking uncertainty to increase arousal) regarding the motivation of curiosity
Litman & Spielberger, 2003	Curiosity – focused on feelings about stimuli that activate cognitive processes ***Epistemic Curiosity Scale***
Peterson & Seligman, 2004	Curiosity as feelings of enjoyment and interest ***Values in Action Inventory of Strengths; Curiosity Subscale***
Collins, Litman, & Spielberger, 2004	***Perceptual Curiosity and Subscales*** measure of curiosity
Kashdan, Rose & Fincham, 2004	Conceptualized curiosity as an emotional-motivational state associated with recognition pursuit and self-regulation of novelty & Challenge Curiosity as a personal disposition (personality trait) Defines a curious person as 'one who has the propensity more readily to recognize, pursue, and become absorbed in novel and challenging experiences" (Kashdan et al., 2004, p. 292). Developed: ***Curiosity & Exploration Inventory (CEI)*** with two dimensions Exploration (appetitive strivings for novelty and challenge Absorption (full engagement in specific activities)
Litman & Jimerson, 2004	Developed a measurement of curiosity based on feelings of deprivation in support of Loewenstein's work (1994). ***Curiosity as a Feeling-of-Deprivation Scale (CFD)***
Litman, Collins & Spielberger, 2005	Sensory Curiosity (perceptual)
Litman, 2005	Model of curiosity as related to neuroscience research regarding basic behaviors of 'wanting' & 'liking' (Berridge, 1996; 2003)
Litman, Hutchins, & Russon, 2005	Epistemic curiosity as feeling-of-knowing (tip-of-the tongue), and exploratory behavior
Reio et al., 2006	Three-factor model of curiosity: cognitive curiosity, physical thrill-seeking, and social thrill-seeking
Silvia, 2006	Curiosity as dispositional-attention-based behaviors Identifies curious individuals by observing dispositional behaviors (attention devotion; deep processing, information recall, greater persistence)
Litman & Silvia, 2006	Trait curiosity as enduring, stable dispositional tendency to seek out opportunities to be curious or desiring novel environments and new

	knowledge. Evidence for interest and deprivation dimensions of curiosity.
Peterson, Ruch, Beerman, Park & Seligman, 2007	Dispositional curiosity. Greater dispositional curiosity leads to higher probability of pleasure and meaning in life
Friedman, 2007	Curiosity is more important than intelligence
Kashdan & Yuen, 2007	Explored curiosity as relevant to academic achievement (epistemic curiosity) and social environments (interpersonal curiosity) Curiosity & Exploration
Litman & Pezzo, 2007	Interpersonal curiosity as a dimension of curiosity
Litman, 2008	Defined curiosity as a drive or a desire to seek out experience or situations that are novel, complex, challenging and/or exploratory in nature Considered interest and deprivation as possible factors of curiosity
Kashdan et al., 2009	Curiosity dimensionality: aversive dimension, individual differences (trait) and context differences (situational or state) ***The Curiosity & Exploration Inventory-II***
Kashdan, 2009	Considers curiosity as attention regulation and direction. Defines two dimensions of curiosity as stretching and embracing with respect to novel, uncertain and challenging stimuli
Kashdan & Silvia, 2009	Considers curiosity as personality trait and exploratory behavior Two factors of curiosity: Stretching (motivation to seek out knowledge and new experience) and Embracing (willingness to embrace novel, uncertain, unpredictable situations) in everyday life ***Curiosity & Exploration Inventory II*** (36 items).
Kang, 2009	Humans and animals are biologically wired for exploration and information seeking as is evidenced by the dopaminergic system in the brain (reward system) that is activated by curiosity stimulation (neuroscience field) Epistemic curiosity activates the reward center and enhances memory
Litman, Crowson, & Kolinski, 2010	Curiosity as Interest-type epistemic and Deprivation-type epistemic I-type EC is the desire to acquire new information for the purpose of interest and fun D-type EC is the desire to acquire new information to reduce uncertainty, unknowing (similar to diversive)
Litman, 2010	Curiosity as I- and D- Type epistemic curiosity, ambiguity tolerance and need for closure: Initial test of wanting-liking model of information seeking

Mussel, 2010	The three constructs of curiosity theorized as need for cognition, typical intellectual engagement and openness for ideas were analyzed and no discriminant validity was found. One factor explained variance of the three constructs, so Mussel conclude integration of these three bodies of curiosity research should be considered
Arnone et al., 2011	Theorized a new definition of curiosity relevant to technology-pervasive learning environments. Considering unprecedented access to information via the internet, curiosity was considered as a dynamic construct composed of interest, curiosity and engagement
Jirout & Klahr, 2012	Focus on origination of curiosity Curiosity can be evoked by underlying mechanisms (novelty, surprise, conceptual conflict, uncertainty, anticipation of acquiring new knowledge) Focus on information-seeking behaviors
Gottlieb et al., 2013	Curiosity related behaviors (information-seeking; exploratory) can be extrinsically or intrinsically motivated Defines a new type of exploratory process (common in machine learning) that does not require prior knowledge (as posed by Loewenstein's information-gap theory, 1994).
Mussel, 2013	Curiosity and Job Performance. Defined trait epistemic curiosity as a set of traits that underlie an individual's preferences for knowledge acquisition learning and thinking Curious people expend greater effort toward exploration, discovery, and personally meaningful goal pursuits
Baranes & Oudeyer, 2013	Developmental robotics, exploratory behaviors related to curiosity can occur autonomously in open-ended environments (this type of exploratory behavior is common to digital games)
Markey & Loewenstein, 2014	Defines curiosity as 'a desire for information in the absence of extrinsic reward (p 230)'.
Luce & Hsi, 2014	Children engage in question asking and making sense of the world (early scientific practices) as examples of curious behaviors
Kidd & Hayden, 2015	Curiosity, from psychology and neuroscience perspectives, as a biological function, cognitive element, and learning motivator
Grossnickel, 2016	Defines curiosity as a "desire for knowledge or information in response to experiencing or seeking out collative variables, which is accompanied by positive emotions, increased arousal, or exploratory behavior p 37."
To, Ali, Kaufman & Hammer, 2016	Reviewed curiosity in the context of games and Costikyan's uncertainty in games. Conclude that designers can use uncertainty to accommodate curiosity

Weible & Zimmerman, 2016	Curiosity as domain specific (specifically scientific processes curiosity) ***Science Curiosity in Learning Environments (SCILE)***
Kashdan et al., 2018	Five distinct factors of curiosity (Joyous Exploration, Deprivation Sensitivity, Stress Tolerance, Social Curiosity, Thrill-Seeking) Identified four distinct types of curious people (personality profiles) (Fascinated, Problem-Solvers, Empathizers, Avoiders) ***Five-Dimensional Curiosity Scale (5CD) (Trait Curiosity & Personality)***

Appendix B

Learning Objectives for Radix and DragonMist

The learning objectives for *DragonMist* were directly matched to the learning objectives outlined in *The Radix Endeavor* teacher dashboard (MIT, 2006).

Learning Objective	*The Radix Endeavor* Sample task	*DragonMist* Sample task
Understand that different organisms can have different phenotypes	• Lumabells come in three colors • Use trait examiner tool • Pick one flower of each color	• Dragons are aggressive in the wild • Different factions in the war would love to have dragon allies • Use the Dragon Priest's research journal • Choose the correct sample to breed a passive dragon
Understand simple dominant inheritance	• Glum bugs are toxic and non-toxic • The baker needs non-toxic to bake a cake • Use the trait decoder to select glum bug parents • Breed a non-toxic glum bug	• Dragons in the wild are aggressive • Paarthurnax's bloodline can be passive • Use the sample case to select two dovah sil • Use the Punnett square to select the passive offspring
Identify a dominant trait	• The trait decoder shows the genotypes for glum bugs (TT, Tt, tt) • Use this information to breed a non-toxic bug • Player should understand if T is in the genotype the bug will be toxic based on the phenotype produced (toxic vs non-toxic) • T is dominant, t is recessive	• The sample case shows the genotype of the dovah sils (AA, Aa) • Player is not given a choice of aa • Player must understand if A is present, phenotype will be aggressive (A is dominant) • Genotype aa is required for a phenotype of passive • Knowledge is supported by Bhusari's dialog and the Dragon Priest's journal

See results of breeding certain parents and the distribution of offspring using the trait cross tool	• Pick two red myzle plants • Use the trait crossing station • Cross the two red parents • Consult the chart that shows genotype with the resultant phenotype to see percentages of offspring (presented as numbers and text)	• Select two parent dragons • Use the breeding station • Combine two dragon parents • Consult the animated essence and stone (color coded to match genotypes) • Consult the animated Punnett square (color coded to match genotypes) • Punnett square is intuitive based on an algorithm constructed to adhere to Mendelian probability • Explicit instruction is given by Bhusari's dialog and the Dragon Priest's journals.
Understand dominant and recessive traits	• Collect seed from two different zyboriser plants • Take seed to breeding station • Pick a heterozygous plant by using the trait decoder • Instruction is given by Wilder's dialog	• Examine the dovah sil case to see that there are two genotypes AA and Aa • Know to choose the heterozygous sample (Aa) to get recessive phenotype with genotype aa. • Instruction is given by Bhusari's dialog and the journals • Intuitive learning is supported by color coded animations in the breeding station
Use a Punnett square to predict offspring from a set of parents	• Cross parent plants that will always produce the desired offspring • Turn in the Punnett Square as evidence of success (NPC will accept or reject – no detailed feedback)	• Use the breeding station to combine two parents to produce the desired offspring • Notice the color-coded Punnett square animation is based on Mendelian probabilities but samples may need to be re-combined to get the desired set of offspring • Feedback is given by Bhurari and the dragon (attacks if aggressive, or speaks to you if passive)

Explain Mendelian genetics	• In-game quiz required for the student to move forward • Player is rewarded by getting the next quest if successful, or penalized by given remedial tasks if failed	• No in game quiz mechanic is used in DragonMist • Bhusari explains the experiment to the player based on which dragon was bred • Feedback is given by the dragon (aggressive will attack and must be destroyed, passive will speak to the player). • Player is rewarded by getting a pet dragon and given a new quest
Identify dominant recessive traits & complete dihybrid cross to breed for particular trait	• Continues with the concept of dominant and recessive • Adds complexity by asking for a dihybrid cross (two genes for two different phenotypes) • Ex. Find and collect a lumabell that is white and blinking	• Continues with the concept of dominant and recessive gene for temperament trait • Adds complexity by asking for a dihybrid cross. Two genes for two different traits (temperament and Thu'um (voice weapon)) • Ex. Breed a passive dragon that has fire Thu'um
Understand co-dominant traits and breed for specific trait using co-dominant inheritance patterns	• Find parent plants that will produce splotchy leaves • Use trait examiner and decoder tools • NPC tells the player the two genes are equally expressed • Genotypes are DD = dark leaves, LL = light leaves, DL will be splotchy because both dark and light are expressed (co-dominant)	• Find the new dovah sil samples above Whiterun • Demonstration scaffold: Bhusari takes the samples and creates a large aggressive fire dragon that attacks • Bhusari explains dihybrid cross and co-dominance and says there are 16 combinations so I will give you all passive phenotype (aa genotype) as a starting point • Player then has a choice of FF = fire, II = ice, FI = no voice because fire and ice equally express and cancel each other out. • Learning is supported by the journals and the color-coded animations.

