Relationships Between Game Attributes and Learning Outcomes : Review and Research Proposals

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Games are an effective and cost-saving method in education and training. Although much is known about games and learning in general, little is known about what components of these games (i.e., game attributes) influence learning outcomes. The purpose of this article is threefold. First, we review the literature to understand the "state of play" in the literature in regards to learning outcomes and game attributes—what is being studied. Second, we seek out what specific game attributes have an impact on learning outcomes. Finally, where gaps in the research exist, we develop a number of theoretically based proposals to guide further research in this area.

Keywords: *game attributes; games; learning; learning outcomes; research; simulation; training*

The American Society for Training and Development (2007) estimates that organizations spend over $129 billion on learning and development. Within companies designated as American Society for Training and Development leaders in training and employee development, nearly 40% of training is technology based, including online learning, simulation-based training, and games. While high fidelity simulations have been the primary tool for decades (especially in aviation and the military), computer-based and console-based games (e.g., Xbox, Playstation) have become the focus of recent research and training because they offer an easily accessible, low-cost, yet effective alternative for learning (e.g., Belanich, Sibley, & Orvis, 2004; Driskell, & Dwyer, 1984; Rieber, 1996; Smith, Sciarini, & Nicholson, 2007). Others disagree, arguing that games only lead to superficial learning, which does not satisfy the educational needs of students (e.g., Egenfeldt-Nielsen, 2005, and Squire, 2004, as cited in Mishra & Foster, 2007).

Despite the lack of supporting evidence by some researchers, the popularity of games for education and training has increased over the past decade (e.g., Arnseth & McFarlane, in press); Fletcher & Tobias, 2006). This has brought increased interest in simulation and gaming organizations (e.g., North American Simulation and Gaming Association, International Simulation and Gaming Association), scientific journals (e.g., *Journal of Educational Multimedia and Hypermedia* Special Issue on Learning and Teaching with Electronic Games), and gaming initiatives (e.g., Serious Games).

Despite the increased attention, there appears to be some confusion in the literature as to what constitutes a game and what constitutes a simulation. Are they the same or are they different? Can a simulation be a game and vice versa? This is not to say that simulations do not contain elements of games and that games do not contain elements of simulations. Indeed they do, as the following definitions describe. Hays (2005) defines a *game* as "an artificially constructed, competitive activity with a specific goal, a set of rules and constraints that is located in a specific context" (p. 15). Furthermore, games lie on a continuum from humorous and lighthearted (Dormann & Biddle, in press) to violent (C. A. Anderson & Bartlett, in press). Simulations, like games, are interactive, with the purpose of achieving specific goals in a specific context; however, simulations make "a serious attempt to accurately represent a real phenomenon" (Crawford, 1984, p. 8) and generally incorporate a model of complex processes (ranging from routine to extreme) that are determined by a specific algorithm (Randel, Morris, Wetzle, & Whitehead, 1992). Figure 1 (adapted from Percivel & Ellington, 1980, as cited in Leemkuil, de Jong, & Ootes, 2000) illustrates the relationships between games, simulations, and case studies. Although we chose not to focus on case studies in this current article, we think that its inclusion in the figure is valuable at illustrating the relationship. Simulations are widely accepted and utilized frequently in health care (e.g., Gaba, Howard, Fish, Smith, & Sowb, 2001; Lane, Slavin, & Ziv, 2001), the military (Oswalt, 1993),

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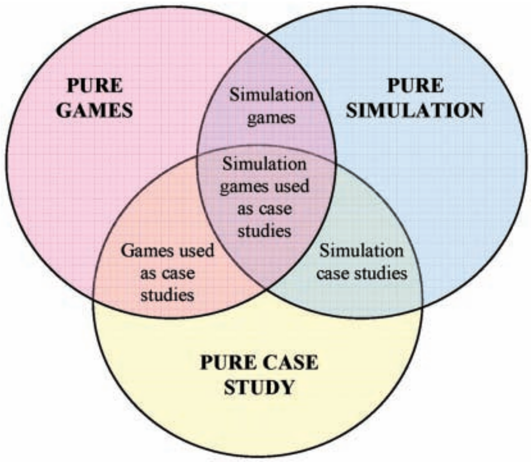
Figure 1
Relationships Between Games, Simulations, and Case Studies



business (e.g., P. Anderson & Lawton, 2008; Faria, Gold, Wellington, & Hutchinson, in press), emergency management (e.g., Strohschneider & Gerdes, 2004), and many other fields. Moreover, with recent advances in technology and computer graphics, games can now accurately represent (or simulate) a task and/or environment, making them a viable alternative to simulations. Readily available, commercial-off-the-shelf games are thus becoming a staple in classrooms and organizations for education and training purposes (e.g., Fong, 2006).

Research over many years indicates that the use of games for learning leads to improved general learning, increased motivation, and improved performance (e.g., Blunt, 2007; Borodzicz & van Haperen, 2002; Bredemeier, & Greenblatt, 1981; Chen, & Michael, 2005; Habgood, Ainsworth, & Benford, 2005; Prensky, 2001). For example, Blunt (2007) used three different games in three different education domains (i.e., Industry Giant II in business, Zapitalism in economics, and Virtual U in management) to understand their impact on student learning. In each of the education areas, students provided with a game to facilitate learning scored significantly higher on tests. These findings were only true for students younger than 40 years old. Yet, as noted by Hays (2005), a finding regarding the use of a particular game on a specific population does not tell us that all games are effective for all learners in all learning situations.

In light of the above, it is safe to assume that the literature is lacking research that links the various elements of games to types of learning. Little research indicates what aspects of games (i.e., what game attributes) lead to learning outcomes. In addition, we do not know if the relationship between games and learning is direct or indirect, and if so, what the mediating variables may be. We must also understand whether a single game attribute leads to learning or if a combination of multiple attributes within a game has a stronger effect. Many areas of research remain unexplored.

In 2002, Feinstein and Cannon presented a simulation validation process to address the lack of a scientifically acceptable methodology to evaluate simulation-based learning. However, their purpose was to create a coherent framework from which to evaluate *simulations*, and accordingly, their work provides a systematic way to categorize simulation evaluation, with an emphasis on the validation process. There remains a gap in the literature with respect to games: the links between particular game attributes and learning outcomes. Tying game attributes with specific learning outcomes in order to achieve targeted learning goals would appear beneficial to trainers, instructors, practitioners, and certainly the learners themselves. Without being able to make explicit or even inferred linkages between attributes and learning outcomes, questions regarding development and appropriateness remain unanswered.

Given this, the purpose of this article is threefold. First, we turn to the literature to determine the critical components of learning and learning outcomes. Second, we seek out what specific game attributes are being studied in order to determine their impact on learning outcomes (i.e., which attributes lead to which learning outcomes). Our review revealed many gaps in the literature. Therefore, this led to the development of a number of propositions hypothesizing the relationships between specific game attributes and established learning outcomes. Our hope is to provide the education and training research communities with guidance from which to examine the potential for instructional games to be effective learning tools.

What Are the Components of Learning and Learning Outcomes?

Learning is a part of our everyday lives. Through formal and informal training and experience, we develop our procedural, declarative, and strategic knowledge. In recent years, the study of learning has moved away from the traditional model (learning through lectures), toward a learner-centered approach, which encourages and even requires more active participation on the part of the learner (Garris, Ahlers, & Driskell, 2002). Instructional games, whether for education or training, directly focus on active learner participation. Computer games were hypothesized to aid instructional purposes because they theoretically provide diverse approaches that can address cognitive and affective learning, interactivity, and, perhaps most critically, motivation for learning (O'Neil, Wainess, & Baker, 2005). Garris and Ahlers (2001) speculate that motivational characteristics of games encourage participation and that this greater participation leads to learning. In addition, research has provided some evidence that educational games aid in learning of complex material (Garris & Ahlers, 2001; Ricci, Salas, & Cannon-Bowers, 1996). Yet it is still under debate as to which particular aspects of a game lead to learning of any kind. Do the motivating aspects lead to active participation or does the active participation increase motivation? And what specific learning outcomes can be achieved? Without evaluation of the impact of games on specific learning outcomes, games will continue to be categorized largely as motivating and fun, but instructionally useless (O'Neil et al., 2005).

Researchers conceptualize learning as a process. Kolb (1984, as cited in Thatcher, 1990) defines learning as the process of transforming experience into knowledge and that this process is composed of four phases (concrete experience, reflective observation, abstract conceptualization, and active experimentation). Others focus on the conscious and unconscious aspects of learning and that while learning generally occurs as a result of real life situations, it can also result from simulations or imagined scenarios (Botkin, Elmandra, & Melitza, 1979, as cited in Thatcher, 1990). For decades, one particular aspect of the learning process, motivation, has driven much of the interest in instructional game research, with researchers creating theories of intrinsically motivating instruction, using attributes of highly motivating computer games (Malone, 1981) and discussing the implications of game motivation on classroom instruction (Bowman, 1982). An understanding of the impact of games on other learning outcomes has been lacking. Without a thorough understanding of general learning principles, it is difficult—if not impossible—to effectively develop or select the most appropriate training game, let alone evaluate its effectiveness.

Theories of Learning

Researchers have been interested in theories of learning for decades. For the purpose of this effort, we reviewed the literature to determine which theories of learning are most relevant to investigating the impact of game attributes. As a part of this effort, we chose the theory offered by Kraiger, Ford, and Salas (1993) to incorporate into our conceptualization of games and learning for several reasons. First, this theoretically based model of learning outcomes is a multidimensional, construct-oriented approach to learning—cognitive, skill-based, and affective outcomes, under which a number of subdimensions are associated (more about this later). Second, this framework serves as a guide for aligning evaluation methods to each of the specific learning outcomes proposed. Finally, we chose the theory proposed by Kraiger and his colleagues because it is based on theories from a number of schools of thought beyond psychology (e.g., Bloom [1956] from the education literature). This theory is also based on cognitive, social, and human factors research. In the following section, we discuss each of the learning outcomes within the Kraiger et al. framework, focusing on various evaluation measures associated with each outcome (see Table 1). We briefly discuss the major tenets of this theory next.

