Seriously Considering Play: Designing Interactive Learning Environments Based on the Blending of Microworlds, Simulations, and Games

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Little attention has been given to the psychological and sociological value of play despite its many advantages to guiding the design of interactive multimedia learning environments for children and adults. This paper provides a brief overview of the history, research, and theory related to play. Research from education, psychology, and anthropology suggests that play is a powerful mediator for learning throughout a person's life. The time has come to couple the ever increasing processing capabilities of computers with the advantages of play. The design of hybrid interactive learning environments is suggested based on the constructivist concept of a microworld and supported with elements of both games and simulations.

□ The field of instructional technology has witnessed tremendous growth in research and development of interactive multimedia learning environments in recent years, especially computer-based environments (e.g. hypertext/hypermedia; examples include Blanchard & Rottenberg, 1990; Jonassen, 1991a, 1992; Locatis, Letourneau & Banvard, 1989; Marsh & Kumar, 1992; Yoder, 1994). At the same time, there has been increased openness in the field to consider the influence of a constructivist philosophy of learning on instructional design decisions (Duffy & Jonassen, 1992). Researchers and developers are struggling to find innovative ways to exploit the interactive potential of the learning environments afforded by computers while remaining consistent with psychological and philosophical beliefs about how people learn and the practicalities of learning in schools and the work place (Hannafin, 1992; Hannafin & Rieber, 1989a, 1989b).

Given the serious work and thought evident in these areas, it is somewhat surprising that one of the most fundamental and important concepts of human interaction—play—has received so little attention from our field. Why this is so is unclear. Perhaps it is because the word *play* can invoke so many misconceptions. For example, play is traditionally viewed as applying only to young children. Play seems to be something you have to give up when you grow up (Provost, 1990). There is also a sense of risk attached to suggesting an adult is at play. Work is respectable, play is not. Another misconception is that play is easy. Quite the contrary, even as adults we tend to

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engage in unusually challenging and difficult activities when we play, such as sports, music, hobbies, and games like chess (though adults may balk at using the word *play* to describe these activities) (Csikszentmihalyi, 1990). Likewise, children's play is an engaging and deliberate activity to which they devote great effort and commitment. Another misconception is that the activity of play is irrelevant or inconsequential to either formal or informal learning.

These misconceptions are all unfortunate because the extensive research on play with children *and* adults in anthropology, psychology, and education indicates that play is an important mediator for learning and socialization throughout life (Blanchard & Cheska, 1985; Csikszentmihalyi, 1990; Provost, 1990; Yawkey & Pellegrini, 1984). Given the range of open-ended explorable environments that can be constructed with computers, the time has come to revisit the almost alarmingly simple, yet powerful, construct of play and to legitimize play's role in the field of instructional technology.

The purposes of this paper are to review briefly the theoretical and conceptual foundations of play and to explore its relevance in the design of interactive multimedia. The attributes of three well known learning environments (or strategies) consistent with play—microworlds, simulations, and games—will also be reviewed. A careful blending of their attributes offers promise in guiding the design of interactive learning environments where structure and motivation are optimized without subverting personal discovery, exploration, and ownership of knowledge—in other words, learning environments that encourage people to play.

OVERVIEW OF PLAY

Play is a difficult concept to define. Play appears to be one of those constructs that is obvious at the tacit level but extremely difficult to articulate in concrete terms—we all know it when we see it or experience it. Its definition can also be culturally and politically constrained. Nevertheless, play is generally defined as having the following attributes: (a) it is usually voluntary; (b) it is intrinsically motivating, that is, it is pleasurable for its own sake and is not dependent on external rewards; (c) it involves some level of active, often physical, engagement; and (d) it is distinct from other behavior by having a make-believe quality (Blanchard & Cheska, 1985; Csikszentmihalyi, 1990; Pellegrini, 1995; Pellegrini & Smith, 1993; Yawkey & Pellegrini, 1984).

The commonsense tendency is for people to define play as the opposite of work, but this is misleading. Blanchard and Cheska (1985) assert that the opposite of work is leisure and that people's work has the *potential* to be considered as play as well. Work becomes play when one's job is so satisfying and rewarding that getting paid to do it is of secondary importance. In fact, Blanchard and Cheska (1985) contend that our culture does not have an adequate word to describe the opposite of play (they use the term *not-play*). They go on to construct a model of human activity with two dimensions: Play/Not-Play and Work/Leisure. Activities such as games and sports are embedded in this model. Further anthropological implications of gaming will be discussed later.

Current theories of play are generally organized around four themes: play as progress, play as power, play as fantasy, and play as self. These themes have been inspired in large part by the work of Brian Sutton-Smith (Pellegrini, 1995). Play as progress concerns the belief that the purpose of play is to learn something useful. Play is a means to improve or enable psychological or social needs. This type of play is almost always described as an important mechanism by which children become adults, thus strongly suggesting a clear distinction between children's play and adults' play (though many researchers dispute this by viewing such distinctions as artificial). Play as power refers to contests or competitions in which winners and losers are declared. Such examples center around players or participants involved in some source of conflict, whether that be a game of football or chess. Unlike play as progress, play as power belongs almost exclusively to adult forms of play. Play as fantasy refers to play's role in liberating the mind to engage in creative and imaginative thinking. There are some obvious connections here to play as progress, such as when one views creativity as an outcome to be pursued as opposed to a state to be intrinsically valued. Play as self is the most recent of themes. It places value on play's role as a way to achieve optimal life experiences. What is valued is the quality of the experience and not other secondary outcomes (such as learning). The main issue here is the intrinsic worth of an experience. (See Sutton-Smith, 1995, for a critical analysis of these four themes.)

