Linking Gaming Characteristics with Learning: A Literature Review

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Abstract

This article presents empirical findings of a literature review focusing on the effects of gaming design characteristics on learning. Gaming characteristics (GCs) are believed to play a critical role in improving instructional quality of computer-assisted learning. In particular, researchers suggest that linking GCs with specific learning outcomes can harness the power of games and inform learning and teaching theories. While there has been a growing body of empirical research focusing on games’ learning effectiveness, the systematic knowledge linking GCs with human performance is extremely limited. Only nine empirical studies evaluating instructional benefits of singular GCs were found. Among the investigated GCs were storyline/fantasy, competition, reward, and interactivity with learning content. Research linking these GCs with specific learning outcomes suggests directions for future investigations.

Background

Empirical research has shown that well-designed games have a potential to improve academic achievement and engagement (Young, Slota, Cutter, Jalette, Mullin, Lai et al., 2012). Games have been used as a means to improve communication, present instructional materials, train, and motivate learners in a variety of settings, such as educational institutions, military, business and industry.

Although there are many claims about instructional effectiveness of games, researchers do not have yet an answer on how to make fundamental decisions whether or not to consider games as part of an instructional solution. For example, learners’ audience, quality of a game, subject matter domain, instructional objectives, desired learning outcomes, or environmental constraints, are just a few factors that may influence educators’ decisions on whether or not to incorporate games in a curriculum. Popular video gaming websites (e.g., http://www.gamespot.com/, http://www.gamespy.com/) offer a large variety of game categories to choose from including puzzles, action, adventure, shooters, role-playing, strategy, racing and driving, sports, platformers, fighting, simulations, etc. One of the major differences between the categories is the game design or more specifically gaming characteristics (GCs). The question is how to choose an appropriate game to achieve specific instructional objectives and what role GCs play in this process.

There are many different perspectives on the mix of GCs that define a good instructional game. Many researchers agree that motivation is one of the major benefits associated with game-based learning (Barab, Gresalfi, & Ingram-Goble, 2010; Belanich, Orvis, & Sibley, 2006). Researches relying primarily on motivational benefits that games offer over other computer-based activities focused on identifying GCs that facilitate engagement and interest. Malone and Lepper (1987) and Malone (1981) suggested that challenge, control, curiosity, and fantasy are the major gaming characteristics that influence game player intrinsic motivation. More recently, Belanich, Sibley, and Orvis (2004) conducted an experimental study to determine motivational attributes of a successful PC-based game that has a potential to facilitate learning. The authors identified the following four motivational elements that contributed to participants’ interest to playing the games: challenge (not too hard and not too easy), realism (audio-visual realism and adhering to laws of nature), exploration (opportunity to discover new things), and control (manipulating the virtual environment through keyboard/mouse interface).

Another set of thinkers considered all possible game features that may contribute toward a definition of a good instructional game. De Felix and Johnson (1993), for instance, viewed a game as a mix of dynamic visuals, interactivity, rules, and goals. Garris, Ahlers, and Driskell (2002) identified six characteristics of video games: fantasy, rules/goals, sensory stimuli, challenge, mystery, and control. According to Juul (2003), six elements compose a game: rules, variable quantifiable outcome, player effort, valorization of the outcome, attachment of the player to the outcome, and negotiable consequences. Vogel, Greenwood-Ericksen, Cannon-Bowers, and Bowers (2006) argued that the following five game attributes distinguish games from other types of computer-assisted instruction: motivation, reward, interactivity, score, and challenge. Gee (2009) proposed six elements that constitute a good instructional game: (a) an underlying rule system and game goal to which the player is emotionally attached; (b) micro-control that creates a sense of intimacy or a feeling of power; (c) experiences that offer good learning.
opportunities; (d) a match between affordance (allowing for a certain action to occur) and effectivity (the ability of a player to carry out such an action), (e) modeling to make learning from experience more general and abstract, and (f) encouragement to players to enact their own unique trajectory through the game (p. 78). Whereas Shute and Ke (2012) identified seven elements of well-designed games: interactive problem solving, specific goals/rules, adaptive challenges, control, ongoing feedback, uncertainty evokes suspense and player engagement, and sensory stimuli (a combination of graphics, sounds, and/or storyline used to excite the senses) (p. #). This list of game "must haves" relied mainly on two descriptions of games: (a) as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (Salen & Zimmerman, 2004), and (b) as a mix of game elements that includes rules, goals, interaction, outcomes, feedback, win states, conflict, competition, problem solving, and story (Prensky, 2001). Apparently, there is little consensus about all GCs that constitute a good instructional game. Yet, rules/goals, challenge, and control GCs are among the most cited GCs.

