Games, Motivation, and Learning: A Research and Practice Model

Article *in* Simulation & Gaming · December 2002
DOI: 10.1177/1046878102238607

Rosemary Garris
Navy

James E Driskell
Rollins College

Games, motivation, and learning: A research and practice model

Rosemary Garris
Robert Ahlers
Naval Air Warfare Center Training Systems Division
James E. Driskell
Florida Maxima Corporation

Although most agree that games can be engaging and that games can be instructive, there is little consensus regarding the essential characteristics of instructional games. Implicit in the research literature is the notion that if we pair instructional content with certain game features, we can harness the power of games to engage users and achieve desired instructional goals. In this article, the authors present an input-process-output model of instructional games and learning that elaborates (a) the key features of games that are of interest from an instructional perspective; (b) the game cycle of user judgments, behavior, and feedback that is a hallmark of engagement in game play; and (c) the types of learning outcomes that can be achieved. The authors discuss the implications of this approach for the design and implementation of effective instructional games.

KEYWORDS: *education/training; learning; motivation; simulation/games; video games*.

From a popular perspective, computer games seem to evoke mixed reactions. On one hand, many are troubled by the violent themes that constitute certain games, and some are concerned with the intensity of involvement and amount of time that youth devote to playing computer games. However, on the other hand, it seems that some games, such as the popular *SimCity* series, can be quite instructive and enlightening. These "instructional" games can be as engaging as action games, but we tend to regard the zeal that these games engender as less alarming. Regardless of whether you view computer games as a blessing or a curse, in the roughly 25 years in which computer games have existed, they have solidified a place in the market and in popular culture.

In addition to their commercial popularity, computer games have captured the attention of training professionals and educators. There are several reasons for this professional interest. First, there has been a major shift in the field of learning from a traditional, didactic model of instruction to a learner-centered model that emphasizes a more active learner role. This represents a shift away from the "learning by listening" model of instruction to one in which students learn by doing. Moreover, Simon (1996) has noted that how we view learning has changed from being able to recall information to being able to find and use information. New interactive technologies provide opportunities to create learning environments that actively involve students in problem

SIMULATION & GAMING, Vol. 33 No. 4, December 2002 441-467
DOI: 10.1177/1046878102238607

solving. A second reason underlying current professional interest in computer games is that some empirical evidence exists that games can be effective tools for enhancing learning and understanding of complex subject matter (Cordova & Lepper, 1996; Ricci, Salas, & Cannon-Bowers, 1996). Although this evidence is embryonic, recent research has begun to establish links between instructional strategies, motivational processes, and learning outcomes. Third, training professionals are also interested in the intensity of involvement and engagement that computer games can invoke. There is a large cohort of individuals, youth and young adults sometimes referred to as *generation.com*, for whom computer games provide an immensely compelling and rewarding experience. The "holy grail" for training professionals is to harness the motivational properties of computer games to enhance learning and accomplish instructional objectives.

In brief, the potential of instructional games as platforms for training is appealing. As Simons (1993) claimed, "If video games can be transformed so that their users learn, a great many people may come to understand and control dynamic systems" (p. 149). Unfortunately, there is little consensus on game features that support learning, the process by which games engage learners, or the types of learning outcomes that can be achieved through game play. Ultimately, we run the risk of designing instructional games that neither instruct nor engage the learner. Bargain bins in software stores attest to the difficulty in designing appealing and instructionally sound computer games.

The purpose of this article is to present and elaborate a model of instructional games and learning. We do not intend in this space to provide a comprehensive review of the literature on simulation/gaming (we refer the reader to Crookall & Arai, 1995; Crookall, Greenblat, Coote, Klabbers, & Watson, 1987; Greenblat & Duke, 1981). Our goal is a bit more modest: to examine the unique aspects of games that can enhance learning. We address three primary questions. First, what are the primary characteristics of games that are of interest from an instructional perspective? Second, what is the nature of the motivational process that these characteristics trigger in users? Third, how do instructional games affect learning outcomes? Discussion addresses the application of this approach to the design and implementation of effective training games.

Defining games

Prior to delving into these issues, it is useful to provide some definition of what we mean by the term *game* and, more specifically, what we mean when we refer to *instructional computer games*. Caillois (1961) has provided perhaps the most comprehensive analysis of games per se, describing a game as an activity that is voluntary and enjoyable, separate from the real world, uncertain, unproductive in that the activity does not produce any goods of external value, and governed by rules. However, there is little consensus in the education and training literature on how games are defined. Wittgenstein (1953, 1958) admitted failure in defining the essential characteristics of games, noting that there are no properties that are common to all games and that games belong in the same semantic category only because they bear a “family resemblance” to one another.

Crookall, Oxford, and Saunders (1987) provided some clarification to this problem by distinguishing between games and simulations. A simulation is an operating model of some system (Greenblat, 1981). Crookall and Saunders (1989) viewed a simulation as a representation of some real-world system that can also take on some aspects of reality for participants or users. Key features of simulations are that they represent real-world systems; they contain rules and strategies that allow flexible and variable simulation activity to evolve; and the cost of error for participants is low, protecting them from the more severe consequences of mistakes. By contrast, Crookall, Oxford, and Saunders (1987) noted that a game does not intend to represent any real-world system; it is a “real” system in its own right. Games also contain rules and strategies, and generally when we lose at a game, the costs can be consequential but may be contained within the game world (although Crookall, Oxford, & Saunders noted that when we lose at a game like poker, this distinction may not hold). Thus, it is not too improper to consider games and simulations as similar in some respects, keeping in mind the key distinction that simulations propose to represent reality and games do not.

Furthermore, at the risk of introducing a bit more ambiguity, we would propose that simulations can contain game features. We argue in the following sections that there are six key dimensions that characterize games: fantasy, rules/goals, sensory stimuli, challenge, mystery, and control. Simulations that incorporate these features become more game-like. We later describe BOTTOM GUN, which we refer to as a game-based trainer but which is a simulation of an actual Naval task that incorporates features such as fantasy and scoring that are not present in the real-world task. Thus, the distinction between games and simulations can be a blurred one. In this context, we are specifically interested in the use of instructional games that are designed for training or to promote learning. The generally accepted position is that games themselves are not sufficient for learning but that there are elements of games that can be activated within an instructional context that may enhance the learning process.

Training effectiveness of games

There are a number of empirical studies that have examined the effects of game-based instructional programs on learning. For example, both Whitehall and McDonald (1993) and Ricci et al. (1996) found that instruction incorporating game features led to improved learning. The rationale provided for these positive results varied, given the different factors examined in these studies. Whitehall and McDonald argued that incorporating a variable payoff schedule into a simulation game led to increased risk taking among students, which resulted in greater persistence on the task and improved performance. Ricci et al. proposed that instruction that incorporated game features enhanced student motivation, which led to greater attention to training content and greater retention.

Although students generally seem to prefer games over other, more traditional, classroom training media, reviews have reported mixed results regarding the training effectiveness of games. Pierfy (1977) evaluated the results of 22 simulation-based training game effectiveness studies to determine patterns in training effectiveness across games. Twenty-one of the studies collected learning data that generally consisted of paper-and-pencil fact-and-principle knowledge tests. Three of the studies reported results favoring the effectiveness of games over conventional teaching; 3 reported results favoring the effectiveness of conventional teaching over games; and the remaining 15 found no significant differences. Eleven studies also tested retention of learning. Eight of these studies indicated that retention was superior for game-based training; the remaining 3 yielded no significant differences. Level of student preference for training games over classroom instruction was assessed in 8 of the studies, and in 7 of those, students reported greater interest in simulation game activities than in conventional teaching methods. In a more recent review, Druckman (1995) concluded that games seem to be effective in enhancing motivation and increasing student interest in subject matter, yet the extent to which this translates into more effective learning is less clear.

A model of games and learning

We should first discuss the end state that we desire to achieve: the motivated learner. Motivated learners are easy to describe. They are enthusiastic, focused, and engaged. They are interested in and enjoy what they are doing, they try hard, and they persist over time. Their behavior is self-determined, driven by their own volition rather than external forces. Skinner and Belmont (1993) noted that although motivated learners are easy to recognize, they are hard to find; and they are, we would add, hard to create.