Appendix C

Demographics Survey

DIRECTIONS: This research is interested in how we can design better educational games. Since individual preferences can influence your game play experience, we ask that you tell us a little bit about yourself.

Please answer each question as accurately as possible by choosing one answer or filling in the space provided.

First Name: ____

Last Name: ____

Gender: ______________________

Age: _________________________

Grade: ________________________

1. How would you describe yourself?

- ○ Asian
- ○ Hawaiian / Pacific Islander
- ○ Black/African American
- ○ Hispanic/Latino
- ○ Native American / Alaskan Native
- ○ White/Caucasian
- ○ Other
- ○ I prefer not to answer

2. How often do you play video games?

- ◯ Not at all
- ◯ About once a month
- ◯ A few times a month
- ◯ A few times a week
- ◯ Every day, less than 1 hour per day
- ◯ Every day, 1 to 3 hours per day
- ◯ Every day, more than 3 hours per day

3. Do you prefer playing games to other activities (ex. going out with friends, watching TV)?

- ◯ Never
- ◯ Seldom
- ◯ Sometimes
- ◯ Frequently
- ◯ Often

4. How would you describe yourself as a gamer?

- ◯ A non-video game player
- ◯ A novice video game player
- ◯ An occasional video game player
- ◯ A frequent video game player

○ An expert video game player

5. What device do you use most frequently to play games?

○ Computer

○ Mobile device (phone, tablet)

○ Game console

○ I do not play digital games

6. What is your favorite game(s) to play?

____

7. Have you ever played Skyrim?

○ Yes

○ No

○ I am not sure

8. If yes (you have played Skyrim), what level are you?

○ 0 to 25

○ 26 to 50

○ Over 50

9. Have you ever played The Radix Endeavor? (Y/N)

○ Yes

○ No

○ I am not sure

10. Please rate the following game genres based on your favorite games to play to your least favorite games to play.
(1 = never play, 2 = Rarely Play, 3 = Sometimes Play, 4 = Often Play, 5 = Always Play)

	Never Play (1)	Rarely Play (2)	Sometimes Play (3)	Often Play (4)	Always Play (5)
First Person Shooters (FPS) (ex. Halo)	○	○	○	○	○
Fighting / Competitive Action (ex. Street Fighter)	○	○	○	○	○
Racing Games (ex. Need for Speed, Grand Turismo Sport)	○	○	○	○	○
Sports (ex. Madden)	○	○	○	○	○
Virtual Worlds (ex. Sims, 2nd Life)	○	○	○	○	○
MMORPGs (ex. WOW)	○	○	○	○	○

11. Please rate the following game genres based on your favorite games to play to your least favorite games to play.
(1 = never play, 2 = Rarely Play, 3 = Sometimes Play, 4 = Often Play, 5 = Always Play)

	Never Play (1)	Rarely Play (2)	Sometimes Play (3)	Often Play (4)	Always Play (5)
RPGs (ex. Skyrim, Fallout 4)	○	○	○	○	○
Puzzle Games (ex. Candy Crush Saga)	○	○	○	○	○
Real Time Strategy (ex. Starcraft, Company of Heros)	○	○	○	○	○
Simulations (ex. SimCity, Flight simulators)	○	○	○	○	○
Turn-based games (ex. Chess)	○	○	○	○	○
Platformers (ex. Mario Brothers, Sonic Hedgehog)	○	○	○	○	○

12. Please tell us how you feel about science. Rate each statement according to how much you believe this to be true about yourself. (1 = never, 2 = sometimes, 3 = about half the time, 4 = most of the time, 5 = always)

	Never (1)	Sometimes (2)	About half the time (3)	Most of the time (4)	Always (5)
I am confident I can learn science	○	○	○	○	○
I make good grades in science courses	○	○	○	○	○
I think science is too hard	○	○	○	○	○
I think science is boring	○	○	○	○	○
I think science is fun	○	○	○	○	○
I do **NOT** think I am good at science	○	○	○	○	○
I am curious about science	○	○	○	○	○
I am curious about what scientists do	○	○	○	○	○

Appendix D

Genetics Knowledge Pre-Test

First Name: ____

Last Name: ____

Gender: _______________________________

School Grade: __________________________

DIRECTIONS: This research is interested in how we can design better educational games. One of the questions we seek to answer is the degree to which students may learn basic genetics concepts by playing games. To determine what you may learn by playing these games, we need to know what you understand about basic genetics concepts prior to playing the game.

Please take your time and consider each question carefully. Please answer each question based on your current understanding of genetics. Do not feel pressure while answering these questions. Your answers will not impact your grades or your standing in this Video Game Camp in any way.

For each of the following questions, please **circle** the **<u>best</u>** answer.

1. A “gene” is best or correctly described as _____________
    a. A segment of de-oxy ribonucleic acid that contains biological information for helping organisms’ function
    b. A mutation that causes an animal to appear or behave abnormally
    c. A large molecule that is made up of a chain of many different amino acids
    d. A type of food molecule that is used as a source of energy during digestion
2. The science of genetics deals mainly with ____________
    a. Integrating the biblical origins of life with the biological origins of life
    b. The classification of plants & animals into distinct groups of organisms
    c. Understanding how certain traits are passed from one generation to the next
    d. Describing the structures and functions of the various organs that animals have

3. You are experimenting with pea plants. You realize that the genotype for the dominant trait for seed pods is green designated with a capital 'G' and the genotype for yellow seed pods is designated with a lower-case 'g'. If you choose to cross plants with green pods (genotype GG) with plants that have yellow pods (genotype gg), what percent of the time can you expect to get plants with yellow pods?

    a. 100%

    b. 75%

    c. 25%

    d. 0%

4. You want to breed pea plants that produce round seeds. You discovered the gene for seed shape has a dominant and recessive allele. Based on this knowledge, how many possible phenotypes would you expect?

    a. 0

    b. 2

    c. 4

    d. 1

5. You have seeds from red roses and seeds from white roses. You have a tool that shows you genotype. You discover that the dominant trait is red and is designated with a capital 'R' and the recessive trait is white designated with a lower-case 'r'. You want to ***always*** breed white roses. To **best** accomplish this task, you would do which of the following?

    a. Plant seeds from white roses (rr seeds) & examine the new plants

    b. Plant seeds from red roses with genotype RR & examine the new plants

    c. Plant seeds from hybrid roses with genotype (Rr) & examine the new plants

    d. Stop using chemicals on the plants & examine the plants a few weeks later

6. Suppose you mated a yellow Labrador Retriever with a black Labrador Retriever, and all of the puppies had black fur. Which of the following statements **best** describes the pattern of fur color inheritance in these Labrador Retrievers?

    a. Labrador Retrievers can only have black fur or yellow fur

    b. Black fur is recessive over yellow fur

    c. Black fur is dominant over yellow fur

    d. Genes for yellow fur mutate to produce black fur

7. You discovered from your experiments with peas that the gene for seed shape has a dominant allele and a recessive allele. If you perform a monohybrid cross (Rr x Rr) using pea plants with round seeds. What offspring phenotypes do you expect?

    a. 2 possible phenotypes with the offspring **unlike** the parents 25% of the time.

    b. 2 possible phenotypes with the offspring **unlike** the parents 50% of the time.

    c. All offspring plants have round seeds

    d. All offspring plants have wrinkled seeds

8. Artists know that when you mix red paint with yellow paint, you get orange paint. In nature, plants can genetically mix colors used to make their flowers. You discovered a patch of Dragon-Mist flowers where 25% of the flowers were red, 25% were yellow, and 50% were orange. Which the following statements **best** (or correctly) describes the pattern of inheritance in this patch of flowers

    a. Flower color in Dragon-Mist flowers is controlled by three genes

    b. Red color and yellow colors in Dragon-Mist flowers are co-dominant

    c. Orange color in Dragon-Mist flowers is recessive to both red and yellow colors

    d. Orange flowers in Dragon-Mist are homozygous for the genes that control flower color

9. Suppose you were breeding peas and you know that the gene for seed type has both a dominant and recessive form. You noticed some pea plants produced seeds that were round (RR) and some plants produced wrinkled seeds (rr). When you crossed the plants with round seeds (RR) with plants with wrinkled seeds (rr), you would expect to get offspring that produce what kind of seed?

    a. Some round and some wrinkled seeds

    b. Mutants

    c. Wrinkled seeds

    d. Round seeds

10. You have discovered that the Dragon-Mist flower does not have a single dominant color. Your theory is that the colors, red (RR) and yellow (YY) are co-dominant and express equally in a hybrid. If you cross two hybrid Dragon-Mist flowers (RY and RY) from orange parents, what possible outcome would you expect?

    a. 2 Phenotypes with 1 out of 4 (25%) of the offspring **unlike** the parents

    b. 3 Phenotypes with 2 out of 4 (50%) of the offspring **unlike** the parents

    c. All flowers will be red

    d. All flowers will be orange

11. Suppose you were breeding glow bugs. You noticed some glow bugs produced glow colors that are yellow (YY) and some glow bugs produce a glow color that is green (yy). Through your experiments you discover that yellow glow color is dominant in glow bugs. You decide to continue your experiments with wing size. There seems to be three phenotypes for wing size, Large (LL), Small (SS) or Medium (LS). You discover that this is co-dominance. You decide to cross a green glowing glow bug with large wings with a green glowing glow bug with small wings. What offspring do you expect?