To be sure, research results related to each of these themes are complex and difficult to generalize. One important point is that play should not be idealized. Despite its many advantages, one should avoid the view, commonly referred to as the *play ethos*, that *all* play is good (Smith, 1995). Indeed, much research demonstrates the darker side of play, such as the phenomena of playground bullies (Pellegrini, 1994). Similarly, it is naive to think that play *always* involves solely voluntary participation. Pressure from one's culture (e.g. peers, local/national pride) makes much participation in play activities obligatory.

An understanding of the philosophical assumptions of play is a critical first step to understanding its role or value in learning and instruction. For example, Glickman's (1984) historical review of play in public schools clearly shows how play has been viewed either as a valuable instructional cornerstone or as frivolous and nonproductive, depending on the political agendas at the time. According to Glickman essentialism, progressivism, and existentialism have been the three general educational philosophies that have alternatively dominated policy in public education over time.

An essentialist view of education maintains that there are things that everyone should know and the best way to achieve this learning is through careful curriculum planning that is rigidly enforced. In this transmission model of education the "all knowing" teacher is expected to deliver or transmit the knowledge society believes its citizens need to know. However, many now feel this demeans teachers by technicizing their role in the classroom (Papert, 1993). In general, play holds little value here. Experimentalism is the practical view of education closely following the progressive ideas of John Dewey. Knowledge must be meaningful and relevant to the individual to be useful. One determines this kind of knowledge by teachers and students working collaboratively—both engaged in finding productive purposes to the knowledge they identify. In reviewing the time when experimentalism held its strongest influence in this country in the early 1900s, Glickman (1984, p. 258) notes that ". . . reason and science were the means, not the ends, of education. The purpose of education was for man to be able to assess his environment and then experiment with ways to improve it." Play is completely consistent given this view. Experimentalism corresponds to what currently has been called pragmatic constructivism (Good, Wandersee & St. Julien, 1993). At the far extreme is existentialism, which corresponds to radical constructivism (Jonassen, 1991b). This view holds that any attempt by one group of people (e.g. teachers) to make decisions about what another group of people (e.g. students) should learn is at best misleading and at worst unethical. Educationally speaking, there are few or no rules here. Radical constructivism is equivalent to instructional chaos.

There are several main points to be gained from Glickman's review. First, historical phases and events, such as the advent of the industrial age at the turn of the century or the impact of World War II, all have had a tremendous influence on what a society's citizens think education should be. As the prevailing philosophy in education changes, so too does the attitude toward play. In one era, play can be viewed as a productive and natural means of engaging children in problem solving and knowledge construction, but in another era it can be viewed as a wasteful diversion from a child's studies. The fact that play has evoked such opposite reactions in the history of education is a sobering reminder of the political realities of school. Perhaps most important is the relationship of play to achieving educational outcomes. According to Glickman, the benefits of play are long-term—enabling intellectual and social growth over many years (see also Singer, 1995). If, on the other hand, one is primarily interested in short-term gains on performance tests of narrow objectives, such as standardized achievement tests, the value of play becomes less evident.

The history of play in American education strangely resembles the current discussion and debate between objectivism and constructivism in instructional technology (see Cooper, 1993; Dede, 1995; Duffy & Jonassen, 1991; Jonassen, 1991b; Perkins, 1992; Rieber, 1993, for background). It is not hard to understand how play and traditional applications of instructional systems design (ISD) can come into conflict. When one believes that what the learner needs to know has already been identified, the obvious course of action is to teach the learner this content as effectively and efficiently as possible. Play may be tolerated or even encouraged for short periods of time, perhaps in the belief that it will act as a motivating strategy. However, play can quickly be viewed as a threat to instructional design efforts when it leads to learning sequences or learning outcomes other than those already determined or anticipated by the designer.

MICROWORLDS: A FRAMEWORK FOR LEARNING THROUGH MEANINGFUL AND PLAYFUL INTERACTION

One design artifact consistent with play is the constructivist idea of a microworld (Papert, 1981; Rieber, 1992). A microworld is a small, but complete, version of some domain of interest. People do not merely study a domain in a microworld, they "live" the domain, similar to the idea that the best way to learn Spanish is to go and live in Spain. Microworlds can be found naturally in the world or artificially constructed (or induced). A child's sandbox is a classic example of a natural microworld. Given buckets and shovels, the sandbox becomes a volume and density microworld for the child. In contrast, artificial microworlds model some system or domain for the user. Probably the most well-known computer example is LOGO, a programming language in which the computer models a variety of domains, such as geometry and physics (Papert, 1980, 1993). Other examples include *Geometer's Sketchpad* and *Interactive Physics*. Of course, even a natural microworld can have artificial elements—a parent (or teacher) could intentionally structure the children's sandbox in some way, such as providing buckets of special sizes (e.g. each doubling in volume) in order to increase the likelihood that the child might discover some underlying principles or relationships.