Several researchers attempted to create a broad taxonomy of GCs and link GCs with specific learning outcomes in order to provide the basis for the decision of whether or not to consider games as part of an instructional solution and, if so, which GCs are appropriate from an instructional point of view. Johnson, Spector, Huang, and Author (2007), for example, suggested 14 GCs based on a comprehensive literature review: challenge, competition, rules, goals, fantasy, changed reality, immediate feedback, interaction, story or representation, engagement or curiosity, role playing, control, tasks, and multimodal presentation. The authors found that that 1) GCs are critical to successful game design in general, and that 2) the literature does link games (not GCs) to some learning situations (but not to specific instructional objectives or outcomes). Later, Wilson et al.’s (2009) literature review on game attributes resulted in identifying 18 GCs believed to have an impact on learning: adaptation, assessment, challenge, conflict, control, fantasy, interaction (equipment), interaction (interpersonal), interaction (social), language/communication, location, mystery, pieces or players, progress and surprise, representation, rules/goals, safety, and sensory stimuli. The authors analyzed games employed in the gathered studies in terms of GCs and learning outcomes that researchers aimed to achieve with the use of a particular game. However, vast majority of the reviewed games utilized a mix of multiple GCs, and as a result, it was impossible to determine the instructional benefits of singular GCs. Wilson et al. concluded that empirical studies are needed to examine which GC leads to which learning outcomes.

The notion of effects of GCs on learning is equally important to design of digital learning environments and theories of learning. According to Lepper (1985), linking instructional objectives with GCs can help in refining learning and teaching theories. Similarly, Garris et al. (2002) stressed the importance of examining characteristics of instructional games. The authors state, “Although most agree that games can be engaging and that games can be instructive, there is little consensus regarding the essential characteristics of instructional games. Implicit in the research literature is the notion that if we pair instructional content with certain game features, we can harness the power of games to engage users and achieve desired instructional goals.” (p. 441). More recently, the Federation of American Scientists (2006) emphasized the importance of developing “a sound understanding of which features of games are important for learning and why, and how to best design educational games to deliver positive learning outcomes” (p. 5).

By looking at the effects of different gaming characteristics and their interactions with student’s attributes, it is possible to identify GCs that make learning with computers appealing and motivating and provide practical recommendations for designing effective digital learning environments. Particularly, the effect of gaming characteristics on learning might depend on student’s traits or a desired learning outcome (Hays, 2005; Johnson, et al., 2007; Wilson, et al., 2009).

Although many researchers have stressed the importance of examining the effects of GCs on human performance and linking GCs with learning objectives, empirical research investigating the relationships between GCs and specific learning outcomes is very limited. Probably, only feedback (Shute, 2008) and control over the pace of learning (Azevedo, 2005) GCs were extensively examined empirically, as essential elements of well-designed computer-assisted learning environments.

Gaming Characteristics

The effect(s) of a particular GC on learning depends greatly on learning theories related to each GC. However, the way a GC is embedded into a game plays equally important role. The following sections present a review of learning theories and design issues related to competition and storyline/fantasy GCs. These two GCs were the focus of the majority of the identified empirical studies.
**Competition**

Competition in digital games serves several purposes. It allows risk-taking in a safe environment and contributes to motivation and skills testing, the enjoyment that was reported by many game players (Griffiths 1991a, 1991b, as cited in Lucas & Sherry, 2004). Competition has been cited among the major motivational gaming characteristics (e.g., Malone & Lepper, 1987; Prensky, 2001; Vockell, 2004).

It is believed that students follow performance-oriented goals when an environment emphasizes social comparisons of ability and competition for grades (Meese, Anderman, & Anderman, 2006). Although some researchers argue that competition facilitates motivation and academic performance (Hromek & Roffey, 2009), adopting performance-oriented goals may also decrease motivation to learn (Meese, Anderman, & Anderman; Colquitt & Simmering, 1998). Particularly, low-achieving learners are the first to be handicapped in learning structures that encourage competition (Powell, Ames, & Maehr, 1990, as cited in Schunk & Zimmerman, 1994).

Little consensus regarding the effect of competition on students' performance in classroom settings was found in empirical research as well. Colquitt and Simmering (1998), for instance, found that performance orientation was negatively related to motivation to learn. On the other hand, other studies showed the tendency to perform is stronger in the competitive than on non-competitive conditions (Horner, 1968; Rudow & Hautaluoma, 1975). Although the effect of competitive situations on individual performance has been extensively examined in classroom setting, extremely limited empirical research concerning the effect of competition on individual performance in instructional simulations or games has been found. Most of the literature examining digital simulations and games advocates a cooperative environment rather a competitive one, since competition may lower motivation of some students (Williams & Williams, 2007).

Generally, there are four main types of competition that can be used to increase a learner's motivation in computer-assisted learning (presented in order of decreasing motivational effect for the average learner): (1) competition against other learners, (2) competition against the computer, (3) competition against oneself, and (4) competition against the clock (Alessi & Trollip, 2001). Although competition against other learners is the most motivating method, many educators avoid using competition among individual learners because it might affect high- and low-achieving learners in different ways. Students who do well benefit from this competition type, while students who do poorly may experience feelings of embarrassment and punishment when competing against others.