    a. Yellow glow color with large wings

    b. Yellow glow color with medium wings

    c. Green glow color with small wings

    d. Green glow color with medium wings

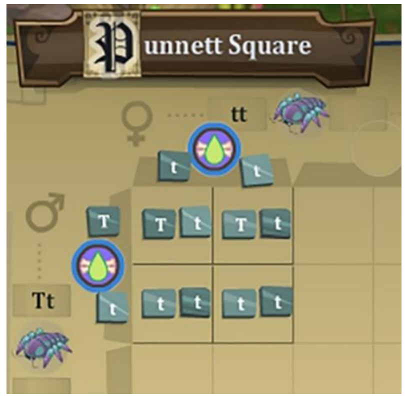
12. Suppose you are a scientist, and while on a quest to find more traits that you could use to breed unicorns, you discovered a remote population of giant unicorns that were all roughly five times bigger than all the other unicorns you have seen. Accordingly, you designated this giant trait with the letter "G". When you bred this unicorn with some of your previously captured "normal-sized" unicorns, you found that all of the offspring always grew up to be giants like their giant parents. Which of the following statements describing this situation is true?

    a. The smaller (normal) unicorn size is recessive to giant unicorn size
    b. The genotype of the offspring obtained is best represented by the letters "Gg"
    c. The offspring obtained can be referred to as "heterozygous" for the giant trait
    d. All of the above are true

13. Suppose you are a geneticist (i.e a person who studies how traits were passed down from one generation to the next). You live in an imaginary land where unicorns live in the wild and as pets along with people. The wild unicorns are almost always large (about the size of a horse). The pet unicorns are always small (about the size of a dog). There are never any medium sized unicorns seen. Even when you try to breed a large unicorn with a small unicorn, you never get a medium sized unicorn. You observe that every time you breed a large unicorn with a small unicorn, the baby unicorn always grows up to be small (never medium or large). Which of the following statements best describes the patterns of inheritance of unicorn size?

    a. Small unicorn size is dominant over large unicorn size
    b. Large unicorn size is dominant over small unicorn size
    c. Large unicorns are a mutated form of small unicorns
    d. Small unicorns' size is recessive to large unicorns' size

14. Based on this Punnett Square and the knowledge that the gene for toxicity in glumbugs has a dominant form, what percentage of toxic offspring do you expect?



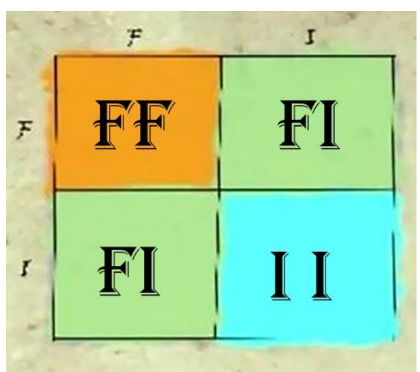
a. 100%

b. 75%

c. 50%

d. 25%

15. Wild dragons have a way to protect themselves by breathing fire or ice. This is called Thu'um (or voice). If you know that the genes for Thu'um (voice) are co-dominant (F = fire; I = ice) and were given this Punnett Square, what percentage of fire breathing dragons would you expect?



a. 100%

b. 75%

c. 50%

d. 25%

Appendix E

Genetics Knowledge Post-Test

First Name: ____
Last Name: ____
Gender: _______________________________
School Grade: __________________________
Which game did you play?

1. Radix Endeavor
2. DragonMist (Skyrim Quest)

Did you have enough time to complete the genetics quest?

1. Yes
2. No

DIRECTIONS: This research is interested in how we can design better educational games. One of the questions we seek to answer is the degree to which students may learn basic genetics concepts by playing games. To answer this question, we need to know what you may have learned about basic genetics concepts while playing this game.

Please take your time and consider each question carefully.

Do not feel pressure while answering these questions. Your answers will not impact your grades or your standing in this Video Game Camp in any way.

For each of the following questions, please **circle** the **best** answer.

1. A "gene" is best or correctly described as _____________
    a. A segment of de-oxy ribonucleic acid that contains biological information for helping organisms' function
    b. A mutation that causes an animal to appear or behave abnormally
    c. A large molecule that is made up of a chain of many different amino acids
    d. A type of food molecule that is used as a source of energy during digestion

2. The science of genetics deals mainly with _____________
    a. Integrating the biblical origins of life with the biological origins of life
    b. The classification of plants & animals into distinct groups of organisms
    c. Understanding how certain traits are passed from one generation to the next
    d. Describing the structures and functions of the various organs that animals have

3. You are breeding dragons and realize the genotype for the dominant trait of aggression is designated with a capital ‘A’ and the genotype for the recessive trait (**non**-aggressive) is designated with a lower-case ‘a’. If you choose to combine a dovah sil (dragon soul) from an aggressive parent (genotype AA) with a dovah sil (dragon soul) from a **non**-aggressive parent (genotype aa), you can expect to get a **non**-aggressive dragon what percent of the time?
    a. 100%
    b. 75%
    c. 25%
    d. 0%

4. A baker wants you to breed **non**-toxic glumbugs so he can bake glummy-cakes. You discovered that the gene for glumbug toxicity has a dominant and recessive allele. Based on this knowledge, how many possible phenotypes would you expect?
    a. 2
    b. 0
    c. 4
    d. 1

5. While breeding dragons, you discover that the dominant trait for temperament is aggressive and is designated with a capital "A" and the recessive trait for **non**-aggression is designated with a lower-case 'a'. When you breed two dragons you want to ***always*** get a **non**-aggressive baby that will be a pet. To **best** accomplish this task, you would do which of the following?

    a. Start feeding the captive dragons a different diet

    b. Combine two hybrid dovah sils (dragon souls) with the 'Aa' genotype

    c. Always combine two dovah sils (dragon souls) from the non-aggressive dragons you just bred (genotype aa)

    d. Always combine two dovah sils (dragon souls) from wild dragons (genotype 'AA')

6. Suppose you mated an aggressive dragon with a **non**-aggressive dragon, and all of the offspring were aggressive. Which of the following statements **best** describes the pattern of aggression inheritance in these dragons?

    a. Dragons are always aggressive

    b. Aggression is dominant over non-aggression

    c. Aggression is recessive over non-aggression

    d. Genes for non-aggression mutate to produce aggression

7. You discovered from your experiments with glumbugs that toxicity has a dominant allele and a recessive allele. You perform a monohybrid cross (Tt x Tt) using two toxic parents. What offspring phenotypes do you expect?

    a. All the glumbugs are toxic

    b. All the glumbugs are non-toxic

    c. There are 2 phenotypes and 25% of the offspring are **unlike** their parents

    d. There are 3 phenotypes and 25% of the offspring are **unlike** their parents

8. In DragonMist, wild dragons have “Thu’um” which is a voice weapon used to protect themselves. You discovered a group of wild dragons where 25% of them had fire voice, 25% of them had ice voice, and 50% of them had no voice weapon at all (no fire or ice, they cancelled each other out). Which of the following statement ***best*** describes the pattern of inheritance in this group of dragons for Thu’um (voice weapon).

    a. Thu’um (voice weapon) in dragons is controlled by three genes

    b. Fire and Ice voice weapons in dragons are co-dominant

    c. No voice weapon is recessive to both Fire and Ice voice weapon

    d. Thu’um (voice) must be sex-linked

9. Suppose you were breeding glumbugs and know that the gene for toxicity has both a dominant and recessive form. You noticed some glumbugs produced poison (toxic) (TT) and some bugs were **non**-toxic (tt). When you crossed the toxic bugs with genotype “TT” with **non**-toxic bugs with genotype “tt”, you would expect to get what kind of bugs?

    a. Mutants

    b. Toxic

    c. Non-Toxic

    d. Some toxic and some non-toxic

10. You are conducting experiments on Brightwits for Prunessa. Prunessa told you that some genes do not have a simple dominant form but that both forms are dominant. She calls this co-dominance. If you combine two hybrid brightwits (DL x DL) that have splotchy leaves, what possible outcome would you expect?

    a. 2 Phenotypes with 1 out of 4 (25%) of the offspring **unlike** the parents

    b. 3 Phenotypes with 2 out of 4 (50%) of the offspring **unlike** the parents

    c. All brightwits will have dark green leaves

    d. All brightwits will have splotchy leaves

11. Suppose you are breeding dragons. You noticed some dragons are aggressive (AA) and some dragons are **non**-aggressive (aa). Through your experiments, you discovered that the aggressive temperament is dominant in dragons. You decide to continue your experiments with Thu'um (voice weapon). There seems to be three phenotypes for Thu'um (voice): Fire (FF), Ice (II) and no voice (FI; where fire & ice cancel each other out). You decide to cross a **non**-aggressive fire breathing dragon with a **non**-aggressive ice breathing dragon. What dragon offspring will be the result?

    a. Non-aggressive with no voice
    b. Aggressive with no voice
    c. Non-aggressive fire dragon
    d. Aggressive ice dragon

12. Prunessa tells you that Blinking lumabells with sturdy shells make the best medicine. You know that the sturdy shells are the dominant form of the gene (HH) and that delicate shells are the recessive form of the gene (hh). You need to continue your experiments with Lumabell brightness. There seems to be three brightness phenotypes Bright (BB), Dim (DD) and Blinking (BD). You decide to cross a bright delicate lumabel with a dim delicate lumabel. What possible outcome do you expect?

    a. Sturdy lumabells that blink
    b. Delicate lumabells that are a mix of bright, dim and blinking
    c. Sturdy lumabells that are dim
    d. Delicate lumabells that blink

13. Suppose you are DragonBorn, and while on a quest to find more traits that you could use to breed dragons, you discovered a remote population of giant dragons that were all extremely aggressive. Accordingly, you designated this aggressive trait with the letter "A". When you bred this dragon with some of your previously created "**non**-aggressive" dragons, you found that all of the offspring were extremely aggressive like their aggressive parents. Which of the following statements describing this situation is true?

    a. The non-aggressive pet dragon temperament is recessive to aggressive dragon temperament

    b. The genotype of the offspring obtained is best represented by the letters "Aa"

    c. The offspring obtained can be referred to as "heterozygous" for the temperament trait of aggression

    d. All of the above are true

14. Suppose you are a geneticist (i.e. a person who studies how traits are passed down from one generation to the next). You live in DragonMist where dragons live in the wild and as pets along with people. The wild dragons are always large (about the size of a horse). The pet dragons are always small (about the size of a dog). There are never any medium sized dragons. Even when you breed a large wild dragon with a small pet dragon, the baby dragon will grow up to be large (not medium). Which of the following statements best describe the patterns of inheritance for dragon size?

