CHAPTER

25

What Can We Learn From Playing Interactive Games?

Debra A. Lieberman
University of California, Santa Barbara

Interactive games are powerful environments for learning. Research consistently finds that players learn new skills, knowledge, insights, attitudes, or even behaviors in games that challenge them to think, explore, and respond (see, for example, Betz, 1995; Gee, 2003; Dempsey et al., 1996; Jayakanthan, 2002; Kirriemuir, 2002; Lieberman, 1997, 2001a; Potter, K. R. 1999; Prensky, 2001).

How do games stimulate and support learning? Consider the following features of well-designed games, found also in the best nongame learning environments (Choi & Hannafin, 1995; Reigeluth & Squire, 1998; Schank et al., 1994; Tennyson & Breuer, 2002). Typically, interactive games challenge players to solve compelling problems. Players learn by doing, in a virtual setting that responds to every move or decision or input they make. They interact with the game environment, develop skills to succeed in that environment, and rehearse those skills repeatedly. They have opportunities to experiment, fail, and try again until they succeed, and they receive help when needed. Games usually adapt to players' abilities and keep the level of difficulty in a range that is challenging but not impossible for each individual. Players receive feedback on their progress and they are able to see how their choices enhance or hinder their advancement toward their goal. They learn what is valued by receiving rewards (e.g., gaining points or status) or punishments (e.g., losing points or status) for their decisions and performance. They may also observe role-model characters experiencing positive or negative consequences for their behaviors. And, players often collaborate with other people, learning information, skills, and strategies from each other.

These well-established approaches to teaching and learning occur with skillful tutors and classroom teachers, and also with interactive games. It is important to note that the capacity of games to teach does not guarantee that their lessons will be desirable ones. For example, the entertainment industry has produced a variety of popular games that promote fear, hate, and violence. Most studies investigating their effects on players' emotions, attitudes, and behavior conclude that players learn these lessons well, sometimes to the point of antisocial behavior

(see Buckley & Anderson, this volume; Calvert et al., 2002; Cassell & Jenkins, 1998; Cooper & Mackie, 1986; Kinder, 1996, 2000; Lee & Peng, this volume; Schutte et al., 1998; S. Smith, this volume; Weber, Ritterfeld, & Kostygina, this volume). On the other hand, games designed to teach more valuable lessons can also be effective (see Amory et al., 1999; Bosworth, 1994; Lieberman, 2001a; Subrahmanyam & Greenfield, 1994; Thomas, Cahill, & Santilli, 1997; Walshe et al., 2003), and the curriculum of games has been expanding into new topic areas and applications (Gee, 2003; Goldstein, 2003; Prensky, 2001; Stewart, 1997; Wolf, 2002). Almost any message could be conveyed, supported, and rehearsed in an interactive game. To paraphrase former FCC Commissioner Nicholas Johnson's famous quotation made decades ago about the effects of television, and substituting interactive "games" for "television," it is fair to say today that "All games are educational games. The question is: What are they teaching?"

To begin to answer that question, and to consider implications for future game design, this chapter cites research that has identified many kinds of learning that take place with games and, in some cases, how this learning happens. It organizes current research on interactive games and learning into nine areas:

- Motivation to learn
- Perception and coordination
- Thinking and problem solving
- Knowledge
- Skills and behaviors
- Self-regulation and therapy
- Self-concepts
- Social relationships
- Attitudes and values

MOTIVATION TO LEARN

Interactive games can motivate people to learn, including those who at first are not particularly interested in the subject matter (Reigeluth & Squire, 1998; Lepper & Henderlong, 2000; Lieberman & Linn, 1991). The incentive of trying to win a game, which is an extrinsic, external motivation for learning, can draw players into the learning activity, which can then stimulate an intrinsic, internalized interest in the subject matter itself (Cordova & Lepper, 1996; Millians, 1999). For example, quiz games and simulation games have been used successfully both to attract adolescents to online health information and to increase their interest in health topics (Bosworth, 1994).

People who play interactive games in the United States are diverse (see Raney, Smith, & Baker, this volume; Weber this volume) and more than 50% of the population plays them regularly (ESA, 2003). Enthusiasts come from all socioeconomic backgrounds, genders (43% of game players are female), and age groups (65% of game players are age 18 or older), and the amount of leisure time spent playing interactive games continues to grow (Buchanan & Funk, 1996; ESA, 2005; Ipsos-Insight, 2003). In a survey of 1,500 representative U.S. households (ESA, 2003), respondents ranked interactive games as the most fun form of entertainment, ahead of watching television, surfing the Internet, and going to the movies. The top reasons they selected for playing interactive games were, "It's fun," "They're challenging," and "I like to play with friends and family." More than three quarters of all U.S. children play interactive games, and those who play games spend an average of about 1 to 1.5 hours per day playing them during leisure time (ESA, 2005; Huston et al., 1999; Ipsos-Insight, 2003; Roberts et al., 1999).