Cognitive learning outcomes. Within the cognitive category, Kraiger et al. (1993) developed three cognitively based, chronological, general evaluation measures. First, the researchers propose that learners must gain knowledge. Specifically, learners gain three types of knowledge: *declarative knowledge* (i.e., knowledge about what), *procedural knowledge* (i.e., knowledge about how), and *strategic or tacit knowledge* (i.e., knowledge about which, when, and why). These three types of learning outcomes describe the cognitive process of learning. These most closely resemble Bloom's (1956) subcategories of *knowledge* (later revised as *remember*) and *comprehension* (later revised as *understand*; also see Krathwohl, 2002). These types of learning lend themselves to certain measurement techniques such as the traditional notion of classroom testing. However, it is important to note the difference between speed and power tests. Speed tests measure the rate at which individuals can recall stored information, whereas power tests measure the accuracy of the acquired knowledge. Both of these measures tend to focus more on declarative and procedural knowledge, rather than strategic knowledge.

Once knowledge has been gained, the learner must organize that knowledge. *Knowledge organization* involves grouping meaningful pieces of information into mental models, which are stored in long-term memory for later recall (Kraiger et al., 1993). This is similar to Bloom's (1956) analysis subcategory, which involves breaking information down into conceptual parts through identification of motives or causes. As an individual moves from the novice to the expert level, additional mental models are developed and existing mental models become more complex. Models that are more complex integrate problem definitions and solutions strategies for ease and increased speed of recall (Kraiger et al., 1993). Bloom described this process as combining pieces of information to create new meaning or "synthesis." A later revision to Bloom's taxonomy refers to this process as "create" (Krathwohl, 2002). A number of measurement implications related to knowledge organization can be drawn, most importantly that the measurement of supporting cognitive structures may be the key to assessing the understanding of course material. At this level, strategic knowledge is being measured most frequently (Kraiger et al., 1993).

Finally, using the knowledge previously gained and organized, cognitive strategies are developed and applied. Within the Bloom taxonomy, this most closely resembles "application" (i.e., use of a concept to solve new or novel problem) and "evaluation" (i.e., making judgment about information). These are also similar to "learning styles" as defined by Boyatzis and Kolb (1995). This stage encompasses meta-cognition and self-insight. Kraiger and colleagues (1993) discuss differences between experts and novices in regards to the broad spectrum of mental abilities that relate to knowledge development and application. Measurement implications within this category expand on recognition and recall by drawing on the trainees' progression toward a learning goal and/or the awareness of the required stages in order to achieve that goal.

(text continues on p. 227)

Table 1
Learning Outcomes and Evaluation Methods

General Learning Outcomes	Specific Learning Outcomes	Definition	Evaluation Method	Source
Cognitive	Declarative knowledge	• Information about something • Base for cognitive skills • Acquired during initial stage of training • Recall data or information	• Recognition and recall tests • Power tests • Speed tests	• Bloom, 1956 • Kraiger, Ford, & Salas, 1993
	Knowledge organization, analysis, and synthesis	• Meaningful framework to categorize information • Mental model-organize existing knowledge • Influence attaining new knowledge • Creating a structure or pattern from diverse elements	• Free sorts • Structural assessment	• Bloom, 1956 • Kraiger et al., 1993
	Cognitive strategies, comprehension, and evaluation	• Activities that facilitate learning, understanding, and application • Understanding the meaning, translation, interpolation, and interpretation of instructions and problems • Make judgments about the value of ideas or materials	• Probed protocol analysis • Self-report measures • Readiness for testing	• Bloom, 1956 • Kraiger et al., 1993 • Boyatzis & Kolb, 1995
	Application	• Use in a new situation • Applies material to novel situation	• Posttraining task	• Bloom, 1956

(continued)

Table 1 (continued)

General Learning Outcomes	Specific Learning Outcomes	Definition	Evaluation Method	Source
Skill-Based	Compilation	• Skills acquired with continued practice • Performance faster with fewer mistakes • Occurs after initial acquisition • Result of proceduralization and composition • Have ability to generalize and discriminate information • Substages: guided response, mechanism, complex overt response	• Targeted behavioral observation • Hands-on testing • Structured situational interviews	• Kraiger et al., 1993
	• Automaticity set • Mechanism • Complex overt responses	• Processes occur automatically • Complete tasks without conscious awareness • Possess ability to perform multiple tasks • Performance is fluid and accuracy improves • Readiness to act	• Secondary task performance • Interference problems • Embedded measurement	• Bloom, 1956 • Kraiger et al., 1993
	Psychomotor	• Perception use sensory cues to guide motor activity	• Tracking tasks	• Bloom, 1956
	Adaptation	• Skills are well developed and the individual can modify them as needed	• Embedded measurement	• Bloom, 1956

(continued)

Table 1 (continued)

General Learning Outcomes	Specific Learning Outcomes	Definition	Evaluation Method	Source
	Origination	• Creating new patterns as needed to fit unique situations creatively		• Kraiger et al., 1993
	Guided response	• Learn skills through imitation and trial and error	• Behavioral observation	• Bloom, 1956
Affective	Attitudinal valuing	• Internal emotional and/or cognitive state that impacts choices • Determines behavior • The worth or value attached to a targeted object, phenomenon, or behavior	• Self-report measures	• Bloom, 1956 • Kraiger et al., 1993
	Motivation	• Internal state that influences choices • Motivational disposition ○ Mastery orientation: Increasing expertise at a specific task ○ Performance orientation: Intention to succeed and receive positive feedback from other people	• Self-report measures	• Bloom, 1956 • Kraiger et al., 1993
		• Self efficacy ○ Perception of own abilities ○ Task specific ○ Influences activities, effort, performance ○ Good indicator of long-term transfer	• Self-report measures	• Bloom, 1956 • Kraiger et al., 1993
		• Goal setting ○ People tend to perform better ○ Indicator of development in training ○ Awareness increases on the job application	• Self-report measures • Free recall measures • Free sorts	• Bloom, 1956 • Kraiger et al., 1993
	• Receiving phenomenon • Responding phenomena	• Awareness, willingness to hear, select attention • Active participation by the learner	• Self-report measures	• Bloom, 1956
	Organization	• Organize values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system	• Self-report measures	• Bloom, 1956
	Internalizing values	• Has value system that controls their behavior	• Self-report measures	• Bloom, 1956

Skill-based learning outcomes. Following the development of cognitive-based outcomes, learners progress to skill-based learning that focuses on the development of technical or motor skills. Psychomotor skills demand practice and can be categorized within one of seven categories. These categories range from simple to complex: (1) perception (i.e., using sensory cues to guide motor activity), (2) set (readiness to act), (3) guided response (i.e., imitation), (4) mechanism (i.e., exhibiting habitual movement patterns), (5) complex overt response (i.e., exhibiting proficient, habitual movement patterns), (6) adaptation (i.e., modification of habitual movement patterns to meet a special need), and (7) origination (i.e., creation of new movement patterns to meet specific situations (Simpson, 1972). Skill-based learning outcomes are characterized by goal orientation and the systematic organization of behaviors in a sequential and hierarchical manner.

Kraiger et al. (1993) discuss compilation and automaticity as skill-based outcomes (similar to the "complex overt response" category mentioned above). Behavior during the compilation stage (the result of both a proceduralization and a composition process) is more fluid and quicker than during the initial skill acquisition stage as errors are reduced, due in part to a more task-focused approach. Organizing and linking behaviors are necessary steps to achieve skill mastery, understand the application of newly learned skills, and modify behaviors as required by circumstances. Automaticity specifically refers to a shift away from controlled processing toward a more automatic operational mode, thus demonstrating fluid behaviors in an individualized, accomplished manner. Automaticity is a combination of both adaptation and origination from the Simpson (1972) model of skill-based outcomes. Learners modify or create processes to adapt to the demands of novel situations.

Measurement implications for each stage differ as the two constructs tap distinct cognitive processes. Compilation can be assessed with behavioral observations, hands-on performance measures, and skill generalization measures, while automaticity would require performance measurement of the completion of simultaneous, multiple tasks, or the use of a single task to solve normal problems with the addition of interference issues (Kraiger et al., 1993).

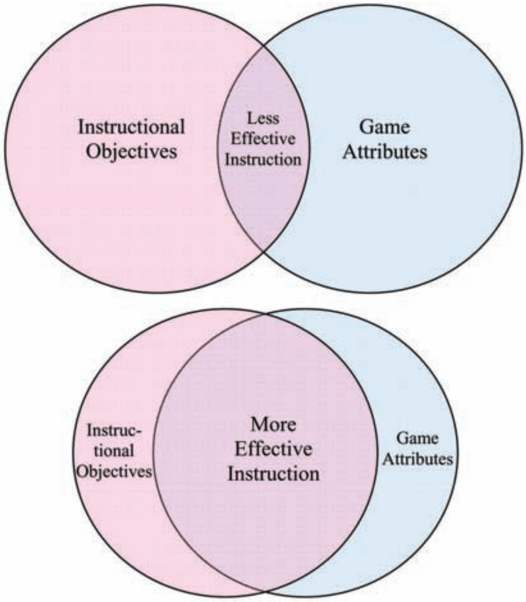
Affective learning outcomes. Finally, learning also shapes an individual's feelings. Kraiger et al. (1993) describe affectively based learning outcomes as involving constructs such as attitude, motivation, and goals. Krathwohl, Bloom, and Masia (1964) further subdivided these categories into five groups: receiving phenomena, responding phenomena, valuing, organization, and internalizing values. Within the Kraiger et al. framework, these outcomes are classified into two categories: those that target direct attitudinal or preference changes, and those that indirectly focus on motivational changes. Attitudinal outcomes include creative individualism, inner growth, self-awareness, and change in values. Motivational outcomes include motivational dispositions, self-efficacy, and goal setting. While often ignored, these variables are an important part of any learning outcome classification system, as attitude change is often a desired training/learning objective (Garris et al., 2002). Gagne (1984) appropriately focused on these variables' essential role by describing the impact of these constructs on performance while touching on their dynamic nature. He noted that attitudes are composed of both cognitive and emotional components and believes that attitudes are internal states that influence choices of personal behavior. While many types of learning can influence attitude change, Bandura (1977) discussed the importance of observational learning in his social learning theory. Gagne extended this idea by saying that what a learner actually encodes is a representation of the model person making a choice of action. This representation is then compared to the planned behavior of the learner. An important implication for measurement relates to the focus on both the direction and strength of the feelings or attitudes toward the desired goal. The stronger the attitude(s), the more likely the attitude(s) will influence the behavior. The direction (positive or negative) of the attitude will also determine the resulting behavior.