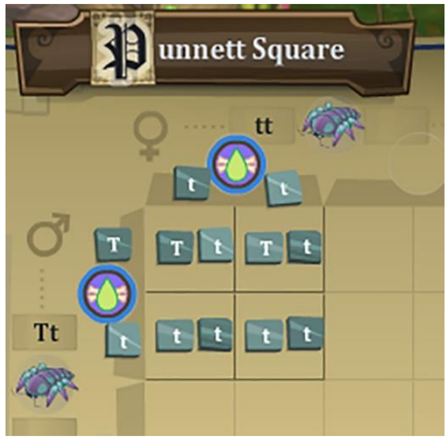
    a. Small dragon size is dominant over large dragon size

    b. Large dragon size is dominant over small dragon size

    c. Small dragons are a mutated form of large dragons

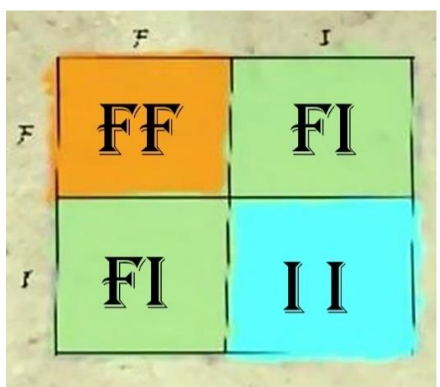
    d. Dragon size is controlled by three genes

15. Based on this Punnett Square and the knowledge that the gene for toxicity has a dominant form, what percentage of toxic offspring do you expect?



a. 100%
b. 75%
c. 50%
d. 25%

16. Wild dragons have a way to protect themselves by breathing fire or ice. This is called Thu'um (or voice). If you know that the genes for Thu'um (voice) are co-dominant (F = fire; I = ice) and were given this Punnett Square, what percentage of fire breathing dragons would you expect?



a. 100%
b. 75%
c. 50%
d. 25%

17. You are experimenting with Myzle flowers. You realize that the genotype for the dominant color trait of red flowers is designated with a capital ‘R’ and the genotype for white flowers is designated with a lower-case ‘r’. If you choose to cross a red parent plant (genotype RR) with a white parent plant (genotype rr), you can expect to get plants with white flowers what percent of the time?

    a. 100%

    b. 75%

    c. 25%

    d. 0%

18. You want to breed **non**-aggressive dragons so that they will be your friend. You discovered the gene for dragon temperament has a dominant and recessive allele. Based on this knowledge, how many possible phenotypes would you expect?

    a. 0

    b. 2

    c. 4

    d. 1

19. You have successfully bred some **non**-toxic glumbugs for the baker to use for his glummy-cakes. You have a trait decoder tool that shows you genotype. You discover that the dominant trait for toxicity is toxic and is designated with a capital ‘T’ and the recessive trait is **non**-toxic designated with a lower-case ‘t’. You want to ***always*** breed **non**-toxic glumbugs so the baker can bake his glummy-cakes. To **best** accomplish this task, you would do which of the following?

    a. Always cross the non-toxic glumbugs with the ‘tt’ genotype

    b. Always combine the wild genotype (TT) to breed the glumbugs

    c. Continue breeding the hybrid glumbugs with the ‘Tt” genotype

    d. Start feeding the captive glumbugs a special diet

20. You are helping Prunessa learn how to breed Myzle flowers. You found red Myzle flowers and yellow Myzle flowers. You collected one wild red parent plant and one wild yellow parent plant. You took them to a breeding station and crossed the two plants. All the new plants were red. Which of the following statements ***best*** describe the pattern of inheritance for the color trait in Myzle flowers?

    a. Myzle flowers can only be red or yellow

    b. Red colored flowers are recessive over other colors

    c. Red colored flowers are dominant over other colors

    d. Flower color is determined by how much sun the plant gets

21. You discovered from your experiments with dragons that the gene for temperament (aggression) has a dominant allele and a recessive allele. If you perform a monohybrid cross (Aa x Aa) using dovah sil (dragon souls) from two aggressive parents what offspring choices do you expect?

    a. 2 possible phenotypes with the offspring **unlike** the parents 25% of the time.

    b. 3 possible phenotypes with the offspring **unlike** the parents 25% of the time.

    c. All aggressive dragons

    d. All passive dragons

22. You have decided to experiment with brightwits. Brightwits leaf color seem to have 3 phenotypes instead of 2. You come across a patch of brightwits where 25% of them have dark green leaves, 25% of them have light green leaves, and 50% of them have splotchy leaves. Which of the following statements ***best*** describes the pattern of inheritance in this group of brightwits for leaf color?

    a. Leaf color in brightwits is controlled by three genes

    b. Dark green and bright green leaf colors are co-dominant

    c. Splotchy leaf color is recessive to both dark green and light green leaf color

    d. Splotchy leaf color must be a mutant

23. Suppose you were breeding dragons and know that the gene for temperament has both a dominant and recessive form. You noticed some dragons were aggressive (AA) and some dragons were **non**-aggressive (aa). When you crossed an aggressive dragon with genotype “AA” with **non**-aggressive dragons with genotype “aa”, you would expect to get what kind of dragons?

    a. Mutants
    b. Aggressive
    c. Non-aggressive
    d. Some aggressive and some non-aggressive

24. The dragon priest discovered that the gene for Thu’um (Dragon voice) does not have a single dominant form, but instead has two dominant forms (F=fire voice; I=ice voice). His theory is that the two forms are co-dominant and express equally in a hybrid. If you combine two hybrid Dovah Sils (FI x FI) from parents with no voice, what possible outcome would you expect?

    a. 2 Phenotypes with 1 out of 4 (25%) of the offspring **unlike** the parents
    b. 3 Phenotypes with 2 out of 4 (50%) of the offspring **unlike** the parents
    c. All dragons will have Fire voice
    d. All dragons will have no voice

25. Suppose you are collecting glumbugs for the baker to make glummycakes. While on a quest to find more traits that you could use to breed glumbugs, you discovered a remote population of giant glumbugs that were all extremely toxic. Accordingly, you designated this toxic trait with the letter "T". When you bred this glumbug with some of your previously created "**non**-toxic" glumbugs, you found that all of the offspring were extremely toxic like their toxic parents. Which of the following statements describing this situation is true?

    a. The non-toxic glumbug trait is recessive to toxic glumbug trait
    b. The genotype of the offspring obtained is best represented by the letters "Tt"
    c. The offspring obtained can be referred to as "heterozygous" for the toxicity trait
    d. All of the above are true

26. Suppose you are a geneticist (i.e. a person who studies how traits are passed down from one generation to the next). You live in an imaginary land called Radix where wild milkflies live in the mines and in people's houses. Milkflies from the mines have mold-detecting taste buds on their feet because they eat mold off the cave walls. Milkflies that live in people's houses do not have taste buds on their feet. You collected specimens of milkflies from both the mines and the houses. When you bred a milkfly from the mine with a milkfly from a house, the offspring always have taste buds on their feet even if they have no mold to eat in your lab. Which of the following statements best describe the patterns of inheritance for taste buds on milkfly feet?

    a. Taste buds on milkfly feet is dominant over no taste buds on the feet
    b. Taste buds on milkfly feet is recessive to no taste buds on the feet
    c. The mold in the mines mutated the milkfly feet
    d. Milkfly taste buds are controlled by three genes

Appendix F

Curiosity Pre- Survey

First Name: ____
Last Name: ____
Gender: ________________________
School Grade: ____________________
Please read the following statements and rate them based on how strongly you feel that the statement describes you on most days of your life and in most experiences.
1 = Never (you never feel this statement describes you), 2 = Not Often (you rarely feel this statement describes you), 3 = Sometimes (you feel this statement describes you occasionally), 4 = Often (you often feel this statement describes you), 5 = Always (you always feel this statement describes you).

There are no right or wrong answers, please choose the answer that you feel **best** describes you on **most** days and in **most** experiences in your life.

This sounds like me …..	Never 1	Not Often 2	Sometimes 3	Often 4	Always 5
I view challenging situations as an opportunity to grow and learn.	○	○	○	○	○
I am always looking for experiences that challenge how I think about myself and the world.	○	○	○	○	○
I seek out situations where it is likely that I will have to think in depth about something.	○	○	○	○	○
I enjoy learning about subjects that are unfamiliar to me.	○	○	○	○	○
I find it fascinating to learn new information.	○	○	○	○	○

This sounds like me …..	Never 1	Not Often 2	Sometimes 3	Often 4	Always 5
Thinking about solutions to difficult conceptual problems can keep me awake at night.					
I can spend hours on a single problem because I just can't rest without knowing the answer.					
I feel frustrated if I can't figure out the solution to a problem, so I work even harder to solve it.					
I work relentlessly at problems that I feel must be solved.					
It frustrates me **NOT** having all the information I need.					
The smallest doubt can stop me from seeking out new experiences.					
I cannot handle the stress that comes from entering uncertain situations.					
I find it hard to explore new places when I lack confidence in my abilities.					
I cannot function well if I am unsure whether a new experience is safe.					
It is difficult to concentrate when there is a possibility that I will be taken by surprise.					

This sounds like me …..	Never 1	Not Often 2	Sometimes 3	Often 4	Always 5
I like to learn about the habits of others.	○	○	○	○	○
I like finding out why people behave the way they do.	○	○	○	○	○
When other people are having a conversation, I like to find out what it is about.	○	○	○	○	○
When I am around other people, I like listening to their conversations.	○	○	○	○	○
When people quarrel, I like to know what's going on.	○	○	○	○	○

The anxiety of doing something new makes me feel excited and alive.	○	○	○	○	○
Risk-taking is exciting to me.	○	○	○	○	○
When I have free time, I want to do things that are a little scary.	○	○	○	○	○
Creating an adventure as I go is much more appealing than planned adventure.	○	○	○	○	○
I prefer friends who are excitingly unpredictable.	○	○	○	○	○

This sounds like me …..	Never 1	Not Often 2	Sometimes 3	Often 4	Always 5
I would like to invent something new.	○	○	○	○	○
I mix things together to see what happens.	○	○	○	○	○
I compare things to see if there are any changes or differences.	○	○	○	○	○
I like to work on problems or puzzles that have more than one answer.	○	○	○	○	○
I experiment with stuff to see what will happen.	○	○	○	○	○
I like to make things that no one else has made	○	○	○	○	○
I apply new information to an existing problem to see if that helps.	○	○	○	○	○
When I see a word I don't know, I look it up or ask someone what it means	○	○	○	○	○

Appendix G

Game Play Experience Survey I and II

First Name: ____

Last Name: ____

Gender: _________________________ School Grade: _________________________

I consider myself to be (circle one):
A gamer
A non-gamer

Game 1 played (circle one):
DragonMist
Radix Endeavor

This research wants to understand how to design engaging educational games. You can help us design better games by telling us about your play experience.

For the questions that give you a scale, please rank each question of strongly disagree to strongly agree. For open-ended questions, please tell us anything that you believe will help us design better games.

These questions are designed to help us understand your game play experience. Please remember that the questions are asking you how you feel about the game that you just finished playing for this study.

