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THE EFFECTIVENESS OF INSTRUCTIONAL GAMES: A LITERATURE REVIEW AND DISCUSSION

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13. ABSTRACT *(Maximum 200 words)*
This report documents a review of 48 empirical research articles on the effectiveness of instructional games. It also includes summaries of 26 other review articles and 31 theoretical articles on instructional gaming. Based on this review the following 5 conclusions and 4 recommendations are provided. Conclusions: (1) The empirical research on the instructional effectiveness of games is fragmented, filled with ill defined terms, and plagued with methodological flaws. (2) Some games provide effective instruction for some tasks some of the time, but these results may not be generalizable to other games or instructional programs. (3) No evidence indicates that games are the preferred instructional method in all situations. (4) Instructional games are more effective if they are embedded in instructional programs that include debriefing and feedback. (5) Instructional support during play increases the effectiveness of instructional games. Recommendations: (1) The decision to use a game for instruction should be based on a detailed analysis of learning requirements and tradeoffs among alternate instructional approaches. (2) Program managers and procurement officials should insist that instructional game developers demonstrate how their game will support instructional objectives. (3) Games should be used as adjuncts and aids, not as stand-alone instruction. (4) Instructor-less approaches (e.g., web-based instruction) must include all "instructor functions."

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EXECUTIVE SUMMARY

PROBLEM

The Navy, DoD, and private industry need new, innovative and effective instructional methods and media to ensure that personnel have the necessary skills to perform in today's high technology, rapidly changing environment. There is a growing advocacy for the use of instructional games as a primary delivery medium for this required instruction. However, the decision to use instructional games is often made on the basis of "leaps of faith" rather than empirical data on the effectiveness of instructional games.

OBJECTIVE

The objective of this effort was twofold:

- To conduct a review of the literature on instructional games with a focus on the empirical research on the instructional effectiveness of games.
- To document conclusions and recommendations from this literature review.

APPROACH

This effort proceeded through the following steps:

- Researchers in the field of instructional games were contacted to obtain literature reviews either published or in progress.
- The Internet was searched to obtain additional documents.
- Review articles were read to identify empirical research articles.
- Articles that documented empirical data on the instructional effectiveness of games were obtained.
- The empirical articles were read and summarized.
- The empirical data were used to draw conclusions and recommendations about the design and use of games as instructional media.

RESULTS

Two hundred and seventy-four documents on the design, use, and evaluation of games were reviewed. Of these, 169 could not be used:

- 77 of these articles were not used because they only provided the author's opinion on the potential of instructional games
- 11 articles were on game design and analysis
- 29 articles were simulation studies (not games)
- 14 articles were computer-based instruction studies (not games)
- 36 articles documented studies with major methodological problems, and
- 2 were proposals for future research.

One hundred and five articles are documented in this report. These included:

- 26 review articles

- 31 theoretical articles, and
- 48 articles that provided empirical data on the effectiveness of instructional games.

CONCLUSIONS AND RECOMMENDATIONS

This review of empirical research on the effectiveness of instructional games leads to the following five conclusions and four recommendations. The conclusions are:

- The empirical research on the effectiveness of instructional games is fragmented. The literature includes research on different tasks, age groups, and types of games. The research literature is also filled with ill defined terms, and plagued with methodological flaws.
- Although research has shown that some games can provide effective learning for a variety of learners for several different tasks (e.g., math, attitudes, electronics, and economics), this does not tell us whether to use a game for our specific instructional task. We should not generalize from research on the effectiveness of one game in one learning area for one group of learners to all games in all learning areas for all learners.
- There is no evidence to indicate that games are the preferred instructional method in all situations.
- Instructional games should be embedded in instructional programs that include debriefing and feedback so the learners understand what happened in the game and how these events support the instructional objectives.
- Instructional support to help learners understand how to use the game increases the instructional effectiveness of the gaming experience by allowing learners to focus on the instructional information rather than the requirements of the game.

The following four recommendations may help the instructional gaming industry produce more instructionally effective games.

- The decision to use a game should be based on a detailed analysis of the learning requirements and an analysis of the tradeoffs among alternate instructional approaches.
- Program managers and procurement personnel should insist that game developers clearly demonstrate how the design of a game will provide interactive experiences that support properly designed instructional objectives (see for example, Gagné & Briggs, 1979; Merrill, 1983; 1997 for guidance on the proper design of instructional objectives).
- Instructors should view instructional games as adjuncts and aids to help support instructional objectives. Learners should be provided with debriefing and feedback that clearly explains how their experiences with the game help them meet these instructional objectives.
- Instructor-less approaches (e.g., web-based instruction) must include all "instructor functions." These include performance evaluation, debriefing, and feedback.

TABLE OF CONTENTS

Table of Contents
(Continued)

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

PROBLEM

Recently there has been increased interest in the use of instructional games. It has been argued that young people, raised playing video games, have changed in ways that turn them off to conventional instruction (Prensky, 2001, p. 01-6). It has also been suggested that instructional games, because of their applied and dynamic nature, can heighten the learner's motivation and interest more effectively than classroom lectures (Greenblat, 1981, p. 147). Another suggested benefit of instructional games is that they may improve the retention of learned skills and knowledge (Pierfy, 1977).

Unfortunately, many decisions about whether to use games for instruction are based on unfounded assumptions about the ability of games to provide effective and efficient instruction. This problem was stated by a senior naval officer as follows. "Lack of quantifiable metrics or data to validate use of gaming technology as an effective delivery media [*sic*] for various training solutions has relegated decisions of the same to being 'leaps of faith' vice based on solid business case solutions" (M. K. Gritton, personal communication, September 26, 2005).

OBJECTIVE

The objective of this report is to provide a review and discussion of empirical research on the effectiveness of instructional games. Based on this review, a series of conclusions and recommendations are provided.

ORGANIZATION OF THE REPORT

This report contains six sections. Following the introduction, the second section summarizes a variety of descriptions and classifications of games. The third section discusses how games are not always used for instructional purposes, but how the characteristics of games (e.g., challenge, rules, and context) can motivate learners. The fourth section provides summaries of review articles on the effectiveness of various games and empirical articles on the effectiveness of specific games. The fifth section summarizes the empirical research and compares what we know about instructional games today with several "claims" made about instructional games twenty-five years ago. Finally, a series of conclusions and recommendations are provided in the final section, followed by a complete reference list.

CONFUSION IN TERMS

Certainly, it can be argued that games can attract and hold an individual's attention. It is less certain that they always provide instructional value. Before discussing the research on instructional games, it is important to distinguish games from other instructional activities. In the literature on instructional games, we often find the terms simulations, games, simulation-games, and computer games used interchangeably (e.g., Greenblat & Duke, 1981; Reiber, 1996; Thomas, Cahill & Santilli, 1997). Greenblat (1981) observed that "in many studies, 'games' and 'simulations' are at least implicitly treated as homogeneous" (p. 181). Although aware of the problem, even Greenblat used the term simulation in one sentence and the term game in the next sentence to describe the same thing (p. 144).

All simulations are based on models of reality. A *model* can be defined as "a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process (Department of Defense, 1997, p. 138). A *simulation* is "a method for implementing a model over time" (p. 160). Thus, a model provides the rules and data that are used to represent some portion of reality. Then, a simulation uses these rules and data to dynamically represent these aspects of reality for some purpose. A specific type of simulation is sometimes called a *microworld* (e.g., Miller, Lehman, & Koedinger, 1999). Microworlds are simulations that attempt to capture the relevant aspects of some topic or phenomena so learners can interact within it to observe the effects of their interactions. For our purposes, microworlds will be referred to as simulations unless there is a reason to make a distinction between the two terms. Simulations can incorporate aspects of games (e.g., competition, rules, rewards, etc.) or be used as games, but only if the simulation includes these game aspects, should it be called a simulation game.

One of the purposes of simulations can be to provide instruction, but only if they are designed to do so. For example, Simons (1993) believes that "the educational value of a simulation comes with repeated simulation of a model" (p. 137). In this type of application, the learner is able to try various policies or parameters and observe the results. Through this closed-loop process, the learner gradually builds an understanding of the simulated system. This is a powerful instructional benefit of simulation games. Unfortunately, most of these games do not meet their potential. Simons explains that simulation games are ineffective because they do not "directly communicate their underlying models and the reasons for those models' behaviors" (p. 148). One might rephrase this in instructional terms—the simulation game is ineffective because it does not directly address instructional objectives and does not ensure that the learner has met those objectives.

Not every game is intended to be used for instruction. Most games are intended for enjoyment. Just putting a game in a course does not ensure that it will facilitate the learning of the intended knowledge or skill. Games can be designed for instruction, but only if they are designed to support specific instructional objectives and are incorporated logically into an instructional program. Before elaborating on this point, it is useful to discuss the various types of games and the characteristics that make them games.

DESCRIPTIONS AND CLASSIFICATIONS OF GAMES

Some authors (e.g., de Felix & Johnson, 1993) described games by listing their structural components, such as dynamic visuals, interaction, rules, and goals. Others (e.g., Gredler, 1996) stated that the essential elements of a game are the task, the player's role, the multiple paths to the goal, and the degree of player control. Baranauskas, Neto, and Borges (1999) stated that the essence of gaming is challenge and risk.

Csikszentmihalyi (1990) discussed how Roger Caillois (1958/2001), the French psychological anthropologist, classified games into four broad classes based on the kind of experiences they provide.

1. *Agnostic games* are those that have competition as their main feature (e.g., sports and athletic events). These types of games stretch the player's skills to meet the challenge provided by the skills of their opponents.
2. *Aleatory games* are games that involve the element of chance (e.g., dice or bingo). These games give the illusion that the player somehow controls the inscrutable future.
3. *Vertigo or Ilinix games* are activities that alter one's consciousness by scrambling ordinary perception. Examples are riding a merry-go-round, skydiving, or young children turning around in circles until they are dizzy.
4. *Mimicry games* allow the player to create alternative realities (e.g., dance, theater, and the arts in general). These games make one feel as though they are more than they actually are through fantasy, pretence, and disguise. Caillois (1958/2001) uses the term simulation as a synonym for mimicry (p. 36).

Any given game may include some or all of these experiences, but it is usually designed to only provide a subset of these experiences. Furthermore, games are played with a variety of media, from game boards to networked computers. It is not the medium on which the game is played, but its characteristics that make it a game. One of the most important of these characteristics is the specificity of the game's rules. Caillois (1958/2001) discussed the issue of rules by defining a continuum anchored by the terms *paidia* and *ludus*. He defined *paidia* as "the spontaneous manifestations of the play instinct" (pp. 27-28). Games at the *paidia* end of the continuum have few or no rules and are played for shear joy. At the other end of the continuum we find *ludus*, which "is complementary to and a refinement of *paidia*, which it disciplines and enriches" (p. 29). *Ludus* refers to games with rules and requirements for play. The more a game is bounded by specific rules, the closer it falls toward the *ludus* end of the continuum. For example the *paidia* feelings found in *illinix* (vertigo) games are challenged and constrained by the rules and skills required in mountain climbing or tightrope walking.

The "Folk Model" divides games into 4 (non-exclusive) categories: games of skill, games of chance, games of strategy, and simulation games (Wikipedia, 2005).

1. <u>Games of skill</u> include: board games, card games, letter games, mathematical games, puzzle games, guessing games, word games, games of physical skill, and instructional games.
2. <u>Games of chance</u> include: dice games, card games, casino games, lottery-type games, Bingo, and Piñata.

3. Games of strategy include: Checkers, Chess, Go, and Mastermind.
4. Simulation games include: role-playing games, board games like Monopoly, and computer and video games.

Björk and Holopainen (2003) describe games in terms of four overlapping conceptual groups.

1. The overall activity of the game. This is how the players understand the meaning of the activity and how the activity unfolds. Sub components of activities include:
    - The game instance, which is the specific players, their experience, and the location and requirements of a single completion of a game.
    - The game session, which is the activity defined by the time spent on playing a game instance.
2. The boundary components of the game. These include the rules, modes of play, and goals of the game.
3. The temporal components of the game. These are used to record the activity of playing the game. They include discrete actions (e.g., moving a chess piece) or continuous actions (e.g., driving a racing car). Temporal components include:
    - Events, which are discrete points in the game where the game state changes. Events usually occur as the result of player actions, but can also be the result of trigger events such as elapsed time.
    - Closures are a change of game state resulting from completion of a goal or subgoal.
    - End conditions, which specify when a closure occurs.
    - Evaluation functions, which determine the outcome of an event.
4. The objective components of the game, such as the types of players, the game interface, and the physical and logical components that inform players about the current game state (e.g., tokens that represent which player is currently in control or physical elements that describe the game space like chess squares).