At first glance, computer-based microworlds are often confused with simulations. However, microworlds have two important characteristics that may not be present in a simulation. First, a microworld presents the learner with a simple case of the domain, even though the learner would usually be given the means to reshape the microworld to explore increasingly more sophisticated and complex ideas. Second, a microworld must match the learner's cognitive and affective state. Learners immediately know what to do with a microworld—little or no training is necessary to begin using it (imagine first "training" a child how to use a sandbox). In a sense, then, it is the learner who determines whether a learning environment should be considered a microworld since successful microworlds rely and build on an individual's own natural tendencies toward learning. It is possible for a learning environment to be a microworld for one person but not for another. In contrast, a simulation is determined by the content or domain it seeks to model and is usually judged on the basis of its fidelity to the domain (Alessi, 1988). For example, most flight simulators would not be considered microworlds for most people because they would be quickly overwhelmed with the environment. However, several characteristics of simulations are relevant to the design of microworlds and this issue will be considered later.

The two dominant characteristics of microworlds (i.e., simple case of a domain; match the user) present a large set of complex assumptions and expectations for a would-be microworld designer to meet. Among the most important is that learners are expected to self regulate their own learning in a microworld. Self-regulated learning is when a person takes responsibility for his or her learning and, as a result, takes appropriate action to ensure that learning takes place.

Self-regulated learning has three main characteristics (Zimmerman, 1989, 1990). First, learners find the environment to be intrinsically motivating, that is, they find participating in the activity to be its own reward and do not seek or need external incentives (Deci, 1985; Lepper & Malone, 1987; Malone & Lepper, 1987). Second, self-regulated learners are metacognitively active. Learners actively engage in planning and goal-setting and are able to monitor and evaluate their own learning. Third, self-regulated learners are behaviorally active in that they take the necessary steps to select and structure the environment to best suit their own learning styles. Learner control is essential for self-regulated learning.

Theoretical Foundations of Self-Regulated Learning Within a Microworld

Few psychologists or educators would dispute the argument that the most effective learners self regulate their own learning. Many models of self-regulated learning have been reviewed (such as that by Butler & Winne, 1995; Schunk & Zimmerman, 1994) and their implications to instructional design considered (e.g. Kinzie, 1990). Disagreements arise, however, as to the best approach to establishing and maintaining self-regulated learning. Unfortunately, the idea that there exists one best method for facilitating the self-regulated learning process is misguided (though particular learning or study strategies may be successfully taught; see Just & Carpenter, 1987 for examples). Instead, it may be more useful to describe conditions that may lead to self-regulated learning. For that reason, two theoretical frameworks describing the underlying conditions of self-regulated learning in a microworld are briefly considered at this point: components of Piaget's theory of intellectual development and the Flow Theory of Optimal Experience developed by Mihaly Csikszentmihalyi. Both illustrate the close relationship between self-regulated learning and play.

Piagetian Learning Theory. It is almost impossible to discuss the design of microworlds without invoking the name of Jean Piaget because of the influence of his work on Seymour Papert, a pioneer of constructivist uses of computers probably best known for his role in the development of the LOGO programming language. Probably the first well articulated and developed description of microworlds and their implications can be traced to Papert's much cited (and debated) book *Mindstorms* (Papert, 1980). Although most educators are well aware of the stage dependent part of Piaget's theory characterized by the four developmental stages (i.e., sensorimotor, preoperational, concrete operations, and formal operations), self-regulated learning in a microworld is most closely based on the stage independent part of Piaget's theory which can be summarized by the following three properties: epistemic conflict, self reflection, and self regulation (Forman & Pufall, 1988). Epistemic conflict denotes an ongoing cognitive "balancing act" by each individual. On one hand, we each seek an organized, orderly world, but we are continually confronted with an ever-changing environment. Self reflection involves an individual's deliberate attempt at assessing and understanding a given situation. However, only through self-regulation will an individual arrive at a resolution or solution to the conflict. Either the conflict is resolved as fitting an established mental structure (i.e., assimilation), or a new structure is formed (i.e., accommodation) (a third possibility is that the conflict remains unresolved and no learning takes place).

According to this theory, learning cannot occur unless an individual is in a state of disequilibrium (i.e., mental structures not in balance). Learning is defined as the construction of new knowledge resulting from the resolution to the conflict. Piaget theorized that knowledge was always transitory, continually shifting in shape and form. Piaget referred to individual mental structures as *schemes*. Assimilation is the process of understanding the world through *existing* schemes, whereas accommodation is the process of building new schemes (based on refinements and blending of existing schemes) (Phillips, 1981; Piaget, 1952). The purpose of a microworld is to foster, nurture, and trigger the equilibrium process (Dede, 1987; Papert, 1980, 1981). It is important to note that Piaget's theories have recently been criticized for neglecting social and cultural influences on cognition and are often contrasted with the theories of Vygotsky. Attempts have been made to reconcile these differences by suggesting that Vygotsky and Piaget offer complementary rather than competing views (see Fowler, 1994).