With regard to the motivational component of this category, motivational disposition, self-efficacy, and goal setting are all integral individual difference components that lead to motivational state changes. An increase in motivation can be a desired learning outcome or can be a secondary one. Locke and Latham (1990, 2002), among others, have demonstrated that goal setting improves performance. They believe that the mechanisms underlying the effects of goal setting (direction, intensity, and persistence of effort) are the same ones that relate to motivation (for more on the mechanisms that underlie motivation, see Naylor, Pritchard, & Ilgen, 1980; Pritchard & Ashwood, 2008). Bandura (1994) looks at perceived self-efficacy as one's belief about his or her capabilities. He argues that self-efficacy influences motivation in terms of the amount of effort spent toward an activity and the persistence of that effort. Positive changes in these motivational states throughout training provide evidence that development has occurred, and this can be assessed through self-report of confidence levels and goal commitment (Kraiger et al., 1993).

Summary of Learning Outcomes

In instructional gaming, we find a number of applicable learning outcomes. Matching the desired outcomes with the game attributes, or rather selecting the game attributes to produce a desired outcome, is a difficult task. As described above, learning outcomes can be considered indicators for evaluation methods. The Kraiger and colleagues (1993) model of learning outcomes provides a systematic framework for research on training or learning evaluation. Learning measurements are key variables in the link between learning outcomes and game attributes. Instruction should be designed in a way to achieve desired learning outcomes, and one way to assess this is through measures that detect the desired learning outcomes. Any game that is designed for instructional purposes should be heavily linked to instructional objectives (Hays, 2005). Figure 2 provides a graphical interpretation of instructional

Figure 2
Instructional Effectiveness as Degree of Overlap Between Learning Objectives and Game Attributes



Source: Adapted from Hays, 2005.

effectiveness as the degree of overlap between learning objectives and game attributes. Through such an evaluative focus, one can begin to conceptualize a framework designed to match instructional game attributes with desired learning outcomes.

What Game Attributes Are Being Studied?

Although experts share similar views on several characteristics, their opinions also differ greatly in other aspects of necessary game attributes. Juul (2003) suggested that games consist of six elements: rules, variable quantifiable outcome, player effort, valorization of the outcome, attachment of the player to the outcome, and negotiable consequences. According to de Felix and Johnson (1993), games are composed of dynamic visuals, interactivity, rules, and a goal. Malone and Lepper (1987) mentioned challenge, curiosity, control, and fantasy as integral features of games; and Thiagarajan (1999) asserts that conflict, control, closure, and contrivance are the four necessary components.

In 2001, Garris and Ahlers cited 39 game descriptors; however, 12 of these gaming attributes were found to be statistically significant and are important for increasing the "game-like" feel of simulations. In a follow-up study, Garris and colleagues (2002) discuss a subset of these attributes, which were considered the key gaming features necessary for learning: (a) fantasy, (b) rules/goals, (c) sensory stimuli, (d) challenge, (e) mystery, and (f) control. To date, we argue that Garris and associates have conducted one of the most comprehensive discussions of game attributes in the literature. Since Garris's review is intuitively stronger than other reviews, we use this as a departure point for this effort. However, we expand on that review by including additional attributes that we believe also have an impact on learning. As a thorough discussion of all attributes is not possible due to space limitations, we discuss a subset of attributes here. Furthermore, we provide brief explanations of all the game attributes we included in our review in Table 2 as well as references to assist readers if they are interested in learning more about them. Our discussion for now focuses on the subset of fantasy, representation, sensory stimuli, challenge, mystery, assessment, and control.

Fantasy

Fantasy is a common attribute seen in many games, especially in computer games. However, in more classic games (e.g., cross-cultural or business games), fantasy is found in the game itself as well as in the participants' mind. From shooting laser guns to slaying dragons, to building businesses and even cities, fantasy is an attribute that engages the learner. The fantasy element in a game represents something that is separate from real life and evokes mental images that do not exist (Garris et al., 2002; Malone & Lepper, 1987). Researchers discuss two distinct types of fantasy: endogenous/intrinsic (i.e., the content and the fantasy context are embedded within one another) and exogenous/extrinsic (i.e., no relationship exists between the content and fantasy context; e.g., Asgari & Kaufman, 2004; Malone & Lepper, 1987; Rieber, 1996). Both types of fantasy can be used to teach math facts. For example, DARTS uses darts and balloons positioned on the number line to teach fractions (i.e., endogenous; Malone, 1980), whereas SUPER CROSS teaches players math facts while riding a motorcycle (i.e., exogenous). Fantasy not only allows the user to interact without fear of real-life consequences but also has the added benefit of making users feel immersed in the game (Driskell & Dwyer, 1984; Garris et al., 2002). Research on fantasy has suggested that users become more interested than traditional classroom techniques as well as nonimmersive games and are therefore able to learn material more readily than when using paper-based formats (e.g., Asgari & Kaufman, 2004; Cordova & Lepper, 1996; Parker & Lepper, 1992).

Table 2
Game Attributes and Definitions

Attribute	Definition	Source
Adaptation	• Level of difficulty adjusts to the skill level of the player by matching challenges and possible solutions.	• Prensky, 2001
Assessment	• The measurement of achievement within game (e.g., scoring). Tutorials teach users how to play game and what aspects are important to achieving the goals. Scoring compares performance among players. Feedback provides a tool for users to learn from previous actions and adjust accordingly.	• Chen & Michael, 2005
Challenge	• Ideal amount of difficulty and improbability of obtaining goals. A challenging game possesses multiple clearly specified goals, progressive difficulty, and informational ambiguity. Challenge also adds fun and competition by creating barriers between current state and goal state.	• Garris, Ahlers, & Driskell, 2002 • Owen, 2004
Conflict	• The presentation of solvable problems within the game and usually drives the game's plot or in-game action by providing interaction. There are four types of conflict: (1) direct, (2) indirect, (3) violent, and (4) nonviolent.	• Crawford, 1984
Control	• The player's capacity for power or influence over elements of the game. Learner control occurs when the learner has control over some aspects of the game. Instructional program control determines all elements of the game.	• Garris et al., 2002
Fantasy	• Make-believe environment, scenarios or characters. It involves the user in mental imagery and imagination for unusual locations, social situations, and analogies for real-world processes. The user is also required to take on various roles in which they are expected to identify. Exogenous fantasy is a direct overlay on learning content. It is dependent upon the skill, but the skill does not depend on the fantasy. Endogenous fantasy is related to learning content. It is an essential relationship between the learned skill and the fantasy context (engaging and educational).	• Garris et al., 2002 • Owen, 2004 • Habgood, Ainsworth, & Benford, 2005
Interaction (equipment)	• The adaptability and manipulability of a game. The game changes in response to player's actions.	• Prensky, 2001
Interaction (Interpersonal)	• Face-to-face interaction, relationships between players in real space and time, It provides an opportunity for achievements to be acknowledged by others, and challenges become meaningful, which induces involvement.	• Crawford, 1984
Interaction (Social)	• Interpersonal activity that is mediated by technology, which encourages entertaining communal gatherings by producing a sense of belonging.	• Prensky, 2001
Language/ Communication	• Specific communication rules of the game, and may be a significant part of the game. The two types of communication are verbal and text.	• Owen, 2004

(continued)

Table 2 (continued)

Attribute	Definition	Source
Location	• The physical or virtual world that the game takes place in. It influences rules, expectations, and solution parameters. The location may be real or fantasy, and the space may be bound, unbound, or augmented.	• Owen, 2004
Mystery	• Gap between existing information and unknown information. It is a product of discrepancies or inconsistencies in knowledge. This attribute is enhanced by: information incongruity, complexity, novelty, surprise and expectation violation, idea incompatibility, and inability to make predictions, incomplete or inconsistent information. Sensory curiosity is the interest evoked by novel sensations, and cognitive curiosity is the desire for knowledge related with curiosity (inverse quadratic).	• Garris et al., 2002
Pieces or players	• Objects or people (e.g., proxy items, avatars, or human participants) being included in the game narrative or scenario.	• Owen, 2004
Progress and surprise	• Progress and surprise is how the player progresses toward the goals of the game. It is also considered the random elements of the game.	• Owen, 2004
Representation	• The player's perceptions of the game's reality. It is a subjective feature that makes the game appear psychologically real. • Narrowing the scope of representation provides focus for the player.	• Crawford, 1984
Rules/goals (also referred to as game aims or objectives)	• Rules are the goal makeup of game and established criteria for how to win. Specific, well-defined rules and guidelines are a necessary component for an effective educational game, as well as feedback on progression toward achieving the goals. There are three types of rules: (1) system rules, (i.e., functional parameters inherent in the game), (2) procedural rules (i.e., actions in game to regulate behavior), and (3) imported rules (i.e., rules originating from real world).	• Blunt, 2007 • Garris et al., 2002 • Owen, 2004
Safety	• Disassociation of actions and consequences (i.e., safe way to experience reality). The only consequence is loss of dignity when losing. The results are less harsh than modeled scenarios.	• Crawford, 1984
Sensory stimuli	• Visual or auditory stimulations, which distort perception and imply temporary acceptance of an alternate reality.	• Garris et al., 2002

Representation

On the opposite of the continuum from fantasy is representation, or the precision of reproduction. In other words, representation is the physical and psychological similarity between a game and the environment it represents (Crawford, 1984). Physical representation or fidelity is how accurately the game replicates the real-world environment (i.e., the "bells and whistles"). In addition, psychological fidelity, argued by Prince and Jentsch (2001) to be more important than physical fidelity, is demonstrated when a game requires that users experience the same cognitive processes to complete the task as they would if they were performing the task in the real world. To illustrate, Microsoft FLIGHT SIMULATOR mimics the surroundings a pilot experiences when flying an aircraft using realistic flight controls and aircraft sounds (i.e., physical fidelity). At the same time, players are required to think like a pilot and make similar decisions to complete the game successfully.