Leemkvil, de Jong, and Ootes (2000) and Bright and Harvey (1984) discussed several characteristics of games. According to these authors, all games include:

- Voluntary Play. A game is freely engaged in. Persons normally play games because they want to, not because it is required.
- Some goal state that must be reached. The goal state may be the same each time a game is played or it can change over time. The goal may also consist of subgoals that may change during play (e.g., when a player reaches a certain proficiency and moves to a higher difficulty level). Players can sometimes set their own goals.
- Constraints and rules. These define which actions are allowed and which are not. They also define the setting and goals of the game. Certain actions may introduce additional constraints, often defined by if-then statements (e.g., If a player misses a target three times, then he or she must complete a practice session and achieve a criterion score before the game can continue). Constraints are sometimes induced by setting time limits on certain actions.
- Competition. Players can compete in several ways:
    - With other players or teams by beating them to a goal or outperforming them by achieving a higher score.
    - With the system (e.g., by moving to higher difficulty levels).

  - o With themselves (e.g., by improving their performance).
- A specific context. A game is always situated in a specific context that makes it more or less realistic, appealing, or motivating to the players. This context is *separate from real life* in terms of time and space. Leemkvil et al. quote Graham and Grey concerning how game players must place themselves into the situated game context. "In one sense all gaming involves role playing since the individual participants are asked to assume the situation assigned" (Leemkvil, et al., 2000, p. 15 citing Graham and Grey).

Dorn (1989) defines a game as "any contest or play among adversaries or players operating under constraints or rules for an objective goal" (p. 2). He defines a simulation as "an operating representation of central features of reality" (p. 2). He then defines a simulation game as "activities undertaken by players whose actions are constrained by a set of explicit rules particular to that game and by a predetermined end point. The elements of the game constitute a more or less accurate representation or model of some external reality with which players interact by playing roles in much the same way as they would interact with reality itself" (p. 3).

A Game Designer's Definition of a Game. Greg Costikyan is a game designer and commentator on gaming. He defines a game as "an interactive structure of endogenous meaning that requires players to struggle toward a goal" (Costikyan, 2002, p. 22). Let us look at each of these components in greater detail. Costikyan maintains that a game's structure is the rules, components, and other characteristics (e.g., delivery medium) that define the way people play the game. He states that this structure is interactive because the game changes based upon the actions of the players. This structure also provides the meaning of the game. Thus, a game's meaning is endogenous—it is created by the internal structure of the game and has no meaning outside of the game. Furthermore, the game's endogenous meaning defines the goals which game players attempt to achieve. Finally, players must struggle to achieve the goals of a game. In this sense, struggle means that the players must work to achieve the goals. A good game challenges the players, often allowing them to move to greater levels of difficulty as they become more skilled at the game.

HYBRID GAMES

As discussed above, the terms game and simulation are often confused. Leemkvil, et al. (2000) discuss the relationships among games, simulations, and case studies. Figure 1 illustrates these relationships. As defined above, a simulation is "a method for implementing a model over time" (Department of Defense, 1997, p. 138). A case study is an actual or hypothetical problem situation taken from the real world. As illustrated in Figure 1, games, simulations, or case studies can be found in a pure form or as hybrids with the others. In the literature on games, the simulation game is the most often encountered hybrid.

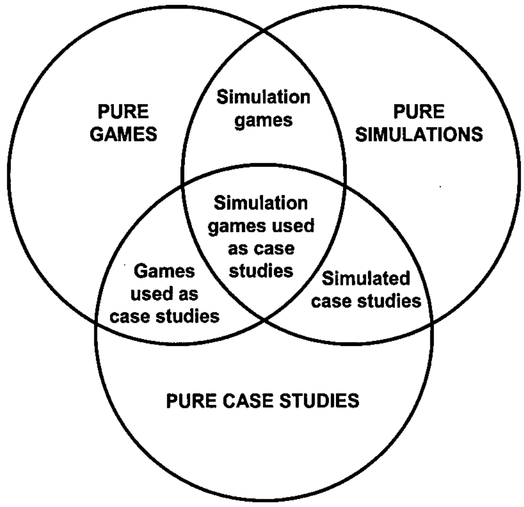

Figure 1:
Relationship among Games, Simulations and Case Studies

ELEMENTS OF ENJOYMENT

One of the aspects that attract people to games is that they are enjoyable. Csikszetmihalyi (1990) has studied many enjoyable activities, including games. He argued that there are several elements (components) that make an activity enjoyable.

- A challenging activity that requires skills. Individuals report that they enjoy activities that challenge their skills. "...the overwhelming proportion of optimal experiences are reported to occur within sequences of activities that are goal-directed and bounded by rules—activities that require the investment of psychic energy, and that could not be done without the appropriate skills" (p. 49). Csikszetmihalyi goes on to explain that "an 'activity' need not be active in the physical sense and the 'skill' necessary to engage in it need not be a physical skill" (p. 49). What is necessary is that the individual directs his or her attention (psychic energy) to the task and applies skills to accomplish it. One of the aspects of games that offer challenge is competition. However, "competition is enjoyable when it is a means to perfect one's skills; when it becomes an end in itself, it ceases to be fun" (p. 50).
- The merging of action and awareness. Another element of enjoyment is when one "loses" oneself in the activity. "People become so involved in what they are doing that the activity becomes spontaneous, almost automatic; they stop being aware of themselves as separate from the actions they are performing" (p. 53). This merging of an individual's action and activity is why Csikszetmihalyi calls an optimal experience "flow." "The short and simple word describes well the sense of seemingly effortless movement" (p. 54).

- Clear goals and feedback. "The reason it is possible to achieve such complete involvement in a flow experience is that goals are usually clear, and feedback immediate" (p. 54). This is another important feature of games. It is usually clear if a goal has been made or a target hit. One does not have to wonder if they performed correctly, the game provides immediate feedback.
- Paradox of control. Enjoyable experiences involve a sense of control—or, "more precisely, as lacking the sense of worry about losing control that is typical in many situations of normal life" (p. 59). "What people enjoy is not the sense of *being* in control, but the sense of *exercising* control in difficult situations...Only when a doubtful outcome is at stake, and one is able to influence that outcome, can a person really know whether she is in control" (p. 61, author's emphasis).
- The loss of self-consciousness. Because attention is so focused, because the activity is so engrossing, "there is not enough attention left over to allow a person to consider either the past or the future, or any other temporarily irrelevant stimuli" (p. 62). When enjoying an activity, like a game, one of the items that disappears from awareness is our thinking about our own self. Loss of self-consciousness "does not involve a loss *of* self, and certainly not a loss of consciousness, but rather, only a loss of consciousness of the self" (p. 64, author's emphasis).
- The transformation of time. In an enjoyable activity, "time no longer seems to pass the way it ordinarily does" (p. 66). One second can seem to stretch out for minutes or conversely an hour can seem like only a few minutes.
- The Autelic (intrinsically rewarding) experience. An enjoyable activity is intrinsically rewarding. The word autelic derives from two Greek words, *auto* meaning self and *telos* meaning goal. "It refers to a self-contained activity, one that is done not with the expectation of some future benefit, but simply because the doing itself is the reward" (p. 67).

WORKING DEFINITION OF A GAME

Based on the above definitions and for the purposes of this paper, the following working definition of game will be used.

> *A game is an artificially constructed, competitive activity with a specific goal, a set of rules and constraints that is located in a specific context.*

A game is not reality. It is a constructed activity that resembles portions of reality. It provides a competitive environment for a player by challenging him or her to reach a goal. The purpose of the game (e.g., enjoyment, information, instruction, etc.) helps define the goals, rules, and context of the game.

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INSTRUCTIONAL USES OF GAMES

Most definitions of games, including the working definition above do not include any reference to instruction. Most games are played because they provide enjoyment, not because the player wants to learn something. However, *instruction is a specific type of interaction.* It is an interactive dialogue between the learner and the instructional material (Jacobs & Dempsey, 1993). The control of the learning experience is an essential feature of instruction. Without this control, we cannot be sure that the student learned what is required from a given instructional product. Instruction, as a minimum, must include the following four elements. First, instruction must be designed to support specific instructional objectives, which are determined by job requirements. Second, instruction must include the opportunity for a learner to interact with the instructional content in a meaningful way. Third, the student's performance must be assessed to determine if he or she has learned what was intended. Finally, the results of the assessment must be presented to the student in a relevant and timely manner to either reinforce correct actions or to provide remediation for incorrect actions. If these four elements are not present, we are not dealing with instruction.

Games can be used as instructional activities or some of the aspects of games can be incorporated into other instructional activities to make them more enjoyable for the learner (Garris, Ahlers, & Driskell, 2002). For example, Parker and Lepper (1992) found that learners preferred educational programs that included fantasy elements. They also found that learners showed greater learning and retention in the fantasy conditions when compared to activities without fantasy elements.

Hays and Singer (1989) discussed several ways that games could be used for instruction. They observed that potentially, games can:

- Be used to assess entry level performance
- Measure criterion performance
- Aid in formative and summative evaluations of instructional approaches and programs
- Provide instructional information on specific knowledge and skills
- Help change attitudes
- Serve as advance organizers prior to other forms of instruction
- Replace alternate forms of instruction to transmit facts, teach skills, and provide insights
- Serve as a means for drill and practice
- Help integrate and maintain skills
- Illustrate the dynamics or abstract principles of a task

Based on their review of several studies of motivating computer games, Malone (1981) and Malone and Lepper (1987) provide a framework for designing intrinsically motivating instructional environments. Many of these design heuristics can be used to help design motivational instructional activities other than games. However, they are most relevant for the design of instructional games. Table 1 provides brief descriptions of these motivational heuristics. The reader should consult the original articles for additional details.

Table 1: Design Heuristics for Motivating Instructional Environments

INDIVIDUAL MOTIVATIONS	**Challenge**	Goals: (a) clear, fixed goals; or (b) ability for learners to generate goals for themselves
		Uncertain Outcomes: (a) variable difficulty; (b) multiple levels of goals; (c) hidden information, selectively revealed; and (d) randomness
		Performance Feedback: frequent, clear, constructive, and encouraging
		Self-Esteem: (a) gradually increasing difficulty levels to promote feelings of competence; (b) goals that are meaningful to the learner
	Curiosity	Sensory Curiosity: may be promoted using variable audio & visual effects
		Cognitive Curiosity: may be promoted by: (a) using surprise, paradoxes, incompleteness; and (b) using activities that contain topics in which the learner is already interested
	Control	Contingency: learning environment should be responsive to learner actions
		Choice: activities should provide learner with choice over various aspects of the learning environment (e.g., narration or full text)
		Power: activity should allow learner to produce powerful effects
	Fantasy	Emotional aspects: appeal to the emotional needs of learners
		Cognitive Aspects: use appropriate metaphors or analogies for the material to be learned
		Endogeneity: fantasies should have an integral (endogenous) relationship to the material to be learned
INTERPERSONAL MOTIVATIONS	Cooperation: design some activities to promote cooperation among learners	
	Competition: design some activities to require learners to compete with one another (e.g., actions affect each other)	
	Recognition: learners' efforts should receive social recognition so they are appreciated by others	

As should be apparent from the above discussions, it is difficult to distinguish games from other instructional activities that incorporate game elements. Nevertheless, there have been many efforts that have tried to evaluate the effectiveness of instructional games. The next sections summarize some of the research on the instructional effectiveness of games.

RESEARCH ON INSTRUCTIONAL GAMES

There have been many articles written and published on the use of instructional games. Most of this literature is based on the writers' opinions about the potential of instructional games (e.g., Driskell & Dwyer, 1984; Rieber, Smith, & Noah, 1998) and the questions that must be answered about how games will be developed to make them instructionally sound (e.g., Oblinger, 2004). Far fewer articles have documented the empirical data on the effectiveness of instructional games. The following sections provide summaries of the results of some of these empirical research efforts. The first section summarizes the results of review articles, which attempted to draw general conclusions about the effectiveness of instructional games from collections of research efforts. Other review articles are not summarized, but were used to locate original articles on research efforts (e.g., Dempsey, Rasmussen, & Lucassen, 1996; Hogle, 1996; Leemkuil, do Jong, & Ootes, 2000). Subsequent sections provide summaries of individual research efforts that have evaluated specific instructional games for different types of learners (e.g., school children, college students, or military trainees) and for different types of learning tasks (e.g., factual information, technical skills, etc.). These summaries focus on the effects of each game on learner performance and also, where possible, describe the characteristics of the games used in the studies. Where the information is available, the summaries include how the game was used in a given instructional program.

REVIEW ARTICLES ON THE EFFECTIVENESS OF INSTRUCTIONAL GAMES

Simulation games have been used extensively in sociology and social science courses. Pierfy (1977) concluded from a review of 22 research studies that "in terms of fostering student learning, simulation games are no more effective than conventional classroom instruction" (p. 266). However, he did find that some research indicated that the use of games might improve the retention of learned information. Dorn (1989) also reviewed the use of simulation games in this area. He maintained that simulation games are based on the model of experiential learning. In this model, learners first act in a particular instance of application. In the second stage, they attempt to understand the effects of their behaviors and decisions in the particular instance. Thirdly, they seek to understand the general principles under which that instance falls. Finally, they apply the principles to new circumstances so that the learning is useful to their future behavior.