Flow Theory. Although the developmental nature of Piaget's work has long been associated with children's learning, the stage independent part remains relevant throughout life. However, one notable body of research related to self-regulated learning focuses exclusively on adults—the Flow Theory of Optimal Experience developed by Mihaly Csikszentmihalyi (1990). Though rarely considered by instructional technologists, flow theory provides an important framework for an adult's motivation for learning. Flow theory gets its name from the way so many adults have described a peculiar state of extreme happiness and satisfaction. They are so engaged and absorbed by certain activities that they seem to "flow" along with it in a spontaneous and almost automatic manner—being "carried by the flow" of the activity. Csikszentmihalyi (1990, p. 4) defines flow as ". . . the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it." Csikszentmihalyi's research includes a wide range of individuals and activities, from rock climbers to surgeons, from concentration camp survivors to those simply reading or listening to music.

Attaining flow is not necessarily easy and rests on certain conditions and skills. For example, people who experience flow must have the ability to focus attention, to concentrate without distraction. Attention is so important that Csikszentmihalyi defines it as *psychic energy* because it acts as the "fuel" for the rest of consciousness. In contrast, *psychic entropy* occurs whenever information that is so disruptive that it diverts our attention enters our consciousness.

One result of flow is psychological growth; that is, the individual becomes more complex or elaborate. The psychological mechanisms that account for growth are *differentiation* and *integration*. Differentiation is the need for the individual to remain unique from others whereas integration is the need to feel connected to other people and other ideas. These seemingly opposite processes work together to achieve a state of balance between goals and expectations, not unlike the Piagetian process of equilibration.

Flow derives from activities that provide enjoyment (as compared to mere pleasure). Enjoyment results when an activity meets one or more of the following eight components:

1. Challenge is optimized;
2. Attention is completely absorbed in the activity;
3. The activity has clear goals;
4. The activity provides clear and consistent feedback as to whether one is reaching the goals;
5. The activity is so absorbing that it frees the individual, at least temporarily, from other worries and frustrations;
6. The individual feels completely in control of the activity;
7. All feelings of self-consciousness disappear; and
8. Time is transformed during the activity (e.g. hours pass without noticing)

Not surprisingly, these components are quite consistent with characteristics of gaming.

Optimizing challenge is particularly important in order to experience flow. People must constantly be able to match challenge with their current skill or ability. If one's skill in an activity (such as tennis) is low and the challenge (such as playing against Monica

Seles) is too high, then the individual will enter a state of anxiety. Monica, on the other hand, will probably experience boredom because her skill mismatches challenge in the opposite way. However, if an expert tennis player is playing the game with a novice because of a desire to teach the game, flow may be derived not from the act of playing the game but from the satisfaction of the student's motivation and progress. Of course, as an individual's skill or ability increases, the challenge needs to be increased accordingly. Flow is only possible as long as a person avoids boredom and anxiety simultaneously.

Finally, Csikszentmihalyi stresses that transforming ordinary experience into flow demands effort and work. One does not attain flow by being passive. However, the ability to reach optimal experience can be improved over time with deliberate effort. Csikszentmihalyi also warns of the danger of addiction, when the desire to participate or engage in an activity is so consuming that the quality of one's life actually deteriorates (e.g. obsessive gambling or drug addiction).

CONSIDERING SIMULATIONS AND GAMES IN THE DESIGN OF MICROWORLDS

Of course, it is easy to demand self-regulated learning as a requirement for a successful microworld. It is quite another to describe how to design a microworld that supports and encourages a self-regulated learning process. As already mentioned, finding an appropriate *objectivist* methodology is difficult, if not misguided, because of the critical and unpredictable role of each individual learner. Despite this, characteristics of simulations and games may provide some practical means of meeting the assumptions of a successful microworld. Both offer extensions of critical parts of the psychology underpinning the constructivist nature of microworlds, while also providing some of the inherent structure called for by most objectivists. Simulations offer a direct link to the subject matter or content; and games offer a practical means for meeting the microworld assumption of self-regulation. Games in particular offer many intriguing psychological and social insights to microworld design, and for that reason their value is underscored.

Simulations

A simulation is any attempt to mimic a real or imaginary environment or system (Alessi & Trollip, 1991; Reigeluth & Schwartz, 1989; Thurman, 1993). A simulation usually serves one of two purposes: scientific or educational. In both cases, there is usually some inherent reason why the actual system should not be experienced directly, such as cost, danger, inaccessibility, or time. Scientific simulations provide scientists with a means of studying a particular system, such as assisting a meteorologist to study a tornado. These simulations help scientists to establish and refine existing theory and understanding of the system. Educational simulations are designed to teach someone about the system by observing the result of actions or decisions through feedback generated by the simulation in real-time, accelerated time, or slowed time.