Sensory Stimuli

Tapping into the user's senses, sensory stimuli involves presenting new and vivid visual, auditory, or tactile stimulations with the purpose of distorting perception and using temporary acceptance of an alternate reality (e.g., Nintendo Wii's TRAUMA CENTER: SECOND OPINION; see http://www.atlus.com/tcso/). These audio, visual, and sometimes tactile effects can be used to enhance fantasy. In addition, sensory stimuli can be effectively used as feedback for performance (Malone, 1980). For example, a loud sound of an explosion and vibration in the controller may occur when blowing up an opposing aircraft; similarly, a loud siren and flashing light may designate a failed mission. Some games are even tapping into our olfactory senses to create an immersive environment (e.g., Rosenblum et al., 2008).

Challenge

In games (and in most daily activities), things that are too easy or too difficult will not pique our interest, as they lead to boredom or frustration, respectively. The optimal amount of difficulty (or challenge) should match the user's abilities to the skills required to accomplish each goal. Ideally, the optimal amount of challenge embedded in a game should create "motivational tension" (Driskell & Dwyer, 1984). In other words, motivation is maintained by creating uncertainty about goal attainment. Uncertain outcomes are challenging because of the variability depending on the user's actions, multiple goals, hidden information, and randomness (Malone, 1981; Malone & Lepper, 1987). Research has shown that challenge is correlated with both intrinsic motivation and "effectance" motivation (i.e., the desire to foster competence and efficacy; R. W. White, 1959).

Mystery

Mystery exists when a gap exists between known and unknown information—but unknown information is actually meta-information, as users must first know that the information exists, even if they do not know the information themselves. For instance, not knowing the location of an enemy in GHOST RECON is one example. The following qualities enhance mystery: novelty, complexity, inconsistency, surprise, incomplete information (Malone & Lepper, 1987), and the inability to predict the future (Garris et al., 2002; Kagan, 1972). Mystery arouses curiosity within the user and can exist in two forms—sensory curiosity (enhanced through novel stimuli) and cognitive curiosity (provoked by paradoxical information). Users are motivated to fill in the gaps and locate discrepancies in information. However, there is an optimal amount of complex information, which is neither too incongruent nor too similar. If information is perceived as being too similar, it will be overlooked and dismissed. On the other side of the coin, information viewed as too inconsistent will be confusing and difficult to incorporate into our existing knowledge base (Garris et al., 2002).

Assessment

Assessment, the measurement of achievement within a game, is another attribute fundamental for improvement and progression toward a game's goals. Essentially, assessment teaches users how to "play" the game by indicating what aspects of the game are important. This is achieved by tracking performance, tabulating comparisons between players, and providing feedback to users. Feedback occurs when something in the game changes as a result of the players' actions; it immediately informs users of their progress and whether their decisions were positive or negative (Prensky, 2001). Moreover, feedback is offered through many different mediums (e.g., numerical score, graphically, orally, and tactile). Based on this information, players learn from their actions and adjust performance accordingly. In order for players to improve performance and even enhance learning, it is critical that they see the connection between their actions and the outcomes. According to Chen and Michael (2005), this connection can occur through three forms of assessments: completion assessment, in-process assessment, and teacher evaluation. Completion assessments are simply asking the question, was the task completed; did they get the right answer? In-process assessments focus more on processes (e.g., what are the steps players took to complete the task?) rather than outcomes (e.g., time to complete task, number of errors, performance score). The decision made, for example, by a player to accomplish a goal can be equally important and possibly more informative than whether the player made the right decision. Last, teacher evaluations are a combination of completion and in-process assessments. A facilitator can provide both an evaluation at completion as well as instructions during the process to provide the user with guidance.

Control

The final attribute we feel is critical for learning is control, or the users' ability to influence elements of their learning environment (e.g., the type of feedback received, how they navigate through content, and their pace through the game; Stoney & Wild, 1998). Furthermore, control allows users to make the interactions progressive and personalized (Harbeck & Sherman, 1999). For example, in the SIMS games, users can select the appearance of their character and can determine the ultimate outcome of that character. When given control over their learning, research has shown that students invested more and attempted more complex strategies than when they had no control (e.g., Cordova & Lepper, 1996).

Summary of Game Attributes

Although the literature varies regarding which game attributes are critical for learning, many researchers agree that educational games do serve a purpose in the learning process and that they may lead to greater cognitive, skill-based, and attitudinal gains over traditional instructional methods (e.g., Egenfeldt-Nielsen, 2007; Vogel et al., 2006). When informational content combines with the appropriate gaming characteristics, the combination of the two elicits a motivated learner. An example of this is an engaged learner who participates unprompted and exerts both effort and concentration to accomplish the goals of the game while gaining the appropriate skills (educational goals) to use later in another application. The ultimate goal is to encourage this desired learner state by using certain information with certain game attributes in order to produce specific learned knowledge, skills, and attitudes. Producing accurate training outcomes from specific game attributes requires precise and well-defined explanations of the various learning constructs.

What Do We Know and Need to Know About Games and Learning? Proposals for Research

With an established framework of learning outcomes and criterion of fundamental game attributes developed from the literature, we find evidence to show a connection between instructional games and learning outcomes. We attempted to link not only which attributes lead to better learning but also explored how different levels of these attributes (i.e., high, medium, or low) affected outcomes. Table 3 provides an overview of the game attributes and learning outcomes that have been studied to date. This table shows a number of areas that remain underexplored or unexplored. Table 4 discusses the specific findings of previous research on game effectiveness. Given that research has been limited on linking specific game attributes with specific learning outcomes, we provide some propositions for future research and promising research to support additional exploration of these areas where we see the greatest potential. We submit that some of these propositions may seem obvious or like old news; however, we feel that there are not (yet) enough systematic and robust evaluations of games for learning to adequately support the relationships.

Cognitive Outcomes

Within the cognitive arena, there was one area that dominated much of the research examining game attributes and outcomes: declarative knowledge (Renaud & Stolovitch, 1988; Szafran & Mandolini, 1980; B. Y. White, 1984; Wishart, 1990). As previously noted, Vogel and colleagues (2006) found that learners who used interactive games for learning had the greatest cognitive gains over learners provided with traditional classroom training. For example, Ricci et al. (1996) used a computer-based game to improve knowledge acquisition and retention. They compared three conditions—text (i.e., text only), test (i.e., game used active participation and immediate feedback only), and game. The game condition included a number of game attributes: active participation/dynamic interaction (i.e., control), immediate feedback (i.e., assessment), goal direction (i.e., rules/goals), competition (i.e., challenge), and novelty (i.e., sensory stimuli). Dynamic interaction, competition, and novelty were embedded in the game for motivational appeal. Results of this study indicate that trainees in the game condition (versus the text condition) led to enhanced learning as indicated by a posttest. Participants in the game condition, however, did not perform significantly better than the test condition immediately following the training. When completing a retention test 4 weeks following training, there was a significant decrease in performance in all three groups; however, only trainees in the game condition performed significantly better on the retention test than the pretest. Furthermore, participants in the game condition rated training as more enjoyable and effective than did participants in the text or test conditions. It can then be hypothesized that the addition of goal direction, competition, and novelty led to more positive attitudes and ultimately better retention.

In addition, Veale (1999) reviewed the use of FAST FORWORD, an instructional program that evolved from computer games, to help children with auditory temporal processing deficits learn. The program focuses on visual graphics and animations (i.e., sensory stimuli) while children interact with the software (i.e., control). FAST FORWORD also adjusts to the user's skill level to maintain learning (i.e., adaptation) and remains in a challenging environment (i.e., challenge) while continuously recording performance (i.e., progress) to reinforce behavior. Veale (1999) discusses the results of several studies that indicate FAST FORWORD leads to an increase in overall language abilities, phonological awareness, listening and comprehension skills (i.e., general learning), self-confidence (i.e., motivation), and discrimination and understanding of spoken words (i.e., cognitive strategies, application), among others.

(text continues on p. 253)

Table 3
Research Linking Game Attributes and Learning Outcomes

(a)

	Adaptation	Assessment	Challenge	Conflict	Control	Fantasy	Interaction (Equipment)	Interaction (Interpersonal)	Interaction (Social)
Application	• 39	• 3,6,11,16,37	• 3,6,15,36,37,38,39 + 33	• 6,11,16,38	• 3,6,11,15,16,37,39	• 6,11,15,16,18,36,37	• 3,6		
Cognitive Strategies	• 20	• 3,5,11,13,26,27,32,37	• 3,4,13,15,28,30,32,37 + 20,32	• 11	• 3,11,13,15,26,27,28,30,37	• 4,11,13,15,20,28,30,37	• 3,11,28 + 5	26,27,28 + 20	• 4,30
Declarative Knowledge	• 20,33,39,40	• 1,2,3,5,12,16,33,37,40 + 9,29	• 2,3,15,19,20,29,31,33,37,38,39,40 + 12,34,36	• 1,2,9,16,33,35,38 + 12	• 1,3,9,15,16,19,29,33,37,39 + 22	• 2,15,16,20,33,36,37,40	• 3 + 5	• 12,20,35	• 29,35
Knowledge Organization	• 20,33	• 6,26,29,33 + 9	• 6,15,20,30,33 + 29	• 6,9,33,35	• 6,9,15,26,29,30,33	• 6,15,20,30,33	• 6	• 26,35 + 20	• 29,30,35
Adaptation		• 27,37	• 37		• 27,37	• 37		• 27	
Automaticity Set	• 39	• 37	• 37,39		• 37,39	• 37			
Compilation					+ 7	• 18			
Guided Response									
Origination		• 37	• 37		• 37	• 37			
Psychomotor	• 20	• 6,11,27,37	• 6,20,37	• 6,11	• 6,11,27,37	• 6,11,20,37	• 11	• 20,27	
Attitudinal Valuing			+ 34	• 35				• 35	• 35
Internalizing Values		• 39	• 39		• 39				
Motivation	• 8,20,33,40 + 17	• 1,3,8,13,16,29,33,40,41 + 10,17	• 3,13,14,15,20,25,31,33,34,40, + 2,8,10,17,29,30,41	• 1,16,33,35	• 1,3,8,13,14,15,16,17,29,33 + 2,10,30,41	• 8,13,14,15,16,17,20,33,40 + 10,25,30,41	• 3,29	• 20 + 35	• 23,29,30 + 35
Organization			• 4			• 4			• 4
Receiving Phenomena; Responding Phenomena	• 20,33,39 + 21	• 33,37 + 21	• 20,33,37,39	• 33	• 33,37,39	• 20,21,33,37		• 20	