Dorn (1989) found mixed results from his review. He observed that there are consistent results that show that games generate interest and motivation in learners. This does not automatically produce greater interest in the subject matter or in learning in general. He cited some research that showed that simulation games did not increase learners' interest in comparison to other active learning techniques like case studies. However, in general, he found that games appear to be as effective as other techniques for teaching factual information, principles, and concepts.

Dorn observed that the results of research that evaluated the ability of simulation games to affect attitudes are confusing and contradictory. Although games appear to change attitudes, this does not occur every time a game is played. Furthermore, some games have been shown to increase positive attitudes and others resulted in an increase in negative attitudes.

To meet instructional goals, Dorn maintained that simulation games must be designed and used properly. Instructional games should:

- Be selected to accomplish particular goals and should be supplemented with discussions, lectures, and other instructional methods.
- Not be inserted into a course as random events. Rather they should be designed to meet specific instructional purposes.
- Include debriefing after the game. Debriefing is crucial and should be more than a simple recounting of the game. It should be a structured, guided, activity that brings meaning to the experience and fosters learning from that meaning.

In 1981, after reviewing books, articles, newsletters, and advertisements about simulation games, Cathy Stein Greenblat listed the claims made in support of their use. These claims were divided into 6 categories: (1) motivation and interest, (2) cognitive learning, (3) changes in later course work, (4) affective learning concerning the subject matter, (5) general affective learning, and (6) changes in the classroom structure and relations. She then summarized the available data in support of these claims.

The strongest empirical support was for the claims that games improve learner motivation and interest (category 1). However, Greenblat observed that most of the discussions concerning the heightened motivation provided by games were supported by anecdotal evidence. There were some data to support the claims in category 2 (cognitive learning), but these data were weak. She found no evidence to support the claims in category 3 (changes in later course work) and little data on the claims in category 6 (changes in the classroom). Some evidence indicated that learners' attitudes about the subject matter (category 4) could be changed through the use of games. However, sometimes these attitudes changed in the *opposite* direction to that which was desired by the game designers. There was even less evidence in support of general affective changes (category 5). Her conclusion was that "there is, at the moment, little hard data to show that such participation leads to greater interest in the subject matter, the course, or learning in general" (Greenblat, 1981, p. 149).

Bredemeir and Greenblat (1981) attempted to synthesize the findings on the educational effectiveness of simulation games available at that time. They found *little hard evidence* on the effectiveness of these games except for some support that games result in increased retention of material. However, like many other reviewers, they concluded that simulation games "are at least as effective as other methods in facilitating subject matter learning" (p. 165). However, their overall conclusions were that "we do not yet have (1) a theoretically based taxonomy of games with (2) clear theories about (a) what aspects of them are expected to have (b) what sorts of distinct effects (c) on what sorts of students (d) for what reasons" (p. 169).

VanSickle (1986) conducted a quantitative analysis of simulation gaming compared to other instructional procedures. He concluded that there was *weak support* for simulation gaming over other approaches (primarily classroom lecture). This conclusion is suspect for several reasons. First, he did not describe the characteristics of the simulation games used in his analysis. Furthermore, six of the twenty-two studies did not compare learners who participated in simulation games with other forms of instruction. Finally, he applied several mathematical transformations to the data prior to drawing his conclusions (e.g., converted means and standard deviations to effect sizes, then averaged these). These transformations may have introduced errors into his results. Even without these cautions, his results only showed a moderate advantage of simulation games. When looking at the specific studies in terms of learner performance:

- only 5 findings favored simulation gaming and 13 findings showed no differential impact on immediate recall of knowledge; and
- only 2 findings favored simulation gaming and 15 findings showed no significant differences on retention of knowledge.

Thus, from this review, it is not possible to conclude that simulation gaming is the preferred instructional approach.

Randel, Morris, Wetzel, and Whitehill (1992) reviewed 68 studies that compared the instructional effectiveness of games to conventional classroom instruction. These studies covered a 28-year span of time. Of the 68 studies, 38 showed no differences between games and conventional instruction; 22 favored games (5 additional studies favored games, but their controls were questionable); and 3 favored classroom instruction. The studies were used to provide instruction in social sciences, math, language arts, logic, physics, and biology. Math was the subject area with the greatest percentage of results favoring games. The review also indicated that games resulted in greater retention of the learned information. The authors reached several conclusions based upon their review:

- "That only 68 studies were reported in 28 years reflects a trend to use descriptive reports rather than empirical studies comparing games with classroom instruction" (Randel, et al., 1992, p. 269).
- A consistent finding is that games are rated as more interesting than conventional instruction.
- Careful consideration should be given to the measures used to demonstrate the effects of games. "If the test for effectiveness does not match what the game is teaching, negative results will occur" (p. 271).
- The experimental designs used to evaluate games need to be more rigorous. Reliability and validity are often not reported. Random sampling is often not used. Experimental designs need to reduce confounding variables such as, Hawthorne effect, teacher bias, selection effects, and time differences for treatments.

Dempsey, Lucassen, Gilley, and Rasmussen (1993-1994) conducted a review of the gaming literature. They collected 51 journal articles based on the results of electronic searches (e.g., ERIC, PSYCHLIT). Most of the articles were discussions (n = 28). A smaller number summarized research efforts (n = 16). The remainder were theoretical discussions and reviews (n=4) or descriptions of how a given game was designed or developed (n=3). In terms of the types of games described, simulation games accounted for the largest number of articles (n = 30). Puzzle and adventure games were described in only 3 articles. They also tallied the types of learning outcomes and the functions of the games described in the articles. Table 2 shows the frequency of articles for each type of game function reported. Table 3 shows the frequency of articles by type of the learning outcome sought through using the game.

Table 2:
Percentage of Articles by Game Function from Dempsey, et al. (1993-1994)

Function of Game	Percentage of Articles
Learn New Skills	23%
Practice Existing Skills	21%
Not Able to Determine	14%
Change Attitudes	11%
Other	11%
Drill Existing Skills	9%
Tutor	6%
Promote Self-Esteem	3%
Amuse	2%

Table 3:
Percentage of Articles by Learning Outcomes from Dempsey, et al. (1993-1994)

Learning Outcomes	Percentage of Articles
Problem Solving	23%
Not Able to Determine	21%
Attitude	13%
Verbal Information	10%
Cognitive Strategy	9%
Concrete Concept	9%
Rules	7%
Other	4%
Defined Concept	3%

A few interesting observations can be made from looking at these frequency data. Table 2 shows that most games are used to teach new skills or to practice existing skills. The next highest percentage of game functions is "not able to determine." This is a problem with the way gaming research is presented. In the opinion of this author, if one wishes to publish the results of research, he or she should ensure that enough information is provided so the reader can fully understand the intent and results of the research. The function of the instructional game is certainly an important item of information if we wish to base future decisions on the results of the research.

In terms of the learning outcome of the games (Table 3) they found that the largest number sought to help learners in problem solving (23%), followed by attitudes (13%) and verbal information (10%). Again an unfortunate result is that like game functions, a similar informational gap was found in the literature on learning outcomes. The second most frequent percentage that Dempsey, et al. (1993-1994) found when looking for learning outcomes is "not able to determine" (21%). If future instructional game designers and developers are to benefit from previous research, the research must be documented in a manner that will provide all the necessary information.

Lee (1999) conducted a meta-analysis on instructional simulations (his term). Nineteen studies met the criteria for inclusion in the analysis. Three modes of simulations were identified:

- *presentations*: simulations used to supplement expository instruction
- *practice*: used to provide learners with a large number of examples and guidance for interaction with the material to be learned
- *hybrids*: combinations of the other two modes

Lee found many methodological problems and confounding variables that make it difficult to draw firm conclusions about the effectiveness of the instructional simulations. Nevertheless, several initial conclusions can be regarded as first steps toward a better understanding of instructional games in the future. First, when used for presentations, hybrid simulations appeared to be more effective than pure simulations. Second, hybrid simulations seem to be equally effective for both presentation and practice. Third, learners seem to perform better when provided with specific guidance on how to use the simulation.

Egenfeldt-Nielsen (2003) conducted a review of the educational usage of games by surveying both single studies and other review articles. The review focused on non-electronic games, but did not distinguish between simulations and games. He concluded that there is "currently no evidence for a better or worse learning outcome, when games are used" (p. 1).

Maria Klawe, a senior game developer stated in a public lecture on "The Effective Design and Use of Educational Computer Games" that the "most common problem with educational software is that students don't pay attention to or learn the way that designers intended" (quoted in Jenson & de Castell, 2002, p. 6 of 15). Caftori (1994) supported this view by providing several examples of how educational software games do not always play an educational role, at least not the role they were intended to play. One history simulation game (*The Oregon Trail Game*) was intended to introduce children to the life of covered-wagon travelers on their way to Oregon in 1848. It contained a number of problem-solving situations like crossing a river, managing food, or dealing with disease outbreaks. It also provided opportunities for the children to shoot at dangerous animals and other targets. Unfortunately, the children concentrated on reaching the end of the trail as fast as possible and shooting animals for the sake of shooting. The critical information about the type of terrain and the animals associated with it were not noticed and/or learned by the children. Similar problems were encountered with other games. Even though the children interacted with the games, "they were able to do it in such a way that at least some (if not all) of the specified educational objectives have been missed" (Caftori & Paprzycki, 1997, p. 1 of 8). This is a conclusion that we will encounter throughout our review of the literature: *an instructional game will only be effective if it is designed to meet specific instructional objectives and used as it was intended.*

SUMMARIES OF RESEARCH ON SPECIFIC INSTRUCTIONAL GAMES

The following sections contain summaries of research on the instructional effects of specific games. The organization of the summaries is based on the type of learner and/or the type of task that was targeted by the game. The first section summarizes the effectiveness of games used to teach school children in pre-kindergarten through the 12th grade. This is followed by summaries of instructional games used with college students. Games used to provide instruction in the workplace are summarized in the final section.

Games Used in Schools (Pre-K-12)

Many different games have been used to teach a variety of topics to school children in pre-kindergarten through 12th grade. The following sections summarize the results of some of this research. The summaries are organized by topic area.

<u>Games Used to Teach Math</u>. Koran and McLaughlin (1990) compared the effectiveness of a drill and practice math game for teaching basic multiplication facts. Twenty-eight fifth grade students participated in ten days of instruction. Their performance was measured using daily tests and a test at the end of the program. Both the game and the drill and practice conditions were found to be equally effective, but the students preferred the game.

Two different card games were evaluated in an elementary school classroom environment to help teach fractions, decimals, and percentages (Rowe, 2001). The students played both games and were then tested on standard questions about the math topics. Only one of the games, *Percent Rummy*, was found to improve the learners' performance. The other game, *Find the Missing Number*, was difficult to use, did not stimulate the learners and did not result in improved performance. These results indicate that every game is not useful instructionally. The instructional effectiveness of a game depends on its characteristics and how it is used.

Van Eck and Dempsey (2002) evaluated the effects of different ways of using an instructional game. They measured the math problem-solving skills of 7th and 8th grade students after they had been given instruction using a computer simulation game using competition and contextual advisement. Some of the students experienced the game in a "competitive" context and others experienced it in a "non-competitive" context. The competition group was told that they were competing with a computer character. A face icon, representing the character, was continuously shown on the computer screen. The non-competition group was only encouraged to work quickly and accurately. Some students were able to access contextual advisement by watching videos of computer characters that provided hints and encouragement. Other students did not have access to contextual advisement. These conditions resulted in a 2x2 design. The performance of these groups was compared to an outside control group who solved identical word problems outside of a game context.

The math problems in both game and control conditions involved determining how much paint, wallpaper, and other materials were necessary to fix up a room. The performance of the students was assessed on a transfer task requiring them to apply the same skills to determine how much paint and other materials were required to fix up a different room. The researchers found an interesting interaction between competition and contextual advisement. The non-competition group had higher transfer when they had access to contextual advisement, but the competition group had higher transfer when they did not access contextual advisement. Unfortunately, these results may be moot because the control group performed as well as the game groups.

An Internet game was used in conjunction with other classroom activities to teach probabilities and statistics to 4- and 5-year old children (Pange, 2003). After a number of activities such as throwing dice and coins, the children played the game to improve their understanding of probabilities. The game required the children to pick one of three doors to find a hidden car, demonstrating a one-in-three chance. After the game, the teacher discussed all of the activities. The children showed improvement in their understanding of probability. The teachers liked using the game and reported that it excited the students' curiosity and made the teaching more interesting. No determination can be made about the separate instructional effectiveness of the game.