More than half of the U.S. population has grown up with games and other computer-based media, and many in this group are comfortable with the technology, enjoy responding to interactive content, and often want and expect to be able to *do* something with a screen in addition to watching it (Harel, 2002; Papert, 1993; Rieber, 1996; Wartella & Jennings, 2000). Following are some of the reasons why interactive games are so attractive and motivating to the younger half of the population and, increasingly, to the older half as well.

Appeal

Research on the appeal of interactive games has found that players especially like to experience challenging goals, stimulation of curiosity, control over the action, and fantasy themes (Cordova & Lepper, 1996; Ermi, Helio, & Mayra, 2004; Malone & Lepper, 1987); verisimilitude, which is authenticity in graphics, sound, and other sensory cues of the presentation (Reid, 1997); problem solving (Reid, 1997); competition (Cordova & Lepper, 1996; Reid, 1997); and collaboration (Cordova & Lepper, 1996). Also, children are attracted to games that support them in developing the skills needed to succeed in the game, and they like explorations and construction activities that help them achieve game-related goals (Ermi, Helio, & Mayra, 2004).

Challenge to Reach a Goal

The central motivating feature of an interactive game is the goal it sets for the player. It is rewarding to succeed in a game and to experience a sense of efficacy and control, and players are often motivated to strive intensely to achieve these rewards (Klimmt & Hartmann, this volume). The challenge to perform and win makes a game highly involving, especially when the challenge is difficult, it is possible to lose, and there is more than one pathway to winning (Malone & Lepper, 1987; Reid, 1997). Players become deeply immersed in games that challenge them—for instance to solve a problem, explore an environment or system, share strategies with others, make something happen, complete a puzzle, prevail over an obstacle, compete against time, or find an answer. In all these examples players have a goal. Learning that occurs in the process of attempting to reach a goal can increase players' interest, motivation to learn, and learning outcomes (Cordova & Lepper, 1996; Schank et al., 1994).

Emotions and Fun

Players enjoy the entertaining, playful aspects of interactive games, which could include an enthralling story; appealing characters; lush production values; a sense of social presence; making choices that affect the direction of the game; assuming the role of a character and playing with a new personality or identity; the extreme emotions that come with failure and success; and the pleasure of interacting with other characters and players (see Gee, 2003; Prensky, 2001; Tamborini & Skalski, this volume; Vorderer, 2000; Vorderer et al., this volume; Wolf, 2002; Wolf & Perron, 2003). These experiences can heighten players' emotional responses to an interactive game and motivate their effort to learn (Garris, Ahlers, & Driskell, 2002; Lepper & Henderlong, 2000).

Interactivity

Games are interactive when their responses take into account previous actions or messages generated by both the player and the game. A game's response to the player at any given point depends to a great extent on the player's previous choices and inputs, in much the same way a

good conversation is based thoughtfully on the previous messages two people have exchanged. (See Rafaeli, 1988, for a discussion of interactivity; also see Vorderer, 2000.)

Interactivity can involve feedback and help messages that are tailored to the individual player and that adapt to the player's changing abilities, and these elements can be educationally effective (Betz, 1995; Kafai et al., 1998; Millians, 1999), providing the kind of learning support that expert tutors give to students (Choi & Hannafin, 1995; Dempsey et al., 1996; Lepper & Henderlong, 2000; Reigeluth & Squire, 1998). Players typically enjoy interactive, experiential learning that gives them a great deal of control, involves them in active decision making, and provides continuous feedback that lets them know how well they are doing and gives hints and support if they are having problems with the material (Amory et al., 1999; Garris, Ahlers, & Driskell, 2002; Harel, 2002; Stewart, 1997). Learning outcomes improve significantly when players receive a flexible and appropriate level of assistance based on recent performance (Davis, 1999; Luckin, 2001); creativity and problem-solving skills can also improve with this kind of adaptive help (Tennyson & Breuer, 2002).

Engagement

Interactive games can be extremely demanding, often requiring deep levels of attention, managing more than one cognitive task at a time, or making quick responses. Players actively participate in a game—applying knowledge, devising strategies, making decisions, using skills, and reviewing the outcomes. The demands of a game engage players in what has been called "productive play," the learning and accomplishment that can occur when playful activities lead, for instance, to building virtual worlds, manipulating simulations, or solving problems (Rieber, 1996). Other terms for this process are "serious play" (Rieber, 1998) with games, and "hard fun" with computer-based interactive media in general (Papert, 1993, 1996). In many cases, the people who are resistant to the more traditional didactic methods of teaching and learning are happy to engage in the productive play and hard fun of interactive games (Betz, 1995; Ermi, Helio, & Mayra, 2004; Papert, 1993).