The design of a simulation-as-microworld must meet the simple case principle. Of course, the simulation should be designed so that ideas expand as the learner is ready for them. In a sense, simulations-as-microworlds are both scientific and educational. The learner should be in a position to make changes to the simulation in order to better understand it, much as does a scientist who changes the simulation in some way to test a hypothesis. It is also important that the simulation's interface be designed to minimize the chance that the user will become disoriented and frustrated.

The design of simulations-as-microworlds closely parallels the research and theory of mental models (Gentner & Stevens, 1983; Jih & Reeves, 1992; Mayer, 1989). This research suggests that people form mental *models* of the physical world in an attempt to successfully understand and interact with the world. Mental models are dynamic cognitive constructs in that they are ever-changing and evolving, similar to the Piagetian process of equilibration in which mental schemes are created and refined.

There are three attributes of mental models relevant to the design of simulations-as-microworlds:

- The target system
- The user's current mental model of the target system
- A conceptual model of the target system.

The *target system* is the actual system of interest, such as a tornado, Newtonian physics, or parenting.

A *user's mental model* describes the person's current understanding or "theory" of the target system. This is the basis for the user's decision-making and action when confronted with problems in the target system (Carroll & Olson, 1987).

Conceptual models are artificial artifacts designed by some external agent (such as an engineer, teacher, or instructional designer) to help the user understand the target system (Gentner & Stevens, 1983; Norman, 1988). An example of a conceptual model would be the popular analogy of an office desktop to help a user understand the operation of a microcomputer.

Good conceptual models partly address the match the user principle. From this point of view, a microworld could be described as an *interactive* conceptual model. However, while a conceptual model may match the user cognitively, it may not do so affectively. In other words, the user may understand the conceptual model, but at the same time find no interest in it.

Games

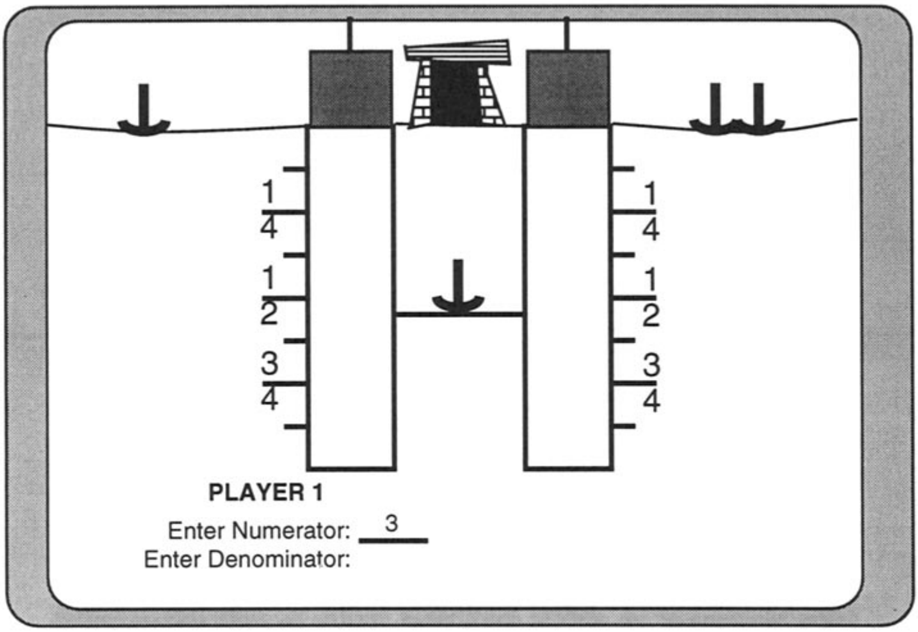
Although a simulation may be designed as an expandable simple case of a system that appropriately matches a learner's prior knowledge and experiences, this, in and of itself, does not satisfy the requirements of self-regulated learning. The learner may not be interested in choosing initially to participate in the activity or may not choose to persist in the activity for extended periods of time at a meaningful level. The learner must find the activity to be intrinsically motivating (Kinzie, 1990; Kinzie & Sullivan, 1989; Lepper & Chabay, 1985).

Motivational researchers have offered the following characteristics common to all intrinsically motivating learning environments: challenge, curiosity, fantasy, and control (Lepper & Malone, 1987; Malone, 1981; Malone & Lepper, 1987). Games represent the instructional artifact most closely matching these characteristics. Fantasy is used to encourage learners to imagine that they are completing the activity in a context in which they are really not present. The fantasy context can be further classified as being either endogenous or exogenous to the game's content. An example of an exogenous fantasy is the common hang man game and its many variations. Any content can be superimposed on top of this fantasy. There is no mistaking the game from the content. Exogenous fantasies can be thought of as educational "sugar coating." Obviously, exogenous fantasies are a common and popular element of many educational games.

In contrast, games that employ endogenous fantasies weave the content into the game. One cannot tell where the game stops and the content begins. An example of an endogenous fantasy to teach fractions is shown in Figure 1. The advantage of an endogenous fantasy is that *if* the learner is interested in the fantasy, he or she will consequently be interested in the content. A good endogenous fantasy is an important first step towards intrinsic motivation. Of course, determining an appropriate endogenous fantasy is difficult. In learning about physics, for example, some learners may prefer a variety of contexts in which the idea of reduced friction is possible, such as piloting a space ship, sailing a boat, or ice skating.