There are a number of models of motivation that differ in emphases and constructs. These range from expectancy/valence approaches (Mathieu, Tannenbaum, & Salas, 1992) to Keller's (1983) Attention, Relevancy, Confidence, and Satisfaction (ARCS) model (for reviews, see Pintrich & Schrauben, 1992; Schunk, 1990). Behavior can be intrinsically or extrinsically motivated. Most models have emphasized intrinsic motivation, focusing on the motives to perform a task that are derived from the participation itself (Malone, 1981; Malone & Lepper, 1987). Malone (1981) proposed that the primary factors that make an activity intrinsically motivating are challenge, curiosity, and fantasy and specifically applied this framework to the design of computer games. Others have examined extrinsic motivation, in which someone engages in an activity as a means to an end (Vallerand, Fortier, & Guay, 1997). Although extrinsic rewards can be less effective than intrinsic motives, both intrinsic and extrinsic motives play a role in determining learner behavior. Deci and Ryan (1985) have noted that self-determined learner behavior can stem from both intrinsic motivation (i.e., the learner engages in an activity because it is interesting or enjoyable) and from extrinsic motivation they termed *identified regulation* (i.e., the learner engages in the activity because he or she desires the outcome and values it as important). Although instructional games are

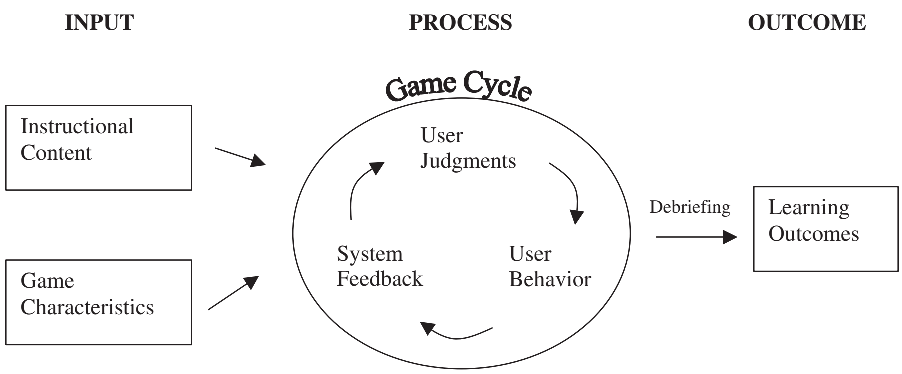

FIGURE 1: Input-Process-Outcome Game Model

primarily seen as a means to enhance intrinsic motivation, extrinsic motivation is also important. The goal is to develop learners who are self-directed and self-motivated, both because the activity is interesting in itself and because achieving the outcome is important.

There is a tacit model of learning that is inherent in most studies of instructional games. First, the objective is to design an instructional program that incorporates certain features or characteristics of games. Second, these features trigger a cycle that includes user judgments or reactions such as enjoyment or interest, user behaviors such as greater persistence or time on task, and further system feedback. To the extent that we are successful in pairing instructional content with appropriate game features, this cycle results in recurring and self-motivated game play. Finally, this engagement in game play leads to the achievement of training objectives and specific learning outcomes. This instructional model is illustrated in Figure 1.

There are several benefits that this perspective offers. First, the traditional input-process-output model of learning emphasizes single-trial learning, a learner performing a task over a single trial. Although the current model adopts the input-process-output framework, the key component is the *game cycle* that is triggered by specific game features. A central hallmark of game play is not that users play a game and then put it down but that users are drawn into playing a game over and over. In fact, a young person engaged in a computer game may often have to be *told* to turn off the game or to stop playing. We view the game cycle as iterative, such that game play involves repeated judgment-behavior-feedback loops. That is, game play can lead to certain user judgments or reactions such as increased interest, enjoyment, involvement, or confidence; these reactions lead to behaviors such as greater persistence or intensity of effort; and these behaviors result in system feedback on performance in the game context. Thus, the game cycle is a defining characteristic of computer game play—that users are engaged in repetitive play and continually return to the game activity over time. It is this feature of computer game play that training professionals hope to capture and incorporate in instructional applications.

Although not explicit in Figure 1, we view the learner as actively constructing knowledge from experience. In this sense, this model is consistent with the experiential learning approaches of Dewey (1938) and Kolb, Boyatzis, and Mainemelis (2000) and with modern constructivists such as Duffy and Jonassen (1992). Although the model presented in Figure 1 is a cyclical training model, we do not imply that all learners necessarily learn in the same way, nor that all learners proceed through these stages in a sequential or linear manner. What we do wish to emphasize from the experiential learning tradition are two points: (a) People do learn from active engagement with the environment and (b) this experience coupled with instructional support (i.e., debriefing, scaffolding) can provide an effective learning environment.

A second advantage of this model is that it provides a structure to organize and integrate the literature on instructional games. Perusing the research literature on games, the reader is faced with a perplexing variety of descriptive terms and conceptual approaches. For example, some researchers have described the essential elements of games by referring to game features, others described games in terms of user reactions or responses to game use, and others described games in terms of the learning outcomes that are achieved. In the following, we elaborate the model provided in Figure 1 by presenting an overview of research on game characteristics, the game cycle, and learning outcomes. Furthermore, we provide a list of cognate research that addresses each content area. Our goal is to make the implicit model of instruction underlying much game research explicit and to provide a common language and approach for examining the instructional use of computer games.

Game characteristics

Lepper (1985) suggested that a systematic examination of game factors or game characteristics should help in refining theoretical formulations of effective instruction. However, identifying just what these essential characteristics of games are has been the subject of some debate. Thornton and Cleveland (1990) noted that the essential aspect of a game is interactivity. de Felix and Johnston (1993) suggested that the structural components of a game, including dynamic visuals, interaction, rules, and a goal, are the essential features. Gredler (1996) stated that the essential elements are a complex task, the learner's role, multiple paths to the goal, and learner control. Malone (1981) argued that there are four characteristics of games that make them engaging educational tools: challenge, fantasy, complexity, and control. Thomas and Macredie (1994) claimed that the core characteristic of games is that actions have no real-world consequences. Baranauskas, Neto, and Borges (1999) stated that the essence of gaming is challenge and risk. Crookall, Oxford, and Saunders (1987) cited game features such as rules, strategy, goals, competition/cooperation, and chance.

Although many have noted the potential benefits that may be gained from incorporating game characteristics into instructional applications, there is clearly little consensus regarding how these essential characteristics are described. This suggests that either the characteristics of games are so varied and diffuse that attempts to categorize

TABLE 1: Game Dimensions

	Fantasy	*Rules/ Goals*	*Sensory Stimuli*	*Challenge*	*Mystery*	*Control*
Descriptors	Imaginary or fantasy context, themes, or characters	Clear rules, goals, and feedback on progress toward goals	Dramatic or novel visual and auditory stimuli	Optimal level of difficulty and uncertain goal attainment	Optimal level of informational complexity	Active learner control
Related research	Cordova & Lepper, 1996; Driskell & Dwyer, 1984; Malone, 1980, 1981; Malone & Lepper, 1987; Parker & Lepper, 1992	Driskell & Dwyer, 1984; Lepper & Chabay, 1985; Malone, 1980, 1981; Ricci, Salas, & Cannon-Bowers, 1996; Schloss, Wisniewski, & Cartwright, 1988; Thurman, 1993	Hereford & Winn, 1994; Lepper, 1985; Malone, 1980, 1981; Rieber, 1991; Surber & Leeder, 1988; Thurman, 1993; Wishart, 1990	Elliot & Harackiewicz, 1994; Lepper, 1985; Lepper & Chabay, 1985; Lepper, Woolverton, Mumme, & Gurtner, 1993; Malone, 1980, 1981; Thurman, 1993; Whitehall & McDonald, 1993; Wishart, 1990	Day, 1982; Lepper, 1985; Loewenstein, 1994; Malone, 1980, 1981; Malone & Lepper, 1987; Terrell, 1990; Thurman, 1993	Cordova & Lepper, 1996; Hannafin & Sullivan, 1996; Kinzie, Sullivan, & Berdel, 1988; Reigeluth & Schwartz, 1989; Simons, 1993; Steinberg, 1989; Wishart, 1990

them are likely to be futile or that different researchers are using different approaches and terms to describe similar game dimensions. We believe the latter is the case.

Based on a review of the literature, we conclude that game characteristics can be described in terms of six broad dimensions or categories: fantasy, rules/goals, sensory stimuli, challenge, mystery, and control. These dimensions are described in Table 1, and related research is shown that addresses each dimension. Any type of game can be described in terms of these six key dimensions. Moreover, they provide a common vocabulary for describing and manipulating the core elements of games for instructional purposes. In the following, we briefly review each of these dimensions.

Fantasy

Games represent an activity that is separate from real life in that there is no activity outside the game that literally corresponds. Games involve imaginary worlds; activity inside these worlds has no impact on the real world; and when involved in a game, nothing outside the game is relevant. Malone and Lepper (1987) defined *fantasy* as an environment that evokes "mental images of physical or social situations that do not exist" (p. 240). Some research indicates that instructional content that is embedded in fantasy contexts leads to greater student interest and increased learning (Cordova & Lepper, 1996; Parker & Lepper, 1992).