Laffey, Espinosa, Moore, and Lodree (2003) attempted to evaluate the potential of interactive computer technology (ICT) for teaching math skills to young, low income, urban children. The ICT environment included several commercially available math games, such as *Mighty Math* and *Millie's Math House*. The 61 study participants were all Pre-K, Kindergarten, or first-graders. The children were randomly assigned to treatment (ICT) or control groups and took a math pretest. Some of the children were also identified as "at-risk," because of previous behavior problems. Both groups received the same math instruction in their classroom. The ICT group participated in two 20-25-minute ICT sessions per week over an eight week period. Both groups later answered posttest questions. Results were based on the difference between pre- and posttest scores. The ICT group had significantly higher gain scores than the comparison group. Within the treatment group, the not-at-risk children gained more than the at-risk children. From this study, it is not possible to draw conclusions about the effectiveness of the games because no details are provided. The results are also confounded because the ICT group received more math instruction than the control group. The authors conclude that their study demonstrates the "potential" of ICT environments. Like many other studies that demonstrate "potential," this research does not provide guidance on how to design and implement instructional games.

A video-game approach was evaluated for teaching basic math and reading comprehension skills to first- and second-graders in economically disadvantaged schools in Chile (Rosas, Nussbaum, Cumsille, Marianov, Correa, Flores, Grau, Lagos, López, López, Rodriguez, & Salinas, 2003). The games were designed to play on a device that looked almost identical to the popular *Gameboy* system. The performance of an experimental group, who used the videogames, was compared to a group from the same school, who did not use the games, and a group from another school. Although both groups from the target school outperformed the external group, there was no difference in their performance. Thus, there is no support for the effectiveness of the game approach over traditional instruction on these basic learning tasks.

Teaching Vocabulary. Malouf (1987-1988) investigated the motivational effect of computer games for special education students. He compared the performance of sixth-, seventh-, and eighth-grade learning-disabled students who were learning vocabulary skills. His results showed no difference between a computer program with game features and the same program without the game features. However, the game condition resulted in significantly higher levels of continuing motivation than the non-game condition.

Teaching Pedestrian Safety. Renaud and Stolovitch (1988) investigated if a game could be used to help five-year-old children improve their pedestrian safety. One hundred and thirty-six 5-year olds were assigned to 4 groups: 3 experimental groups and 1 control group (who received no instruction). The experimental groups included 3 variations of a simulation game. The first version of the game included role playing and interactions among players. The second version of the game included behavior modeling and specific instruction from the experimenter. The third game included all the elements of the other games. The childrens' learning was measured using pictures of a road, to which the children added stickers to answer a series of questions. All of the experimental groups outperformed the control group. The group that engaged in role playing and player interactions performed slightly better than the groups that experienced behavior modeling.

Using Games to Study Motivation. Motivation can be assessed by the amount of involvement players demonstrate in a game. Wishart (1990) examined three game characteristics (control, challenge, and complexity) to determine their effects on learner involvement. She developed three versions of a role-playing game to teach children fire safety knowledge. Three hundred children (ranging in age from 5 years 9 months to 12 years 3 months with a mean age of 8 years 11 months) participated in the study. Six versions of the game were developed, each with a different combination of player control, game challenge, and game complexity. All the subjects took a pretest on fire safety knowledge before playing one of the versions of the game. In the game, a player was presented with a fire safety situation and given a choice of actions. After making the choice, the player advanced to another situation. At the end of the game, the players answered posttest questions about fire safety. She found that learner involvement was increased the most when the players had more control of the game. The separate addition of complexity and challenge to control did not increase learner involvement, but together they did. Furthermore, increased learner involvement was shown to increase the improvement of posttest scores. This research demonstrates that specific game designs can positively affect learning outcomes. Thus, it is important to design instructional games to increase learner involvement.

Costable, De Angeli, Roselli, Lanzilotti, and Plantamura (2003) also investigated motivation. However, they did not look at how a game motivated learners. Rather, they investigated the relationship between learner motivation and the effectiveness of the game. They conducted two experiments with an educational software product called *Logiocando*. It was developed to teach 9-10 year-olds the basic concepts of logic. The product contained Explanation Sections, Logic Games Sections, and Test Sections. The games increased in complexity as the learners successfully completed the simpler exercises. Costable, et al. compared the performance of learners in a lecture group to that of a group of learners who used *Logiocando*. In their first experiment, they found that the lecture group outperformed the game group. However, in their second experiment, they specifically motivated the learners prior to their interactions with the games. They explained that the learners' performance would be carefully monitored by their teachers and would be considered as part of their class work. This time, the learners who used *Logiocando* performed as well as the learners who received lectures. The researchers concluded that with proper motivation, these types of gaming exercises were as effective as traditional lecture methods in helping children improve their knowledge of logic.

The Costable, et al. study introduces an interesting issue about how to use instructional games. Many people believe that the game itself will motivate learners. However, this research indicates that other sources of motivation may also be necessary if a game is to be instructionally effective. Thus, for games, as with other types of instructional activities, how the activity is used is as important as the design of the activity itself.

As discussed earlier, Malouf (1987-1988) investigated whether playing a vocabulary skill game would increase children's motivation to continue studying the topic. He compared two groups of sixth-, seventh-, and eighth-grade learning disabled students who played either the game or used a computer program without game features. He found that the game and nongame programs produced equal gains in vocabulary skill. In addition, the learners who played the game demonstrated significantly higher levels of continuing motivation than the learners who used the nongame program. This indicates that instructional games can have motivational advantages beyond immediate learning gains.

Games Used to Teach Geography. Wiebe and Martin (1994) investigated the effectiveness of a commercial game for teaching geography facts. The game, *Where in the World is Carmen Sandiego*, was compared to map drawing and non-computer games (e.g., "Concentration") with two groups of fifth- and sixth-grade students. Posttests revealed no significant differences between the two groups in their recall of geography facts or their attitudes towards studying geography. The authors concluded that non-computer games and activities can be just as beneficial as computer-based games. Unfortunately, it is not possible to determine if the non-computer games or the map drawing exercises had separate effects on learning or if it was a combination of these activities that was as effective as the computer game.

A tutoring software system that used an adventure game interface and adventure-type scenarios was compared to a tutoring system that did not use these game aspects for teaching geography to fourth graders (Virvou, Katsionis, & Manos, 2005). Based on the number of errors on a posttest, it was found that the learners who used the adventure game interface improved their performance over the learners who used the other system. It was also found that learners who had the poorest performance in geography before using the game received the most benefit. The success of the game can be attributed to the instructional support (e.g., advice, suggestions) that was incorporated into the game. Similar instructional support was not as effective in the non-game condition. Thus, the combination of instructional support with game characteristics appears to be an effective method for teaching geography principles to children.

Teaching Electronic Circuits. Although not specifically called a game, the following study provides useful information that can apply to instructional games. A simulation was used as a supplement to laboratory instruction and exercises to teach two-person teams of 15 year-olds tasks involving electronic circuits (Ronen & Eliahu, 2000). The learners in the experimental condition were given the option to use the simulation to help complete two exercises. The learners in the control group only used existing materials (e.g., workbooks). Although some indications of higher achievement were shown in the group that used the simulation, the authors' observations about learners who did not benefit from the simulation may be more interesting. They observed that the simulation was not effective for three groups:

- Learners who did not need additional assistance (about 10% of the total) and did not use the simulation. Some did use it in later more advanced tasks.
- Learners with insufficient understanding of the domain (about 10-15%), who only performed random trials on the simulation rather that actions that would help them on their specific tasks.
- A few students would not use the computer (about 5%) because they "hated computers."

Teaching Physics. White (1984) used a series of simple force and motion video games to teach high-school students the principles of Newtonian physics. The games all used a representation of a space ship to illustrate the effects of force on motion in a frictionless environment. The games required the students to move the space ship to various targets by applying different amounts and directions of force. The performance of the students on a series of posttest force and motion problems was compared to a group that received no instruction (both groups scored similarly on a pretest). The students who played the games improved their answering of the force and motion problems more than those who did not play the games. This study does show that these games can provide effective instruction on Newtonian force and motion principles. However, there was no comparison to other instructional approaches, so it is not possible to conclude that games are the most effective way to teach these principles.

Use of Games for Health Care Education. Games have been used to help teach people about health care issues and the health care system. Sleet and Stadskley (1977) provided an annotated bibliography of 66 simulation games used in health education. These games were used in a variety of health care areas including: disease management; drug use and abuse; ecology; family planning and human sexuality; nursing; nutrition; physical fitness; and safety. The games allowed individuals to experience various roles and requirements of both health care personnel and their patients. These authors provided no information on the instructional effectiveness of the games.

Thomas, et al. (1997) used an interactive computer game, *Life Challenge*, as a tool to enhance adolescents' sense of self-efficacy in HIV/AIDS prevention. The game allowed learners to travel to different times and role play with imaginary partners, then to hear their recorded statements and decide to "try again" or stay with their original statements. There was also a game show segment where the learners picked the contestant they felt gave the best line in each situation. A pretest, posttest comparison of true-false questions was used to determine if there were learning gains on 7 knowledge items. Learning gains were found on 3 of the 7 items. Learners also showed improved self-efficacy when their pre-test and posttest scores were compared on several self-efficacy items. All learners showed increased self-efficacy with the strongest gains shown by those who began with the lowest self-efficacy scores. Unfortunately, it is not possible to attribute these effects to the game alone since there were no comparisons to other instructional methods.

Brown, Lieberman, Gemeny, Fan, Wilson, and Pasta (1997) assessed the effectiveness of a role-playing video game to teach young diabetic patients about diabetes. They compared two groups of young diabetics (ages 8 to 16). One group played an interactive adventure video game (Packy & Marlon), in which they played the role of a character that had diabetes. The other group played a video game containing no diabetes-related content. The two groups played their games at home as often as they wished. They were interviewed and their parents filled out a questionnaire at the beginning of the study, after three months, and after six months. After six months, the group that played the diabetes game showed higher perceived self-efficacy for diabetes self-management, increased their communication with their parents about diabetes, and improved their daily diabetes self-management behaviors (e.g., monitoring the blood glucose levels and taking insulin as needed). The control group did not change their behaviors. Although the game shows promise, the study did not compare game use with other instructional approaches.

Similar conclusions can be drawn about the evaluation of a game to teach bilingual children about the food pyramid and better eating habits. Serrano and Anderson (2004) found that fifth graders had better knowledge about nutrition and the food pyramid after playing a game when compared to a group that had no instruction. This shows that a game can be better than nothing, but does not help us decide whether using a game is the most effective instructional approach.

Games Used in College

Teaching Social Science. Szafran and Mandolini (1980) examined the effectiveness of a simulation game called *SIMSOC: Simulated Society* for teaching undergraduates in an introductory sociology course. The non-computer game was intended to create a situation where the student examined the processes of social conflict and social control in a simulated society. The results of the game were compared to the performance of students who received conventional classroom instruction. Performance was evaluated in terms of improvements in the students' test scores and their ability to recognize sociological concepts in nonsociological writings (e.g., excerpts from a novel, a magazine story, and a newspaper article). No statistically significant differences were found in the performance of the two groups. They concluded that "there continues to be no evidence that simulation games substantially increase cognitive knowledge" (p. 334).

Teaching Abnormal Psychology. Brewster (1996) used games in both an interactive multimedia computer environment and in a more traditional classroom environment to teach undergraduates the principles of abnormal psychology. The games were modifications of *Concentration* and *Jeopardy*. She found no differences among the groups on any measure of performance. It appears that multimedia is not necessary for games to provide an effective instructional approach. However, this study does not tell us when to use the games rather than other instructional methods.

Teaching Economics. Fraas (1982) compared a simulation gaming approach to the lecture-discussion method for teaching college-level economics principles. The game condition consisted of seven commercial simulation games used in succession. Unfortunately, detailed descriptions of the games were not provided in this publication. He found that neither method was superior to the other in overall effectiveness. However, he also found that learners with less previous knowledge of economics showed better improvement with the simulation game approach. This was also true of students with lower SAT scores. The reverse was also found. Students with higher SAT scores and/or more previous economic knowledge appeared to learn better from the lecture-discussion. This study indicates that games may be differentially effective for learners with different abilities or experiences.

Gremmen and Potters (1995) evaluated whether lectures supplemented with a game were more effective for teaching economics principles than lectures alone. They compared the performance of two groups on a multiple-choice economics test. The group who received a lectures supplemented with the game outperformed the group that only received the lectures.

Reasoning Skills. Wood and Stewart (1987) tried to determine if use of a computerized version of the game *Mastermind* would help college students improve their skills in practical reasoning. Thirty students were divided into two groups. Both groups took a pre and posttest on the *Watson-Galser Thinking Appraisal.* The experimental group played the game between test administrations, but the control group received no treatment. The experimental group reduced their errors on the posttest relative to the control group and indicated that they enjoyed the experience. However, it is not clear whether the game directly affected these results or if they were changed due to repetition of the test and/or more time on the task. If the game did influence the results, it is still not clear what game characteristics might have affected the learners' performance.