On a scale of 1 to 5, how much do you agree with the following statements describing your experience playing DragonMist or Radix Endeavor.

1-strongly disagree; 2-disagree; 3-not sure; 4-agree; 5-strongly agree

Please consider only the game you just played.

While playing this game	Strongly disagree 1	Disagree 2	Not Sure 3	Agree 4	Strongly Agree 5
1. I wanted to invent something new (ex. new dragons, new flowers, new weapons, new potions, etc.)	○	○	○	○	○
2. I was curious about mixing genes together to see what happens	○	○	○	○	○
3. I liked to compare things in the game environment to see if there were any changes or differences	○	○	○	○	○
4. I liked that I had freedom to solve the quest the way I wanted to	○	○	○	○	○
5. I liked being able to experiment with stuff to see what happens.	○	○	○	○	○
6. I wanted to create something that no one else in the game has (ex. dragons, bugs, flowers, weapons, potions)	○	○	○	○	○
7. I applied new knowledge to the quest goals to see if it helped.	○	○	○	○	○
8. If I saw a word that I didn't know, I looked it up or asked someone for help.	○	○	○	○	○

Please consider only the game you just played.

	Strongly disagree 1	Disagree 2	Not Sure 3	Agree 4	Strongly Agree 5
9. Playing this game was fun	○	○	○	○	○
10. I thought this game was boring	○	○	○	○	○
11. I would recommend this game to my friends	○	○	○	○	○
12. This game provided me with interesting options and choices	○	○	○	○	○
13. This game let me do interesting things	○	○	○	○	○
14. I experienced a lot of freedom in this game environment	○	○	○	○	○
15. My ability to play this game is well matched to the game's challenges	○	○	○	○	○
16. When I wanted to do something in this game, it was easy to remember the game controls	○	○	○	○	○

Please consider only the game you just played.

	Strongly disagree 1	Disagree 2	Not Sure 3	Agree 4	Strongly Agree 5
17. I thought this game was very interesting	○	○	○	○	○
18. I would like to discuss this game with my friends	○	○	○	○	○
19. I would play this game again if I had a chance	○	○	○	○	○
20. I got absorbed playing this game without trying to	○	○	○	○	○
21. I will probably think about what I learned playing this game	○	○	○	○	○
22. I thought the topic in this game was fascinating	○	○	○	○	○
23. This game was personally relevant to me	○	○	○	○	○
24. I would like to play more games like this one in the future	○	○	○	○	○
25. This game was one of the more interesting games I have played	○	○	○	○	○
26. This game really grabbed my attention	○	○	○	○	○

Please consider only the game you just played.

	Strongly disagree 1	Disagree 2	Not Sure 3	Agree 4	Strongly Agree 5
27. I felt focused on this game while I was playing	○	○	○	○	○
28. This game required a lot of effort to play	○	○	○	○	○
29. I lost track of time while playing this game	○	○	○	○	○
30. I forgot about my everyday concerns while playing this game	○	○	○	○	○
31. I felt the urge to stop playing this game to see what was going on around me	○	○	○	○	○
32. I felt like I was experiencing this game rather than just doing an activity	○	○	○	○	○
33. The feeling that I was in the game environment was stronger than the sense of being in the real world	○	○	○	○	○
34. I felt like I was moving through the game world according to my own will	○	○	○	○	○
35. I thought the goals in this game were challenging	○	○	○	○	○
36. I was motivated to play this game	○	○	○	○	○

Please consider only the game you just played.

	Strongly disagree 1	Disagree 2	Not Sure 3	Agree 4	Strongly Agree 5
37. I felt like I was making progress in this game	○	○	○	○	○
38. I was emotionally attached to this game	○	○	○	○	○
39. I was emotionally attached to my avatar in this game	○	○	○	○	○
40. I was interested to see how things would turn out in this game	○	○	○	○	○
41. I sometimes spoke to or wanted to speak directly to the characters in this game	○	○	○	○	○
42. I enjoyed the graphics in this game	○	○	○	○	○
43. I was disappointed when I had to stop playing this game	○	○	○	○	○
44. I used resources outside of the game to help me understand the game	○	○	○	○	○
45. I used resources outside of the game to help me understand genetics	○	○	○	○	○
46. I wanted to find more information on genetics	○	○	○	○	○

Please consider only the game you just played.

	Strongly disagree 1	Disagree 2	Not Sure 3	Agree 4	Strongly Agree 5
47. I wanted to find more information about things in the game (ex. dragons, flowers, the character's story)	○	○	○	○	○
48. The way my avatar looked was important to me	○	○	○	○	○
49. The NPCs (non-playing characters) in the game gave me valuable information	○	○	○	○	○
50. The game sparked my curiosity about things in the game	○	○	○	○	○
51. The game sparked my curiosity about genetics	○	○	○	○	○
52. I was curious about how things would turn out in the game	○	○	○	○	○
53. The game made me want to explore the game world more	○	○	○	○	○
54. The game gave me the freedom to explore and discover things on my own	○	○	○	○	○
55. The choices I made in the game made a difference in the game world	○	○	○	○	○
56. I felt like I could choose my own actions in the game	○	○	○	○	○

Please consider only the game you just played.

	Strongly disagree 1	Disagree 2	Not Sure 3	Agree 4	Strongly Agree 5
57. The music and sound effects in this game were very important to me	○	○	○	○	○
58. I enjoyed this game so much I would seek out online communities where I could share my experiences	○	○	○	○	○
59. I enjoyed this game so much I would look for opportunities to create art, stories or game mods for this game	○	○	○	○	○
60. Playing the role of a scientist made me curious about what scientist do	○	○	○	○	○
61. After playing this game, I can see myself as a scientist	○	○	○	○	○
62. The story in this game was very important to me	○	○	○	○	○
63. The fantasy in this game really drew me into the game	○	○	○	○	○
64. The rewards I got in the game were important to me	○	○	○	○	○
65. I felt like it was okay to fail in this game	○	○	○	○	○
66. Sometimes failing was fun in this game	○	○	○	○	○

Please consider only the game you just played.

	Strongly disagree 1	Disagree 2	Not Sure 3	Agree 4	Strongly Agree 5
67. Failing in this game gave me a chance to try something new or different	○	○	○	○	○
68. I felt like a hero in this game	○	○	○	○	○
69. I was always aware of my progress in this game	○	○	○	○	○

Open Response for Game Play Experience I

Your opinion is important to us. Your input can help us design better games that are more fun to play and more educational. Please answer the following questions with a few sentences.

Please consider ONLY the game you just played.

70. Please describe two (or more) things that you were curious about while playing the game. Explain how the game made you curious and how your curiosity was rewarded.

71. Describe 2 (or more) things that you think you learned while playing this game.

72. Describe an experience in the game that made you want to explore and discover new things.

73. Describe three things that you like most about the game you played.

74. Describe three things that you did **NOT** enjoy about the game you just played.

Open Response for Game Play Experience Survey II

Your opinion is important to us. Your input can help us design better games that are more fun to play and more educational. Please answer the following questions with a few sentences.

Think about **BOTH** games that you played during this Video Game Camp.

75. Which game made you more curious about things? Please describe 2 (or more) game-play experiences explaining how the game aroused and rewarded your curiosity.

76. Which game did you enjoy most? Please describe 2 (or more) game-play experiences that made your favorite game more enjoyable to play than the other game.

77. Which game helped you learn more? Please describe 2 (or more) things you think you learned while playing that game? How did the game help you learn?

> **NOTE**: Learning can be considered many things. For example, learning to play the game, learning about things in the game world, creativity, problem solving, decision making, strategy formation, science (genetics), or many other things.

Appendix H

Observation Protocol

Video Game Camp Observation Form

Please complete this form for each participant

Participant____

Played Solo (Which Game) ____

Played with another student (in-game or physically) (Which game, which student(s))

____

Area of Observation	**Observations**
Learning	
How do they interact with learning objectives in the game?	
(neg) Open resistance to learning content (ex. Off-task, avoids learning objective quests in favor of other activities	
(pos) Actively engages with learning content. (ex. Stays on task, completes learning objectives in each quest)	
DragaonMist only _ pet dragon, fire/ice dragon	
Curiosity	
How do they respond to gaps in their knowledge _ do they ask thoughtful questions (genetics or about the game itself)	
Exploratory behavior _How do they interact with the game world? (ex. Wander around, investigate things of interest like movement, sound, visuals, act on NPCs conversations or map markers)	
Information seeking _ how do they engage with the learning content and/or problem solving (do they consult classmates, teacher/researcher, internet, in game resources, printed materials)	
Persistence _ how do they react when faced with failure or challenging problems in the game (ex. exhibit frustration, anxiety, gives	

up vs. try multiple strategies, keep trying until they succeed)	
Engagement / Motivation	
How do they interact with the game?	
(neg) **Openly resists** playing the game. Refuses to play the game, off task behavior, comments "I am bored" "I want to do something else" What negative emotions / behaviors are observed (restless, frowning, on cell phone, being disruptive to others in the classroom, unable to sit still)	
(neg) **Passively resists** playing the game _ pretends to play but plays through quickly with minimal effort and thought. May seem restless, unhappy, anxious or frustrated. May play when they think they are being observed and go off-task when not	
Actively engaged with the game _ what positive emotions/behaviors are expressed (happy, excited, laughing, smiling, talking with friends, sharing their accomplishments with others) Leaning into the monitor, focused attention on the game, tries to complete quests even when difficult, does not get distracted by other things going on around them.	
General mood of the classroom, group, individual	
Avatars_ how did they interact with their avatars, how much time did they spend customizing. Did the avatar look like them?	
Game Design Features	
How did they interact with specific game design features (record passive & active observations in daily field notes)?	