Flow

Participation in a challenging activity bounded by rules often brings a sense of pure concentration and immersion, or "flow" (Csikszentmihalyi, 1990, 2000; Weisler & McCall, 1976). It is a state of pleasure, well-being, and increased cognitive efficiency that occurs during an absorbing task. People experience flow when they are challenged enough to do their best, yet not challenged beyond their abilities. Flow can occur whenever an activity involves intense focus and a sense of control—during work, creative endeavors, sports, or play. People in a state of flow often lose their sense of time and place while they are completely absorbed in the concentrated effort. Children and adults enjoy being in a state of flow when playing a challenging yet achievable interactive game. Here again, the components of interactive games that make them attractive and compelling are the same components that motivate engagement and learning.

Story Line

Intriguing stories can attract and involve an audience (Gee, 2003; Sood, Marard, & Witte, 2004). Some games are designed so that the plot will move forward only after the player has completed a task. In these cases, the goals of the game are interrelated with the unfolding of the story, requiring players to solve problems in order to advance the plot. The desire to see

what happens next in a story is a powerfully motivating force (Amory et al., 1999; Gee, 2003; Goldstein, 2003; Vorderer, 2000; Wolf, 2002).

PERCEPTION AND COORDINATION

Most of the research on effects of games on perceptual skills and coordination has been done with children and adolescents, and some has been done with college students. Many studies ask whether players learn and improve the cognitive and motor skills they use while playing interactive games.

Spatial Perception

Research has found that some visually oriented interactive games improve players' spatial perception and visualization skills, such as the ability to recognize 3-dimensional shapes and mentally rotate them (Dorval & Pepin, 1986; Gunter, 1998; Lowery & Knirk, 1983; Okagaki & Frensch, 1994; Subrahmanyam & Greenfield, 1994). For example, in one study students in Grades 5, 7, and 9 played interactive games that required the use of spatial skills, and students in each grade subsequently improved the spatial skill of mental rotation and became more adept at using mental maps as an aid to memory (McClurg & Chaille, 1987).

Visual Style of Communication

Games often rely heavily on animation, pictures, and diagrams, and not so much on words, to convey information. It makes sense that players of visually oriented games would become more proficient at reading images and might even develop a preference for using images to express themselves. A cross-cultural experiment, designed to show causality, and conducted with college students in the United States and Italy, found that playing a visually oriented interactive game shifted players' representational styles from verbal to iconic and spatial. Participants who spent time playing the interactive game later used more diagrams to convey information, whereas those who played a board game with content similar to the interactive game continued to use a verbal style and did not shift toward a more visual style (Greenfield et al., 1994a).

Cognitive Processing, Visual Processing, and Eye–Hand Coordination

There is also evidence that game playing can improve cognitive processing skills such as visual discernment, which involves the ability to divide visual attention and allocate it to two or more simultaneous events (Greenfield et al., 1994b); parallel processing, the ability to engage in multiple cognitive tasks simultaneously (Gunter, 1998); and other forms of visual discrimination including the ability to process cluttered visual scenes and rapid sequences of images (Riesenhuber, 2004). Experiments have also found improvements in eye-hand coordination after playing video games (Rosenberg et al., 2005).

Correlational studies have found that children who are frequent video game players have greater capacity than infrequent players and nonplayers for deep concentration, are more adept at making quick decisions and responses, and have exceptional eye–hand coordination (Gunter, 1998). Unlike the controlled experiments discussed in this section so far, correlational studies examining the skills of frequent game players are snapshots in time and are usually

not designed to show causality. They cannot tell us if frequent video game playing causes the skills to emerge; an alternative explanation would be that young people who already have the skills are the ones who enjoy and seek out interactive games the most.

Manual Dexterity and Speed

Action-based interactive games, where the player pushes buttons on a game controller device, require players to develop an expert level of manual dexterity and the ability to make quick decisions—skills that are also needed to conduct laparoscopic surgery. In one study, surgeons who usually spent at least 3 hours a week playing action video games during leisure time, made about 37% fewer mistakes in laparoscopic surgery practice tasks and performed them 27% faster than their colleagues who did not play video games (Dobnik, 2004; also see Rosenberg et al., 2005).

Technological Skills and Career Interests

Some have noted (e.g., Gee, 2003; Prensky, 2001; Subrahmanyam & Greenfield, 1994) that the perceptual and coordination skills that players develop with visually oriented interactive games, such as the ability to perceive and apply fast-paced multichannel information on computer screens, are skills also needed for technological literacy. The enjoyment and skill development in video game playing may stimulate interest in a career involving advanced technological work, scientific research, or computer programming. Games may serve as training grounds for future technical careers.

THINKING AND PROBLEM SOLVING

Some theorists have noted that interactive games require players to apply and rehearse sophisticated thinking and problem-solving skills, such as close observation, inferring of the rules and structure of a game, logical thinking, hypothesis testing, experimentation, and strategy development (Gee, 2003; Hogle, 1996). An examination of the tasks involved in playing various game genres concludes that games with puzzles and complex questions may improve players' ability to think logically and tactically; simulation games may enhance scientific thinking, such as the ability to control for a single a variable; and adventure games may increase players' skills in observation, analysis of systems, and coaching of others (Prensky, 2001). Following are some of the skills that have been tested in research.