Teaching About Learning. Klein and Freitag (1991) compared the instructional effectiveness of using a board game to the use of a worksheet for teaching the principles of the information-processing model of learning to undergraduate education majors. The game and worksheet were designed to supplement and provide practice on material from assigned textbook reading. The board game included a set of 25 game cards with practice questions about the topic. The rules of the game "were developed to encourage cooperation, competition, and active participation" (p. 304). The worksheet included the same 25 questions that appeared on the game cards. No performance differences were found as a result of the two methods of instruction. However, the learners who reported that they had read the textbook assignment performed better than those who did not complete the assignment.

Games Used to Change Attitudes. Williams (1980) evaluated the effectiveness of a simulation game to change the attitudes of college students toward a negatively-presented historical character. The students first read a fictional history of a struggle among four noblemen. One nobleman was presented as a "villain." After the reading, they all filled out an attitude questionnaire about the characters. Then they were separated into two experimental groups and one control group. The control group engaged in a non-related activity while the two experimental groups engaged in a simulation game in which they had to "play" the role of the negative character. One experimental group (dissonance) was not given praise or reward for playing the character. The other experimental group (incentive) was given praise and a monetary reward for their role play. It was assumed that cognitive dissonance would increase in the group that had to play the negative character with no outside incentives. Both of the experimental groups changed their attitudes toward the negative character to a significantly greater degree than the students in the control group. No differences were found in the attitude change between the two experimental groups.

Another study (Bredemeier, Bernstein, & Oxman, 1982) found that a game designed to change college students' attitudes on dogmatism and ethnocentrism was effective when used in an anthropology class compared to another anthropology class that did not use the game. However, the same game, used in a different course (philosophy) did not result in the same degree of attitude change. These results indicate the importance of placing instructional games in the appropriate instructional context.

Teaching Empathic Understanding. A role-playing game was compared to classroom lectures for improving the empathic understanding of first-year university students (Barak, Engle, Katzir, & Fisher, 1987). The game was designed to improve the communication skills involved in empathy (understanding another person and communicating this understanding to him or her). It involved analysis, diagnosis, and understanding a target "client." Learners in the game group took turns playing the role of the "client" while other players listened to the "client" describing his or her situation. The control group participated in a lecture and group discussion about listening and understanding others feelings. The performance of the experimental group significantly improved, but the performance of the control group did not change. The authors concluded that the game was an effective method for improving empathic skills.

Teaching Physics, Electronics, and Engineering Principles. Rieber and Noah (1997) used a game to teach university students the relationships between acceleration and velocity. When compared to participants who were taught these topics without a gaming context, it was found that *the game actually interfered* with the participants' learning of these principles. The authors examined several patterns of interaction with the game that may have led to this outcome. The participants who were given assistance by an outside agent were better able to consider the relevancy of the game for learning the science principles. "When left on their own, participants had much difficulty in focusing their attention on how to manipulate the task in order to learn more about the content" (p. 8). Without assistance, "participants focused far too much on the competitive nature of the game and, as a result their ability to monitor their own comprehension was inhibited" (p. 8). This study, although exploratory in nature, illustrates the important issue of the instructional support that surrounds a game and how the game is used to support instruction. Without instructional support, a game may be not only ineffective, but it may be detrimental to learning.

Miller, et al. (1999) examined three versions of an instructional simulation game (Electronic Field Hockey) to determine which was most effective in helping undergraduate students develop a better understanding of the physics of electrical interactions. The simulation was intended to allow learners to observe how the trajectory of a "puck" with an electrical charge was influenced by obstacles with various electrical charges. The three versions of the simulation were:

- A *no-goal condition*, which included no obstacles, no net, and no specific task.
- A *standard-goal condition*, in which the learners' task was to try to position the obstacles so that their charges would cause the "puck" to avoid them and go into the hockey net.
- A *specific path condition*, which showed the learners an ideal trajectory which they attempted to duplicate. It also showed the difference between the ideal trajectory and their actual trajectory that was obtained by their placement of the obstacles.

Both the no-goal and specific-path conditions produced higher learner scores than the standard-goal condition. The authors concluded that these two conditions required learners to engage in broader exploration and to be more selective in interpreting the evidence than the standard-goal condition. The study highlights the importance of carefully selecting and analyzing the intended goals of an instructional game before it is implemented.

Crown (2001) conducted a study to determine the effect of web-based games on the visualization skills of engineering graphics students. However, it is difficult to determine the effect of his instructional games because the game pages were only part of an instructional CD. Although learners who used the instructional CD showed positive performance on exams, it is not possible to separate the effect of the game pages from the effect of other instructional material presented on the CD.

Teaching Principles of Underwater Sound Propagation. Shrestha (1990) compared a simple game to more traditional lecture-type instruction on the principles of underwater sound propagation. She found no learning differences among two groups of college students. However, she did find that the learners in the game condition spent more time interacting with the game. She concluded that games may have motivational benefits over the traditional instruction.

Games to Teach Health Care Decisions. Westbrook and Braithwaite (2001) evaluated a web-based educational game to help college undergraduates make better health care decisions. The game presented four families in a series of health care events. It then generated problems that required the learners to seek out information to assist the families in making decisions like which type of care to seek and how much it would cost. The participants were 55 students from Australia and South-East Asia. They worked in competing teams of six persons. Each team member contributed to a common discussion log over a four week period. The evaluation consisted of a pre- and post-questionnaire that assessed: (1) the participants' interest in and knowledge of the health care system, (2) their experience with computers, (3) their views on team work, and (4) their demographics. Only two questions assessed the learners' factual knowledge.

Although a higher percentage of the participants correctly answered the factual questions on the posttest, these results were highly confounded. Prior to the game, the participants had already received 9 weeks of lectures which included the topics covered in the game. The authors concluded that the improvement on the factual questions indicated the effectiveness of the game. However, other events during the 13 week period (9 weeks of lectures and 4 weeks of game participation) could have influenced their answers.

The Westbrook and Braithwaite (2001) study illustrates many of the problems that make it difficult to reach conclusions about either the effectiveness of a specific instructional game or the effectiveness of games in general. Some of these problems include:

- The evaluators' interest in "proving" the effectiveness of their game (i.e., they developed the game and wanted it to work).
- No control group who experienced an alternate form of instruction to compare to the game.

- No clear and detailed description of the game itself (e.g., what characteristics made it a "game").
- Lack of control of possible confounding variables (e.g., events prior to and during the evaluation).

Teaching Marketing, Business, and Management Principles. Fritzsche (1981) compared the use of a marketing simulation game, *Marketing in Action*, as either the central delivery vehicle for instructional information or as a supplement to the standard lecture on the same material. No differences were found between the two conditions on college students' midterm and final examination grades. Thus, Fritzsche concluded that the game alone was as effective as the lecture with the game as a supplement. The equivalence in effectiveness may be because the game (Day, 1962) included detailed instructions on how and why to fill out the simulated management decision forms. These may have had as much effect on later performance as playing the game itself.

Wellington and Faria (1996) studied the effect of team cohesion, player attitudes, and performance expectations on the instructional effectiveness of a simulation game. Although they do not specifically describe the simulation games, it appears to be a marketing simulation specifically developed for an introductory marketing course. The game was played by 389 students from two sections of a *Principles of Marketing* course. They were divided into 108 teams of three or four players. The teams competed with one another and each team had to make six decisions during the competition. The teams that were more cohesive at the start of the competitions outperformed the teams that were less cohesive. The game did not appear to change the cohesiveness of the teams over the course of the competition. Furthermore, learner attitudes were not found to be statistically related to final game performance although learner expectations were positively related to performance. Unfortunately, this research tells us very little about the specific characteristics of the game. It also does not compare the use of the game with other instructional approaches.

Rowland and Gardner (1973) did not find positive support for the instructional value of a business and management game. In their study of 200 college students who played the *Marksim* business game as seven-person teams, there was no positive relationship between playing the game and grades in a marketing course. They concluded that business games were not the educational panacea envisaged by many advocates.

Games Used in the Workplace

Teaching Attention Allocation Skills. Gopher, Weil, and Barebet (1994) found positive learning effects from a video game called *Space Fortress*. They found that attention allocation skills could be trained using the game. These attention allocation skills were found to transfer to piloting skills in complex fighter aircraft. However, these results are ambiguous because other training (e.g., verbal tips and other part-task training sessions) may also have affected the outcomes.

Teaching Periscope Skills. Garris, et al. (2002) described an initial evaluation of a game called *BOTTOM GUN*. It was developed to help Navy personnel learn periscope skills such as distance estimation and angle-on-the-bow (i.e., the angle at which an observed ship is visually presented to the periscope observer). The game was designed to incorporate game characteristics such as curiosity, competition and control, as well as, visual and sound effects. Although an initial evaluation, their results indicated that learners using the game showed more improved performance than those using a trainer without game elements.

Teaching Principles of Chemical, Biological, and Radiological Defense. Ricci, Salas, and Cannon-Bowers (1996) investigated the learning effects of a very simple game. They compared three groups of Navy trainees (mean age = 20 yrs.) who were taught the basic principles of chemical, biological, and radiological defense. One group (text group) studied a printed text (a 63-page pocket handbook). The second group (test group) was given a printed copy of 88 multiple-choice questions with answers. The third group (game group) interacted with a computer program that presented the 88 questions in random fashion in boxes that resembled a slot machine. This group was given 3 minutes to answer each question and received points for correct answers. Both the test and game groups performed better than the text group on a posttest. However, no performance differences were shown between the test and game groups although the game group scored higher on a retention test given four weeks later. The results of this study are questionable because the game condition was basically a way to randomize the presentation of the questions and may not have been a true game.

Teaching Technical Skills. Oxford, Harman, and Holland (1987) reported the initial evaluations of two hand-held computerized game-based training aids for Army trainees. The two training aids, called *Tutor* and *CHIP*, used simple games (e.g., matching pictures to verbal or visual stimuli to send a projectile against an "enemy" target) to teach technical terminology and basic technical skills. Learners who used the aids completed more instructional units than a group who used a workbook containing the same content. The training aid group also outperformed the workbook group. Although these data were very tentative and the games were simplistic, they did show the instructional potential of gaming activities.

Whitehill and McDonald (1993) compared the effects of the presentation of circuit repair problems in a drill format to presentation of the same problems in a game context. The drill context simply presented the circuit problems one at a time. However, the game context required learners to simulate the role of an electrician repairing the circuits. They used a computer to move a cursor around a Navy ship's floor plan to locate and solve the problems. Video game sound effects accompanied the movement of the cursor through the ship. The payoff for solving the problems was either fixed or variable based on problem difficulty. Although they found no performance differences between learners in either the drill or game conditions, they did find that combining the game with variable payoff resulted in increased learner persistence.

Parchman, Ellis, Christinaz, and Vogel (2000) evaluated four different instructional conditions, including a game, to train basic electricity and electronics fundamentals to beginning Navy electronic technicians. They compared conventional classroom instruction (CI) with computer-based drill and practice (CBDR), enhanced computer-based instruction (ECBI) that added compelling graphics, animations, and simulations to the CBDR, and a role-playing adventure game. The trainees in the CBDR and ECBI conditions outperformed those trained in either the conventional instruction or the game. The CBDR and ECBI conditions were equally effective in teaching symbols and definitions. However, cause-and-effect relationships were learned better by trainees in the ECBI condition. This is probably because of the enhanced visualizations provided by the ECBI program. The ECBI-trained learners were also more confident than those in the other groups that they had learned the required material.

These researchers concluded that instructional developers need to be cautious and not rush into exclusively using games until additional data are available on their effectiveness. Other computer-based instructional approaches may be more effective than games for certain types of instruction. They also recommended that instructional developers not overdevelop computer-based instruction. Simple computer-based instruction may be sufficient when the objective is to teach definitions and symbols. When more complex material needs to be learned (e.g., cause-and-effect relationships), enhanced computer-based instruction may be required.

Business and Management Games. Gaming has been used to teach business and management skills for many years. Faria (1989) observed that business games are direct descendents of war games, dating back at least to the German Kriegspiel of the mid-19th century. He also observed that the RAND Corporation developed an instructional simulation game in 1955. Called *Monopologs*, it was intended to allow U. S. Air Force logistics personnel to make logistics decisions in a "risk-free" environment. No data could be located on the effectiveness of the game.

The first widely known business game was developed by the American management Association in 1956. Called *AMA's Top Management Decision Simulation*, it provided an environment in which two teams of players could represent officers of firms and make business decisions (Cohen & Rhenman, 1961). Five teams with three to five persons each produced a single product which they sold in competition with other teams. Many varieties of this game were developed in subsequent years, although no data on its effectiveness were found.