End of Day Progress

Note progress, save game, log out of computer

Day 1____

Day 2 ____

Day 3 ____

Day 4 ____

Day 5 ____

Field Notes:

Day of Study______________________________

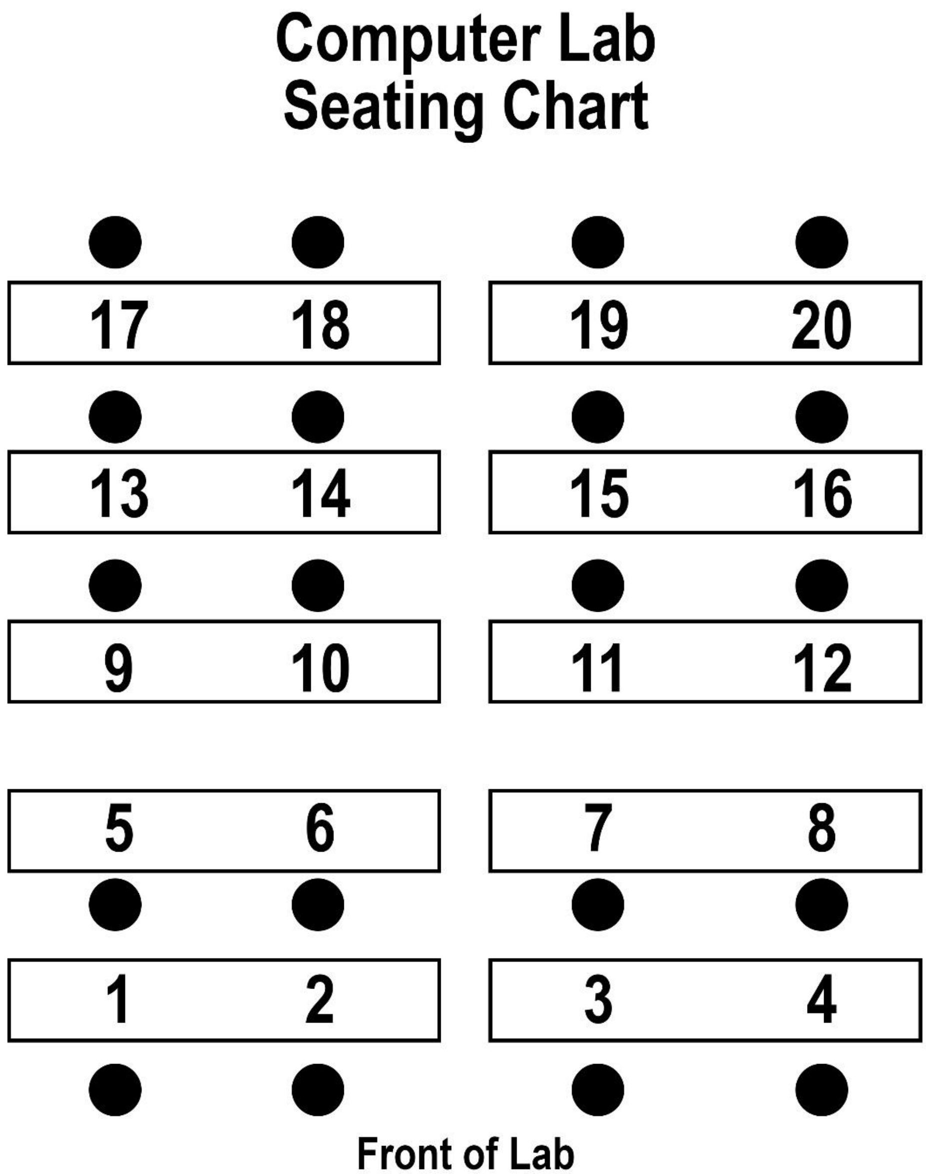
Please make note of the game they are playing, and the participant being observed.

Passive Observations:
Observe game play and participant interactions by observing the computer monitor as they play the game and how they interact with their classmates.

Active Participant-Observer Observations:
Record conversations when a participant asks questions, interacts with other students, or interacts with the game (emotions, actions, verbally, physically). How do they interact with the game? How do they describe certain game design features (ex. fun, exciting, boring, frustrating, helpful, disruptive or distractive)?

Appendix I

Computer Lab Seating Chart



Appendix J

Focus Group Questions

Focus Group Questions (keep it to 6 to 7 minutes per question (25-30 minutes total):

RESEARCHER NOTE: Make sure to ask & note which game they are talking about. Make sure they raise their hands to answer and speak one at a time so that the recording will be easily transcribed.

Topic: Curiosity

1. (open) Introduce topic by asking what scientists and gamers have in common. Discuss curiosity and give examples to make sure they know what curiosity is.
2. What kinds of things were you curious about in the game that you played?
    a. (more specific) If you were curious about something in the game, what did you do?
    b. (more specific) (**If they were curious about the game play only**) – What does the word, "genetics" mean? Were there things about genetics that you were curious about?
    c. (more specific) (Todd Howard, designer of Skyrim, says he tries to make the player curious and he rewards curiosity as much as he can. For instance, if you are curious about a door or chest and investigate you get cool loot or you may notice a fox that leads you to secret paths or secret quests. Can you describe how you would design a game to make the player curious about things?

Topic: Learning

3. (Open) Introduce topic by telling them researchers are interested if games can teach academic topics like genetics. There are a lot of things we learn in games, for instance creative problem solving, strategy formation, scientific reasoning and other thinking skills.
4. Tell me about some things that you learned in the game
    a. (more specific) If they think they only learned to play the game (or game related things): tell me about what you think you learned about genetics while playing the game.
    b. (more specific) Do you think that failing at something in a game is a good thing or a bad thing? Why? Describe a situation where you failed in the game and tell me what you did in response to that failure? (creative problem solving)
    c. (more specific) What do you think about using games in your classroom to learn science?
    d. Which of the 2 games you played do you think would be best for teaching genetics and why do you feel that way?

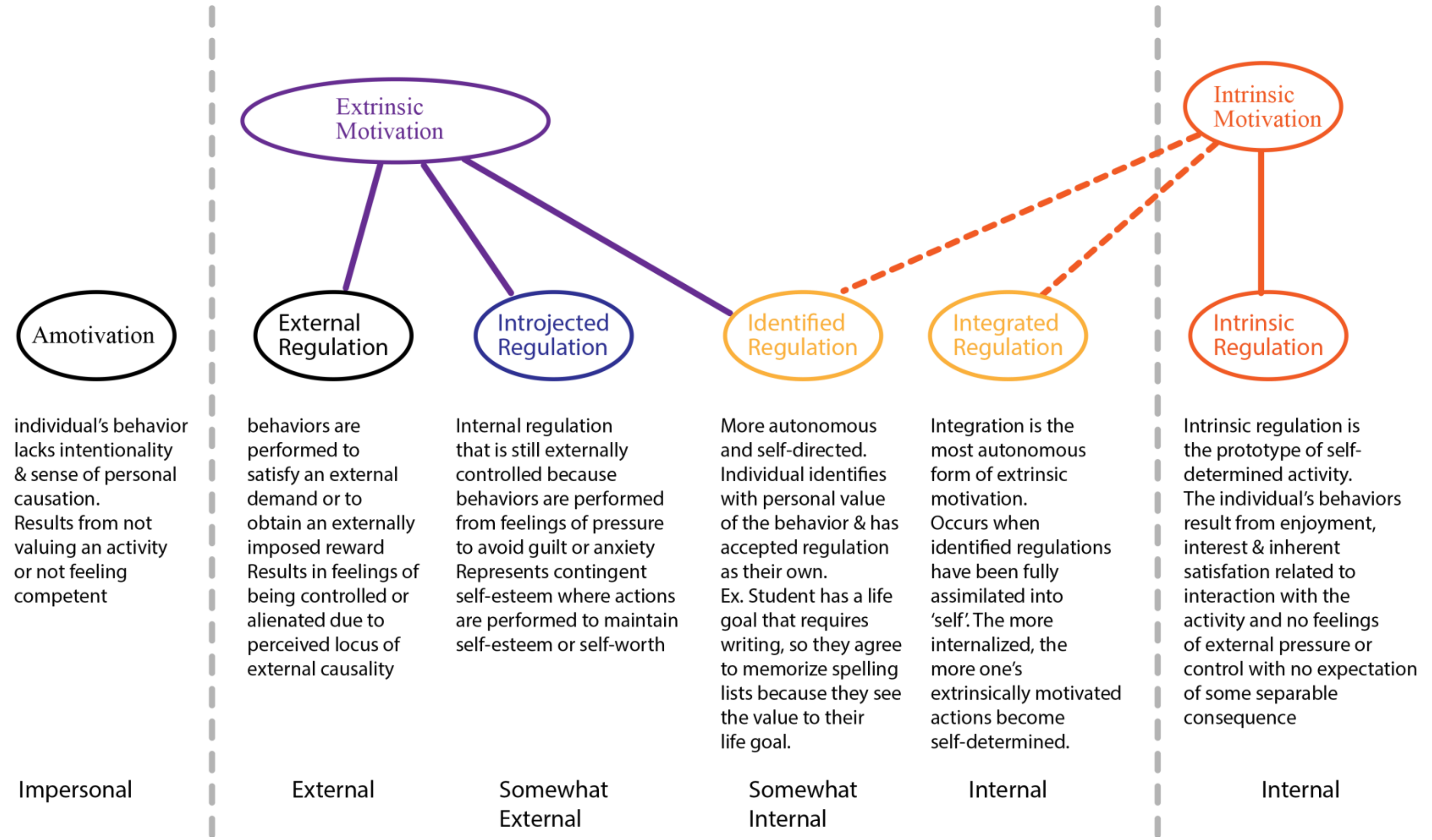
Topic: Engagement

5. (Open) Introduce topic by saying that sometimes students feel that educational games are boring, but they are highly engaged with commercial games and voluntarily play for hours. Researchers want to know how to make better educational games that are fun to play and can teach. Since you are the ones who will be expected to play these games and learn from them, I would be interested in how you think designers can make educational games more engaging and fun to play.
6. Tell me which game you thought was more fun to play. Describe an experience you had in that game that made it more fun than the other game.
    a. (More Specific) If you were to tell your friends about the game you played, what would you tell them?
    b. (more Specific) What was your least favorite experience in the game(s) you played.
    c. (more specific) I would like to get some ideas from you, so we can make the game that you just played better for other students.
        i. How would you re-design DragonMist to make the play experience better for you?
        ii. How would you re-design Radix Endeavor to make the play experience better for you?
    d. Did either game engage you so fully that you became interesting in modding the game? I know you didn't have a lot of time to really get involved with the game, but was it interesting enough that you wanted to learn more or wanted to add something to the game?

7. Is there anything else you wish to add?

Appendix K

A Taxonomy of Human Emotion (Source Ryan & Deci, 2000)



Appendix L

Game Log Statistics for Radix and DragonMist

Play experience (player interactions) statistics were downloaded from *The Radix Endeavor* game logs. Game screen shots were also collected. On the last play session, player location was recorded, but Radix does not provide a statistic on the number of locations visited.

Radix Play experience / Player interactions	**Average**	**Range**
Quests (All quests completed)	10.393	[0, 30]
Information Seeking (tools & data explorer)	18.429	[0,60]
Collected Items	107.179	[1, 856]
Flourins (awarded when accept a quest sometimes, and sometimes when you complete a quest)	35.321	[0, 88]
Experience Points (awarded when complete genetics quest)	13.125	[0, 40]

NOTE: N=27.