There are several implications of the use of fantasy in games. Fantasies allow users to interact in situations that are not part of normal experience, yet they are insulated from real consequences. Thomas and Macredie (1994) have noted that one key characteristic of games is that participants' actions have no impact on the real world (they describe this as a "world with no consequences"). Fantasies facilitate focalization of attention and the self-absorption that occurs when users become immersed in game activity (Driskell & Dwyer, 1984). Finally, Malone and Lepper (1987) noted that fantasies can offer analogies or metaphors for real-world processes that allow the user to experience phenomena from varied perspectives. In brief, rese arch suggests that material may be learned more readily when presented in an imagined context that is of interest than when presented in a generic or decontextualized form.

A game requires the user to adopt various roles and identify with a fictional person or role. Crookall, Oxford, and Saunders (1987) noted that participants "take on" or "act out" a role within the game framework. In noting the role of fantasy in games, we do not intend to imply that games are not "real" to the participants. It is perhaps because users are wrapped up in a unique role in a world separate from day-to-day activities that game play takes on such importance. Certainly games are important, and they may have consequences for the real world (witness the World Cup or the Olympics). Yet games are distinct from reality—if one's role in a game mirrors reality too closely, activity ceases to be a game.

Rieber (1996) has further noted that fantasy contexts can be exogenous or endogenous to the game content. An exogenous fantasy is simply overlaid on some learning content. For example, children may learn fractions and by doing so slay a dragon in an enchanted forest. This type of game is likely to be more engaging than a long page of fractions. However, the fantasy in this case is external to and separate from the learning content. In contrast, an endogenous fantasy is related to the learning content. For example, students may learn about physics by piloting a spaceship on reentry to earth's orbit. Rieber noted that because endogenous fantasies are more closely tied to the learning content, if the fantasy is interesting, the content becomes interesting. Thus, endogenous fantasies are more effective motivational tools.

Rules/Goals

Although game activity takes place apart from the real world, it occurs in a fixed space and time period with precise rules governing game play. Caillois (1961) noted that in a game, the rules and constraints of ordinary life are temporarily suspended and replaced by a set of rules that are operative within the fixed space and time of the game. Moreover, when play violates these boundaries, when the ball goes out of bounds or the person responds out of character, play is stopped and brought back into the agreed boundaries.

The rules of a game describe the goal structure of the game. One of the most robust findings in the literature on motivation is that clear, specific, and difficult goals lead to enhanced performance (Locke & Latham, 1990). Clear, specific goals allow the individual to perceive goal-feedback discrepancies, which are seen as crucial in triggering greater attention and motivation. That is, when feedback indicates that current performance does not meet established goals, individuals attempt to reduce this discrepancy. Under conditions of high goal commitment (i.e., the individual is determined to reach the goal), this discrepancy leads to an increase in effort and performance (Kernan & Lord, 1990). Therefore, game contexts that are meaningful and that provide well-differentiated, hierarchical goal structures are likely to lead to enhanced motivation and performance.

At the same time, whereas rules and goals may be clear and fixed, they must allow for a wide range of permissible actions within the game. Crookall and Arai (1995) noted that the strategic selection of moves or actions within a game must be flexible to allow game activity to evolve based on player styles, strategies, previous experience, and other factors. Although we may clearly know the rules of a game beforehand, we are never able to predict exactly how the game will play out.

Finally, there are different types of rules that are operational within a game framework (see Crookall & Arai, 1995). *System* rules define the operation of the world that is embodied by the game. *Procedural* rules define actions that can be taken within the game (e.g., "If you amass *x* number of points, you can move to this level"). *Imported* rules are those that participants import into the game from the real world that allow play to take place (e.g., "You do not cheat or lie," "You cannot walk through walls"). Imported rules are commonsense or implied rules that govern behavior in general and are important for two reasons. It is these normative, already-learned rules that are imported into game situations that allow games to be played, just like these rules structure our behavior in real life. Yet it is often these commonsense rules being suspended in imaginary worlds that lend computer games their unique flavor (e.g., "Gee, I can walk through walls!" "I can drive 90 mph through the streets of San Francisco!"). Without imported rules, game play could not take place, yet games are fun because they allow some of these everyday rules to be loosened or broken.

Sensory stimuli

Games imply the temporary acceptance of another type of reality. This imaginary world disrupts the stability of normal sensations and perceptions and allows the user to experience a distortion of perception that is not readily experienced in the real world. Caillois (1961) referred to the term *vertigo* as an altered perception that activities such as falling or twirling or being projected through space evoke. It is a type of euphoria or sense of perceptual disorder that can be provided by sights and sounds that stimulate and intoxicate the senses (and that are enjoyed by the public at amusement rides and theme parks). Sound effects, dynamic graphics, and other sensory stimuli that are strange or unfamiliar can be attention grabbing, as noted by Malone and Lepper (1987), but can also appeal to the desire for sensory disorder and sensations that are outside normal experience. Rieber (1991) argued that animated graphics enhance the motivational appeal of instructional activities and found that students overwhelmingly choose to return to practice activities that include dynamic graphics.

Challenge

Malone and Lepper (1987) have claimed that individuals desire an optimal level of challenge; that is, we are challenged by activities that are neither too easy nor too difficult to perform. Moreover, there are several ways in which an optimal level of challenge can be obtained. Goals should be clearly specified, yet the possibility of obtaining that goal should be uncertain. Games should employ progressive difficulty levels, multiple goals, and a certain amount of informational ambiguity to ensure an uncertain outcome. Performance feedback and score keeping allows the individual to track progress toward desired goals. Finally, goals must be meaningful to the individual. Linking activities to valued personal competencies, embedding activities within absorbing fantasy scenarios, or engaging competitive or cooperative motivations can serve to make goals meaningful.

Mystery

Malone and Lepper (1987) noted that curiosity is one of the primary factors that drive learning. Following Berlyne (1960), they described two types of curiosity: (a) sensory curiosity, the interest evoked by novel sensations (which we have described as sensory stimuli above); and (b) cognitive curiosity, which is a desire for knowledge. Most experts agree that curiosity reflects a human tendency to make sense of the world and that we are curious about things that are unexpected or that we cannot explain (Loewenstein, 1994). Thus, curiosity is a product of perceived discrepancies or inconsistencies in our knowledge. Moreover, we seek an optimal level of informational complexity. At a very low level of discrepancy, if a piece of information is only somewhat discrepant, we may easily dismiss it without much attention. If there is too high a level of discrepancy between our existing knowledge and new information, information may be too confusing or bewildering to incorporate. Therefore, curiosity is stimulated by an information gap in our existing knowledge that is intermediate—not too simple or too complex.

We make the distinction between curiosity and mystery to reflect the difference between curiosity, which resides in the individual, and mystery, which is an external feature of the game itself. Thus, according to this perspective, mystery evokes curiosity in the individual, and this leads to the question of what constitutes mystery. Research suggests that mystery is enhanced by incongruity of information, complexity, novelty, surprise and violation of expectations (Berlyne, 1960), incompatibility between ideas and inability to predict the future (Kagan, 1972), and information that is incomplete or inconsistent (Malone & Lepper, 1987). Adventure themes often involve a search for information or exploration of unknown settings. Furthermore, embedding activities in fantasy contexts allows the student to encounter imaginary situations that differ from our knowledge of how things work in the real word, stimulating curiosity.

Control

Control refers to the exercise of authority or the ability to regulate, direct, or command something. Research comparing the effects of instructional programs that control all elements of the instruction (program control) and instructional programs in which the learner has control over elements of the instructional program (learner control) on learner achievement has yielded mixed results (Hannafin & Sullivan, 1996). However, research that has compared the effects of program control versus learner control on user reactions and motivation has yielded consistently positive results favoring learner control. For example, Morrison, Ross, and Baldwin (1992) found that students who were allowed to choose the amount and the context of practice problems reported more positive attitudes. Cordova and Lepper (1996) studied the effects of providing students with control over instructionally irrelevant parts of a learning activity (the advantage being that this would avoid the risk of students' making pedagogically poor choices). They found that providing student control led to increased motivation and greater learning. Games evoke a sense of personal control when users are allowed to select strategies, manage the direction of activity, and make decisions that directly affect outcomes, even if actions are not instructionally relevant.

The game cycle

Perhaps the most evident aspect of computer game play is that it can be engaging, engrossing, and even addictive. In fact, some researchers have adapted the categories in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition* dealing with compulsive behavior to address video game play as a type of addictive behavior (Young, 1996). Although we are not concerned with the pathological aspects of computer game usage, one hallmark of addictive behavior is that people repeatedly return to that behavior. And it is this feature of computer game play—the fact that games are immersive and engaging in a way that traditional workbooks or manuals are not—that constitutes the primary source of appeal to education and training professionals.