In the early 1960s, a game was used to teach diplomats international relations skills (Benson, 1961). The *Simple Diplomatic Game* reproduced, in simplified form, features of the international political arena and allowed learners to see the effects of their actions in a larger action-counteraction cycle. No data were found on its effectiveness.

Faria (1989) conducted surveys of training managers, businesses, and business schools on their use of games. Of the 223 training managers who responded, 54.7% indicated that their companies used simulation games in their training programs. Results also indicated that at least 5000 firms were using business games and 1,700 four-year business schools used games in their programs. Wolfe (1997) observed that by 1974 hundreds of articles on business gaming had appeared in the business and professional press.

Cohen and Rhenman (1961) and Morris (1976) maintain that all management games share several common features.

- They allow the presentation of feedback based on the results of players' actions.
- They represent the environment in logical or mathematical relations. Some of these relations are known to the players as "rules" while others are only vaguely qualified and become known during play.

- They allow interaction between players and the environment. Sometimes players can assume the roles of managers in different functional areas within a company to learn how these areas differ from their own.
- They provide a simplified view of reality so players can focus on single issues or areas as they learn.

Citing Cohen and Rhenman (1961) and Morris (1976), Hays and Singer (1989, pp. 198-200) mentioned several educational properties of business and management games:

- They can provide training on the interactions of functional specialties within companies. The players can learn how their specialty is dependent on others, and how to interact more effectively to reach common goals.
- Playing the game may sensitize learners to the fact that in the real world they must take particular actions solely for the sake of information gathering.
- Games can offer the trainee the opportunity to learn and refine a variety of analytic tools.
- Games may allow learners to become aware of the psychological and organizational interactions and interdependencies in business.
- Players may learn that most decisions are made by teams of several persons and that these decisions are constrained by a variety of variables, such as time, complexity of the decision, and personality factors of the players.
- Games can teach institutional facts about the learners' company (e.g., standard operating procedures).

These properties and many of those mentioned by other authors also apply to games outside of business and management.

Thornton and Cleveland (1990) described management gaming simulations as a hierarchy of increasing complexity. Their hierarchy included:

- *One-on-one interview simulations* that are "short, yet powerful, simulations of specific interpersonal interactions" (p. 192). The authors list several studies that indicated that these were effective in enhancing supervisory skills. However they also cited contradictory evidence that showed no behavior change as a result of participating in this type of gaming simulations.
- *Leaderless group discussions* simulate "numerous ad hoc committee situations in organizations in which problem analysis and decision making take place" (p. 192). The authors cited no specific data on the instructional effectiveness of these discussion simulations.
- *In-basket technique.* A type of simulation named after the in-tray on a manager's desk has been used to practice administrative skills. Although the technique has been shown to have predictive validity and is used in "virtually all assessment centers" (p. 193) for managerial selection, Thornton and Cleveland cited no data on their instructional effectiveness.
- *Complex decision-making simulations* have been used to study the components of managerial decision making (Streufert, 1986). However, Thornton and Cleveland found no evaluations of their instructional effectiveness.
- *Large-scale behavioral simulations* involve "multiple business problems and opportunities, intensive and extensive interaction among managers, and observation by trained staff" (p. 193-194). Little published empirical information was available on these simulations.

Morris and Holman (1976) report the successful application of business gaming at a large pharmaceutical company. A business management competition was held with 638 people divided into 192 teams. These teams, from various divisions, learned an appreciation of business, as a whole, rather than just their work functions. Some of the lessons learned included: methods of increasing profits by either increasing income or decreasing expenditures; team work skills; methods to get along with the competition; and marketing techniques.

Carlson and Hill (1982) examined the effectiveness of a gaming approach to reducing absenteeism and tardiness at a small manufacturing firm. They found that the impact of gaming was minimal on these two areas. However, they did find that when gaming was used as a vehicle for employee communication, it resulted in statistically significant improvement in employee attitudes and cooperation.

Wolfe (1997) conducted a review of business games used to teach strategic management skills. He reviewed seven studies conducted between 1966 and 1988 that: 1) compared game use with at least one other instructional approach, 2) had predefined, objectively measured instructional objectives, and 3) objectively measured learning outcomes. He divided the studies into those that concentrated on results (substantive evaluations) and those that examined the effects of how the game was used (procedural studies).

From his review, Wolfe concluded that there is evidence that computer-based general management games are effective in producing knowledge gains. He found that the only alternative instructional approach that was compared to games was case studies. Both methods produced learning, but games appeared to be superior. It should be remembered, as discussed above, games can be designed as hybrids, incorporating the characteristics of case studies. Although he reported no data on these game-case study hybrids, in future studies, this approach may be found to be effective.

Wolfe found less clear data on the way games are used. Some studies found less complex games as effective as more complex games while others found that more complex games provided better learning outcomes. However, this result is confounded in at least one study because the more complex game included more relevant topics than the less complex games. Wolfe found little data on the role of the instructor in influencing the learning outcomes of games other than that some type of instructor involvement (instructional support) appeared to be required. Instructional support is one of the topics discussed in the next section.

OTHER ISSUES IN INSTRUCTIONAL GAMING

Types of Competition in a Game

As noted above, competition (challenge) is one of the most important characteristics that make games enjoyable (Csikszentmihalyi, 1990) and motivating (Malone, 1981; Malone & Lepper, 1987). Fisher (1976) examined three different types of motivation in a vocabulary skills game (*The Dictionary Game*). Three groups of college students played the game under different types of competition conditions and their performance was compared with each other and with a control group that did not play the game. The first treatment group played the game with 1-to-1 person interpersonal competition. The second treatment group played with 1-to-2 person interpersonal competition. The third treatment group played as three-person groups with 1-to-1 intergroup competition. Post-game performance was measured on a ten-item multiple-choice test. Results showed that learners in all three game conditions performed better than the non-game group. The 1-to-2 interpersonal competition group had the highest score, followed by the 1-to-1 interpersonal competition group and the 1-to-1 intergroup competition group. These results show that specific types of competition can affect the instructional effectiveness of a game. However, since the game was not compared to any alternate types of instruction, it is not possible to say that gaming is the preferred approach to teach vocabulary skills.

Adding Instructional Support to a Game

Leutner (1993) investigated the effectiveness of two varieties of instructional support in a computer-based simulation game to teach economic concepts to seventh-graders and later to university students. The game, *Hunger in the Sahel*, is a role-playing simulation where learners run a small farm and must deal with issues such as rainfall and temperature extremes. The two varieties of instructional support were system-initiated advice and learner-requested background information. He found that learners without any instructional support learned to play the game, but only learned a minimal amount about domain-specific concepts. The opposite occurred with the learners given advice. They learned more domain-specific concepts, but only learned to play the game to a limited degree. These results indicate that instructional support is essential if the goal of the game is to provide instruction. Leutner (1993) stated that it is "very useful to make pieces of information, which are implicitly available in the system, explicit through appropriate instructional support during system exploration" (p. 219).

The importance of instructional support is also discussed by de Jong and van Joolingen (1998). These authors review the effectiveness of discovery learning in simulated environments. Discovery learning is often cited as one of the strengths of instructional simulations and games. The assumption is that learners gain a deeper understanding of a topic if they are allowed to freely explore a domain and "discover" important information and interactions among phenomena. However, after reviewing many studies on discovery learning in simulations, these authors stated: "The general conclusion that emerges from these studies is that there is no clear and univocal outcome in favor of simulations" (de Jong and van Joolingen, 1998, p. 181). They explain these results by highlighting several intrinsic problems with discovery learning. These problems center on difficulties that learners have with forming and testing hypotheses in these discovery environments. The reader is encouraged to consult the original source for details on these problems. The authors conclude that the crucial aspects of successful discovery learning are well designed instructional goals and instructional support for the learner.

Mayer, Mautone, and Prothero (2002) investigated the effect of adding prior pictorial representations of possible features that would be encountered in a game to teach geology principles. These researchers reported the results of 4 experiments with college students. A game called *The Profile Game* was designed to help learners determine which geological features were present on a certain portion of the planet's surface. Prior to playing the game in each experiment, the students either received prior pictorial support or did not. The specifics of how the support was used differed across the experiments. In the first two experiments, no differences were found due to the pictorial support. However, in the second two experiments, the pictorial support groups outperformed the no-support groups. The support given in the second two experiments was accompanied with more detailed instructions on how to use the support. Thus, it appears that instructional support can enhance the instructional effectiveness of games if it supports "guided discovery" rather than just providing information.

What is Learned in an Adventure Game?

Adventure games are very popular and many have advocated their use for instructional purposes. To determine what is learned in this type of game, Ju and Wagner (1997) had 12 college students play *Indiana Jones and the Fate of Atlantis* in which they had to find their way through a South American jungle. The students played the game individually. After an hour of play, they stopped the game and asked the players to answer a set of questions, referring to the material encountered during previous play. No player answered all questions correctly. When the responses were analyzed by question type, they found that more correct answers were given to the questions that asked about physical objects in the game or attributes about the game (mean correct responses of .83 and .84 respectively). Questions about concepts and cause-effect thinking only produced mean correct responses of .55 and .50. The least successful answers (.38 correct) were on questions that required the user to respond with a "plan" or procedure. These results show that different types of learning can result from an adventure game. This is a strong indication of the importance of designing instructional games to contain events that meet specific instructional objectives.

The Danger of Evaluator Interest

An area of game research that indicates how the evaluator's "interests" may influence the results is the investigation of chess playing as a way to develop children's cognitive skills and scholastic achievement. Dauvergn (2000) summarized several studies that he claimed show that "chess is one of the most powerful educational tools available to strengthen a child's mind" (p. 2 of 6). However, as Thompson (2003) pointed out, most of these studies were quasi-experimental in nature and were conducted by chess enthusiasts (some from the U. S. Chess Federation). Thompson (2003) conducted a controlled study that compared the scholastic performance of chess players and non-chess players. When he controlled for grade level and IQ, he found no significant effect of chess playing on scholastic performance. He concluded that the chess enthusiasts want to see a positive effect from playing chess and therefore do not control for other factors like general intelligence. His belief is that children who are interested in chess also tend to be more capable in general scholastic skills. Whichever view is correct, it is important that the interests and goals of researchers be accounted for when interpreting the results of their investigations.

The Instructional Value of a Game Developed for Another Purpose

Recently, a game developed for Army recruiting was evaluated to determine its instructional effectiveness. The game, *America's Army,* was developed by the Office of Economic and Manpower Analysis at the United States Military Academy <u>as a recruiting tool</u>. It was intended to inform the "recruiting age" public about the U. S. Army. Because it was so popular (over 2 million players registered on the web site), some believed it could be assessed to identify features that motivated players and provided instruction.

Belanich, Sibley, and Orvis (2004) assessed the knowledge that 21 players gained from the game using a 35-question posttest. The questions were designed to assess procedural, episodic, and factual knowledge that was either relevant to game play or that did not impact game play. They found that players correctly answered a higher percentage of procedural questions, followed by episodic and factual questions in descending order. They also found that the realism, challenge, exploration, and control afforded by the game were the factors that influenced player motivation.

On the surface, these results seem to indicate that the game provided effective instruction. However, when one examines the study more closely, it becomes apparent that the players only learned procedures, experiences, and facts about the game. There is no indication that any of the learned information is relevant to real-world Army requirements. For example, one of the procedural questions asks *how to select* a "Flash/Bang" grenade. The possible answers involve pressing a number key or clicking the mouse. These procedures are irrelevant in the real-world. From reading the report, it does not seem that the game provided real-world relevant instruction, such as *when to choose* this type of grenade.

This study illustrates one of the greatest dangers of using games for instruction. Yes, they may be motivational and they may help learners retain information. However, if the game is not designed to directly support specific instructional objectives related to actual job requirements, much of the learning may be irrelevant. This is also what was found in the evaluation of *The Oregon Trail Game* (Caftori, 1994). As discussed earlier, children only learned "shoot-em-up" skills rather than the historical information that game designers hoped the game would provide.

This study (Belanich, et al., 2004), like many others, indicates the potential of games for instruction. However, it also highlights the need to carefully design and develop games that will support specific instructional objectives and that will fit into larger programs of instruction.

The Importance of Debriefing

After participation in an instructional game, it is very important to conduct a debriefing session with the participants (Crookall, 1992; Garris, et al., 2002). Debriefing gives the learners the opportunity to reflect on their experience with the game and understand how this experience supported the instructional objectives of the course or program of instruction. Lederman (1992) reviewed the literature on debriefing and presented a model of the debriefing process. According to her model, debriefing should consist of three phases:

- Phase 1: Systematic reflection and analysis. This phase introduces the learners to a systematic self-reflective process about their game experience. It should include a summary of the game experience as it supports the instructional objectives.
- Phase 2: Intensification and personalization. The second phase is a deeper examination of the learners' game experiences. Each learner should be guided through reflections on their own individual experiences and the meanings these experiences have for them. It is the job of

the debriefing facilitator (e.g., instructor) to help ensure that the meaning of the experiences tie into the instructional objectives.