Mandryk, Atkins, and Inkpen (2006) explored users' emotions in various collaborative play conditions. Twenty-four male participants played a sports game in three conditions: against a friend, against a stranger, and against a computer. They found that (1) it was considerably more fun and exciting to play against a friend than against a stranger, and (2) it was considerably more fun to play against a stranger than against the computer. Marginal differences in excitement were revealed between stranger and computer conditions. The results of this study should be interpreted with caution, since a very small sample size of male participants only was employed.

**Storyline/Fantasy**

Storyline was identified among the major reasons people play video games (Sherry & Lucas, 2003). Rieber, Davis, Matzko, and Grant (2001) define a storyline as a "glue" that connects scenes in instructional games. Although some researchers distinguish between storyline and fantasy GCs (e.g., Malone & Lepper, 1987; Prensky, 2001), for the purpose of analysis of the GCs, fantasy and a storyline are used mutually exclusively in this paper, since any fantasy is essentially a story (McKee, 1998). Storyline or fantasy has been identified (Malone, 1981; Malone & Lepper, 1987) among the prominent GCs that promote motivation to continue playing. The role of storyline or fantasy in gaming is to have players experience a kind of unreal activity. Malone (1980) distinguished between intrinsic and extrinsic fantasy as possible factors that may affect games effectiveness. According to Malone and Lepper (1987), an intrinsic fantasy fully integrates the fantasy context into instructional content. Effective storyline or intrinsic fantasy sustains players' engagement by stating clear objectives, providing a variety of paths to complete the objectives, and driving the player to act.

Emotionally appealing storylines can motivate and engage, leading to increased learning (Habgood, Ainsworth, & Benford, 2005). Although, storyline is not powerful enough to sustain players' motivation and engagement throughout the game (Myers, 1990, as cited in Asgari & Kaufman, 2004), it influences players' decision whether or not to engage in the game play. In this way, the storyline facilitates an activation of other gaming characteristics such as interactivity, competition, control, curiosity, challenge, and feedback (Asgari & Kaufman, 2004).

There is little consensus about the instructional effectiveness of integrating storyline into learning materials. Cordova and Lepper (1996) reviewed the literature on the effects of topical or content variables on children's curiosity and interest. They pointed out that children learn better, when materials are connected with topics and characters that are of high interest.
Habgord et al. (2005) analyzed theoretical and empirical foundations of intrinsic fantasy in the domain of instructional gaming and concluded that although fantasy does not play a critical role in improving the effectiveness of instructional games, its motivational power is a significant factor in enhancing motivation and learning in computer-based games.

**Purpose**

The purpose of the literature review was to identify empirical studies examining the effects of singular GCs on learning as opposed to a mix of multiple GCs on learning. Specifically, the goal was to answer to the following questions: (a) What GCs were empirically investigated? (b) How GCs affect learning? (c) Which GCs led to which learning outcomes? (d) What research framework researchers used to explore the effects of GCs on learning? Several GCs, i.e., feedback, control over the pace of learning, and assessment, were excluded from the literature review, since they were already extensively studied and reviewed in the literature (Ifenthaler, Eseryel, & Ge, 2012; Shute, 2008).

**Method**

A large body of literature concerning games and GCs was systematically reviewed. Online databases such as ScienceDirect, ERIC, Google Scholar, and PsychInfo were searched for the relevant literature. However, most of the studies were found using manual search from references. The following search terms and keywords were used: games and learning, gaming characteristics, gaming attributes, game design, game design elements.

The goal of the search was to find published and unpublished articles featuring empirical research on the effects of singular GCs on learning. In order to make the number of the reviewed articles manageable but comprehensive, exhaustive review with selected citation approach (Cooper, 1988) was implemented. Specifically, the following inclusion criteria was applied:

1. The study explored how a specific GC affected learning.
2. Feedback, control over the pace of learning, and assessment GCs were beyond the scope of the study.
3. The study reported research methods (i.e., participants, instructional interventions, instruments, research design, etc.) and results. Studies that employed quantitative research method reported statistical analysis methods and results.
4. The research presented in one study did not overlap research from another study.
5. The article was written in English.

The search was not limited to a particular publication type, date range, or research methods. From over 70 initially collected articles, only nine studies were included in the literature review.

**Findings**

**Rules/Goals GC**

*Breakout: breaking bricks*

Malone (1981) attempted to find the “secret” for the engagement appeal of the Breakout game by examining three game features that seemed to capture the essence of the game: the score, the act of breaking out of the bricks, and the ball bouncing off the paddle. By systematically stripping down these three GCs and the combinations among them from the original game, six versions of the game were developed. The participants, college students, played the games and rated them based on their preferences. Malone found that the versions that excluded a score and “bricks breaking” features were significantly less appealing. While the game feature of “bricks breaking” refers rather to a combination of GCs than a singular GC, the author suggests that “bricks breaking” ultimately represent the goal of the game and the findings of his study suggests that without a clear goal, the game loses completely its gaming appeal. Although the instructional benefit of the Breakout game is somewhat vague, this study represents one of the earliest attempts to examine GCs and their engagement appeal.