Play experience (player interaction) statistics were downloaded from *DragonMist* game logs. Game screen shots were also collected. Related statistics were combined into categories and then averaged (e.g. *Enemies Killed* consists of humans, animals, creatures; *Crimes Committed* includes assaults, murders, theft, etc.).

DragonMist Play Experience / Player Interactions	Average	Range	Count
Engagement			
Player Level	3.07	[1,7]	
Active Effects	2.60	[0,6]	
Quests (completed/in progress)	9.50	[3, 27]	
Enemies Killed	36.13	[0,103]	
Spells Learned (2 healing, all others destructive)	2.83	[2,8]	
Collected Items (currently carried)	153.80	[34, 556]	
Dungeons Cleared	0.57	[0, 3]	
Gold Carried	494.87	[0, 2059]	
Gold Spent	736.63	[0, 12129]	
Skills Increased	16.07	[1, 52]	
Curiosity			
Crafted Items (discovered components, mixing & experimenting)	14.20	[0, 129]	
Crimes Committed (Risk taking, stress tolerance, challenge)	22.00	[0,161]	
Trespasses (exploration)	0.57	[0,4]	
Map Locations Visited (exploration)	9.23	[2, 23]	
Standing Stones Found (exploration)	2.13	[0,5]	
Gold Found (exploration)	1231.50	[0, 12868]	
Chests Looted (exploration)	9.43	[2, 51]	

DragonMist Play Experience / Player Interactions	Average	Range	Count
Information Seeking (lore books read, spell books read, skill books read)	32.50	[0, 163]	
Curiosity (following wolf triggers thieves guild Easter egg			10
Riverwood Horse (# participants who took the horse)			26
Evidence of Learning			
DragonMist Quests Completed out of Three (27 tasks)	2.13	[0, 3]	
Correct Dragon (out of 2 required)	1.40	[0, 2]	
DragonMist Engagement (out of 10) (3 quests, 2 dragons, 5 books)	5.47	[0, 10]	
Fighting Style (counts out of 30)			
Conjuration Favorite Weapon (Avoidance, stands back and lets familiar fight)	3.00		
Sword, Ax (Close range: 1 handed, 2 handed weapons)	25.00		
Destruction Magic (long range)	2.00		
Fighting Skill Increases	94.70		
Sneaking Skill Increases	35.29		
Crafting Skill Increases	32.83		
Speech Skill Increases	16.33		
Crime Skill Increases (pick pocket, lock picking)	37.60		
Magic Skill Increases	17.23		

NOTE: N = 30.

Appendix M

Common Primary Game Mechanics Used in Entertainment Games with Examples Found in the Games Played During this Study

Mechanic	Description	Skyrim	DragonMist	Radix
Searching	Take snapshots and scan quickly for items matching internal symbolization Look for: Specific information, Item, Location, Character Player Objective: find item needed to proceed in the game (key to open a door)	Find weapons, potions, armor that can improve your health, magic and stamina	Go to Riverwood and find the Sleeping Giant Inn. Speak to Bhursari and help him find the abandoned temple	Speak to Dr. Salimar in Bladed Crossing who then asks you to go to Baobab Village and find a feltspittle flower
Matching (part of searching)	Getting the player to put one or more things together so that they become parts of a whole	Matching 3 ingredients with similar traits to create a more powerful potion	Matching the colors in the Punnett square in the Dragon Priest's research journal to the genetics notation on the samples and to the colors in the breeding station animation	Finding and measuring feltspittle flowers to collect several plants of a specified size
Sorting	Make order out of chaos Lowers cognitive load when things are organized	Inventory sorted by category Potions sorted by category Quests in order of smaller goals working towards the boss level and quest item	Quest is ordered by steps of increased skill and knowledge until dragon creation Dovah Sils (dragon soul samples) sorted by genotype	Quests are broken into smaller ordered steps that provide bits of information as needed

			and the breeding station by color coded phenotype	
Chancing	Chance decision making = risk (resource allocation, environment – chasing a bear away from food = increased risk) Chance in games determines probability of future outcomes	Fighting enemies and boss level opponents Leveled dungeons Leveled chests Leveled boss Resource allocation	Decisions: what strategy to use to fight your way to the lab or to collect samples (sneak past, engage, long-range, short-range) What samples do you use for the parents? What offspring choice do you pick for the baby?	I am not aware of any risk in this game other than failing the educational objective in which a remedial task is then assigned
Mixing	Combine objects or actions to produce an outcome unachievable otherwise Combine actions to complete a task (ex jumping while running)	Power attacks Run-Jump Power magic attacks Dual attacks Mixing potions Mixing a poison and applying to a weapon	Power attacks Run-jump Mixing doval sil to create different dragons	Mixing genotypes to create different phenotypes (bugs, flowers)
Timing	Time limits Timing an action Waiting for one event to occur before performing another Creates urgency Time required to level up or training processes to improve skills	Time and experience required to level up and improve skills Real time environment – day / night cycles that NPCs adhere to – different enemies at night, NPCs in different	Time and experience required to level up and improve skills Real time environment – different enemies encountered during the day and night, NPCs different	Imposed quest order

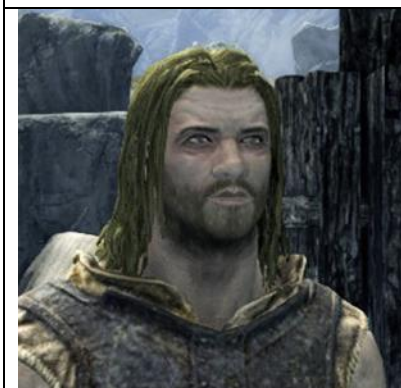
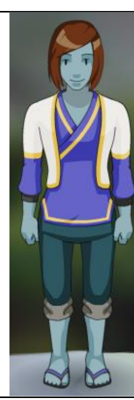
		locations in the game by time of day Weather patterns	locations by time of day,	
Progressing	Begin as noob and progress to expert Feeling of achievement for effort Ex. Longer you play -higher level of training Ex. More money you make more equipment upgrades Progression proceeds naturally but can be built in as reward system	Longer you play more experience allows higher training level More money more things to buy – houses, horses, training Higher level – better equip (ebony, etc)	Longer you play more experience allows higher training level More money more things to buy – houses, horses, training Higher level – better equip (ebony, etc) First level – pet dragon no voice – small, next level – fire breathing dragon etc.	Gain experience points as a leaderboard No skills progress, only academic knowledge for school
Capturing	Take something that belongs to someone else (ex Civilization) Less literal – pickpocketing, knocking out a NPC to get their stuff, knocking out another player to take their stuff	Pickpocket Stealing Knocking out or killing an opponent to take their stuff	Pickpocket Steal Knocking out or killing opponent to take their stuff	None
Conquering	Outdoing or annihilating competition Ex. Chess Less literal: owning a bigger house, having better equipment, higher status	Longer you play – higher level – better equipment More money – can buy houses and horses Can kill opponent and take their stuff	Horse at Riverwood Pet dragon no one else in Skyrim has. Thieves guild armor (easter egg) Ebony Fire Sword (Easter egg in temple)	None

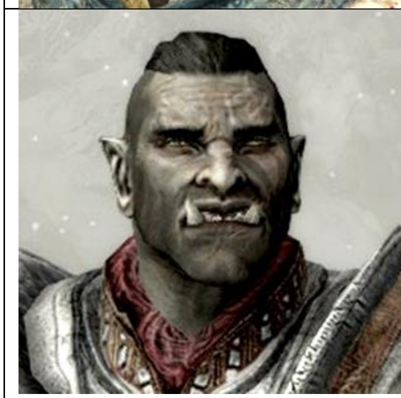
Avoidance	Dangerous items or situations the player should avoid Encountering these items penalizes the player (hit points, reduced health, loss of a life, etc)	Enemy encounter Traps Wards & Spells Animals Falls Water hazards	Enemy encounter Traps Animals Aggressive dragon	None
Collecting	Items collected for a purpose Random – surprise (ex. Super Mario Brothers – collect coins and stars just by moving through the game – not challenging to pick up but can be a record of progression) Can use counters on items found, secret places discovered to give a bonus at the end of a level	Ingredients to make potions Ores and minerals to make weapons Weapons Potions Equipment etc	Same as Skyrim plus Doval Sil to create different dragons	Flowers, bugs, animals to complete genetics quests
Random, Surprise	Random encounters, surprise rare rewards of extreme value	Randomized treasure chests, randomized leveled dungeons, Easter eggs	Ebony fire sword Easter egg, Thieves guild level 90 armor	None
Resource Management	Game resources like money, equipment, land, choices based on risk or trade-off (ex buy equip lowers coin, or make equip takes more time) etc.	Game resources like money, equipment, land, choices based on risk or trade-off (ex buy equip lowers coin, or make equip takes more time) etc.	Game resources like money, equipment, land, choices based on risk or trade-off (ex buy equip lowers coin, or make equip takes more time) etc.	None
Risk and Reward	Press your luck in optional actions	Fight or avoid	Fight or avoid	none

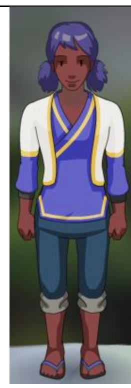
	(choice) – danger or risk must be weighted against the possible reward	Barter or challenge Purchase or steal	Barter or challenge Purchase or steal	
Role-playing	In-game actions are affected by the character's strengths and assets (see character build choices)	Character builds, skills and perks, equipment chosen	Character builds, skills and perks, equipment chosen	none
Loss Avoidance	Victory Condition - losing condition (running out of health, losing a life, losing equipment)	Running out of health, stamina or magic	Running out of health, stamina or magic, creating an aggressive dragon that attacks	Failing an educational task – NPC will not accept the item submitted
Puzzle solving	Victory Condition – solve puzzle or riddle to advance or gain info needed for the next puzzle, quest, etc	Bared doors to hidden locations require searching for clues to solve the puzzle to open, or find hidden keys or levers	Bared doors to hidden locations require searching for clues to solve the puzzle to open, or find hidden keys or levers	none

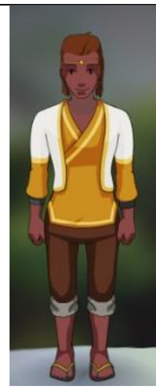
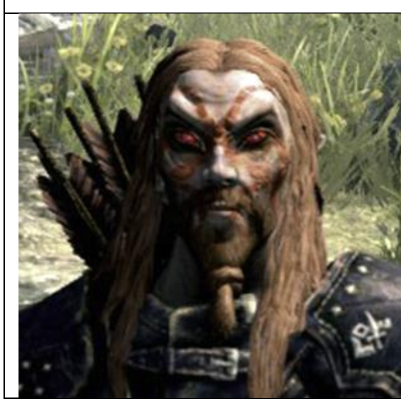
Appendix N