Note: + = positive, – = negative, • = unspecified relationship. Numbers correspond to sources presented in Table 4

(continued)

Table 3 (continued)

(b)

	Language/ Communication	Location	Mystery	Pieces/Players	Progress/Surprise	Representation	Rules/Goals	Safety	Sensory Stimuli
Application	● 39 + 36	● 18	● 37	● 6,11	● 15,16,37,39	● 6,11,18	● 3,15,16 + 38	● 3,18	● 6,11,15,16, 36,37,39
Cognitive Strategies	● 13		● 5,20,30,37	● 11,13	● 4,15,20 26,37	● 4,11,13, 27,28	● 3,4,13,15, 20,28,31 + 26,27	● 3,27	● 11,13,37 + 5,31
Declarative Knowledge	● 36,39	● 1,2	● 2,5,19,20,37 + 24	● 2,9	● 15,16, 20,33,37,39	● 2,33	● 1,2,3,9,15,16,20, 29,31,33,38,40	● 3,12,35 + 22	● 2,15,16,29,33, 34,36,37,39,40 + 5,9,19 − 31
Knowledge Organization			● 20,30	● 6,9	● 15,20,26,33	● 6,33	● 9,15,20, 26,29,33	● 35	● 6,9,15, 29,33
Adaptation			● 37		● 37	● 27	● 27	● 27	● 37
Automaticity Set	● 39		● 37		● 37,39				37,39
Compilation		● 18				● 7,18		● 18	
Guided Response									
Origination			● 37		● 37				● 37
Psychomotor			● 20,37	● 6,11	● 20,37	● 6,11,27	● 20,27	● 27	6,11,37
Attitudinal Valuing			+ 42			+ 42		● 35	+ 34,42
Internalizing Values	● 39								● 39
Motivation	● 13,14	● 1,2	● 8,17,20,30,41	● 13	● 15,16,20,33	● 13,17,33 + 2	● 1,3,8,13,14,15, 20,29,31,33,40 + 10,17	● 3,35	● 13,14,15,16, 29,31,33,40,41 + 10,17,34
Organization						4	4		
Receiving Phenomena; Responding Phenomena	● 39		● 20,37		● 20,33,37,39	● 33	● 20,21,33		● 33,37 + 21,39

Note: + = positive, − = negative, ● = unspecified relationship. Numbers correspond to sources presented in Table 4

Table 4
Summary of Research Conducted Linking Game Attributes and Learning Outcomes

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Assessment • Conflict • Control • Location • Rules/Goals	• SIMCITY 2000	• Develop and modify a city	• Students noted that they enjoyed the game and they had a greater appreciation for geographical development and the game in general.	1. Adams, 1998	• None provided
• Assessment • Challenge • Conflict • Control • Fantasy • Location • Mystery • Pieces or Players • Representation • Rules/Goals • Sensory Stimuli	• AMERICA'S ARMY	• Complete online military missions as a team with four possible sections: (1) marksmanship training, (2) obstacle course, (3) weapons familiarization, and (4) MOUT (military operations in urban terrain)	• Procedural knowledge and declarative knowledge improved. • Participants were able to recall relevant information. • Participants answered more questions correctly in graphic images category vs. text (spoken or written).	2. Belanich, Sibley, & Orvis, 2004	• What mix of motivational features (challenge, control, fantasy, and curiosity) are most beneficial for motivating players? • Are each of these four strict requirements or areas for concern in game development? • Do types of skills and procedures or type of game influence effectiveness of game? • Which instructional features of games influence motivation and which motivational features influence instruction? Need to investigate this interaction

Note: Source numbers correspond to superscripts presented in Table 3. Superscripts in "Platform/Game Used" column correspond to superscripts in "Objectives" column.

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Assessment • Challenge • Control • Interaction (Equipment) • Rules/Goals • Safety	• Business: Industry Giant II[1] • Economics: Zapitalism[2] • Management Virtual U[3]	• Create a profitable business[1] • Run a retail business on a small island[2] • Responsible for operating a university[3]	• Academic achievement (i.e., grades) with the game was significantly better than grades without the game • Participants under 40 years of age scored significantly higher with game play • Participants over 40 did not score significantly higher	3. Blunt, 2007	• Do different types of participants using different types of games produce similar learning outcomes? • Do commercial-off-the-shelf games easily adapt to teaching environments and produce desired learning outcomes? • What is cost savings of using commercial-off-the-shelf games versus custom content video games? • How can we present different learning styles in learning video games? • What role does parental acceptance of game-based learning play? • What can be learned from business models (learning industry vs. gaming industry) in order to help fully integrate game-based learning and pc-based simulations into e-learning companies? • What impact will using game-based learning have on academic programs that focus on Instructional Systems Design majors (i.e. curriculum changes)? • What about attrition in game-based learning?

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Challenge • Fantasy • Interaction (Social) • Progress/ Surprise • Representation	• SID MEIER'S ANTIETAM[1] • RUTHLESS. COM[2] • FLEET COMMAND[3] • HALF LIFE: TEAM FORTRESS CLASSIC[4]	• Civil War Simulation: utilize a fixed pool to resources to achieve victory[1] • Business strategy: utilize their resources to produce the greatest long-term profit[2] • Real-time naval strategy: attend to physical position of their assets as well as resource management, engagements, and so forth.[3] • A two-team game in which teams compete for specific goals[4]	• Aspects of games (e.g., representation) are shown to improve overall performance; however, no specific relationships are identified.	4. Bowers & Jentsch, 2001	• None provided
• Assessment • Interaction (Equipment) • Mystery • Sensory Stimuli	• Interactive computer Web-based games	• Teach visualization skills and engineering graphics	• Students enjoyed using the games and their visualization skills improved • Immediate feedback provided by the game provided a better understanding of visualization skills	5. Crown, 2001	• None provided
• Assessment • Challenge • Conflict • Control	• SPACE FORTRESS	• Maneuver a space ship while avoiding destruction	• Measures of knowledge structure are correlated with skill-based performance and predicted skill retention and skill transfer.	6. Day, Arthur, & Gettman, 2001	• Do structural assessment tools such as expert knowledge structures enhance instruction?

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Interaction (Equipment) • Pieces or Players • Representation • Sensory Stimuli			• Knowledge structures are useful in training and skill development.		
• Control • Representation	• Microsoft FLIGHT SIMULATOR	• Multiship team-task focusing on management of the mission and formation flight • Requires the pilot to emphasize activities outside of the aircraft	• Groups who had no computer based training performed worse than the other groups. The representative flight group had lower workload. The game did not aid in psychomotor skills.	7. Dennis & Harris, 1998	• Future research should establish if games are useful to pilots in terms of aircraft control and cognitive skills (i.e., in-flight navigation).
• Adaptation • Assessment • Challenge • Control • Fantasy • Mystery • Rules/Goals	• Computer-assisted instruction	• Variety of tasks applicable	• Increase frequency of engaging in less desirable behavior by embedding that part in more enjoyable task. • Increased motivation produces better retention and recall by increasing selective attention. • Successful learners use multiple tactics (i.e., chunking, mnemonics, elaborative rehearsal).	8. Driskell & Dwyer, 1984	• What is the impact of augmenting traditional instruction with video game instruction?
• Assessment • Conflict • Control	• HNAM DataQuest	• Strategic game play related to Cerner's three-tiered client server architecture	• Enhanced motivation and improvements in learning the material about Cerner's client server architecture.	9. Gander, 2002	• What impact do different audiences or different games have on learning?

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Pieces or Players • Rules/Goals • Sensory Stimuli					• What are the moderating effects of age, gender, learning and/or thinking modes, game violence, and game type? • Is there an ideal length of play?
• Assessment • Challenge • Control • Fantasy • Rules/Goals • Sensory Stimuli	• BOTTOM GUN	• Practice making estimates of critical visual variables (angle on the bow; AOB)	• Game condition resulted in fewer AOB errors, and higher visual skills, valence, self-efficacy, and goal commitment.	10. Garris & Ahlers, 2001	• How can we broaden general training design approaches to incorporate the "engaging and reinforcing" aspects of games? • What is the true relationship between game design, motivation, and training effectiveness? • What level of a game attribute is required in order for that attribute to be rated as significantly gamey?
• Assessment • Conflict • Control • Fantasy • Pieces or Players • Sensory Stimuli	• SPACE FORTRESS II	• Maneuvering a spacecraft to destroy a space fortress with missiles	• Participants in the game group (vs. control group) performed significantly better. • Performance scores were higher for participants who received training (vs. those who did not receive training).	11. Gopher, Weil, & Bareket, 1994	• Does improved attention lead to greater transfer of skills from flight games to actual flight (requires direct manipulation of attention control)?
• Assessment • Challenge • Conflict • Interaction (Interpersonal) • Safety	• SIMULATING INTERNATIONAL ECONOMIC RELATIONS GAME	• Economic Simulation: Maintain the economic welfare of four countries	• Participants in the game group scored higher on a multiple choice test than participants in the lecture group.	12. Gremmen & Potters, 1995	• None provided

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Assessment • Challenge • Control • Fantasy • Pieces or Players • Representation • Rules/Goals • Sensory Stimuli	• ZOMBIE DIVISION	• Mathematical division strategy game where participants must defeat skeletal enemies in hand to hand combat in order to progress	• The author theorizes that the mentioned game features will enhance motivation and learning. A future study using software will compare learning outcomes in a time-constrained classroom.	13. Habgood, 2005	• What types of learning are appropriate for intrinsically motivating games versus extrinsically motivating games?
• Challenge • Control • Fantasy • Language/ Communication • Rules/Goals • Sensory Stimuli	• BREAKOUT[1] • DARTS[2]	• Break bricks and bounce ball off paddle[1] • Determine position of a balloon on a number by entering fractions[2]	• Fantasy can enhance motivation; however, inappropriate fantasies can actually be detrimental to motivation (e.g., replacing objects with abstract shapes that do not make sense to the user).	14. Habgood, Ainsworth, & Benford, 2005	• Does an intense state of flow inhibit meta-cognition? • What types of learning materials (proceduralization of knowledge or initial acquisition of knowledge) are appropriate for intrinsic games?
• Challenge • Control • Fantasy • Progress/ Surprise • Sensory Stimuli	• Applicable to various games and simulations (e.g., ODELL LAKE)	• Participants play the role of a fish and have to decide if they should attack, flee, or ignore another fish of a different species	• Control, mystery, fantasy, and surprise are all linked to enhance motivation levels in learners. • At the appropriate levels, challenge can increase motivation as well; however, it can also be detrimental to motivation when there is too little or too much challenge. • General attributes of computers are correlated with declarative knowledge, cognitive strategies, knowledge organization, and application.	15. Lepper, 1985	• What more general role will computers play in terms of education content and social development?