**Storyline/Fantasy GC**

Six empirical studies focusing on the instructional benefits of a storyline/fantasy GC or a combination of a storyline GC with another GC were found. In order to conduct the studies, the authors embedded an instructional content within a storyline to facilitate students’ engagement in the learning process.
Computer-based instructional programs for teaching basic graphics commands in Logo

Parker and Lepper (1992) conducted two studies evaluating the effects of a fantasy GC on learning how to draw lines that connect various objects on screen with third- and fourth-grade students. In the first study, the authors created four computer-based instructional programs that shared identical series of instructional tasks but differed in fantasy “embellishments” in order to examine the motivational benefits of different fantasy “embellishments”. In the basal, no-fantasy, version children drew abstract lines and geometric shapes. The other three instructional programs presented the same learning content in the context of simple stories such as a pirate seeking hidden treasures, a detective investigating a crime, and an astronaut looking for new planets. For example, in the no-fantasy version students were asked to connect a circle with other object on the screen. In the astronaut version, faces would replace the circles and a student would be guided to go and meet other astronauts. Simple illustrations were used to create the imaginary world.

During the experiment, students (n=47) briefly reviewed the four programs, rated them, and were offered to play with the activity that they chose for 40 minutes. The results indicated that embedding fantasy elements into a learning content had a significant positive effect on children’s motivation. The no-fantasy version had a significantly lower rating as compared to the other three fantasy versions.

In the second study, Parker and Lepper (1992) examined the instructional benefits of the fantasy contexts explored in the first study. In particular, the authors focused on the immediate learning of materials, retention of materials, and understanding of general geometric concepts. A pre-/posttest experimental design was employed. Twenty-seven third-graders were assigned to one of the following three intervention conditions: (1) a no-fantasy control condition (similar to the first study) (n=7), (2) individualized-fantasy (n=10), and (3) assigned fantasy (n=10). In individualized fantasy condition, children chose the fantasy context that they like the most. In the assigned fantasy condition, children were assigned specific fantasizes.

The results revealed that children in the fantasy conditions outperformed those in the no-fantasy condition on the immediate and delayed (2 weeks) learning of materials. Interestingly, on the general geometric concepts test, non-significant differences across the non-fantasy and fantasy conditions were observed. However, the students in the fantasy conditions performed significantly better on the delayed posttest 2 weeks later. In conclusion, Parker and Lepper (1992) state that including the least possible fantasy “embellishments” can result in better learning, retention, and motivation.

Statistics simulation game

Author (2011) examined instructional benefits of a storyline GC on learning effectiveness, efficiency, and engagement with the use of an online instructional simulation for graduate students in an introductory statistics course. In addition, the study focused on examining the effects of a storyline GC on specific learning outcomes, i.e., factual, conceptual, and application knowledge.

A storyline was embedded in an instructional simulation aiming to engage students in problem solving and data analysis in the context of basic statistics. The author developed two different versions of the simulation that had the same instructional content but differed in presence or absence of a storyline GC: (1) Simulation+No GC and (2) Simulation+Storyline GC. The Simulation+Storyline GC intervention presented learners with the Career Coach Simulation, where a student took on the role of an intern at the career advising company. As an intern, a game player had to assist a career coach with carrying out basic data analysis tasks. The storyline was presented using audio-based dialogs between the storyline characters and animations.

A pre-/posttest experimental design was utilized. Graduate students (n=64) were randomly assigned to two intervention conditions. The results indicated that adding a storyline to a simulation did not result in significant improvements in learning effectiveness or efficiency. The analysis of students’ performance scores for factual, conceptual and application knowledge did not reveal any significant differences between the interventions as well. However, students’ performance from both interventions combined significantly improved from pre- to posttest. Both interventions (simulation and simulation with a storyline) showed significant learning gains related to application knowledge, thus supporting previous research showing a positive effect of simulations and games on developing higher cognitive skills. With regard to engagement, contrary to the authors’ hypothesis, significantly higher engagement levels were observed among the students from the Simulation+No GC than the Simulation+Storyline GC group.

The findings of this study suggest that adding a storyline may distract students from an instructional task and pose a higher level of extraneous cognitive load that may be detrimental to learning outcomes. Moreover, students’ preferences as well as the nature of the storyline and the storytelling system can affect students’ engagement in the learning process.
Cristal Island: a narrative-centered learning environment for teaching microbiology

Spires et al. (2010) conducted an exploratory study aiming to determine the effects of different types of narratives on microbiology science learning and engagement levels with eight-grade students using a narrative-centered learning environment called Cristal Island. The virtual world of Cristal Island creates settings for a recently discovered volcanic island where a game player tries to solve a science mystery. The gaming environment allows a game player to explore the virtual world of the island, interact with game characters, operate lab equipment, manipulate objects, collect data, form and test hypotheses. All interactions in the Cristal Island virtual world are fully text-based and menu-based. Three versions of learning environments were developed to test instructional manipulations of an object, collect data, form and test hypotheses. All interactions in the Cristal Island virtual world are fully text-based and menu-based. Three versions of learning environments were developed to test instructional benefits of a storyline GC: Cristal Island Narrative (n = 60), Cristal Island Narrative-Light (n = 55), and Content Control (n = 36). Both the Narrative and Narrative-Light versions were developed using the Cristal Island game platform and enhanced with a storyline. The Narrative-Light condition used a storyline with less details included. The Content Control group used a PowerPoint presentation that featured content similar to the gaming environment curriculum, but did not include the storyline used in the gaming environment.