The willingness or desire to engage in a task has been termed *motivation*. More specifically, motivation refers to an individual's choice to engage in an activity and the intensity of effort or persistence in that activity (Pintrich & Schrauben, 1992; Wolters, 1998). Individuals who are highly motivated are more likely to engage in, devote effort to, and persist longer at a particular activity. Research has addressed two main issues regarding motivation. First, what are the primary determinants of motivation? In the context of instructional games, we have described in the previous section the features of games that are seen as motivating. The second issue concerns understanding the motivational process itself and how this process links to instructional outcomes.

What are the target motivational outcomes that we desire in the learner? Learner outcomes that have been identified in prior research include intensity of arousal, attention, enjoyment, engagement, depth of involvement, and task persistence (Cordova & Lepper, 1996; Parker & Lepper, 1992). Csikszentmihalyi (1990) described the positive experience of being fully engaged in an activity as a state of “flow.” Csikszentmihalyi defined *flow* as “the state in which people are so involved in an activity that nothing else seems to matter” (p. 4). Thus, flow represents an optimal state of performance at a task, a sense of enjoyment and control, where an individual’s skills are matched to the challenges faced. Furthermore, flow derives from activities that are optimally challenging and in which there are clear goals and feedback, concentration is intensely focused, there is a high degree of control, and users are absorbed to the extent that they lose a sense of time and self. The concept of flow provides one perspective on the feelings of enjoyment and engagement that can be experienced by game users.

We view the motivational process in the context of a game cycle in which game play triggers repeated cycles of user judgments (e.g., enjoyment), behavior (game play), and feedback. The game cycle focuses attention to a critical chain of dependencies: (a) To elicit desirable behaviors from learners, (b) they first need to experience desirable emotional or cognitive reactions, (c) which result from interaction with and feedback generated from game play. In the following, we elaborate each of these components of the game cycle. Related research that addresses these components is provided in Table 2.

User judgments

As users initiate game play, they make subjective judgments regarding whether the game is fun, interesting, and engaging. These judgments are typically represented by self-reports of interest and engagement, enjoyment, and feelings of mastery.

Interest. In a review of research on educational games, Randel, Morris, Wetzel, and Whitehill (1992) concluded that games are consistently perceived as more interesting than traditional instruction. For example, Cohen (1969) found that 87% of students tested reported greater interest for educational games than for classroom approaches. Pierfy (1977) found that seven of eight studies that measured student interest reported greater interest from game use than conventional instruction.

Enjoyment. A central characteristic of games is that they are fun and a source of enjoyment. For Csikszentmihalyi (1990), enjoyment is a sense of achievement that occurs when one’s skills are matched with the task’s challenges. Ricci et al. (1996) found that military trainees who received instruction via a computer-based game rated the training as more enjoyable than those assigned to traditional paper-and-pencil media. They cautioned, however, that trainee enjoyment may not necessarily be related to learning or retention.

TABLE 2: User Judgments

	Interest	*Enjoyment*	*Task Involvement*	*Confidence*
Descriptors	Expressed interest in or preference for an activity	Subjective ratings of fun or enjoyment	Level of attention or depth of involvement in educational activities	Feelings of mastery or self-efficacy
Related research	Bredemeier & Greenblat, 1981; Gosenpud & Miesing, 1992; Parker & Lepper, 1992; Randel, Morris, Wetzel, & Whitehill, 1992	Caillois, 1961; Jacobs & Baum, 1987; Ricci, Salas, & Cannon-Bowers, 1996	Cordova & Lepper, 1996; Elliot & Harackiewicz, 1994; Wishart, 1990	Lepper, Woolverton, Mumme, & Gurtner, 1993; Lieberman, 1997; Thomas, Cahill, & Santilli, 1997

Task involvement. Elliot and Harackiewicz (1994) defined task involvement as the degree to which individuals concentrate on and become absorbed in an activity. Individuals who are highly involved in a task report being more absorbed or immersed in task activities. The degree of immersion experienced in a computer game may be determined by several factors, including: (a) control factors, or the extent to which actions taken to control or manipulate the environment are immediate and natural; (b) sensory factors, referring to the quality, richness, and variety of information presented to the senses; (c) distraction factors, or the extent to which the user is isolated from the external physical environment; and (c) realism factors, including scene detail, texture, and realism (Witmer & Singer, 1994). Research suggests that learning improves as the quality of cognitive engagement increases and that greater engagement during learning leads to longer retention of information (Hannafin & Hooper, 1993).

Confidence. Games can provide a training environment in which users can perform tasks without facing the real-world consequences of failure. Moreover, games that employ progressive difficulty levels allow the user to gain familiarity and build skills in complex or novel task environments in a graduated manner. This can serve to enhance trainee confidence, especially important when training for complex, stressful, or dangerous tasks (Driskell & Johnston, 1998). Individuals with greater confidence in their task capabilities are more resilient to the difficulties faced when applying skills learned in a real-world environment (Bandura & Wood, 1989).

User behavior

The affective judgments that are formed from initial and ongoing game play determine the direction, intensity, and quality of further behavior. Motivated learners more readily choose to engage in target activities, they pursue those activities more vigorously, and they persist longer at those activities than do less motivated learners. In brief, they are more interested and involved in the task, they devote more time on task, they actively pursue challenging activities, and they are more committed to continued task activity. We believe this sustained involvement, or what we term *persistent reengagement*, is the cornerstone of computer game play and epitomizes the behavior that is coveted by instructional designers. That is, those who form positive user judgments more actively engage in game play, exert intense effort and concentration, and return to game play unprompted.

System feedback

Feedback or knowledge of results is critical to support performance and motivation (Annett, 1969; Wexley & Latham, 1991). Research suggests that the effects of feedback on performance are highly variable; under some conditions, feedback may improve performance, and under other conditions, feedback may reduce performance (Kluger & DeNisi, 1996). However, the role of feedback in regulating motivation is more unequivocal. Feedback is a critical component of the judgment-behavior-feedback cycle. Individual judgments and behavior are regulated by comparisons of feedback to standards or goals. If feedback indicates that performance has constantly attained the goal, the game is deemed too easy and motivation declines. However, during initial game play, feedback typically indicates that current performance is below desired standards. To resolve this feedback-standard discrepancy, the individual has several options, including abandoning play or increasing effort to meet the standard. Under conditions in which the goal is clear, there is high goal commitment, and confidence in eventual success is high, individuals respond to the feedback-standard discrepancy by increasing their effort to attain the standard. Thus, feedback provides an assessment of progress toward goals that drives the motivated performer to expend more effort, to persist, and to focus attention on the task.

Debriefing

In Figure 1, we have shown the debriefing process as providing a link between the game cycle and the achievement of learning outcomes. Many consider debriefing to be the most critical part of the simulation/gaming experience (Crookall, 1995; Crookall & Saunders, 1989; Lederman, 1992; Lederman & Kato, 1995). Debriefing is the review and analysis of events that occurred in the game itself. We noted in defining simulations and games that a simulation represents a real-world system and a game provides a reality unto itself that does not directly represent some real-world event. We further noted that this distinction can be blurred—simulations can incorporate elements of games such as fantasy or scoring that may not be present in the real-world referent. Debriefing provides a link between what is represented in the simulation/gaming experience and the real world. It allows the participant to draw parallels between game events and real-world events. If our interests were in “pure” games, this link would not need to be made, as the game would exist within its own boundaries and be played for its own sake. However, given our goal of developing games that are instructive, the debriefing process allows us to transform game events into learning experiences. Debriefing may include a description of events that occurred in the game, analysis of why they occurred, and the discussion of mistakes and corrective actions. Although we are only able to briefly touch on the topic of debriefing, it is a fundamental link between game experiences and learning.

It is critical to emphasize the fact that experiential learning must be paired with appropriate learner support for effective learning to occur, reflecting Dewey’s (1938) “experience plus reflection equals learning” dictum. The most recent evidence supporting this view is provided by Mayer, Mautone, and Prothero (2002), who found that a geology simulation was most effective when learner support (e.g., scaffolding) was provided to help students visualize geologic features. Mayer et al. concluded that evidence for pure discovery-based learning is almost nonexistent. In other words, it is unrealistic to expect even the most self-directed learners to construct knowledge on their own. Thus, learning by doing must be coupled with the opportunity to reflect and abstract relevant information for effective learning to occur and for learners to link knowledge gained to the real world. Kolb, Rubin, and McIntyre (1971) labeled this a “doing, reflecting, understanding, and applying” process. Debriefing and scaffolding techniques provide the guidance and support to aid this process.