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Assessment • Conflict • Control • Fantasy • Progress/ • Surprise • Sensory stimuli	• Educational games (e.g., CHEMAZE[1] and GREEN GLOBS[2])	• Steer a flask through a chemical maze while dissolving obstacles and evading a hostile beaker.[1] • Write mathematical equations that pass through "green globs" on a Cartesian plane[2]	• Learner control and receiving feedback are linked with motivated learners. • Sensory stimuli can be beneficial; however, too much sensory stimuli can be detrimental to learning.	16. Lepper & Chabay, 1985	• What role should computers take in terms of teaching style (i.e., demanding or permission)?
• Adaptation • Assessment • Challenge • Control • Fantasy • Mystery • Representation • Rules/Goals • Sensory Stimuli	• BREAKOUT • DARTS	• Break bricks and bounce ball off paddle • Determine position of a balloon on a number by entering fractions	• Games were rated higher and participants' interest level (motivation) increased especially when the game had a clear, well-defined goal.	17. Malone, 1981	• Postulates a theory of intrinsically motivating instruction and mentions issues with interpersonal versus individual motivation
• Fantasy • Location • Representation • Safety	• Computer simulated team research	• Variety of tasks applicable	• Computer simulations are beneficial in general.	18. Marks, 2000	• None provided
• Challenge • Control • Mystery • Sensory Stimuli	• The Profile Game	• Simulates tasks of geographers (e.g., understanding geographic issues based on visualizations)	• Students learned better when provided assistance on how to visualize geographic features	19. Mayer, Mautone, & Prothero, 2002	• None provided
• Adaptation • Challenge	• Games in general	• Variety of tasks applicable	• Games stimulate interest in kids.	20. McFarlane, Sparrowhawk, & Heald, 2002	• None provided

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Fantasy • Interaction (Interpersonal) • Mystery • Rules/Goals			• Parents surveyed indicated that children learn psychomotor skills as well as decision making skills.		
• Adaptation • Assessment • Fantasy • Rules/Goals • Sensory stimuli	• Circus Sequence[1] • Phoneme Identification Game[2]	• Perceptual identification task[1] • Phonetic element recognition exercise[2]	• Children showed an overall improvement in performance for perceptual identification and phonetic recognition	21. Merzenich et al., 1996	• Suggested that more practice might improve performance
• Control • Safety	• Games in general	• Variety of tasks applicable	• 98% of participants reported that they enjoyed using the game and thought it was a beneficial approach to teaching.	22. Noble, Best, Sidell, & Strang, 2000	• None provided
• Interaction (Social)	• AMERICA'S ARMY	• Complete online military missions as a team with four possible sections: (1) marksmanship training, (2) obstacle course, (3) weapons familiarization, and (4) MOUT (military operations in urban terrain)	• Prior videogame experience predicts learner outcomes such as training satisfaction, team cohesion, and time on task.	23. Orvis, Orvis, Belanich, & Mullin, 2008	• Examine the relationship between trainee preference for videogames and learner outcomes
• Mystery	• Three door problem	• A children's game about probability: had one in three chance of finding a hidden car	• The probability game promoted curiosity, thinking, and reasoning in the children.	24. Pange, 2003	• None provided

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Challenge • Fantasy	• Computer-based instructional programs	• Utilize basic commands in Logo: (1) draw lines connecting objects, (2) navigate through a maze, and (3) construct geometric shapes	• An element of fantasy stimulates motivation and thus increased learning.	25. Parker & Lepper, 1992	• None provided
• Assessment • Control • Interaction (Interpersonal) • Progress/ Surprise • Rules/Goals	• Games or simulations in general	• Variety of tasks applicable	• Participants are capable of thinking analytically, making judgments, and experience. • Participant gains insight into his own behavior and develops sensitivity to perceptions, needs, goals, and management styles. • Learner is active, participating and interacting with others. • Participants can learn without suffering from the consequences of mistakes. • Time can be compressed. • Personal involvement enhances receptivity to new ideas.	26. Parry, 1971	• None provided
• Assessment • Control • Interaction (Interpersonal) • Representation • Rules/Goals • Safety	• Low-fidelity flight simulators	• Train aviation pilots on Crew Resource Management (CRM)	• Low fidelity simulators can offer some of the same benefits to learning as high fidelity simulators when properly administered.	27. Prince & Jentsch, 2001	• Presents guidelines for using PC-based flight simulator games

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
			• Low fidelity simulators are beneficial to psychomotor skills, declarative knowledge, cognitive strategies, and adaptation.		
• Challenge • Control • Fantasy • Interaction (Equipment) • Interaction (Interpersonal) • Representation • Rules/Goals	• Microsoft FLIGHT SIMULATOR	• Multiship team-task focusing on management of the mission and formation flight • Requires the pilot to emphasize activities outside of the aircraft	• Statistical difference between the pretest and posttest results for team-based behaviors (e.g., team situation awareness). • 2 out of 20 found fault with the general concept of off the shelf (OTS) training. • 5 were optimistic about approach. • Participants cited OTS as lacking ability to simulate live fire event. • Impatient about controls and preferred controls similar to the aircraft controls.	28. Proctor, Panko, & Donovan, 2004	• What impact do other low-cost display and interface approaches have on learning? • What are the moderating effects of team tenure? Amount of communication? Different flight conditions?
• Assessment • Challenge • Control • Interaction (Social) • Rules/Goals • Sensory Stimuli	• QUIZSHELL	• Learn about chemical, biological, radiological defense training • Answer four questions correctly to win the game	• Participants in game condition (vs. test condition) scored significantly higher on a retention test. • Participants in game condition rated training as more enjoyable.	29. Ricci, Salas, & Cannon-Bowers, 1996	• None provided

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Challenge • Control • Fantasy • Interaction (Social) • Mystery	• Interactive multimedia learning environment	• Applicable to various tasks	• Motivation levels are linked with fantasy, challenge, mystery, and control. • Games can serve as an opportunity to rehearse cognitive strategies.	30. Rieber, 1996	• Proposes hybrid learning environment rooted in constructivist concepts
• Challenge • Rules/Goals • Sensory Stimuli	• Computer-based simulations	• Try to understand the relationship between acceleration and velocity	• The simulations enhanced motivation.	31. Rieber & Noah, 1997	• None provided
• Assessment • Challenge	• DC-KID	• Build and operate models of DC circuits	• Significant differences between students who used simulation compared to students who did not. • Simulations improved confidence and enhanced motivation to stay on task.	32. Ronen & Eliahu, 2000	• Future research can determine the most beneficial ways of incorporating simulations into curriculum
• Adaptation • Assessment • Challenge • Conflict • Control • Fantasy • Progress/ Surprise • Representation • Rules/Goals • Sensory Stimuli	• MAGALU[1] • HERMES[2] • TIKI-TIKI[3] • ROLI[4] • HANGMAN[5]	• Create a bridge and conquer objects[1] • Problem solving[2] • Problem solving[3] • Look for objects and place them in the correct container[4] • Determine the correct word[5]	• Games were rated as being enjoyable and students were more motivated to learn. • Games also improved classroom dynamics (e.g., students ability to pay attention).	33. Rosas et al., 2003	• Future studies on implicit learning with games will be relevant for disadvantaged children.

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Challenge • Sensory Stimuli	• FOOD PYRAMID GAMES	• Provide a better understanding of the Food Guide Pyramid (FGP)	• Game was effective in increasing knowledge about nutrition and the FGP. • Game also improved self-efficacy associated with the FGP.	34. Serrano & Anderson, 2004	• None provided
• Conflict • Interaction (Interpersonal) • Interaction (Social) • Safety	• CIVILIZATION 3	• Control civilizations over an extended period of time ranging from 6 months to 6,000 years	• Participants demonstrated an increase in motivation and declarative knowledge. • Increase in knowledge organization, attitudinal valuing, and cognitive strategies (e.g., different approaches to lead the civilization—what alliances to create? And what resources to use?).	35. Squire, Giovanetto, Devane, & Durga, 2005	• None provided
• Challenge • Fantasy • Language/ Communication • Sensory Stimuli	• LIFE CHALLENGE	• Used to educate adolescents about HIV/AIDS	• Significant gains in knowledge about HIV/AIDS and in self-efficacy scores.	36. Thomas, Cahill, & Santilli, 1997	• To validate the self-report measure, future studies need to assess the correlation between the measures and actual behavior
• Assessment • Challenge • Control • Fantasy • Mystery • Progress/Surprise	• Digital game based learning	• Used to teach various tasks	• Games are effective learning tools in general. • Card games are good for matching concepts manipulating numbers, and recognizing patterns.	37. Van Eck, 2006	• Further research is needed to determine the mechanism of video-based advisement • What role does competition in elaborative load and cognitive processing play?