Spires et al. (2010) used a pre-/posttest experimental design where 151 participants were randomly assigned to the three conditions. The results indicated that students from the Content Control group significantly outperformed students from the Narrative and Narrative-Light groups on the science content learning. Moreover, students from the Narrative-Light group reported a significantly higher engagement levels compared to the Content Control group, while no significant differences were found between the Narrative and the other treatment conditions. However, it is important to mention that a caution should be used when comparing Narrative or Narrative-Light versions with the Content Control condition. Since Narrative or Narrative-Light conditions featured interactive Cristal Island gaming environment, while the Content Control condition used a text-based PowerPoint presentation. Thus, it seems that the Content Control condition differed from the other two conditions in not only the presence or absence of a storyline GC but in interactivity and overall gaming appeal as well. In sum, the authors concluded that the Narrative condition posed excessive cognitive load on students, which negatively affected students’ learning.

Storyline and Reward GCs

Computer-based training program for teaching employment laws

DeRouin-Jessen (2008) manipulated multi-media fantasy and reward GCs with the use of a computer-based training program featuring employment laws that govern selection practices content. The pre-/posttest experimental study systematically investigated the effects of multi-media fantasy (vs. text-based fantasy) and reward (vs. no reward) on learning and motivation. Five versions of computer-based training program were created: (1) Multi-media Fantasy, No Reward, (2) Multi-media Fantasy, Reward, (3) Text-based Fantasy, No Reward, (4) Text-based Fantasy, Reward, and (5) Traditional Version. The multi-media fantasy version was created using a commercial off-the-shelf (COTS) role-playing video game called Neverwinter Nights™, by Bioware. Neverwinter Nights™ game was adapted to allow players interact with the business owners and employees of various companies in a small town. The game characters communicated with the players using audio, while players responded by either typing or selecting responses to characters’ questions from a menu. The text-based fantasy version was developed using Visual Basic and the communication between the characters and the players was in text-based format only. The traditional computer-based version was developed using Visual Basic as well. This version did not include any storyline, sounds, or graphics and the information was presented using a bulleted list format. The reward GC was facilitated by providing players with points in the form of a salary raise or promotion to a higher position.

Declarative and application knowledge, motivation, and satisfaction levels were the focus of the study. One hundred sixty nine college students were randomly assigned to one of the five intervention groups. Contrary to the study hypothesis, traditional version, which looked similar to a PowerPoint presentation, led to better declarative knowledge outcomes than the multi-media versions. Moreover, adding a storyline or reward GCs to a training program led to non-significant differences across the conditions in motivation, satisfaction, and application knowledge. According to author, enhancing traditional learning materials with GCs can distract learners and result in a lower performance. In sum, adding a media-based storyline resulted in a lower declarative knowledge, while adding a reward GC had no effect on learning or motivation.

However, it is unclear whether the only difference between the multi-media fantasy and text-based fantasy versions was the storyline presentation format (media-based vs. text-based) or game navigation, interaction, and/or appeal contributed to the differences between the versions as well. Since these two instructional interventions were created using different game platforms (Neverwinter Nights™ vs. Visual Basic).
Storyline and Interactivity with Learning Content GCs

Greenwood-Ericksen (2008) examined the effects of a storyline (present vs. absent) and the degree of interactivity with the learning content (high vs. low) on learning. The author created a synthetic learning environment that included a hybrid of games and simulations for teaching African American history topics on slavery and the Underground Railroad to college students. The storyline GC was manipulated by presenting a story either through a narrative (storyline present) or text-based list of facts (storyline absent). The degree of interactivity with the learning content was manipulated by presenting the events either through the synthetic learning environment (high interactivity) or through text only (low interactivity). The “Story with Interactivity” condition was created using a COTS computer game called Neverwinter Nights®, by Bioware, that allowed students to interact with the characters and drive the plot development. The author did not provide technical details on how the other treatment conditions were developed except by stating that students interacted with a “limited” synthetic learning environment (p. 36).

Content learning (measured through recall and recognition questions) and enjoyment were the focus of the study. Eighty participants were randomly assigned to the four conditions. After interacting with the synthetic learning environment, the students were evaluated on the content learning. The results revealed that students from the “Storyline with Interactivity” condition performed more poorly than the other intervention groups; but their enjoyment was the highest among the four conditions. The presence or absence of a storyline did not affect students’ performance when interactivity was low. However, when interactivity was high, a combination of a storyline with high interactivity negatively affected students’ learning. In sum, the degree of interactivity with the learning content did not have any effect on learning. While, adding a storyline GC negatively affected students’ performance. With regard to enjoyment, both GCs, i.e., a storyline and interactivity with the learning content, had positive effect on students’ enjoyment.