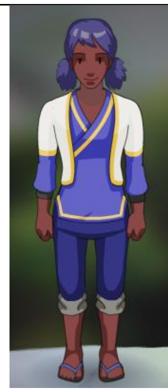
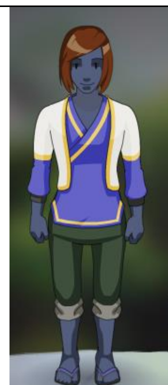
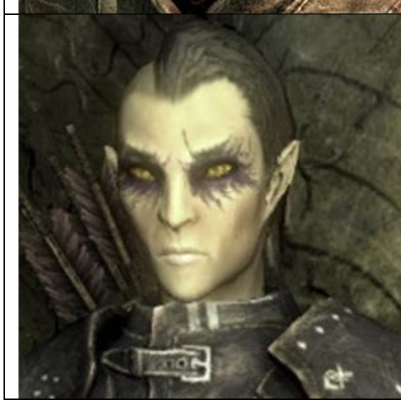
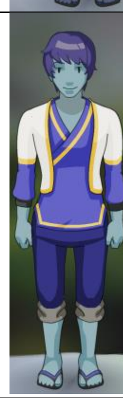
Participant Avatars, Pseudonyms, and Demographics

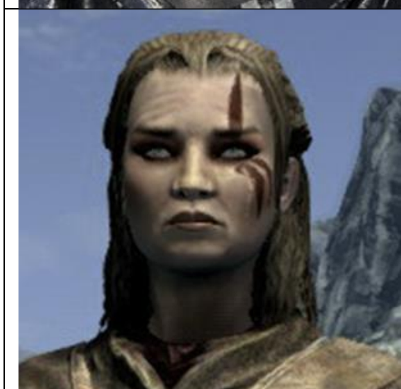
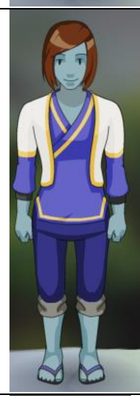
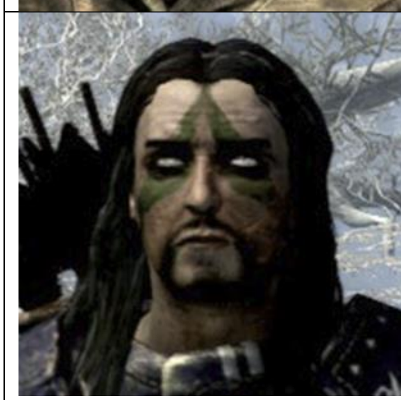
DragonMist Avatar	**Radix Avatar**	**Avatar Name & DragonMist Race**	**Participant Demographics**
		Kusold the Burly Nord	Male Grade: 11 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): Platformers Favorite Game(s): All Platformers
		Ching Chong Nord	Male Grade: 6 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): FPS Favorite Game(s): Borderlands, I Am, Bread, Fallout 4, GTA
		Ancosa Redguard	Female Grade: 7 Race/Ethnicity: White/Caucasian Non-Gamer Frequency game play (Not at all)

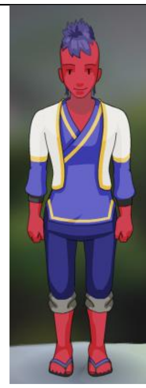
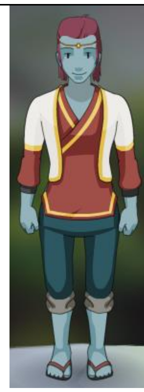
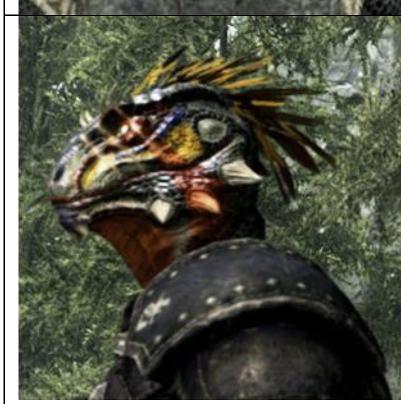
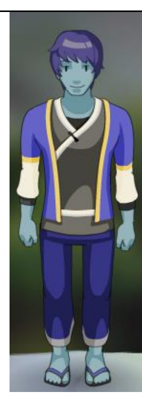
		Dundi Redguard	Male Grade: 8 Race/Ethnicity: African American Game Play: weekly Highest Ranked Game Genre(s): FPS, Sports Favorite Game(s): Ark, Destiny
		Gargel the Third Orc	Male Grade: 6 Race/Ethnicity: White/Caucasion Game Play: every day Highest Ranked Game Genre(s): FPS, Virtual Worlds, MMORPGs, Puzzles Favorite Game(s): Roblox, Fortnite, VR
		Mukmog Orc	Male Grade: 9 Race/Ethnicity: White/Caucasion Game Play: every day Highest Ranked Game Genre(s): FPS, MMORPGs, RPGs Favorite Game(s): Fallout 4, Fortnite
		Shrek Orc	Male Grade: 7 Race/Ethnicity: Other Game Play: every day Highest Ranked Game Genre(s): Platformers, FPS, Fighting, Virtual Worlds, MMORPGs, RPGs, Simulations Favorite Game(s):

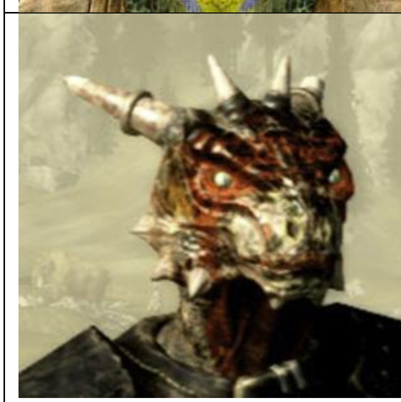
			Fortnite
		Theha Khajiit	Male Grade: 7 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): Sports, Virtual Worlds, MMORPGs, RPGs, RTS Favorite Game(s): Fortnite, Minecraft
		Katniss Khajiit	Female Grade: 6 Race/Ethnicity: Asian / African American Game Play: every day Highest Ranked Game Genre(s): Platformers Favorite Game(s): Zelda, Splatoon, Tetris
		Dill Pickles Imperial	Male Grade: 7 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): FPS, Virtual Worlds, MMORPGs, RPGs, Turn based, Platformers Favorite Game(s): Fortnite; Call of Duty

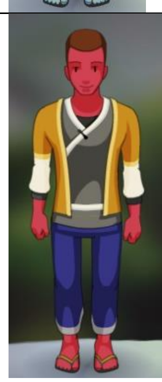
		Ahendria Imperial	Female Grade: 10 Race/Ethnicity: African American Game Play: Monthly Highest Ranked Game Genre(s): FPS, Fighting, Virtual Worlds, MMORPGs, RPGs Favorite Game(s): TombRaider, Resident Evil, Call of Duty
		Nedthroth Dark Elf	Male Grade: 7 Race/Ethnicity: Prefer not to answer Game Play: every day Highest Ranked Game Genre(s): RPGs, Platformers Favorite Game(s): Fortnite, Minecraft
		Rythoth Dark Elf	Male Grade: 7 Race/Ethnicity: White/Caucasian Game Play: weekly Highest Ranked Game Genre(s): RPGs Favorite Game(s): Fallout 4, Fortnite

		Lareia High Elf	Female Grade: 8 Race/Ethnicity: African American Game Play: every day Highest Ranked Game Genre(s): Platformers, Simulations, RTS, Puzzles, Virtual Worlds, Sports, Fighting, FPS Favorite Game(s): WWE2K19; Fortnite
		Zayna High Elf	Female Grade: 6 Race/Ethnicity: Asian Game Play: every day Highest Ranked Game Genre(s): Virtual Worlds, RPGs Favorite Game(s): Fallout 4, Minecraft, Sims
		Vallinalda High Elf	Female Grade: 9 Race/Ethnicity: Prefer not to answer Game Play: every day Highest Ranked Game Genre(s): Virtual Worlds Favorite Game(s): Minecraft, Sims 4

		Ryker Breton	Male Grade: 8 Race/Ethnicity: Hispanic Game Play: every day Highest Ranked Game Genre(s): FPS, Racing Favorite Game(s): Fortnite
		Syncette Breton	Female Grade: 5 Race/Ethnicity: White/Caucasian Game Play: never Highest Ranked Game Genre(s): none Favorite Game(s): none
		Jaegar Breton	Male Grade: 11 Race/Ethnicity: White/Caucasian Game Play: weekly Highest Ranked Game Genre(s): FPS Favorite Game(s): Halo, Rainbow Six Seige, Zelda
		Asdolufiene Argonian	Male Grade: 9 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): FPS Favorite Game(s): Rainbow Six Seige

		Teela Argonian	Male Grade: 6 Race/Ethnicity: African American Game Play: every day Highest Ranked Game Genre(s): FPS Favorite Game(s): Fortnite
		YeeHaw Argonian	Female Grade: 10 Race/Ethnicity: Asian / African American Game Play: every day Highest Ranked Game Genre(s): Platformers, RPGs Favorite Game(s): None listed
		Pajzara Argonian	Male Grade: 7 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): Platformers Favorite Game(s): Zelda, Splatoon, Tetris
		Dragonia Argonian	Male Grade: 6 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): MMORPGs, RPGs Favorite Game(s): Roblox, Zelda

		Talen-Zaw Argonian	Male Grade: 6 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): Platformers, Simulations, Sports, Fighting Favorite Game(s): Roblox, Minecraft
		Tslez'k Argonian	Male Grade: 6 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): Racing Favorite Game(s): Forza
		Stryker Argonian	Male Grade: 8 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): Platformers, Virtual Worlds Favorite Game(s): Minecraft
		Gulum-Mere Argonian	Male Grade: 7 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): MMORPGs Favorite Game(s): Roblox, Stickman Hook, Goons ID

		BeastMode Argonian	Male Grade: 7 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): RPGs Favorite Game(s): Uncharted, Fortnite, Minecraft
		Drago Argonian	Male Grade: 7 Race/Ethnicity: White/Caucasian Game Play: every day Highest Ranked Game Genre(s): FPS Favorite Game(s): Fortnite
		Your-Daddy	Male Grade: 5 Race/Ethnicity: African American Game Play: every day Highest Ranked Game Genre(s): Sports Favorite Game(s): Madden 2020; 2K Basketball

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