Self-Directed Learning

Studies have found that games challenge players to pay attention, monitor and evaluate their own actions, use strategies such as grouping and the use of imagery as aids to memory, reason inductively and deductively, apply new knowledge to novel situations, and use affective strategies such as anxiety reduction and self-encouragement (Chaika, 1996; Goldstein, 2003; Hogle, 1996; Oyen & Bebko, 1996). One study, for example, found that college students improved in cognitive flexibility and creativity after they participated in interactive games that demanded and rehearsed those skills (Doolittle, 1995).

Game players may learn new ways to learn in order to win at games. As players become more aware of and adept at their own learning strategies, they begin to apply them more appropriately. The strategies may include, for example, learning through trial and error, finding patterns that

lead to discovering an answer, or using an inductive style of learning (Lepper & Henderlong, 2000; Lieberman & Linn, 1991).

Components of Learning

Children who are expert players of interactive games tend to be highly skilled at self-monitoring, pattern recognition, iconic representation, principle-based decision making, qualitative thinking, and memory (Vandeventer, 1998), and these skills are components of some of the broader cognitive tasks of learning, such as classifying, planning, critical thinking, scientific and mathematical thinking, decision making, and problem solving (Greenfield, 1993; Kafai et al., 1998; Subrahmanyam et al., 2001). As mentioned earlier, studies of expert players often provide no causal information. It is possible that either game playing causes the skills to develop or alternatively the preexistence of these skills leads the person to play interactive games.

Transfer of Skills

One study provides an example of skill transfer without any coaching or support. It found that arcade-style action games increased players' abilities in inductive discovery, and they transferred their newly acquired skills from the game environment to a non–game environment that required them to use scientific–technical representation (Greenfield et al., 1994b).

KNOWLEDGE

Interactive games often require players to take in new information, apply it toward solving a problem, receive feedback on their performance, and then apply the information again until they are successful. This combination of obtaining information and using it repeatedly helps players learn and retain the information, and applying it in a meaningful context helps them develop deeper understanding (Heinich et al., 1996; Kafai et al., 1998; Potter, K.R., 1999; Reigeluth & Squire, 1998).

Learning Outcomes

Hundreds of studies find that people learn with appropriately designed interactive media, such as software and the Internet (see Fletcher-Finn, 1995; Kozma, 1994; Kulik & Kulik, 1991; Mayer & Moreno, 2002; Mayer, Schustack, & Blanton, 1999; Subrahmanyam et al., 2001; Wartella & Jennings, 2000). Learning is especially well supported when learners proceed at their own ability level and pace, receive individualized and constructive performance feedback, receive help when needed, and review material until they understand it thoroughly (Jayakanthan, 2002; Jonassen & Land, 2000; Reigeluth & Squire, 1998; Tennyson & Breuer, 2002). These features are commonly built into interactive games, including games designed purely for entertainment and games intended for learning and behavior change (Lieberman, 1997). To a greater or lesser extent, most games support players' learning of the content needed to succeed in the game. Following are examples of research on learning effects with interactive games:

Situated Learning and Mindfulness

Games provide situations that stimulate players to learn and apply knowledge. Players learn-by-doing in contexts that afford them some control over environments that change as a result of

their decisions. Not only can players gain information when their learning is situated this way, but they also gain other kinds of knowledge, such as insights into how their decisions affect the physical or social environment portrayed in the game and how the components of systems are interrelated. They also learn firsthand about values, social relationships, and socially acceptable strategies for approaching and solving problems. It is important to note that games contain their own logic and assumptions about cause and effect, which may be biased or inaccurate, intentionally or unintentionally, on the part of the designer. The game environment responds to the player according to those built-in assumptions and can convey persuasive lessons about appropriate ways to behave (Fogg, 2003). For example, many violent entertainment games demonstrate that crime and murder bring status and power to the perpetrator; health games may show medication use as the only way to become healthy, without including alternative therapies or healthy lifestyle changes as viable routes to health; and AIDS prevention games may portray abstinence as the only way to prevent infection.

Situated learning in interactive games can motivate deep cognitive engagement. To succeed in the situation, players become especially mindful of the content they need to know in order to win the game and mindful of the skills they must apply, and they use effortful and strategic processes of thinking (Lieberman & Linn, 1991; Potter, K.R, 1999). This close attention and intense mental effort lead to deeper understanding, learning, and retention of the material (Choi & Hannafin, 1995). There is some evidence that involvement in learning activities tends to be stronger when learning is game-based, compared to more traditional approaches to teaching and learning (Cordova & Lepper, 1996; Dempsey et al., 1996; Hogle, 1996), and this leads to more learning and retention of the content. One study found that children's enjoyment and mental effort were more intense while playing interactive games than while watching animations or solving visual puzzles (Yamada, 1998).