Storyline, Feedback, Sensory Stimuli, and Competition GCs

Darts: a cognitive skill game for teaching mathematics

Malone (1981) used Darts, a game for teaching elementary students fractions, to examine students preferences with regard to various GCs. In the game, three balloons are shown on a number line and students need to guess the balloons position by typing fractions. If a student guesses the balloon position correctly, an arrow pops the balloon on the number line. Seven GCs were stripped down from the original version of Darts to examine their effects on students’ interest to play the game: performance feedback, scoring, constructive feedback, extrinsic fantasy, music, graphic representation, and intrinsic fantasy. The author distinguished between extrinsic fantasy that weakly related to the skill being taught (an arrow pops a balloon not on the number line but in another part of the screen) and intrinsic fantasy that “intimately related” to the skill being taught (an arrow pops a balloon on the number line).

A very small sample size of 80 students was employed in the study. The participants were randomly assigned to the eight conditions. The results revealed two significant findings. First, adding the extrinsic fantasy of balloons and arrows significantly improved students “liking Darts.” Second, a significant interaction between sex and condition was found. Adding the intrinsic fantasy to the game resulted in significantly lower interest toward the game among girls. Malone (1981) suggests that fantasy plays an important role in creating motivating learning environments. However, if the fantasy does not appeal to the target audience it may decrease students’ interest in learning.

Competition and Contextualized Advisement GCs

Simulation game for teaching mathematics

Van Eck and Dempsey (2002) systematically examined how competition and contextualized advisement GCs affect transfer of mathematics skills. An exploratory computer-based simulation game was developed for this study using Macromedia Authorware. In this simulation game, a learner plays a peer-aged character helping her “aunt and uncle” to fix up a house. Learners need to calculate, for example, how much paint is needed for painting a room in a house by operating various mathematical concepts such area, perimeter, addition, subtraction multiplication, division, and number conversion. Contextualized advisement involved aunt and uncle characters providing video-based advisement about solving the problem encountered during the game. By clicking on a walkie-talkie icon students could “call their aunt and uncle from another part of the house” and get an advice, thus activating the contextualized advisement video. Given these features of the contextualized advisement, it is possible to conclude that contextualized advisement is a type of elaborated on-demand feedback (Shute, 2008). In the competitive version of the game, players compete against a computer character.

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One hundred twenty seven middle school students participated in the pre-/posttest experimental study. They were randomly assigned to one of the five intervention conditions generated by crossing the two independent variables, i.e., competition and contextualized advisement, and adding a control group. The control group received a computer-based tutorial. The questions in the tutorial were text-based and identical to those in the other four conditions but did not have any graphics.

An interaction between the competition and contextualized advisement was observed. Students in the noncompetitive group performed better when they had an access to contextualized advisement, while students in the competitive group performed better when they did not have an access to contextualized advisement. Van Eck and Dempsey (2002) suggest to interpret the results with caution due to several study limitations such as low statistical power, assessment issues, and technical glitches. In general, the results may imply that attending to elaborated feedback while trying to beat the game does not complement each other. Elaborated on-demand feedback, i.e. contextualized advisement, may increase cognitive load, thus lowering students’ ability to follow the competition. Conversely, students competing for a higher score do not want to lose their time on attending to and processing of contextualized advisement.

**Virtual Reality GC**

*VR-ENGAGE – a virtual reality game for teaching geography*

Virvou et al. (2005) explored the benefits of virtual reality GC for learning geography with a virtual reality educational game called VR-ENGAGE. VR-ENGAGE is an Intelligent Tutoring System (ITS) that consists, similarly to any ITS, of four components: the domain knowledge, the student modeling component, the tutoring component, and the user interface. In this study, the authors manipulated the user interface component. A game-ITS version operated through a virtual reality user interface, while ITS with a simple user interface did not have the virtual reality features. Similar to the popular game called “DOOM” (ID-Software 1993), VR-ENGAGE has many virtual worlds with mediaeval castles, underwater castles, passages through the file, secret temples, dungeons and dragons where the student has to navigate through. VR-ENGAGE communicates with students through voice-based animated game characters or windows with text-based messages. Users can communicate with the gaming environment by typing their answers in a dialogue box. The ITS with a simple user interface did not have any features of the virtual reality. The system communicated all information through forms, dialogue boxes, hypertext, drop-down menus, etc.