Learning outcomes

Most researchers conceptualize learning as a multidimensional construct. Moreover, there is considerable commonality across different attempts to classify types of learning outcomes. In an attempt to synthesize the work of Gagne (1984), Anderson (1982), and others, Kraiger, Ford, and Salas (1993) proposed several broad categories of learning outcomes: skill-based, cognitive, and affective outcomes. *Skill-based* learning outcomes address technical or motor skills. *Cognitive* learning outcomes include three subcategories of *declarative* knowledge, *procedural* knowledge, and *strategic* knowledge. *Affective* learning outcomes refer to attitudes. These categories of learning outcomes are described below and presented in Table 3.

Skill-based learning outcomes

Skill-based learning outcomes include the development of technical or motor skills. There are a number of game-based instructional programs that have been used for drill and practice of technical skills. For example, Gopher, Weil, and Bareket (1994) found that military trainees in flight school who received 10 hours of training on an aviation computer game performed significantly better on subsequent test flights than those who received standard training.

TABLE 3: Learning Outcomes

		Cognitive			
	Skill-Based	*Declarative*	*Procedural*	*Strategic*	*Affective*
Descriptors	Performance of technical or motor skills	Knowledge of the facts and data required for task performance	Knowledge about how to perform a task	Ability to apply rules and strategies to general, distal, or novel cases	Beliefs or attitudes regarding an object or activity
Related research	Gopher, Weil, & Bareket, 1994	White, 1984	Whitehall & McDonald, 1993	Wood & Stewart, 1987	Thomas, Cahill, & Santilli, 1997; Wiebe & Martin, 1994

Cognitive learning outcomes

Declarative knowledge

Declarative knowledge refers to knowledge of the facts and data required for task performance. For this type of learning outcome, the learner is typically required to reproduce or recognize some item of information. For example, White (1984) demonstrated that students who played a computer game focusing on Newtonian principles were able to answer questions on force and motion problems more accurately than those who did not play the games.

Procedural knowledge

Procedural knowledge refers to knowledge about how to perform a task. This type of learning outcome requires a demonstration of the ability to apply knowledge, general rules, or skills to a specific case. For example, Whitehall and McDonald (1993) found that students who used a variable-payoff electronics game during training achieved higher scores on electronics troubleshooting tasks than students who received standard drill and practice.

Strategic knowledge

Strategic knowledge requires applying learned principles to different contexts or deriving new principles for general or novel situations. This implies the development and application of cognitive strategies and understanding when and why principles apply. For example, Wood and Stewart (1987) found that the use of a computer game to improve practical reasoning skills of students led to improvements in critical thinking.

Affective learning outcomes

Affective reactions include feelings of confidence, self-efficacy, attitudes, preferences, and dispositions. Affective reactions may be viewed as a specific type of learning outcome to the extent that attitude change is a training objective of an instructional program. Some research has shown that games can influence attitudes. For example, Thomas, Cahill, and Santilli (1997) reported success in using an adventure game format to enhance students' confidence regarding safe sex negotiations.

BOTTOM GUN: A training application

BOTTOM GUN is a game-based submarine periscope trainer developed for the U.S. Navy (for more complete details, see Garris & Ahlers, 2001). BOTTOM GUN was developed to enhance submarine technical skills and to examine the effects of the game-based training approach on student motivation. It was designed to provide an entertaining way to practice making estimates of critical visual variables, including angle-on-the-bow (AOB) (i.e., angle at which the observed ship is visually presented to the periscope observer) and divisions (the number of tick marks on the periscope reticle representing the height of the targeted ship from its waterline to its highest visible point).

Two versions of this trainer were developed. The BOTTOM GUN version was designed to incorporate most of the game features previously presented in Table 1. The BOTTOM GUN trainer incorporated simulated contacts, a high rate of interactivity, scoring, and visual and sound effects. A control training simulation provided the same contacts within the same scenarios minus the game characteristics.

BOTTOM GUN presents the user with a display that represents a view through a submarine periscope (see Figure 2). The player scans the area around his or her own ship to determine another ship's AOB and divisions, then uses those estimates to determine whether the other ship will come too close for safety. If a ship is determined to be a safety threat, the player can then eliminate the threat of possible collision with the other ship by destroying it with a missile. The missile-firing solution is determined from a combination of the estimates of AOB and divisions. After selecting the number of weapons to be fired, the student fires at the contact and receives a variety of visual and sound effects based on the outcome. If the firing solution is accurate, the target ship explodes with flames and explosive sounds. If the solution is inaccurate, the missile flies to the location indicated by the student inputs and makes a sound indicating failure and the target is likely to fire back. Additional precise performance feedback is presented, and the game score is appropriately incremented or decremented.

Garris and Ahlers (2001) conducted an initial evaluation of the BOTTOM GUN trainer. First, they found that the BOTTOM GUN trainer was perceived to be more game-like by users than the control trainer. Users rated the BOTTOM GUN trainer as significantly higher in terms of game characteristics such as fantasy, curiosity, competitiveness, control, and visual and sound effects. Second, and more important, results

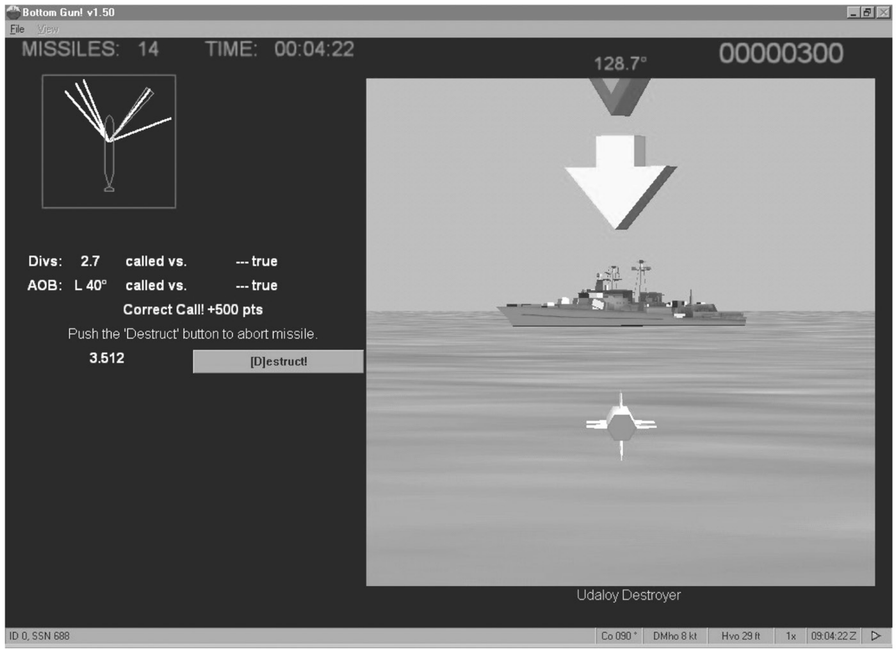

FIGURE 2: BOTTOM GUN

indicated that BOTTOM GUN provided more effective training. Students using the BOTTOM GUN trainer showed greater improvement in periscope performance, as evidenced by decreasing AOB errors, than obtained by students using the control trainer.

Discussion

We have presented an input-process-output model of instructional games and learning that highlights the process of engagement that underlies game play. We propose that specific game features can trigger a game cycle, a repeating cycle of user judgments, behavior, and feedback that characterizes the engagement that game players display. To the extent that we pair game features with appropriate instructional content and practice, we can harness these motivational forces to achieve desired learning outcomes. One advantage of this model is that instead of emphasizing single-trial performance (in which a learner reviews a workbook and is tested), we shift attention to a more dynamic process that characterizes actual game play. Moreover, we have highlighted some of the research that has examined game characteristics, user reactions, and learning outcomes.

We have characterized the game cycle as a repetitive, compulsive, or even addictive process, reflecting the manner in which users are engaged in and repeatedly return to game play. One question regarding this type of absorption in any activity is, At what point does this ardor cool? That is, game players often play a game obsessively until they are "played out" and then become enthralled in a new game. In an early meta-analysis of the effectiveness of simulation games, Dekkers and Donatti (1981) found a negative relationship between duration of training and training effectiveness. In other words, simulation games became less effective the longer the game was used (suggesting that perhaps trainees became bored over time). Although research has attempted to identify the game characteristics that initiate player engagement, we know very little about how this process is sustained over time. Does engagement in a game wane over time? At what point do games lose their appeal? What factors sustain interest over time?