Pedagogical Agents

A character in an interactive game can be designed to interact with the player as a pedagogical agent, serving as a role model, tutor, or guide to support learning, either as a participant in the game environment or as a helper on the side (Amory et al., 1999; Jayakanthan, 2002). One study provides evidence that such agents might be effective in games. It found that seventh-grade students who learned biology with assistance from a software-based interactive pedagogical agent were more interested in the lesson and were better able to transfer the knowledge and skills they learned in the lesson, compared to students who learned biology but did not interact with the agent (Moreno et al., 2001).

Simulations

A simulation is a representation of a physical or social system that lets the user change its parameters and observe its dynamics (Aldrich, 2003; Heinich et al., 1996). With interactive media a simulation can be an algorithm-based artificial world that has some properties of the real world. For example, there are simulations that enable users to learn how ecosystems work, how to lead a country and deal with international conflict, how chemicals interact, how to fly an airplane, how to use food and insulin to keep a diabetic character's blood glucose in the normal range, how to manage a city, how to build a business, how to keep a family happy and thriving, and so on. Simulations can simplify a view of a system by eliminating some of the variables; they can speed up or slow down time so that processes and outcomes are easier to observe; they allow the user to manipulate variables that are not immediately alterable in the real world (such as raising and lowering the Earth's temperature to observe the impact of global

warming); and they are safe because any dangerous outcomes are depicted but not physically experienced.

When a simulation challenges the user to achieve a goal within the simulated world, then it becomes a game. Some simulation games incorporate interactive features that enhance the learning experience, such as calculation tools, multiple modalities to represent events (for example, using the modalities of sound, text, mathematical formulas, and graphs to represent the current state of the simulation); performance feedback; characters that interact socially with the player to teach, guide, or help; logbooks to keep track of the player's decisions and their effects; and debriefing scenarios that help learners reflect on what they achieved and how they got there.

Research has discovered a broad range of learning outcomes that can occur with simulation games, such as, multidisciplinary learning across the curriculum, where students see how academic subjects are interrelated when they try to solve real-world problems (Betz, 1995); insight into cause and effect within complex systems, where learners make decisions and immediately see the consequences (Corbeil, 1999); development of skills in logic and decision making (Aldrich, 2003; Goldstein, 2003); and moral and ethical development as learners see how their decisions can affect others (Aldrich, 2003; Millians, 1999; Reigeluth & Squire, 1998).

SKILLS AND BEHAVIORS

Interactive games can challenge players to apply a wide variety of skills. There are games, for instance, that develop players' skills in reading, math, business management, crisis management, military combat, committing crime, fistfighting, singing, dancing, playing chess or basketball, negotiating safe sex, and taking care of one's health. Direct participation in virtual tasks with interactive media such as games has in some cases developed learners' skills better than traditional didactic, less participatory, forms of learning (Betz, 1995; Kozma, 1994; Moreno et al., 2001).

Example: Health Behavior

Interactive health games can improve players' health-related skills and behaviors. Field studies and clinical trials of a series of console-based (Nintendo) interactive health games found, for example, that players with chronic health conditions (diabetes or asthma) improved their self-care skills and their prevention and self-care behaviors, and this led to improved diabetes or asthma outcomes (Lieberman, 2001a).

In a controlled trial, diabetic children and adolescents were randomly assigned to take home either a diabetes self-management video game or an entertainment video game with no health content, and were told they could play their game as much or as little as they wished, as long as they followed all household rules about when and for how long they were allowed to play interactive games. The study found that participants in both groups played their game about 1.5 hours per week on average over the course of 6 months, but only the group that received the diabetes game increased their communication about diabetes with family and peers, increased their diabetes knowledge and perceived self-efficacy for diabetes self-care, and improved their diabetes-related skills and self-care behaviors. As a result their urgent care and emergency visits related to diabetes decreased by 77%, dropping from an average of about 2.4 visits per child per year down to about 0.5 visits per child per year. The control group that received the entertainment video game experienced no significant changes in diabetes-related skills, behaviors, or outcomes (Brown et al., 1997; Lieberman, 2001a).

Similar randomized controlled trials of an asthma self-management game, with asthmatic children and adolescents, found improvements in their asthma-related knowledge, self-efficacy, self-care skills, and behaviors, and 35 to 40% reductions in urgent care and emergency visits related to asthma, and in missed school days due to asthma. Other studies also found increases in players' asthma knowledge and perceived self-efficacy for asthma self-care (Lieberman, 1997, 2001a).

Another example of behavior change with an interactive health game is a nutrition game that was designed for the elementary school curriculum to increase children's consumption of fruits and vegetables. A randomized study in 26 elementary schools found that fourth graders who participated in the game-based curriculum for 5 weeks ate 1.0 servings more per day of fruits and vegetables, during the week after the curriculum ended, than did the control group that did not participate (Baranowski et al., 2003).