- Phase 3: Generalization and application. Here, the learners are led beyond their own individual experiences to the broader applications of the experiences. For example, they might engage in discussions of how their experiences can contribute to their success on the job or in additional learning situations.

The key point is that no instructional game should be conceived as a stand-alone activity. It should be designed and implemented as part of a larger instructional program that meets the specific instructional requirements of the task and the learners. As Lederman puts it, "The process of debriefing is not ancillary to the educational experience to which it is tied. Debriefing is an integral part of any learning experience that is designed to be experience based" (Lederman, 1992, p. 158).

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SUMMARY OF EMPIRICAL EVIDENCE ON INSTRUCTIONAL GAMES

Instructional games have been used for a wide variety of tasks with learners of different ages. Past reviews have found that the majority of articles on instructional games are opinions about whether to use games and about the potential of games to provide effective instruction (e.g., Dempsey, et al., 1993-1994). Far fewer articles provided empirical data on research that has investigated the instructional effectiveness of games. This was also found in the present review. Over 270 documents were obtained from the literature on games. Of these, only 48 provided empirical data on the instructional effectiveness of games. This review discussed the results of other review articles and also articles on the effectiveness of specific games. Table 4 provides a summary of the 48 empirical articles discussed in earlier sections.

Several observations can be derived from an examination of Table 4. First, the empirical research on instructional games examined their effects for a *wide range of age groups*. Twelve of the studies examined the learning effects of games with elementary school children and two with high school students. Twenty-one studies used instructional games with college students. Six studies examined game effects with military trainees and the remainder of the studies evaluated games for adults working in various industries. The results of any given study must be evaluated in a restricted manner. We cannot necessarily generalize the results of a study conducted with one age group to another age group.

The empirical research also includes studies that examined the instructional effectiveness of games for *many different tasks*. These tasks range from basic mathematics principles to complex business and marketing decision making. They include general reasoning skills and specific electronics repair tasks. Care should also be taken when generalizing from one instructional task to tasks in another domain.

The empirical research *does not make a compelling case for games as the preferred instructional method*. In most cases, the research shows no instructional advantage of games over other instructional approaches (such as lectures). In several cases, games were shown to provide effective learning, but were not compared to other instructional methods. The research does not allow us to conclude that games are more effective than other well-designed instructional activities.

Too much of the empirical research on instructional games contains methodological problems (e.g., experimental confounds) that make it difficult to draw valid conclusions about the effectiveness of the games. Researchers need to ensure that they understand experimental design and apply sound decisions when designing and reporting their research. In addition, editors of educationally oriented journals need to filter out studies that do not follow sound experimental design procedures.

Table 4:
Summary of Empirical Effectiveness Studies Reviewed

Study	Learning Task	Age/Grade	Results
Koran & McLaughlin (1990)	Math Facts	5th Gr.	No Differences
Rowe (2001)	Math	Elementary School	Only **one of two** games provided learning. No comparison to other approaches.
VanEck & Dempsey (2002)	Math Problem Solving	7-8th Gr.	No Differences
Pange (2003)	Probability	4-5 yrs.	Can't Determine
Laffey, et al. (2003)	Math Skills	Pre-K-1st Gr.	Can't Determine
Rosas, et al. (2003)	Basic Math & Reading	1st & 2nd Gr.	No Differences
Malouf (1987-88)	Vocabulary	6-8th Gr.	No Differences
Renaud & Stolovitch (1988)	Pedestrian Safety	5 yrs.	**Learning**, but no comparison
Wishart (1990)	Motivation	5 – 12 yrs.	**Learning**, but no comparison
Costable, et al. (2003)	Basic Logic	9-10 yrs.	No Differences
Wiebe & Martin (1994)	Geography Facts	5th-6th Gr.	No Differences
Virvou, et al. (2005)	Geography	4th Gr.	**Game** favored over non-game software
Ronen & Eliahu (2000)	Electronics	15 yrs.	**Slight**, but not effective for certain groups
White (1984)	Physics	H.School	**Learning**, but no comparison
Thomas, et al. (1997)	Self-efficacy in HIV/AIDS prevention	Adolescents	Can't Determine
Brown, et al. (1997)	Diabetes Facts	8-16 yrs.	Can't Determine
Serrano & Anderson (2004)	Nutrition Facts	5th Gr.	**Learning**, but no comparison
Szafron & Mandolini (1980)	Sociology	College	**Learning**, but no comparison
Brewster (1996)	Psychology	College	No Differences
Fraas (1982)	Economics	College	No Differences (game better for learners with less previous knowledge)
Gremmen & Potters (1995)	Economics	College	**Game supplementing lecture favored** over lecture alone
Wood & Stewart (1987)	Practical Reasoning	College	**Learning**, but only compared to no instruction.
Klein & Freitag (1991)	Principles of Learning	College	No Differences
Williams (1980)	Attitudes toward subject matter	College	**Favored Game** over non-related activity
Bredemeier, et al. (1982)	Attitudes toward subject matter	College	**Game successful** in appropriate context
Barak, et al. (1987)	Empathy	College	**Favored Game** over lecture & discussion.
Rieber & Noah (1997)	Physics Principles	College	**Game interfered with learning**

Table 4: (Continued)

Study	Learning Task	Age/Grade	Results
Miller, et al. (1999)	Electrical Interactions	College	No comparison to alternate instruction. Different versions of game were compared.
Crown (2001)	Engineering Visualization	College	Can't Determine
Shrestha (1990)	Underwater Sound Propagation	College	No Differences
Westbrook & Braithwaite (2001)	Health Care Decisions	College	Can't Determine
Frizsche (1981)	Marketing	College	Game alone as good as game and lecture
Wellington & Faria (1996)	Team Cohesion & Attitudes	College	No Comparison
Rowland & Gardner (1973)	Marketing	College	No support for game
Gopher, et al. (1994)	Attention Allocation Skills	Pilot Trainees	**Learning**, but no comparison
Garris, et al. (2002)	Periscope Skills	Navy Trainees	**Favored Game** (over trainer without game elements)
Ricci, et al. (1996)	CBRD Defense Principles	Navy Trainees (Mean age = 20yrs.)	No Differences ("game" slightly better for retention)
Oxford, et al. (1987)	Technical Skills & Terminology	Army Trainees	**Favored Game** (over workbook)
Whitehill & McDonald (1993)	Electrical Repairs	Navy Trainees	No Differences
Parchman, et al. (2000)	Electronics Fundamentals	Navy Trainees	Drill & Practice favored over game
Morris & Holman (1976)	Business Issues	Adults	No Comparison
Carlson & Hill (1982)	Attendance Attitudes	Adults	No effect
Fisher (1976)	Different types of Competition	College	No Comparison
Leutner (1993)	Economics Concepts	7^{th} Gr. & College	Without instructional support, **Only Learned Game**
Mayer, et al. (2002)	Geology	College	Instructional support enhanced value of game
Ju & Wagner (1997)	Playing an adventure game	College	Learned more about physical objects in game than concepts
Thompson (2003)	Effect of playing chess on scholastic performance	Elementary school children	No effect
Belanich, et al. (2004)	What is learned in a game?		Learned only game-relevant skills not real-world skills

A REEXAMINATION OF THE "CLAIMS"

As discussed earlier, Greenblat (1981) summarized evidence in support of six categories of "claims" about the efficacy of games used for instructional purposes. We can use the same categories of claims to help us summarize the research on the instructional uses of games since that time. By comparing the evidence presented by Greenblat in 1981 to the results of later research we can draw some conclusions about the progress that has been made over the last 25 years in our understanding of the effectiveness of games for instructional purposes. Table 5 summarizes the evidence, then and now.

Comparing the evidence on the instructional effectiveness of games that was available in 1981 to the results of more recent research shows that there are still many questions that need to be answered about when and how to use games. The first "claim," that games improve the motivation and interest of learners, is still weakly supported. There has been little additional evidence beyond a few studies that use self-reports or time-on-task to show that games are motivational. Unfortunately, there is little evidence that these measures of motivation are related to improved task performance. Games do motivate. They motivate players to play the game. This can be beneficial if the game is designed to target and meet instructional objectives. Otherwise, learners may spend their time learning to be successful at the game without receiving instructional benefits from these experiences.

The second "claim," that games enhance cognitive learning, continues to be supported. The research shows that people can learn from games. However, the research *does not indicate* that games are superior to other instructional methods in all cases. Like any instructional activity, games should be chosen because they provide learners with interactive experiences that help them meet instructional objectives.

The third and sixth "claims" were not supported. No additional evidence was found that games change later course work. This effect may occur, but no research was found to support this "claim." This may be because it is difficult to track learners from one class to another and document this effect. Likewise, no evidence was found for the sixth "claim," that the use of games changes the classroom structure and relations. This does not mean that instructors who use games in their courses do not change their classroom structure or that game players do not change how they relate to other learners. Some anecdotal evidence indicates that these changes do occur, but no empirical evidence was found.

Finally, the fourth and fifth "claims," that games change learners' feelings (affect) about the learning domain and learning in general has mixed support. Two studies (Williams, 1980; and Bredemeier, et al., 1982) provide some support for the utility of games to change learners' attitudes toward subject matter (claim 4). No empirical research was found that supports the claim that games can change learners' attitudes about learning in general (claim 5).

Table 5:
Evidence in Support of the "Claims": Then and Now

Categories of Claims	Original Evidence (prior to 1981)	Later Evidence (1981 - 2005)
1. Motivation & Interest	Strongest support. A great deal of anecdotal reports. Only one study (Robinson et al., 1966) used several indicators of motivation to show simulation-games generated greater interest than other modes of teaching.	Little additional evidence. A few studies found that learners indicated that they enjoyed games and spent more time playing. However, only weak connection between this and improved performance.
2. Cognitive Learning	Some weak empirical evidence favoring games. Some showing no differences.	Similar pattern. Some studies show that games are effective for some learning tasks, but do not show them superior to other instructional approaches. Some evidence that games can be detrimental to learning if they do not include instructional support. Games have been shown to be more effective if they are followed by a debriefing session that highlights the importance of the game experiences in terms of instructional objectives.
3. Changes in Later Course Work	None	None Found
4. Affective Learning (re: Subject Matter)	Mixed results. Some anecdotal evidence. Empirical evidence shows increases in both positive and in negative attitudes.	Two studies provide some additional support. There are indications that a game is more effective if used in the appropriate context.
5. General Affective Learning	Almost none	None Found
6. Changes in Classroom Structure & Relations	None	None Found

In summary, this review identified several general problems with instructional game research that make it difficult to draw firm conclusions. These problems include:

- There are many published articles, but most are opinions about the "potential" of games. There are few empirical studies.
- There is considerable confusion in the use of terms. When is a simulation a game? Are all competitive activities games? It is often difficult to determine if the instructional activity was actually a game.
- There are many methodological flaws in the empirical game research, such as poor experimental designs that lack the control of possible confounding variables (e.g., events prior to and during the evaluation).

- Some of the research appears to be biased by the evaluators' interest in "proving" the effectiveness of their game (i.e., they developed the game and wanted it to work).
- Too much research fails to use control groups who experienced an alternate form of instruction to compare to the game.
- Most published articles provide no clear and detailed description of the game itself (e.g., what characteristics made it a "game").

TO GAME OR NOT TO GAME?

As can be seen from the above discussions, the research on the use of instructional games is mixed. It appears that games can be of instructional value if they are well designed and targeted to meet specific instructional objectives. Unfortunately, many program managers and game developers do not appreciate the importance of instructional design. They often assume that the game is sufficient, in itself, to provide the necessary instruction. Squire (2005) conducted case studies of three companies that develop game-based learning products. "It is worth noting that *none* of the featured companies *started in instructional design*...they come from business strategy, marketing, and the games industry" (p. 13, my emphasis). Although each company used interdisciplinary design teams to create their instructional games, none of the teams included instructional developers. The teams usually consisted of: 1) graphic artists, 2) program managers, and 3) programmers. Commenting on the avoidance of instructional designers, Squire stated, "Most game-based learning approaches do not employ that particular category of expert whatsoever" (p. 35). In most cases, the game designers fulfilled the role of instructional developer. It appears that the "instructional gaming" industry does not value the skills of instructional developers.