Challenge and curiosity are intertwined and closely conform to he Piagetian process of equilibration. When confronted with a problem without an immediate solution, a learner will seek resolution if a solution seems possible and within reach, assuming that the context (i.e., fantasy) is inherently interesting. Learners will choose to participate in tasks that they perceive as neither too easy nor too difficult. Designing a game with just the right amount of challenge is an extremely difficult task. Many computer

Figure 1 □ An example of an educational computer game that uses an endogenous fantasy to teach middle school students about fractions. The goal of this game for two players, called *Mineshaft,* is to retrieve a miner's lost ax. Each enters a fraction and the one who is closest to the level of the lost ax wins the round. Computer animation is used as motivation and feedback: each player's elevator is lowered down the shafts (i.e., number line) to the "depth" of their respective fraction; the ax is then taken back to the surface by the winning elevator and "dumped" onto that player's pile.



games solve this problem by increasing or decreasing the game's difficulty according to the performance of the player.

Games offer many advantages to microworld designers by having the potential to meet most, if not all, of the characteristics of intrinsic motivation. Games can be designed for both children and adults with clear and simple goals but with uncertain outcomes. Challenge can be increased or decreased by the learner to keep the challenge of the task optimal. Games can also be designed with layers of complexity, a common element to many commercial computer entertainment games. Feedback can also easily be provided in order for learners to quickly evaluate their progress against the established game goal. This feedback can take many forms, such as textual, visual, and aural. Feedback is a very important component in giving the user information about whether or not their intended actions resulted in the expected outcomes (Norman, 1988, 1993; Rieber, 1996).

Cognitive, Social, and Cultural Functions of Games. The utility of gaming as a microworld design tool goes well beyond its inherent motivational characteristics. Games also offer an organizational function based on cognitive, social, and cultural factors all related to play. For example, games serve as a vehicle for both play and imitation, two functions that Piaget (1951) considered crucial in the equilibration process. Piaget considered play as an assimilation strategy and imitation as an accommodation strategy. For example, a child who attempts to understand how and why to assume proper table manners during dinner is likely to be found imitating the dinner time ritual with dolls, toy dishes, and imaginary food. Such imitation is the child's way of building or constructing (i.e., accommodating) the dinner scheme. Afterwards, the child may use these pretend dinners as play to assimilate new rules (such as offering a toast at special occasions) and objects (such as the salad fork).

Play and imitation are natural learning strategies at which children are experts. Having children play games to learn is simply asking them to do what comes naturally. Though imitation and play are generally considered as strategies for very young children (Piaget discussed imitation and play most at the sensorimotor stage), imitation and play remain important accommodation and assimilation strategies throughout life. Adults tend to underestimate the complexity of children's games. However, playing a game successfully can require extensive critical thinking and problem-solving skills.

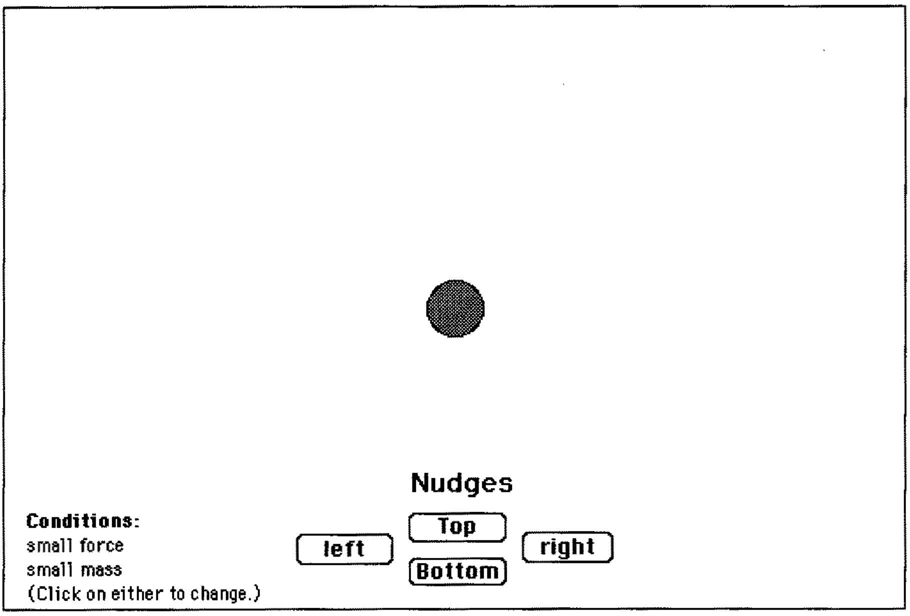
Even the simplest games contain a complex set of properties. We all know that children quickly develop an understanding of the concept of a game (though at developmentally appropriate levels). It is almost as though the game concept plays a special organizing role in cognition, not unlike a story schema, an important concept long recognized by reading psychologists (e.g. Bartlett, 1932; Schank, 1990). In fact, many computer games can be described as interactive stories (Bielenberg, 1995). A story schema provides a mental framework containing a number of components, or *slots*, such as setting, goal, complication, and resolution (Just & Carpenter, 1987). Likewise, a game schema also provides a mental framework with similar slots. A beginning set might include fantasy or context, players, game objects, game goals, rules and conditions, and the *challenge*. This structure provides organization and expectancies in a complex interaction.