A second concern is as follows: When we attempt to harness the positive aspects of games for instructional purposes, at what point do we risk violating or corrupting some of the basic principles of games—that play is free and voluntary, nonproductive, and separate from the real world? In other words, play differs from work. Caillois (1961) has claimed that a game that one is forced to play ceases to be play. Huizinga (1950) argued that the "fun element" underlies the intensity, absorption, and power of games and that play is the direct opposite of seriousness. As we adapt games for serious purposes, we must be aware of this tension between the world of play and the world of work. Thus, in one sense, the term *instructional game* is an oxymoron. Game play is voluntary, nonproductive, and separate from the real world. Instruction or training is typically nonvoluntary, undertaken to achieve certain learning outcomes, and related to life or work skills. Moreover, the instructional games that we wish to design are not merely games in which learning is a by-product of play but games that are devoted to learning. The challenge is to adapt game features for instructional purposes, to engage the game cycle that sustains self-directed interest, without squeezing out what is enjoyable about games in the first place. If we succeed, we will be able to develop games that instruct and instruction that engages the student. If we fail, we end up with games that are dull and instructional programs that do not teach.

There are a number of basic research issues that are unresolved and a number of gaps in our current knowledge of how to design and implement games for instructional purposes. First, further research is needed to examine the characteristics of games that trigger the game cycle. This is the "front end" of the model presented in Figure 1. For example, Rieber (1991) has examined the role of animated graphics in enhancing student interest, and Elliot and Harackiewicz (1994) have examined the extent to which task-specific goals influence involvement in game play. On the other hand, Simons (1993) has warned that although sound and animation may enhance game realism, they can also under certain circumstances be annoying and divert attention from learning.

Related to this issue is the problem of transfer. Certain characteristics that are present in a game-based simulation, such as those shown in Table 1, are generally not present in the real-world performance setting. To the extent that game features and events differ from the real world in which learning is to be applied, we run the risk of poor transfer. Gick and Holyoak (1980) illustrated this problem. During the learning phase of one study, students were introduced to the problem of a fortress that could be taken by means of distributing forces directed toward a focal point. After students demonstrated knowledge of this concept, they were presented with a radiation problem where the same strategy was applicable. Many students were able to find the solution and make the necessary transfer of learning—but only when given the hint that the fortress problem might be related to the radiation problem. As noted earlier, the debriefing process is critical to making the link between game activities that may take place in a fantasy world and the application of game experiences to the real world.

Furthermore, some researchers have noted that simulation games may be ineffective stand-alone training tools because people do not learn from simple exposure or experience alone to understand complex relationships (Simons, 1993). That is, people often have difficulty in abstracting general principles from concrete experiences. Winn (2000) stated that one would not

> simply turn literature students loose with [a] "Citizen Kane" videodisk without any guidance, learning would be inefficient at best and probably quite chaotic. Perhaps, like the proverbial ten thousand chimpanzees, a student might eventually hit on an acceptable notion of literature. But it is very unlikely. (Support for Basic Knowledge Construction section, para. 1)

Although our goal is to achieve self-directed, self-motivated learners, we must provide support for knowledge construction. The role of the instructor in debriefing learners is a critical (if somewhat overlooked) component in the use of instructional games, as are other learner support strategies such as online help, cues/prompts, and other activities.

A second area in which further research is needed is to examine the "back end" of the model shown in Figure 1. Lepper (1985) and others have noted that whereas games may be fun and engaging, a key question in applying gaming approaches to training is whether an increase in interest or motivation leads to greater learning. Lepper stated, "The central instructional question that follows . . . is whether such potential motivational differences have important consequences for learning or retention" (p. 14). Parker and Lepper (1992) examined the use of fantasy in instructional programs and found that learning was enhanced when content was embedded in fantasy contexts and students were more interested in the educational materials. Intuitively, we would assume that greater effort, engagement, and persistence would lead to a more positive learning outcome, yet there are clearly instances (such as when effort is directed to activities that are not congruent with instructional objectives) in which this is not the case.

Third, research is needed to examine and elaborate the game cycle in more detail than we have accomplished here. Although it is generally accepted that computer games are engaging for many people, what is fun to some people will not necessarily be fun to others. Individual differences in personality traits such as competitiveness, curiosity, or sensation seeking may be predictive of preferences for certain types of game themes or of preferences for game play itself, although research on this topic is lacking. Certainly, there are gender differences in computer usage and computer game preferences. Cassell and Jenkins (1998) noted that boys are more likely than girls to choose to play with computers and that boys show greater preference for action, adventure, and aggressive game themes. Others have examined the role of individual differences in attitudes toward computers, general computer experience, and computer proficiency on learning in computer-simulated environments (Waller, 2000).

Identifying significant mediating variables is an important step in understanding the attraction of games and the effectiveness of instruction. Analyses of training effectiveness have revealed a number of variables that mediate training outcomes. Three such attitudinal constructs are locus of control (Bar-Tal & Bar-Zohar, 1977; Kren, 1992; Reimanis, 1970; Rotter, 1992; Spector, 1982), self-efficacy (Ames, 1984; Bandura, 1977, 1986; Gist, 1988), and valence (Vroom, 1964). According to Lefcourt (1976), *locus of control* describes characteristics of individuals that correlate with their willingness and ability to take initiative to pursue desired outcomes. *Self-efficacy* determines what activities people participate in, how much effort they will put forth, and how long they will persist to overcome difficulties (Tipton & Worthington, 1984). Vroom (1964) reported that the *valence* of an activity (or the attractiveness of outcomes) plays a major role in effort expenditure. We believe that training experiences can change students in other ways than just increasing knowledge. We propose that the game cycle—the recurring judgment-behavior-feedback loops that characterize game play—can lead to changes in locus of control (the perception that outcomes are a result of one's own control), self-efficacy (perceptions of competence and mastery), and valence (the value placed on the activity). Moreover, a student that values an activity, believes he or she has the skills to achieve it, and has the capacity to control desired outcomes, is more likely to achieve educational goals. Further research is needed to establish these relationships.

A final comment addresses the learning approach inherent in this model. Dewey (1916) stated that "education is not an affair of 'telling' and being told, but an active constructive process" (p. 38). Instructional games offer the opportunity for the learner to learn by doing, to become engaged in authentic learning experiences. However, people do not always learn by doing. Sometimes we learn by observing; sometimes we learn by being told. Learners are not passive blotters at which we toss information; nor are they active sponges that absorb all they experience unaided. We must temper our enthusiasm for the gaming approach with the knowledge that instructional games must be carefully constructed to provide both an engaging first-person experience as well as appropriate learner support.

The task ahead is a difficult one. On one hand, it is fairly simple to cobble together a scoring mechanism onto an existing drill and practice lesson and call it an instructional game, but the results will be predictable. Brody (1993) described one lackluster educational game in which learning was only peripherally incorporated, noting that "learning . . . becomes important in the same way that it would if highway toll takers made everyone perform an arithmetic problem or recite a line of Shakespeare before being permitted to continue driving" (p. 55). On the other hand, recent research provides evidence of well-conducted studies of instructional game features that further our understanding of how to increase student interest and learning (cf. Cordova & Lepper, 1996). Simon (1995) has noted that

> it is imperative for progress in instructional methods that we deal simultaneously with cognition and motivation in our research. . . . We already have too much medicine that is (cognitively) good for the patient—who will not take it—and medicine that patients find delicious—but that contributes little to their cognitive abilities. (p. 508)

If we are successful in developing good instructional games, we may be able to produce a tonic that is both delicious and effective.

References

Ames, C. (1984). Achievement attributions and self-instructions under competitive and individualistic goal structures. *Journal of Educational Psychology*, *76*(3), 478-487.

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review*, *89*, 369-406.

Annett, J. (1969). *Feedback and human behavior.* Middlesex, UK: Penguin.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Bandura, A., & Wood, R. (1989). Effect of perceived controllability and performance standards on self-regulation of complex decision making. *Journal of Personality and Social Psychology*, *56*, 805-814.

Baranauskas, M., Neto, N., & Borges, M. (1999). Learning at work through a multi-user synchronous simulation game. In *Proceedings of the PEG'99 Conference, Exeter, UK* (pp. 137-144). Exeter, UK: University of Exeter.

Bar-Tal, D., & Bar-Zohar, Y. (1977). The relationship between perception of locus of control and achievement: Review and some educational implications. *Contemporary Educational Psychology*, *2*(4), 181-199.

Berlyne, D. E. (1960). *Conflict, arousal, and curiosity.* New York: McGraw-Hill.

Bredemeier, M., & Greenblat, C. (1981). The educational effectiveness of simulation games. *Simulation & Games*, *12*, 307-332.

Brody, H. (1993). Video games that teach? *Technology Review*, *96*(8), 51-57.

Caillois, R. (1961). *Man, play, and games*. New York: Free Press.

Cassell, J., & Jenkins, H. (1998). Chess for girls? Feminism and computer games. In J. Cassell & H. Jenkins (Eds.), *From Barbie to Mortal Combat: Gender and computer games* (pp. 1-17). Cambridge, MA: MIT Press.