Example: Aggressive Behavior

Effects of violent interactive games on aggressive behavior have been studied extensively (for reviews of the research and discussion of theory in this area, see Buckley & Anderson, chap. 5, this volume, Kinder, 1996, 2000; Lee & Penge, this volume; W. J. Potter, 1999; S. Smith, this volume; Weber, Ritterfeld, & Kostygina, this volume), especially with children and adolescents, who are considered to be particularly vulnerable. Several studies have found increases in aggressive behaviors and in fearful and hostile emotional states after playing violent games, but not after playing nonviolent games (Cooper & Mackie, 1986; Lee & Peng, chap. 22, this volume, Schutte et al., 1988; Weber, Ritterfeld, & Kostygina, chap. 23, this volume).

SELF-REGULATION AND THERAPY

Interactive games have been used to teach people how to regulate physiological processes such as brain waves and relaxation, cognitive processes involved in allocating attention, emotional reactions to events and the environment, and phobias.

Regulating Brain Waves and Attention

Biofeedback games challenge players to keep their brain in a particular wave state in order to progress in the game. Images, sounds, and events in the games provide biofeedback to the player and show the current brain wave state. In addition to self-control of brain waves, interactive games can motivate players to self-monitor and regulate their attention. In one study, players with attention deficit disorder (ADD) improved their ability to sustain their attention by playing an interactive game that detects the player's brain waves (Pope & Bogart, 1996). The game is based on a biofeedback system that was developed to assess the mental engagement of airplane pilots. When the system detects, from the player's brain waves, that attention is waning, the game becomes more difficult to play. The player can only succeed in the game by maintaining an adequate level of attention, and is motivated to attend in order to win the game.

Therapy, Social Skills, and Pain Management

In a clinical context, interactive games have led to positive therapeutic outcomes for children and adolescents (see Griffiths, 2003). They have helped young people undergoing chemotherapy and psychotherapy, children with emotional and behavioral problems, and

youngsters with communication and social skill problems related to impulsivity, ADD, and autism. In addition to teaching young people how to regulate attention, manage emotions, and interact socially, interactive games have also helped distract patients to reduce their perception of pain during physical therapy and during medical procedures for conditions such as Erb's palsy, muscular dystrophy, and burns.

Phobias

Virtual environments have been used very successfully in exposure therapy, for patients who have phobias such as fear of snakes, spiders, public speaking, elevators, and flying (Wiederhold, 2003). Under the guidance of a therapist, patients learn to approach the object of their fears in small, incremental steps. In the past this was done through direct experience, but now virtual environments are providing a more economical way to achieve the same outcomes. In one study, an interactive game provided effective therapy for auto accident victims who wanted to reduce their fear of driving (Walshe et al., 2003).

SELF-CONCEPTS

Interactive games provide performance feedback that can call attention to a player's skills and accomplishments to such an extent that they influence players' sense of self. Following are a few of the ways games teach players about themselves, especially in the areas of self-esteem and self-efficacy.

Self-Esteem and Pride of Achievement

Players enjoy having control over the action in an interactive game. Control helps make the experience immersive and involving, allowing players to explore their own pathways through the material, make choices, and experience the resulting rewards (Klimmt & Hartmann, this volume). When they have a high level of control and then succeed, they feel pride and self-esteem because the success was based to a great extent on their own decisions and skills (Colwell, Grady, & Rhaiti, 1995; Corbeil, 1999; Luckin, 2001; Stewart, 1997; Tennyson & Breuer, 2002).

Combining Interactivity and Privacy

Computer-based media such as interactive games offer users the unique experience of receiving interactive and individualized performance feedback *without* the presence or surveillance of another person. This combination of interactivity and privacy can be especially effective for game players who are not yet confident of their skills and would be embarrassed to try them out in front of others. Working alone, a player can rehearse new skills in a game—and receive feedback and help—without fear of publicly exposing their weaknesses. After the skills improve, the player will be eager to show others, and both the sense of pride in one's own achievement and the social approval received from others can increase self-esteem (Amory et al., 1999; Lieberman, 2004; Millians, 1999).

Another advantage of privacy plus interactivity can occur when players want to explore a topic without others knowing they are interested in it, such as sex, alcohol, drugs, or other high-risk behaviors. People can save face and avoid the embarrassment of admitting an interest in forbidden, taboo, or illegal behaviors, while still being able to assess their own risks,

develop prevention and self-care skills, and obtain information, in an interactive environment (Bosworth, 1994).

Self-Efficacy

Social cognitive theory (Bandura, 1997, 2004; Klimmt & Hartmann, this volume) points to the importance of the individual's sense of self-efficacy as a mediator of behavior change. Self-efficacy is the belief that one is capable of carrying out a particular activity or behavior. People with high self-efficacy for an activity that they consider to be desirable are more likely to engage in that activity than people whose self-efficacy is low. Encouragement, positive performance feedback, vicarious experience, and the actual experience of success can raise a person's sense of self-efficacy and can increase the likelihood of future behavior.