Of course, children are also expert game designers—the equilibration process makes them uniquely equipped to invent highly imaginative games to understand the world. Research suggests that strategies involving *learning by designing* (Perkins, 1986) or *learning by building* (Harel & Papert, 1991) are excellent ways for people to explore a domain in rich and meaningful ways. As an example, children were given the opportunity in a recent project to use game design as a way to learn about subjects they were studying in school (Rieber, 1995). In one class, two groups of fifth-grade children were asked to design their own game that embedded the simple simulation of Newton's laws of motion illustrated in Figure 2. The result of each group's efforts are shown in Figure 3.[1] A premise of the project is that the creative investment one takes in the design process leads directly to *intellectual* "ownership" of the game's content. Rather than viewing the subject matter taught in school as disconnected and unrelated to anything more meaningful than passing an approaching test, what Perkins (1986, p. xv) calls "truth mongering," the design process provides students with a relevant context for adapting content for a useful purpose. This is similar to the not-so-surprising phenomenon that the people who learn the most from instructional design projects are not the end users, but the designers and developers themselves (Jonassen, 1994). Rather than designing computer-based materials (and other forms of instructional technology) for children, perhaps a better strategy is to give them access to the most powerful design tools for them to use in their own design projects (Kafai, 1994).

Given the natural role that play and imita-

1. Specific tasks accomplished by each group included the following: identify a suitable game context or fantasy; define the game rules; write game directions; and draw all necessary graphics. The role of the teacher and myself was to facilitate the efforts of the two groups. I also acted as game editor and computer programmer. An obvious difference between this project and that reported by Harel (1991) and Kafai (1992) is that these children did not get involved in the programming aspects of the games. This project took place in a public school without special funding or special commitments of time and other resources. Consequently, the school was only able to allot four days to the project which, of course, is totally inadequate for children to learn authoring software sufficiently to build games. Despite this difference, the benefits gained through empowering the children to assume all design responsibilities are still quite noteworthy. I have since worked with other classes of students to design games on subjects such as understanding plants, mathematics, Greek mythology, and language arts (Rieber, Ellington & Ward, 1996).

Figure 2 □ A screen snapshot of the simulation template used by the fifth grade children as the starting point in constructing an original game that used the laws of motion.



tion serve to intellectual development, game playing and game designing can also be considered as authentic tasks for children. Researchers have stressed the importance of anchoring, or situating, learning in authentic situations (Brown, Collins & Duguid, 1989; Choi & Hannafin, 1995; Cognition and Technology Group at Vanderbilt, 1990). One benefit is that learners become engaged by the material, invoking a state of *mindfulness*, in which learners employ nonautomatic, effortful, and metacognitively guided processes (Salomon, Perkins & Globerson, 1991). Learning in mindful ways results in knowledge that is considered meaningful and useful, as compared to the *inert* knowledge that results from decontextualized learning strategies (such as traditional classroom worksheets). Games are not just a diversion to children, but an integral part of their social and cultural lives. For example, children often evaluate their status in a peer group based on their interaction in games.

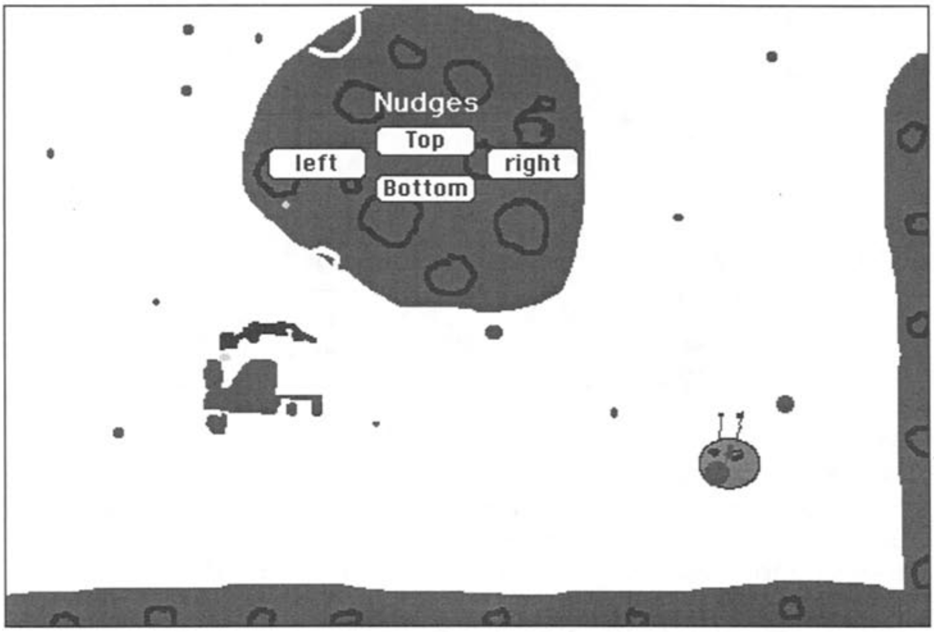
There is also compelling evidence of the role of games as a sociological agent (Chick & Barnett, 1995). Games have a long history in the development of almost every culture and society—a fact that continues to this day. Anthropologists typically define games according to four broad categories (Loy & Kenyon, 1981):