Cohen, K. C. (1969). *The effects of two simulation games on the opinions and attitudes of selected sixth, seventh, and eight grade students*. Baltimore: Johns Hopkins University, Center for the Study of Social Organization of Schools. (ERIC Document Reproduction Service No. ED031766)

Cordova, D. I., & Lepper, M. R. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology*, *88*, 715-730.

Crookall, D. (1995). A guide to the literature on simulation/gaming. In D. Crookall & K. Arai (Eds.), *Simulation and gaming across disciplines and cultures: ISAGA at a watershed* (pp. 151-177). Thousand Oaks, CA: Sage.

Crookall, D., & Arai, K. (Eds.). (1995). *Simulation and gaming across disciplines and cultures: ISAGA at a watershed*. Thousand Oaks, CA: Sage.

Crookall, D., Greenblat, C. S., Coote, A., Klabbers, J. H. G., & Watson, D. R. (Eds.). (1987). *Simulation-gaming in the late 1980s*. Oxford, UK: Pergamon.

Crookall, D., Oxford, R. L., & Saunders, D. (1987). Towards a reconceptualization of simulation: From representation to reality. *Simulation/Games for Learning*, *17*, 147-171.

Crookall, D., & Saunders, D. (1989). Towards an integration of communication and simulation. In D. Crookall & D. Saunders (Eds.), *Communication and simulation: From two fields to one theme* (pp. 3-29). Clevedon, UK: Multilingual Matters.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal performance*. New York: Cambridge University Press.

Day, H. I. (1982). Curiosity and the interested explorer. *Performance and Instruction*, *21*, 19-22.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum.

de Felix, W., & Johnston, R. T. (1993). Learning from video games. *Computers in the Schools*, *9*, 199-233.

Dekkers, J., & Donatti, S. (1981). The interpretation of research studies on the use of simulation as an instructional strategy. *Journal of Education Research*, *74*(6), 64-79.

Dewey, J. (1916). *Democracy and education*. New York: Macmillan.

Dewey, J. (1938). *Experience and education*. New York: Macmillan.

Driskell, J. E., & Dwyer, D. (1984). Microcomputer videogame based training. *Educational Technology*, *24*(2), 11-16.

Driskell, J. E., & Johnston, J. H. (1998). Stress exposure training. In J. A. Cannon-Bowers & E. Salas (Eds.), *Making decisions under stress: Implications for individual and team training* (pp. 191-217). Washington, DC: American Psychological Association.

Druckman, D. (1995). The educational effectiveness of interactive games, In D. Crookall & K. Arai (Eds.), *Simulation and gaming across disciplines and cultures: ISAGA at a watershed* (pp. 178-187). Thousand Oaks, CA: Sage.

Duffy, T. M., & Jonassen, D. H. (1992). Constructivism: New implications for instructional technology. In T. M. Duffy & D. H. Jonassen (Eds.), *Constructivism and the technology of instruction: A conversation*. Hillsdale, NJ: Lawrence Erlbaum.

Elliot, A. J., & Harackiewicz, J. M. (1994). Goal setting, achievement orientation, and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology*, *66*, 968-980.

Gagne, R. M. (1984). Learning outcomes and their effects: Useful categories of human performance. *American Psychologist*, *39*, 377-385.

Garris, R., & Ahlers, R. (2001, December). *A game-based training model: Development, application, and evaluation*. Paper presented at the 2001 Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.

Gick, M. L., & Holyoak, K. J. (1980). Analogical problem solving. *Cognitive Psychology*, *12*, 306-355.

Gist, M. E. (1988). The influence of training method on self-efficacy and idea generation among managers. *Personnel Psychology*, *42*, 787-805.

Gopher, D., Weil, M., & Bareket, T. (1994). Transfer of skill from a computer game trainer to flight. *Human Factors*, *36*, 387-405.

Gosenpud, J., & Miesing, P. (1992). The relative influence of several factors on simulation performance. *Simulation & Gaming*, *23*, 311-325.

Gredler, M. E. (1996). Educational games and simulations: A technology in search of a (research) paradigm. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (pp. 521-540). New York: Macmillan.

Greenblat, C. S. (1981). Basic concepts and linkages. In C. S. Greenblat & R. D. Duke (Eds.), *Principles and practices of gaming-simulation* (pp. 19-24). Beverly Hills, CA: Sage.

Greenblat, C. S., & Duke, R. D. (Eds.). (1981). *Principles and practices of gaming simulation*. Beverly Hills, CA: Sage.

Hannafin, M. J., & Hooper, S. R. (1993). Learning principles. In M. Fleming & W. H. Levie (Eds.), *Instructional message design: Principles from the behavioral and cognitive sciences* (pp. 191-231). Englewood Cliffs, NJ: Educational Technology Publications.

Hannafin, R. D., & Sullivan, H. J. (1996). Preferences and learner control over amount of instruction. *Journal of Educational Psychology*, *88*, 162-173.

Hereford, J., & Winn, W. (1994). Non-speech sound in human-computer interaction: A review and design guidelines. *Journal of Educational Computing Research*, *11*, 211-233.

Huizinga, J. (1950). *Homo ludens: A study of the play-element in culture*. Boston: Beacon.
Jacobs, R., & Baum, M. (1987). Simulation and games in training and development. *Simulation & Games*, *8*, 385-394.
Kagan, J. (1972). Motives and development. *Journal of Personality and Social Psychology*, *22*, 51-66.
Keller, J. M. (1983). Motivational design of instruction. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 383-434). Hillsdale, NJ: Lawrence Erlbaum.
Kernan, M. C., & Lord, R. G. (1990). Effects of valence, expectancies, and goal-performance discrepancies in single and multiple goal environments. *Journal of Applied Psychology*, *75*, 194-203.
Kinzie, M., Sullivan, H., & Berdel, R. (1988). Learner control and achievement in science computer-assisted instruction. *Journal of Educational Psychology*, *80*(3), 299-303.
Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin*, *119*, 254-284.
Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (2000). Experiential learning theory: Previous research and new directions. In R. J. Sternberg & L. F. Zhang (Eds.), *Perspectives on cognitive, learning, and thinking styles* (pp. 227-247). Mahwah, NJ: Lawrence Erlbaum.
Kolb, D. A., Rubin, I. M., & McIntyre. J. (Eds.). (1971). *Organizational psychology: An experiential approach*. Englewood Cliffs, NJ: Prentice Hall.
Kraiger, K., Ford, J. K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. *Journal of Applied Psychology*, *78*, 311-328.
Kren, L. (1992). The moderating effects of locus of control on performance incentives and participation. *Human Relations*, *45*(9), 991-1012.
Lederman, L. C. (Ed.). (1992). Debriefing [Special issue]. *Simulation & Gaming*, *23*(2).
Lederman, L. C., & Kato, F. (1995). Debriefing the debriefing process. In D. Crookall & K. Arai (Eds.), *Simulation and gaming across disciplines and cultures: ISAGA at a watershed* (pp. 235-242). Thousand Oaks, CA: Sage.
Lefcourt, H. M. (1976). *Locus of control: Current trends in theory and research*. Hillsdale, NJ: Lawrence Erlbaum.
Lepper, M. R. (1985). Microcomputers in education—Motivational and social issues. *American Psychologist*, *40*, 1-18.
Lepper, M. R., & Chabay, R. (1985). Intrinsic motivation and instruction: Conflicting views on the role of motivational processes in computer-based education. *Educational Psychologist*, *20*(4), 217-230.
Lepper, M. R., Woolverton, M., Mumme, D. L., & Gurtner, J. (1993). Motivational techniques of expert human tutors: Lessons for the design of computer based tutors. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as cognitive tools* (pp. 75-105). Hillsdale, NJ: Lawrence Erlbaum.
Lieberman, D. A. (1997). Interactive video games for health promotion: Effects on knowledge, self-efficacy, social support, and health. In R. Street & W. Gold (Eds.), *Health promotion and interactive technology: Theoretical applications and future directions* (pp. 103-120). Mahwah, NJ: Lawrence Erlbaum.
Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting and task performance*. Englewood Cliffs, NJ: Prentice Hall.
Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin*, *116*, 75-98.
Malone, T. W. (1980). *What makes things fun to learn? A study of intrinsically motivating computer games*. Palo Alto, CA: Xerox.
Malone, T. W. (1981). What makes computer games fun? *Byte*, *6*(12), 258-277.
Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning, and instruction: Vol. 3. Conative and affective process analyses* (pp. 223-253). Hillsdale, NJ: Lawrence Erlbaum.
Mathieu, J. E., Tannenbaum, S. I., & Salas, E. (1992). Influences of individual and situational characteristics on measures of training effectiveness. *Academy of Management Journal*, *35*, 828-847.
Mayer, R. E., Mautone, P., & Prothero, W. (2002). Pictorial aids for learning by doing in a multimedia geology simulation game. *Journal of Educational Psychology*, *94*, 171-185.