Some interactive games are designed to increase players' self-efficacy by giving them vicarious experiences in which they can succeed. Players apply specific skills and the game supports them with encouragement, feedback, help, and rehearsal and application of skills until they are successful. Research has found that interactive games can help players improve their self-efficacy for skills involved in HIV/AIDS prevention (Thomas, Cahill, & Santilli, 1997), diabetes self-management (Brown et al., 1997; Lieberman, 2001a), and asthma self-management (Lieberman, 1997, 1999).

SOCIAL RELATIONSHIPS

A discussion of interactive games and learning should consider not only the solo activity of a person playing a game but also the social environment in which game playing occurs. Research finds that for most people interactive game playing is essentially a social activity. Game players are not social isolates; instead they tend to meet friends outside of work or school more often than occasional players or nonplayers do (Colwell, Grady, & Rhaiti, 1995; Funk, Germann, & Buchman, 1997; Orleans & Laney, 2000), and they often play interactive games with family and friends instead of playing alone (ESA, 2003). Although most research finds that game players are more socially active than nonplayers, one study found no differences in the amount of social interaction for game players and nonplayers (Phillips et al., 1995).

In addition to playing games with others, interactive game players like to talk about games when they are not playing (ESA, 2003). Players often help each other with game strategies and this develops their knowledge about topics presented in the game, and also helps improve social and communication skills (Goldstein, 2003; Vandeventer, 1998).

Social Recognition for Game Skills

The desire to demonstrate expertise to others and gain social approval motivates players to invest considerable effort so that they will ultimately perform well in games (Griffiths, 1997). When they gain the admiration and approval of peers, they are then motivated to continue striving to succeed in order to stay in the spotlight (Sakamoto, 1994). Video game arcades, for example, are meeting places for adolescents, where they can socialize without parental control and can show off their skills to others (Michaels, 1993).

Using Social Interaction to Enhance Learning

Games have been created to encourage social interaction as a route to learning (Choi & Hannafin, 1995; Griffiths, 1997; Mayer, Schustack, & Blanton, 1999; Reid, 1997). The health

games discussed earlier (Lieberman, 2001a) were designed to stimulate discussion about health, by including two-player options that required both players to communicate with each other and cooperate in order to win the game. Clinical trials found that young people who were randomly assigned to take home a health game for six months gained more health knowledge, shared more information about the health topic with family and friends, and discussed their personal feelings about the health topic with others more often than those who were randomly assigned to take home a nonhealth entertainment game for the same period of time (Lieberman, 1997, 2001a). When people have opportunities to talk about their health with others this way, they receive more social support and this is associated with better self-care, better health, and more effective coping strategies when problems arise (Peterson & Stunkard, 1989).

Game Communities as Learning Environments

Communities develop around games, offline and online, and they often involve extensive social interaction and sharing of knowledge. With offline games (standalone console, computer, or arcade games), players meet to play together face-to-face and enjoy both competitive and collaborative experiences. Online games (via consoles or computers) bring people together from diverse geographical locations. Some of the most commercially successful interactive games each have dozens of fan sites where players create, share, and trade game objects, maps, levels, scenarios, game codes, and stories. They develop personal relationships and social structures, use their own language and jargon related to games, and collaborate in a group effort to beat the game, and these interactions are an important part of the game playing experience (Amory et al., 1999; Bruckman, 1998).

Some games are designed especially for collaboration and group participation, activities that foster learning. Playing in a MUD (Multi User Domain—or Dungeon or Dimension) or MOO (MUD, Object Oriented) allows players to collaborate in groups to complete quests, solve puzzles, or defeat enemies. Each character has unique strengths and weaknesses, and usually cannot survive without working cooperatively with other characters who have different, complementary abilities. This builds a sense of community, where players design and construct personally meaningful projects, and are self-motivated and peer-supported (Bruckman, 1998). Participation in online game communities is growing and the more popular role-playing games have many thousands of players participating online at any given time.

ATTITUDES AND VALUES

Games can potentially affect players' attitudes and values related to learning, social roles, and behaviors such as violence or nurturing. More research is needed in this area.

Attitudes About Learning: Enjoyment and Rewards

Players may develop more positive attitudes about learning after they learn in an interactive game. There is evidence that players who have enjoyable and productive learning experiences with a game will develop and sustain positive attitudes about learning that subject outside the game environment, and will develop more positive attitudes toward learning in general. This is especially likely to happen if the rewards of the game focus on a job well done and on the value of the learning itself, and not on extrinsic rewards such as points and prizes (Lepper & Henderlong, 2000; Papert, 1993; Schunk & Zimmerman, 1994).