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Sensory Stimuli			• Jeopardy style games are good for learning verbal information and concrete concepts. • Arcade type games are good for speed of response, automaticity, and visual processing. • Adventure type games are good for hypothesis testing and problem solving.		
• Challenge • Rules/Goals	• Mathematics computer-based simulation game	• To provide a better understanding about (1) number properties and operations, (2) measurement, and (3) geometry by helping an "aunt and uncle" fix up a house	• Participants in the contextualized advisement noncompetitive group had higher transfer scores than participants in the no contextualized advisement competitive group	38. Van Eck & Dempsey, 2002	• Future studies are needed to replicate similar findings over longer periods of time with more participants • Future research incorporating the game over the course of the normal school year
• Adaptation • Challenge • Control • Language/ Communication • Progress/ Surprise • Sensory Stimuli	• FAST FORWORD	• Train specific auditory or phonological skills that have been related to the acquisition of speech	• Increase in overall language. • Phonological awareness improved • Listening and comprehension skills improved • Syntax usage improved • Focus of attention on class activities. • Increased self confidence. • Fewer behavior problems. • Better discrimination with words.	39. Veale, 1999	• Do games that teach to the type of assessment lead to greater learning outcomes? • Does the use of different measurement techniques (nonstandardized tests) improve learning outcomes? • What role can technology play on language interventions?

(continued)

Table 4 (continued)

Gaming Attribute	Platform/ Game Used	Objective	Conclusions	Source	Suggested Future Research
• Assessment • Challenge • Fantasy • Rules/Goals • Sensory Stimuli	• VR-ENGAGE	• Improve geographic knowledge by navigating in a virtual world to find missing pages of a book	• All students' knowledge improved with the game. • Students who were considered "poor performers" improved the most compared to "good" students	40. Virvou, Katsionis, & Manos, 2005	• Future versions of the game will have improved usability and more online-help
• Assessment • Challenge • Control • Fantasy • Mystery • Sensory Stimuli	• MISSION: ALGEBRA (MA)[1] • LODE RUNNER (LR)[2]	• Rescue the sister ship by solving clues in the form of a linear equation[1] • Infiltrate treasury rooms, recover treasure, and evade guards[2]	• Motivation when playing LR decreased with experience because of the attributes challenge and curiosity. • Motivation did not change in MA with experience, • Control significantly increased in MA	41. Westrom & Shaban, 1992	• Note that they did not examine cooperation, competition, and recognition so perhaps those are areas for future research
• Mystery • Representation • Sensory Stimuli	• CLOSE COMBAT: FIRST TO FIGHT	• Perform tactical tasks in close quarters, urban combat.	• Experimental group (received both game-based and live fire training) outperformed the control group (only live fire training) on the live fire tactical evaluation, but only approached significance. • Experimental group rated themselves significantly higher than the control group on self assessment evaluations.	42. Woodman, 2006	• Authors suggest that the game may be better suited for infantry school rather than the advanced security force training. • Research should focus on differences between gamers and nongamers. • Research should focus on the effect of instructor bias. • Consider attitudes towards game-based training of trainees and instructors.

Note: Source numbers correspond to superscripts presented in Table 3. Superscripts in "Platform/Game Used" column correspond to superscripts in "Objectives" column.

In another example, Crown (2001) conducted a study comparing the effectiveness of traditional lecture-based learning versus game-based learning in an economy classroom setting. For the game condition, the researcher utilized the SIMULATING INTERNATIONAL ECONOMIC RELATIONS game. Intended to teach overall economic knowledge and principles, this game incorporated varying degrees of difficult economic models (i.e., challenge), competition between four countries (i.e., conflict) in an environment without consequences (i.e., safety), and feedback on economic standing (i.e., assessment). Scores on the postmeasure knowledge test improved for both the traditional and game-learning groups; however, students scored significantly higher in the game condition compared to the traditional condition. Thus, this study provided empirical support that games could improve learning.

Finally, Driskell and Dwyer (1984) consulted the literature and found that several gaming characteristics influence motivational and learning properties, specifically, goals, challenge, fantasy, and mystery. They theorize that an increase in motivation will in turn increase attention and lead to better retention, recall of learned information (i.e., declarative knowledge), and focalization of attention (i.e., cognitive strategies). Driskell and Dwyer also suggest that higher levels of fantasy and mystery increase user motivation by arousing curiosity and excitement to play the game. These relationships remain to be tested.

Given what we know thus far in terms of game attributes and cognitive outcomes, we identified a number of research areas where further exploration is needed. Therefore, we propose the following:

Proposition 1: The amount of conflict presented within a game will be positively related to cognitive learning (i.e., overall cognitive abilities).

Conflict, or the presentation of solvable problems within the game (Crawford, 1984), provides learners with the opportunity to demonstrate that they comprehend and can evaluate the conflict being presented to them. Prensky (2001) suggests that conflict in games gives users adrenaline. For example, Gander (2002) found that learners showed increased motivation and general learning when presented with a game involving conflict. We argue that conflict, thus, allows learners to utilize or adapt existing cognitive strategies, as well as to formulate new cognitive strategies as necessary to reduce the amount of conflict. In other words, learners can verify or modify existing knowledge organization (i.e., mental models) to address the existing conflict.

Proposition 2: As the challenge feature in a game increases, so will declarative knowledge and learner's retention of that knowledge. However, a point will be reached when too much challenge will hinder and decrease learning (i.e., an inverted U relationship).

In addition to learner control, games are more likely to be effective when they provide progressive difficulty and an uncertainty of obtaining a specific outcome (e.g., Garris et al., 2002; Malone, 1981; Mayer, Mautone, & Prothero, 2002; McFarlane, Sparrowhawk, & Heald, 2002; Veale, 1999). We expect the relationship between challenge and knowledge gain and retention to be an inverted U. This is not surprising in that research has suggested that too much or too little challenge frustrates and lessens learners' motivation. Providing the ideal amount of challenge will motivate users to continue to play the game, enhancing their learning potential.

Proposition 3: Increasing the adaptation feature in a game will result in an increase in a learner's cognitive strategies.

Adaptation is critical for learning (e.g., Senge, n.d.). A game that maintains a consistent level of information presentation, demonstration, and practice without taking into consideration the knowledge and skill level of the learner will be less successful. As learners acquire the knowledge and skills, which will occur at different rates for each learner, the game should recognize this acquisition and adjust accordingly (Prensky, 2001). The game should also consider the baseline knowledge and skills at which the learner begins the game. It does not make sense to continue teaching user competencies already mastered. By taking an adaptive approach to learning, it maximizes the amount of learning that can occur rather than reaching a plateau at a predetermined level. For example, SUPER TANGRAMS, a game developed to help children learn mathematics, adapts to players' performance (Klawe, 1998). Research suggests that the use of SUPER TANGRAMS in combination with more active participation by the teacher leads to better learning.

Skill-Based Outcomes

We found limited research regarding games and skill-based outcomes when compared to other learning outcomes. Psychomotor skills and automaticity set (i.e., the process of making a task automatic) were most readily studied. For example, Gopher, Weil, and Bareket (1994) used a low-fidelity simulator (i.e., the PC-based game SPACE FORTRESS II) to improve performance on an actual flight task. Results of this study indicated that participants given the opportunity to train using the game outperformed those in the control group. The game attributes of SPACE FORTRESS II include the ability of the learner to control the game as well as a degree of realism in that trainees maneuvered the spacecraft using a game stick while maintaining the fantasy of a space mission. Score feedback was provided to trainees throughout the game (i.e., in real time). Similarly, Dennis and Harris (1998) studied the impact of computer-based training using task representation provided Microsoft FLIGHT SIMULATOR, versus no computer-based training. The authors provided two levels of representation by manipulating the flight controls; specifically, one group was given realistic flight controls (e.g., joystick) and the other group was given keyboard controls (e.g., "up" cursor key acts as if pushing the stick forward).

Participants in the game condition (regardless of type of controls) outperformed those in the nongame condition on actual flight trials. While performance did not significantly differ between the two groups in the game condition, participants who trained using keyboard controls reported significantly higher levels of mental workload (equal to those in the nongame condition). Overall, the authors suggest that using the game for initial flight training is beneficial in terms of performance (possibly due to increased familiarity with aircraft dynamics and/or the flight task); however, it did little to benefit psychomotor skill acquisition in participants.

In a third study, Day, Arthur, and Gettman (2001) examined the relationship of knowledge structures and skill-based performance in participants after playing SPACE FORTRESS. They looked at the knowledge structures as predictors of skill retention and skill transfer. SPACE FORTRESS adjusted to the trainee's skills (i.e., adaptation), utilized a level of difficulty and unknown outcomes (i.e., challenge), and included an element of fantasy embedded throughout the game. The main task of the game was to fly a ship in space while avoiding collisions or being destroyed by others. Results from the study show that measures of knowledge structures were correlated with skill-based performance and were predictive of skill retention and skill transfer.

In light of the above discussion, a number of propositions can be derived about the impact of game attributes on skill-based learning outcomes:

Proposition 4: As representation (i.e., fidelity) of the task in a game increases, psychomotor skill learning will also increase but then level off.

As previously discussed, only a few studies have looked at representation (or fidelity) and psychomotor learning. This limited research to date has indicated that a relationship may exist but leaves one questioning what level of representation is necessary for learning to occur (e.g., Belanich et al., 2004; Prince & Jentsch, 2001; Proctor, Panko, & Donovan, 2004). Given what we know from this initial research, we argue that as both physical and psychological representation of the task increases, the user will increase his or her psychomotor skill learning, as it will be necessary to utilize similar physical and cognitive processes to accomplish the task. However, we also argue that a point will come in which increasing the level of representation will no longer be beneficial and learning will reach a plateau.

Proposition 5: Automaticity set will increase as the level of fantasy in a game increases.

Among the studies that examined the impact of game attributes on skill-based outcomes, it was found, for the most part, that a positive relationship does exist. There were a few that found a negative relationship (e.g., Lepper [1985] found that too much challenge can negatively affect adaptation), but overall, the results were consistent. More research is needed in this area to determine the true impact of fantasy on skill-based outcomes.

Proposition 6: Requiring learners to participate in their learning through interaction with the game (i.e., interaction, equipment) will result in improved skill-based learning.

As noted, interactive gaming characteristics lead to greater cognitive outcomes among participants (Vogel et al., 2006). Perhaps learners become more engaged in the learning process when they are required to interact with it. This phenomenon has not been readily studied in terms of interactivity and skill-based outcomes, although similar findings would be expected.