Morrison, G. R., Ross, S. M., & Baldwin, W. (1992). Learner control of context and instructional support in learning elementary school mathematics. *Educational Technology Research and Development*, *40*, 5-13.
Parker, L. E., & Lepper, M. R. (1992). Effects of fantasy context on children's learning and motivation: Making learning more fun. *Journal of Personality and Social Psychology*, *62*, 625-633.
Pierfy, D. A. (1977). Comparative simulation game research. *Simulation & Games*, *8*, 255-268.
Pintrich, P. R., & Schrauben, B. (1992). Students' motivational beliefs and their cognitive engagement in classroom tasks. In D. Schunk & J. Meece (Eds.), *Student perceptions in the classroom: Causes and consequences* (pp. 149-183). Hillsdale, NJ: Lawrence Erlbaum.
Randel, J., Morris, B., Wetzel, C., & Whitehill, B. (1992). The effectiveness of games for educational purposes: A review of recent research. *Simulation & Gaming*, *23*, 261-276.
Reigeluth, C., & Schwartz, E. (1989). An instructional theory for the design of computer-based simulations. *Journal of Computer-Based Instruction*, *16*(1), 1-10.
Reimanis, G. (1970). Teacher-pupil interaction and achievement striving in the kindergarten. *Psychology in the School*, *7*, 179-183.
Ricci, K., Salas, E., & Cannon-Bowers, J. A. (1996). Do computer-based games facilitate knowledge acquisition and retention? *Military Psychology*, *8*(4), 295-307.
Rieber, L. P. (1991). Animation, incidental learning, and continuing motivation. *Journal of Educational Psychology*, *83*, 318-328.
Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research and Development*, *44*, 43-58.
Rotter, J. B. (1992). Some comments on the "cognates of personal control." *Applied and Preventive Psychology*, *1*(2), 127-129.
Schloss, P., Wisniewski, L., & Cartwright, G. (1988). The differential effect of learner control and feedback in college students' performance on CAI modules. *Journal of Educational Computing Research*, *4*(2), 141-150.
Schunk, D. H. (1990). Introduction to the special section on motivation and efficacy. *Journal of Educational Psychology*, *82*, 3-6.
Simon, H. A. (1995). The information-processing theory of mind. *American Psychologist*, *50*, 507-508.
Simon, H. A. (1996, September 6). *Observations on the sciences of science learning*. Paper presented at the Committee on Developments in the Science of Learning for the Sciences of Science Learning: An Interdisciplinary Discussion, Carnegie Mellon University, Department of Psychology, Washington, DC.
Simons, K. L. (1993). New technologies in simulation games. *Systems Dynamics Review*, *9*, 135-152.
Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology*, *85*, 571-581.
Spector, P. E. (1982). Behavior in organizations as a function of employee's locus of control. *Psychological Bulletin*, *91*(3), 482-497.
Steinberg, E. (1989). Cognition and learner control: A literature review. *Journal of Computer-Based Instruction*, *16*(4), 117-121.
Surber, J., & Leeder, J. (1988). The effect of graphic feedback on student motivation. *Journal of Computer-Based Instruction*, *15*(1), 14-17.
Terrell, D. (1990). *Strategies of computer-based instructional design: A review of guidelines and empirical research*. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
Thomas, P., & Macredie, R. (1994). Games and the design of human-computer interfaces. *Educational and Training Technology International*, *31*(2), 134-142.
Thomas, R., Cahill, J., & Santilli, L. (1997). Using an interactive computer game to increase skill and self-efficacy regarding safer sex negotiation: Field test results. *Health Education & Behavior*, *24*, 71-86.
Thornton, G. C., & Cleveland, J. N. (1990). Developing managerial talent through simulation. *American Psychologist*, *45*, 190-199.
Thurman, R. (1993). Instructional simulation from a cognitive psychology viewpoint. *Educational Technology Research & Development*, *41*(4), 75-89.
Tipton, R. M., & Worthington, E. L. (1984). The measurement of generalized self-efficacy: A study of construct validity. *Journal of Personality Assessment*, *48*(5), 545-548.

Vallerand, R. J., Fortier, M. S., & Guay, F. (1997). Self-determination and persistence in a real-life setting: Toward a motivational model of high school dropout. *Journal of Personality and Social Psychology*, *72*, 1161-1176.

Vroom, V. H. (1964). *Work and motivation*. New York: Wiley.

Waller, D. (2000). Individual differences in spatial learning from computer-simulated environments. *Journal of Experimental Psychology: Applied*, *6*, 307-321.

Wexley, K. N., & Latham, G. P. (1991). *Developing and training human resources in organizations* (2nd ed.). New York: HarperCollins.

White, B. Y. (1984). Designing computer games to help physics students understanding Newton's laws of motion. *Cognition & Instruction*, *1*, 69-108.

Whitehall, B., & McDonald, B. (1993). Improving learning persistence of military personnel by enhancing motivation in a technical training program. *Simulation & Gaming*, *24*, 294-313.

Wiebe, J. H., & Martin, N. J. (1994). The impact of a computer-based adventure game on achievement and attitudes in geography. *Journal of Computing in Childhood Education*, *5*, 61-71.

Winn, W. (2000). *Learning in hyperspace*. Retrieved from http://healthlinks.washington.edu/iaims/ideal/webpaper.html

Wishart, J. (1990). Cognitive factors related to user involvement with computers and their effects upon learning from an educational computer game. *Computers in Education*, *15*, 145-150.

Witmer, B. G., & Singer, M. J. (1994). *Measuring immersion in virtual environments* (Technical Rep. 1014). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Wittgenstein, L. (1953). *Philosophical investigations*. New York: Macmillan.

Wittgenstein, L. (1958). *The blue and brown books*. New York: Harper & Row.

Wolters, C. A. (1998). Self-regulated learning and college-students' regulation of motivation. *Journal of Educational Psychology*, *90*, 224-235.

Wood, L. E., & Stewart, P. W. (1987). Improvement of practical reasoning skills with a computer game. *Journal of Computer-Based Instruction*, *14*, 49-53.

Young, K. S. (1996, August). *Internet addiction: The emergence of a new clinical disorder.* Paper presented at the 104th annual meeting of the American Psychological Association, Toronto, Canada.

Rosemary Garris is a research psychologist with the Science and Technology Division of the Naval Air Warfare Center Training Systems Division. She has directed and executed training research and developed trainer design specifications for several submarine operator and team trainers, including many of the Submarine Skills-Training Network (SubSkillsNet) products. She currently leads a team that is designing and developing virtual tour capabilities to provide spatial orientation to sailors prior to their reporting aboard. In addition, she leads a team that investigates the motivational aspects and training effectiveness of game characteristics. She graduated from Stetson University with a B.A. degree in liberal arts (psychology) and from the University of Central Florida with an M.S. degree in industrial/organizational psychology.

Robert Ahlers is a research psychologist with the Science and Technology Division of the Naval Air Warfare Center Training Systems Division. He has managed research projects concerned with the application of knowledge-based modeling to the simulation of intelligent agents within a training environment. He currently leads an interdisciplinary team that is developing Windows 95, 98, and NT training simulations for use onboard submarines (SubSkillsNet). He is interested in matching emerging software and hardware technologies to training requirements. He is additionally engaged in research to develop advanced techniques for designing computer-based instruction that is intrinsically motivating. He graduated from the University of Virginia with B.A. and M.A. degrees in experimental psychology and from North Carolina State with a PhD in human factors.

James E. Driskell is president and senior scientist of Florida Maxima Corporation and adjunct professor of psychology at Rollins College, Winter Park, Florida. He has conducted research on training and human performance for the National Science Foundation, NASA, National Institutes of Health, Federal Aviation

Administration, Army Research Institute, Naval Training Systems Center, and other organizations. Current research interests include the examination of team performance in technology-mediated environments. He received his PhD from the University of South Carolina.

ADDRESSES: RG: Naval Air Warfare Training Systems Center, Code 4961, 12350 Research Parkway, Orlando, FL 32826, USA; telephone: +1 407-380-4833; e-mail: rosemary.garris@navy.mil. RA: Naval Air Warfare Training Systems Center, Code 4961, 12350 Research Parkway, Orlando, FL 32826, USA; telephone: +1 407-380-4833; e-mail: robert.ahlers@navy.mil. JED: Florida Maxima Corporation, 507 North New York Avenue, R-1, Winter Park, FL 32789, USA; telephone: +1 407-647-8021; e-mail: james.driskell@rollins.edu.