This is not a new phenomenon. In the late 1980s, Greenblat (1987) observed that the teaching enterprise was undervalued in our society. Technological issues involved in game development seem better able to catch people's interest, while the development of instructional objectives and logical programs of instruction seems to be boring. The data on instructional effectiveness of games (e.g., Randel, et al., 1992; Parchman, et al., 2000; Wolfe, 1997) indicate that the role of the instructor and the way a game is incorporated into an instructional program are major factors in whether a game will contribute to successful learning. Nevertheless, it is not clear that current game-development teams understand the principles of instructional development. It may be up to the program managers and other individuals who procure instructional games to demand that they support instructional objectives and that this support be demonstrated. This will then probably require that game companies begin to include individuals who understand learning and instruction on their development teams. As illustrated in Figure 2, it is more likely that games will be instructionally effective if the specific characteristics of the game (e.g., setting, player roles and activities, rules, etc.) overlap with specific instructional objectives. This overlap must be consciously structured on the basis of a thorough analysis of the reasons for the instruction and the instructional objectives to be met.

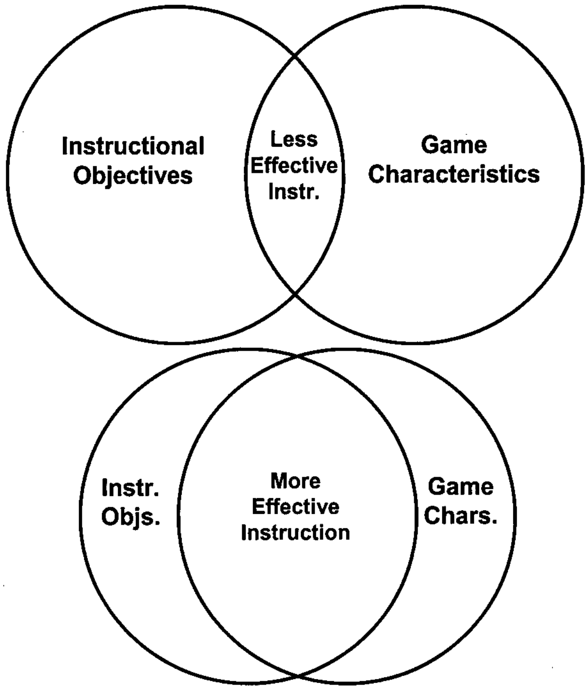

Figure 2:
Instructional Effectiveness as Degree of Overlap among Instructional Objectives and Game Characteristics

Rieber (1996) advocated a mixing of simulations and games in a hybrid learning environment. This approach would use the strengths of simulations (e.g., dynamic and interactive representations of real-world systems or phenomena) and the strengths of games (e.g., challenge and fantasy) to create instructionally sound, realistic learning activities. Additional research needs to be conducted that will provide guidance about how to create effective hybrid learning environments (e.g., how to determine if the specific features of specific hybrid games will support instructional objectives).

Much of the empirical research indicates that instructional games are only effective if they are designed to support instructional objectives. This is more likely if the design of the instructional game is the result of a systematic analysis process. Atkinson (1977) advocated that the design and development of instructional games should follow the same basic systems approach that is required for the design of any instructional activity. The basic steps in this approach are shown in Figure 3 as applied to the design and use of instructional games. The first section of the approach includes steps that are exactly the same, no matter what the outcome (e.g., choosing a game or another instructional activity). The first two steps are to identify the instructional problem and the instructional objectives. A problem statement is a general statement of the overall instructional problem (e.g., improve students overall understanding of and competence in a topic area). Next, specific instructional objectives must be determined. These objectives should be stated in terms of observable learner behaviors, under specific conditions that help the

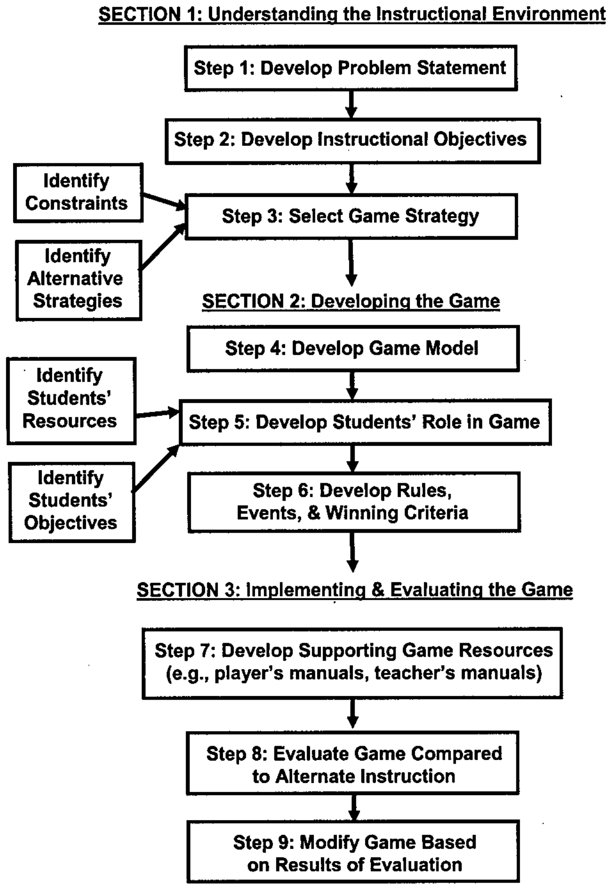

Figure 3:
A Systematic Approach to Instructional Game Design and Use

learners reach an acceptable level of performance. These foundational requirements are next used to help determine the possible alternative instructional strategies and/or approaches that can be selected. The choice of a specific instructional strategy is then determined on the basis of the constraints of each instructional situation (e.g., numbers of students, available facilities, budget, etc.). Only when a gaming approach has been selected from the alternative instructional strategies does one move to the next section: the design or modification of a specific game.

The second section of Figure 3 shows the basic steps in developing an instructional game. The fourth step is to develop the game model. Like any model, it is a simplified representation of only certain elements of reality. The specific elements chosen for the game should be selected on the basis of how they will support the instructional objectives already identified. Step 5 is the identification of how the students will participate in the game. Several questions, like the following, must be answered to support game design. Will each student play the same role or different roles? Will they play as individuals or as a team? Will learner actions affect the outcome of the game or do they just observe? These and other questions will lead to the development of specific rules and events in the game. Finally, the criteria for winning the game must be developed. Winning the game should involve improved learner performance on the instructional objectives. Sometimes an existing game can be modified for a new instructional situation. Even if an existing game is chosen, it must be modified to meet the specific requirements of the new instructional situation.

The third section of Figure 3 shows the three main steps involved in the implementation and evaluation of an instructional game. In addition to the game, supporting materials, like players' instructions and teachers' manuals must be developed. As indicated by the data from studies such as Leutner (1993) and Mayer, et al. (2002), instructional support that explains the purpose of the game and how to play it can enhance the instructional value of the game. In step 8, the instructional game is evaluated. Ideally this evaluation should compare the effectiveness of the game (as measured by learner performance) to the effectiveness of alternate instructional approaches. The final step in this process uses the results of the evaluation to modify the game to improve its instructional effectiveness.

In any systematic process, like the one depicted in Figure 3, it is necessary to make specific design decisions about the game. Malone (1981, 1982) reported the results of a series of studies that detailed the characteristics that made several simple video games enjoyable to students. As discussed earlier, he used his results to develop a general framework for analyzing the appeal of instructional environments, computer games, and computer interfaces (see Table 1). The framework was based on three categories: challenge, fantasy, and curiosity. Because this framework is consistent with the important characteristics of games and motivational instructional environments summarized earlier (e.g., Malone & Lepper, 1987; Lepper & Malone, 1987; Csikszentmihalyi, 1990; Leemkuil, et al., 2000), it has been adapted to help us make recommendations about the design of effective and motivational instructional games. Table 6 shows these design recommendations applied specifically to instructional games.

One thing that is fairly clear is that instructional games are not a panacea. Like any instructional medium or approach, games must provide a means for learners to engage in cognitive and/or motor interactions that directly support instructional objectives. Gratuitous use of games or the use of games with no clear instructional goals will probably increase the cost of the instruction without providing the instructional benefit that learners require (see the earlier discussion of de Jong & van Joolingen, 1998). If a game is chosen as an instructional approach, it is important that it includes instructional support, such as emphasizing important information in the game that support the instructional objectives (e.g., Leutner, 1993).

If designed with instructional goals in mind, games can provide effective instruction. Jacobs and Dempsey (1993) expressed the opinion that "By facilitating learner involvement via simulation and gaming and incorporating sound instructional features, learning outcomes should show improvements relative to other training methods that are less engaging or that provide less effective means of instructional interaction" (p. 198). They suggest that instructional gaming design should take several factors into account. Instructional games should include relevant activities that make up the job or domain of interest. The relative "criticality" of the various activities should be determined and the most critical should be included in the game. Finally, the performance of learners in the game activities should be evaluated so learners are rewarded for performing correctly and given remediation to improve incorrect performance.

Table 6:
Design Recommendations for Instructional Games

Design Category	Recommendations
Challenge	**A. Goal.** • There should be a clear goal to the game. • The goal should be consistent with the instructional objective. • Performance feedback should be provided about how close the learner is to achieving the goal.
	B. Uncertain Outcome. • The outcome of reaching the goal should be uncertain. The learner should have to exert effort to achieve the goal. • If the subject matter is complex, the game should include multiple levels of difficulty or complexity. Sub-goals should help the learner successfully complete enabling instructional objectives.
	C. Competition. • A game can be made more challenging by introducing competition. • Competition can be against a live opponent, against a computer-controlled opponent, or against a criterion score. Achieving a criterion score can be one of the factors that allows a learner to advance to higher levels of difficulty. • Game scores should be clearly related to the achievement of instructional objectives (e.g., not just how many shots are fired accurately or how many opponents are defeated).
Fantasy	**A. Emotional Appeal.** • The fantasy should embody emotional appeal for the learners (e.g., not everyone reacts positively to shooting weapons or conversely, to complex interpersonal situations).
	B. Fantasy Metaphor. • The metaphor used in the fantasy should embody physical or other characteristics that the learner already understands.
Curiosity	**A. Optimal Level of complexity.** • The game should provide an optimal level of informational complexity to meet the needs of the learners. • The level of complexity should increase as learners gain higher levels of expertise.
	B. Incorporation of Interesting Media. • The game should use interesting audio and visual effects to enhance the fantasy and emphasize instructional content. • The game can incorporate elements of randomness to avoid boredom for the learner.
Instructional Quality	**A. Logical Instructional Structure.** • The game should capitalize on the learner's desire to have "well-formed" knowledge structures. • Elements of the game should build on and reinforce each other to help build the learner's knowledge structures. • Learners should be able to easily see when their knowledge structures are incomplete. Feedback during the game should be used to help learners complete their knowledge structures.
	B. Incorporation into the Larger Instructional Program. • The game should not "stand alone." Rather, it should be part of a larger instructional program. • Debriefing and feedback should be provided after the game to help the learner understand how the experiences in the game supports instructional objectives.

CONCLUSIONS AND RECOMMENDATIONS

This review of empirical research on the effectiveness of instructional games leads to the following five conclusions and four recommendations. The conclusions are:

- The empirical research on the effectiveness of instructional games is fragmented. The literature includes research on different tasks, age groups, and types of games. The research literature is also filled with ill defined terms, and plagued with methodological flaws.
- Although research has shown that some games can provide effective learning for a variety of learners for several different tasks (e.g., math, attitudes, electronics, and economics), this does not tell us whether to use a game for our specific instructional task. We should not generalize from research on the effectiveness of one game in one learning area for one group of learners to all games in all learning areas for all learners.
- There is no evidence to indicate that games are the preferred instructional method in all situations.
- Instructional games should be embedded in instructional programs that include debriefing and feedback so the learners understand what happened in the game and how these events support the instructional objectives.
- Instructional support to help learners understand how to use the game increases the instructional effectiveness of the gaming experience by allowing learners to focus on the instructional information rather than the requirements of the game.

The following four recommendations may help the instructional gaming industry produce more instructionally effective games.

- The decision to use a game should be based on a detailed analysis of the learning requirements and an analysis of the tradeoffs among alternate instructional approaches.
- Program managers and procurement personnel should insist that game developers clearly demonstrate how the design of a game will provide interactive experiences that support properly designed instructional objectives (see for example, Gagné & Briggs, 1979; Merrill, 1983; 1997 for guidance on the proper design of instructional objectives).
- Instructors should view instructional games as adjuncts and aids to help support instructional objectives. Learners should be provided with debriefing and feedback that clearly explains how their experiences with the game help them meet these instructional objectives.
- Instructor-less approaches (e.g., web-based instruction) must include all "instructor functions." These include performance evaluation, debriefing, and feedback.

Herbert Simon (2000) provides a succinct prescription for designing improved instruction. Although he was not speaking specifically about instructional games, his prescription applies equally well to instructional games as to other forms of instructional activities. As Simon puts it, "A first step toward improved instruction is to examine the understanding we hope students will acquire, the things they should be able to do with their knowledge....Next, we must design a series of experiences that will enable students to learn the relevant cues in the situations they encounter and to evoke from memory the actions that are effective and appropriate in specific situations" (pp. 117-118).

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