The experiment consisted of two parts that were carried out simultaneously. During the first part of the experiment, 90 fourth-grade students were randomly assigned to either game-ITS or ITS with simple user interface condition. During the second part of the experiment, 90 fourth-graders were divided into three groups – poor (n=30), average (n=30), and good (n=30) – based on the grade they received in geography in the previous term. Students in each of the three groups were randomly assigned to either game-ITS or ITS with simple user interface condition. A pre-/posttest research design was employed. The results of the first part of the experiment indicated that VR-ENGAGE ITS led to significantly higher learning gains in comparison to the ITS with simple user interface. The results of the second part of the experiment revealed that students from the poor performance group that learned with VR-ENGAGE benefited the most of all conditions. Moreover, students from the average performance group that used VR-ENGAGE outperformed students from the respective performance level group that used ITS with simple user interface. Finally, non-significant differences in students’ performance were observed between the good students from the VR-ENGAGE and non-game ITS conditions.

In conclusion, a positive effect of virtual reality GC was observed when compared to the ITS with simple user interface. In addition, when students’ prior knowledge was considered, virtual reality GC benefited poor performers the most, whereas it had no significant effect on good performers. According to the authors, these findings suggest that virtual reality GC can provoke an interest in the subject of study among the students who tend to perform poorly in class and thus increase their learning, whereas good students perform well under any circumstances. However, no motivational data were collected to further support this claim.

**Summary and Discussion**

The literature review revealed an extremely limited number of empirical studies examining the effects of GCs on learning. Only nine studies were found. Several studies linked GCs with specific learning outcomes such as declarative, factual, conceptual, application types of knowledge (DeRouin-Jessen, 2008; Author, 2011), and knowledge transfer (Van Eck & Dempsey, 2002) or general learning benefits such as motivation, engagement, and retention (Malone, 1981; Parker & Lepper, 1992). The paucity of empirical investigations systematically linking GCs with learning outcomes suggests that more empirical studies should be conducted in this area. It is important to
mention that the goal of investigating singular GCs effects on learning is not to “dissect” successful games. Rather it is an attempt to identify gaming design elements that help achieve desired learning outcomes and/or make learning with computers appealing and motivating, and consequently provide practical recommendations for designing effective digital learning environments.

The reviewed studies linked GCs with various learning outcomes across a variety of domains (see Table 1). Interestingly, six out of the nine gathered studies examined a storyline/fantasy GC. A storyline/fantasy GC was embedded in learning environments designed to teach mathematics, statistics, microbiology, graphic design, employment laws, and history. The analysis of finding demonstrated contradictive effects of a storyline/fantasy GC on learning. Some studies showed a positive effect, while others demonstrated negative or no effect on learning. Nevertheless, the researchers agree that a storyline/fantasy GC has a strong motivational effect and non-appealing storylines/fantasies can detrimentally affect students’ motivation. A closer examination of various types of storyline and fantasy elements used in the gathered studies revealed that storylines represent a quite broad concept. Stories can serve a major role in the learning process by guiding the presentation of the learning materials via audio-based, text-based, or interactive multi-media based narratives (e.g., DeRouin-Jessen, 2008; Greenwood-Ericksen, 2008; Author, 2011) or just provide an idea about the location or settings where the instructional activity takes place (Malone, 1981; Parker & Lepper, 1992). Moreover, researchers were also concerned with the amount of details a story should provide and how it may affect learning (DeRouin-Jesss, 2008; Spires, et al., 2010). In addition, there are many ways in which storylines can be presented, including multi-media (graphics, music, and interactions with the gaming environment) or text-based only. Apparently, a deeper investigation on the effects of storylines in digital learning environments should be attempted.

A study of Virvou et al. (2005) illustrates further the broad range of storyline representations. The authors examined the effects of virtual reality created by a combination of story, audio, and visual elements on learning. According to the authors, adding virtual reality component to an intelligent tutoring system was beneficial for learning geography concepts, particularly for low-performing students.

Interesting findings related to the effect(s) of GCs combinations were found. For instance, combining a storyline with highly interactive media was found to significantly decrease learning gains (Greenwood-Ericksen, 2008). While interacting with the learning content without a storyline contributed to higher players’ enjoyment.

Competition GC (sometimes represented as a score) was investigated in several studies (Malone, 1981; Van Eck & Dempsey, 2002). According to the results of these studies, competitive learning environments do not affect learning. However, combining competition GC with contextualized advisement GC appears to result in an ill-designed instructional game, since students in competitive learning environments are more concerned with getting a higher score or a better time than receiving an elaborated feedback regarding the instructional task (Van Eck & Dempsey, 2002).

There are many challenges in exploring the effects of GCs on learning. In order to examine the relationships between the GC and learning, it is important to understand how each particular GC affects learning and/or specific learning outcomes. This means that GCs need to be studied in isolation from each other. This is a very difficult task, since commercial off-the-shelf games usually incorporate multiple GCs and do not allow code altering. In addition, research design and sample size considerations affect the number of GCs that can be systematically investigated in a particular study. These facts can probably explain the paucity of empirical research linking the GCs with human performance and the limited number of GCs explored in each particular study.