Attitudes About Others: Role Playing and Role Modeling

Role playing and role modeling in games can teach attitudes and values (Cassell & Jenkins, 1998; Gunter, 1998; Kinder, 2000; Lee & Peng, this volume; Lieberman, 2001b) Social cognitive theory (Bandura, 1997, 2004) explains how attractive role model characters that are similar to the player can teach by example. Players may observe role model characters or interact directly with them They may even play the role of the character, make behavioral choices, and virtually experience the rewards and punishments that occur as a result of the character's actions Further research is needed on the attitudinal effects of having a first-person experience of virtual rewards and punishments in the context of an interactive game.

Research on effects of violent games offers some evidence that role playing and role modeling can influence attitudes and values For example, playing violent games can desensitize players to the horrors of real-world violence, increase their hostility and mistrust of others, and teach them to accept violence as a legitimate way to solve problems (Buckley & Anderson, this volume; Potter WJ, 1999) Violent games often portray repetitive, sometimes constant, use of weapons or fistfights, and this violent behavior is rewarded with flashy graphics, sound effects, game progress, points, and other affirmations. Violent role modeling and role playing like this may significantly influence players' attitudes about the appropriateness of violence in society (Kinder, 1991, 1996; Wartella & Jannings, 2000; Wartella, O'Keefe, & Scantlin, 2000; Weber, Ritterfeld, & Kostygina, this volume)

CONCLUSION

Interactive games are dynamic learning environments that can motivate players to achieve, and can instill confidence, stimulate thinking and problem solving, and successfully support the development of new knowledge, skills, and behavior. Current research has found a broad and diverse range of learning outcomes with interactive games, both desirable and undesirable.

The most effective interactive games intended for learning are designed on the basis of well-established theories and learning principles from the fields of education, psychology, communication, human--computer interaction, and the arts and humanities. Game designers should know their intended players well, should have a clear idea of what they want the game to achieve and why, and should understand how to craft a game so it will lead to the intended outcomes. Theory and research can contribute significantly to help identify players' needs and characteristics, determine the learning outcomes the game will bring about, shape the goals the player will be challenged to achieve, guide user testing before the game is completed, and develop evaluation studies to test hypothesized outcomes and to explain how the game helped make them happen (see Hanna et al., 1999; Lieberman, 1999).

Along with knowing the kinds of learning outcomes games are capable of achieving, designers should know the limitations of interactive games as learning environments. More research is needed to identify the kinds of learning that are—and are not—well supported by interactive games. Future research should also investigate the strengths and weaknesses of instructional design approaches in games, processes of learning with games in general, variation in players' cognitive needs and abilities and the implications for design, and the role of social interaction and emotional responses in learning

All age groups, including very young children, play interactive games and their abilities and interests vary Children have particularly special needs because they select, attend to, and cognitively and even physically process media differently than adults do. In general, they are ready and eager for interactive media at extremely young ages but they need content and

formats designed for their developmental capabilities and learning needs. From birth to age 18, children progress from concrete to abstract thinking; from an egocentric view of events to an ability to take the other's perspective; from holding very few to holding many schemas, or mental models, about the way events occur and how social and physical environments function; from low interest in learning rules and following them to high; from low reading skills and media literacy skills to high; from focusing on content regardless of its relevance to the main message to focusing almost entirely on content likely to be most relevant to the main message; and from "centration" on one attribute in a presentation to perceiving multiple attributes simultaneously (Blumberg, 1998; Calvert, 1999; Calvert, Jordan, & Cocking, 2002; Druin et al., 1999; Vorderer & Ritterfeld, 2003; Wartella & Jennings, 2000). These and other developmental shifts should be addressed in the design of interactive games so that the material is appropriate for specific age groups and ability levels and, whenever feasible, supports and enhances children's cognitive, emotional, and social development (Luckin, 2001; Wartella, O'Keefe, & Scantlin, 2000).

Many of the interactive games tested in research so far are screen-based and use a console game controller or a computer keyboard as an input device, but this is changing. Now interactive games are moving to other platforms (such as, cell phones, robots, virtual environments, interactive TV, smart toys, DVDs, and handheld mobile devices with geographical positioning systems) and some of them provide new kinds of input devices (such as, dance pad on the floor, camera pointed at the player, microphone for voice input, sensors that detect brain waves and other physiological states, haptic devices that detect movement and pressure, movable objects that can be sensed by a computer system). These new ways of playing interactive games will raise new questions about effects on learning, and what can be learned, in each environment, while at the same time the fundamental questions about processes of human learning will continue to be relevant.

As the design strategies and technological capabilities of interactive games evolve, research should continue to investigate both intended and unintended learning, so that designers of entertainment games can avoid teaching undesirable lessons and designers of games for learning can improve players' learning experiences and outcomes. There is much more research and theory development yet to be done. In the meantime, current research in this nascent field has already shown us that indeed we can learn a great deal from playing interactive games.

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