Proposition 7: The amount of control given to learners will positively affect skill-based learning.

Learner control, or the ability of the learner to dictate the pace and sequence of learning activities, has been shown to have a mixed impact on learning (DeRouin, Fritzsche, & Salas, 2004). For example, when learners were given the opportunity to navigate through the computer program based on their personal preferences, this led to increased positive attitudes and higher cognitive outcomes (Vogel et al., 2006). Control is actually valued at all levels of a game from simply picking out a wardrobe or specific facial features to determining strategies in game play (Chamberlain, 2003). The optimal amount of control is empowering, making the game more interactive and engaging. On the other hand, a few studies have shown that too much learner control can lead to a decrease in training effectiveness (e.g., Lai, 2001) and satisfaction (e.g., Carlson, 1991). In spite of these limited studies with negative results, given an appropriate level of control and guidance (see DeRouin et al., 2004; Stoney & Wild, 1998), it is predicted that learner control will have a positive impact on skill-based learning. This will occur by allowing learners to determine how much time to spend learning a particular skill (i.e., learners can spend more time learning skills they are weak in and less time on skills they are familiar with).

Affective Outcomes

Research examining the impact of game attributes on affective outcomes has been readily studied. A majority of this literature focuses on the impact of games on motivation and attitudinal valuing. For example, Westrom and Shaban (1992) found that as participants gained experience on a game (i.e., LODE RUNNER), the game became less challenging and curiosity diminished, thereby reducing participant motivation. These authors also looked at the influence of control using MISSION: ALGEBRA and found that participants maintained motivation when given the opportunity to choose their own missions, create and edit missions, and adjust the game's difficulty level (i.e., control). Similarly, Belanich and colleagues (2004) found that participants who played AMERICA'S ARMY (a multiplayer, first-person perspective game that elicits decision making and collaboration skills) reported challenge, realism (i.e., representation), exploration (i.e., ability to discover new things), and control as the most motivating factors of the game. To add further support, Virvou, Katsionis, and Manos (2005) conducted an evaluation and found that educational virtual reality games increased motivation while maintaining the educational impact on students.

In addition, feedback (assessment) and control have been shown to be critical components to motivation. Bowman (1982) noted that the appeal of the video game, Pac-Man, was due to a flow state induced from clear goals and immediate feedback that was unambiguous, in addition to the fact that players could choose what direction to move around the board. Whitehall and McDonald (1993) compared a game-based or drill-based training context, which utilized either fixed or variable payoff points (assessment). They found that the game with feedback in the form of variable payoff points was correlated with an increase in selecting high difficulty levels and a decrease in using helps. In addition, participants in the game-based context with variable payoff points performed better in overall accuracy.

Finally, researchers have also examined attitudinal valuing. For example, it has been shown that aspects of games, such as learner control and realism, led to more positive attitudes toward learning versus traditional training methods (Vogel et al., 2006). Similarly, Garris and Ahlers (2001) implemented a training game to assess the impact on self-efficacy and attitudinal valuing. Based on reviewing the literature about essential gaming characteristics, the authors chose to utilize BOTTOM GUN, a fantasy game relevant to submarine fleet training. The game provided feedback (i.e., assessment), was embedded with uncertain goal attainment (i.e., challenge), and the participants felt as though they had control (i.e., learner control). Results of the study indicate that students in the Bottom Gun condition had superior performance to those in the control condition. They made fewer errors overall, found valence in visual skills (i.e., attitudinal valuing), had a higher locus of control and higher self-efficacy, and goal commitment (i.e., motivation).

Given what is known about game attributes and affective outcomes, we can begin to propose where gaps in the literature exist and where future research should focus:

Proposition 8: The specificity of the rules/goals in a game is positively related to learner motivation.

Specific goals that are tied to a task are important because the discrepancy between the goal and the present state creates tension, which encourages the user to become personally invested toward achieving the goal. This will lead to an overall increase in motivation to learn.

Proposition 9a: Learner motivation will increase as the level of endogenous fantasy and safety increase in a game.

Proposition 9b: The relationship between learner motivation and exogenous fantasy will be curvilinear as too little or too much will lead to decreased motivation.

A gap in knowledge (mystery) is necessary for learners to become involved; there must be something to search for or something to solve. Engaging learners' imagination and creating scenarios (fantasy) is important to keep attention focused on the game *as long as* learners can identify with the situations to some degree. Too little or too much fantasy may make it difficult to identify with the game scenario. In addition, users may more readily identify with fantasy situations that have an element of safety in that learners can disassociate their actions from consequences of reality. To illustrate, Thomas, Cahill, and Santilli (1997) taught adolescents about HIV/AIDS using LIFE CHALLENGE, a time travel adventure game. Since LIFE CHALLENGE added the fantasy component of time travel, users were capable of learning about HIV/AIDS and safer sex practices in a nonthreatening environment.

Proposition 10: Representation in a game (both physical and psychological) is positively related to learner motivation.

Similar to the level of fantasy, the learners' perceptions of the game's reality should also affect motivation. Games with high levels of physical representation (like Microsoft FLIGHT SIMULATOR) mimic the real-world environment (e.g., that of a flight cockpit). Using FLIGHT SIMULATOR as an example, pilots are able to learn and apply the basic knowledge and skills needed to fly an aircraft. Additionally, games high in psychological representation require learners to utilize the same cognitive processes that they would if they engaged in the activity in the real world (Bowers & Jentsch, 2001). Thus, we would argue that the combination of physical and psychological representation in a game would lead to increased motivation in learners as they are able to learn in a realistic setting without the threat of real-world consequences.

Proposition 11: Learner motivation is positively related to the level of mystery in a game.

A gap in knowledge (mystery) is necessary for learners to become involved. Increasing the level of mystery in a game will engage the learner as it provides the learner with something to search for or something to solve (Rieber, 1996). However, ensuring that what is being searched for or solved is achievable is also important, which leads to the next proposition:

Proposition 12: The relationship between motivation and challenge will be curvilinear in that too little or too much challenge will lead to decreased motivation.

Research has shown that challenge is also a vital component in maintaining motivation (e.g., Driskell & Dwyer, 1984; Gander, 2002); however, the optimal level of challenge is even more crucial. In fact, researchers have found support for enhanced motivation and improved learning with games that contain a challenge component compared to possessing a simple storyline without any difficulty (Serrano & Anderson, 2004). A game that is not challenging enough is seen as too easy and the outcome becomes obtainable regardless of the behavior. This lack of challenge results in the user becoming disinterested. A game that is believed to be too difficult will induce a sense of imminent failure, which also leads to a decrease in motivation. Finding the right level of challenge for the task and user is critical for motivation levels to remain high and for learning to occur.

Proposition 13: The specificity and immediacy of the feedback (i.e., assessment) is positively related to learner motivation and attitudinal valuing.

Assessment is critical to learning, as it provides learners with a clear picture as to how they are doing (Salas & Cannon-Bowers, 2000). For example, Ronen and Eliahu (2000) found that constructive feedback that assists students with identifying errors and providing suggestions to improve their understanding improved not only the students' confidence but also enhanced their overall motivation to stay on task. To be effective, assessments of performance must be specific (e.g., 12 of 15 enemy aircraft destroyed) and timely (i.e., updated continuously throughout the game) if the learner is to benefit from them.

Proposition 14: The relationship between learners' attitudinal value of training content and challenge will be curvilinear.

In line with the motivational research, the level of challenge present in a game could affect learner value of training content. The relationship between attitudinal valuing and challenge will be an inverted U shape, where too little or too much challenge will decrease learner's perception of the training value (Serrano & Anderson, 2004).

Summary

Overall, the research in this area indicates that games do positively influence trainees in terms of cognitive, skill-based, and affective outcomes. Caution should be taken, however, when using this information to make predictions about which game attributes lead to which learning outcomes. A majority of the research found used games in which a number of game attributes were embedded within the game. While this is likely inherent in the design of most off-the-shelf games, it makes it difficult to determine causality (i.e., did one game attribute have a greater effect than another has, or was it the combination of multiple game attributes that led to the results?). To truly understand the relationships that exist, we must first explore these game attributes in isolation. The propositions presented here focus on singular attributes. The hope is that they will provide researchers, educators, and the like with a starting point from which to conduct further research.

Conclusions

Games are increasingly used for educational, training, and research purposes. Overall, a review of the literature indicates that games can lead to better cognitive, skill-based, and affective outcomes. However, more robust, scientific research is needed that provides a clearer picture of their true impact. For example, in all of the studies reviewed, multiple game attributes were embedded in the games. It is not clear whether one attribute had a greater impact on learning than another, or whether it was the combination of attributes that led to success. Therefore, future research must seek to understand which specific game attribute(s) have the greatest impact on learning. The propositions we provide seek to address this issue. In addition, research needs to focus on identifying the tasks to which game attributes are most relevant. For example, representation may be more important for learning piloting skills, whereas adaptation may be more important for learning tactical decision making. Third, research must seek to understand how levels of game attributes affect learning—more or less of a particular attribute may have detrimental effects on learning. As we first approached this topic, we sought to break down each attribute in terms of high, medium, or low levels to answer this question. However, of the studies found, relatively few actually indicated the level of the game attribute within the game (e.g., Day et al., 2001); rather, a general statement was provided indicating that a game attribute was embedded. Finally, future research should focus on distinguishing research conducted with adolescents versus that of adults. It is possible that games will have a different effect depending on the age of the participants.

In this article, we offer a collective glimpse at how researchers are studying game attributes and their impact on learning outcomes. In addition, we provide conceptually based links between specific gaming characteristics with learning outcomes and propositions for future research. Such links are highly desirable and can provide the necessary foundation for future research on the effectiveness of instructional games, and practical implications can be drawn for game developers, content designers, and evaluators. For example, developers could create products that directly lead to specific learning outcomes and market their products accordingly. In addition, designers could select appropriate game characteristics based on desired learning outcomes and incorporate the specific game attributes into their instruction. Finally, evaluators could easily focus on proven measures that target the specific learning outcomes that a game has been designed to elicit. We submit that the set of research ideas presented here is not exhaustive, but we hope what we discuss will encourage and stimulate additional thinking in this area.

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