The literature review findings underscores the challenges associated with carrying out this type of research. The majority of found studies used relatively small sample sizes thus affecting the generalizability of the findings. Moreover, all reviewed studies employed unique learning environments that were specifically created to address research questions in each study. Researchers either systematically manipulated one or two GCs, or stripped GCs down from an original game. More information about how to manipulate particular GCs can be found in Malone (1981).
<table>
<thead>
<tr>
<th>GC(s)</th>
<th>Learning Outcome/ Benefit</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DeRouin-Jessen (2008) – Employment Laws</strong></td>
<td></td>
<td></td>
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<tr>
<td>Fantasy</td>
<td>- Declarative Knowledge</td>
<td>↓</td>
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<tr>
<td></td>
<td>- Application Knowledge</td>
<td>=</td>
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<tr>
<td></td>
<td>- Motivation</td>
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<tr>
<td>Reward</td>
<td>- Declarative Knowledge</td>
<td>=</td>
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<tr>
<td></td>
<td>- Application Knowledge</td>
<td>=</td>
</tr>
<tr>
<td></td>
<td>- Motivation</td>
<td>=</td>
</tr>
<tr>
<td>Fantasy &amp; Reward</td>
<td>- Declarative Knowledge</td>
<td>=</td>
</tr>
<tr>
<td></td>
<td>- Application Knowledge</td>
<td>=</td>
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<td></td>
<td>- Motivation</td>
<td>=</td>
</tr>
<tr>
<td>Storyline</td>
<td>- Overall Performance (recall and recognition)</td>
<td>↓</td>
</tr>
<tr>
<td></td>
<td>- Enjoyment</td>
<td>↑</td>
</tr>
<tr>
<td>Interactivity with Learning Content</td>
<td>- Overall Performance (recall and recognition)</td>
<td>=</td>
</tr>
<tr>
<td></td>
<td>- Enjoyment</td>
<td>↑</td>
</tr>
<tr>
<td>Storyline &amp; Interactivity with Learning Content</td>
<td>- Overall Performance (recall and recognition)</td>
<td>↓</td>
</tr>
<tr>
<td></td>
<td>- Enjoyment</td>
<td>↑</td>
</tr>
<tr>
<td><strong>Malone (1981) – Mathematics</strong></td>
<td></td>
<td></td>
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<tr>
<td>Fantasy</td>
<td>- Interest toward the game</td>
<td>↑</td>
</tr>
<tr>
<td>Feedback</td>
<td>- Interest toward the game</td>
<td>=</td>
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<tr>
<td>Score</td>
<td>- Interest toward the game</td>
<td>=</td>
</tr>
<tr>
<td>Sensory stimuli</td>
<td>- Interest toward the game</td>
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<tr>
<td><strong>Malone (1981) – Breaking Bricks</strong></td>
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<tr>
<td>Goal</td>
<td>- Interest toward the game</td>
<td>↑</td>
</tr>
<tr>
<td><strong>Novak (2011) – Statistics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storyline</td>
<td>- Learning Effectiveness</td>
<td>=</td>
</tr>
<tr>
<td></td>
<td>- Learning Efficiency</td>
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</tr>
<tr>
<td></td>
<td>- Factual Knowledge</td>
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<td>- Conceptual Knowledge</td>
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<td></td>
<td>- Application Knowledge</td>
<td>=</td>
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<tr>
<td></td>
<td>- Engagement</td>
<td>↓</td>
</tr>
<tr>
<td><strong>Parker and Lepper (1992) – Graphic Design</strong></td>
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<td></td>
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<tr>
<td>Fantasy</td>
<td>- Overall Performance</td>
<td>↑</td>
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<tr>
<td></td>
<td>- Retention</td>
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<td></td>
<td>- Motivation</td>
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</tr>
</tbody>
</table>
Table 1 (continued)

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<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Spires et al. (2010) – Microbiology</strong></td>
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<tr>
<td>Storyline</td>
<td>Overall Performance</td>
<td>↓</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td>↑</td>
</tr>
<tr>
<td><strong>Van Eck and Dempsey (2002) – Mathematics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competition</td>
<td>Knowledge Transfer</td>
<td>=</td>
</tr>
<tr>
<td>Contextualized Advisement</td>
<td>Knowledge Transfer</td>
<td>=</td>
</tr>
<tr>
<td>Competition &amp; Contextualized Advisement</td>
<td>Knowledge Transfer</td>
<td>attending to contextualized advisement while trying to beat the game does not complement each other</td>
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<tr>
<td></td>
<td></td>
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<tr>
<td><strong>Virvou et al. (2005) – Geography</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virtual Reality</td>
<td>Overall Performance</td>
<td>↑</td>
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<td></td>
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<tr>
<td><strong>Note.</strong></td>
<td>* Significant effects only. ↑ – positive effect; ↓ – negative effect; = – no effect</td>
<td></td>
</tr>
</tbody>
</table>

References

Author (2011). *Effects of an instructional gaming characteristic on learning effectiveness, efficiency, and engagement: Using a storyline to teach basic statistical analytical skills*. PhD Dissertation, Florida State University, Tallahassee, FL.