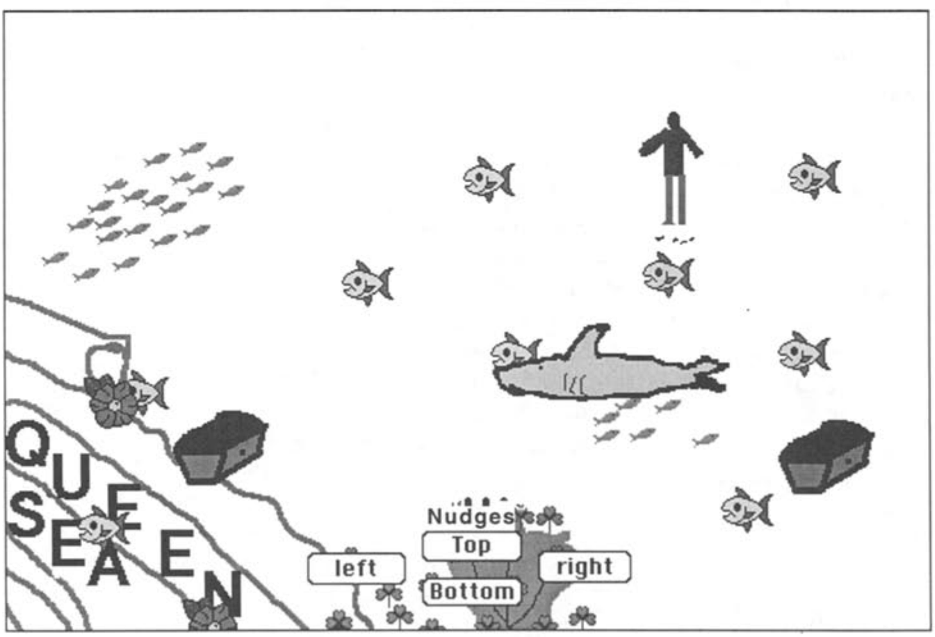
1. Agon, or games of competition;
2. Alea, or games of chance;
3. Mimicry, or games of pretense or imitation; and
4. Ilinx, or games/activities that result in physical exhilaration, such and swings and roller coasters.

Anthropologists have long viewed games as but one aspect of expressive culture, or how people in a culture project their psychological dispositions.

The watershed work of John M. Roberts has been critical in the history of sports and games in anthropology. His theoretical concept of *conflict enculturation* describes the way people in a culture use games to provide nonthreatening ways to practice conflicts typical to that culture. Games become models or enactments of real-life dramas (Roberts, Arth & Bush, 1959). According to this theory, games provide

Figure 3 ☐ Screen snapshots of the games developed by the two groups of children: *Space Race* (above) and *Underwater Sea Quest* (below). The laws of motion are embedded in each game. The goal of *Space Race* is to drive the "rig" successfully around the track to the finish line without going off the track and while avoiding the roaming alien (a rig with a large mass will defeat the alien, but the larger rig will also be harder to maneuver). The goal of *Underwater Sea Quest* is to help the diver find the gold treasure while avoiding the roaming "shark." However, only one of the two treasure chests contains the gold treasure. (Actual computer versions are in color.)





a socially acceptable means of rehearsing the necessary skills and anxieties that may be needed later in real life. Roberts's research has shown that a culture's dominant games are different in a hunting-gathering society than in an industrial society. In general, more complex societies have a stronger tendency toward games of strategy and games in egalitarian societies tend to involve physical skills. Games of chance indicate different interpretations of people's relationship with the supernatural. Similarly, boys and girls play different games because of the different demands that the society places upon them.

Despite some important psychological and cultural relationships to games, the education profession has long been ambivalent about the value of games as an instructional tool or strategy. Surprisingly, the use of games and simulations is often embraced in other educational settings, such as corporate and military training environments (Dempsey, Lucassen & Gilley, 1993, April; Greenblat, 1987; Greenblat & Duke, 1981). In schools, on the other hand, games have the greatest acceptance in the early grades with decreasing interest among teachers and parents in middle and secondary schools. Again, games and play are prone to unfortunate misconceptions that reduce their potential use within learning environments with both children and adults.

A FINAL WORD

The purpose of this paper has been to renew interest in the role of play as a source of rich and meaningful interactivity within interactive multimedia learning environments. There appear to be many advantages to seriously considering play as a dominant goal for these types of learning environments, despite the caution that not all forms of play should be considered positive or beneficial. Play also holds promise as a benchmark for evaluating interactive learning environments—those that evoke it deserve special recognition and consideration. This paper has proposed a hybrid learning environment in which the constructivist concept of a microworld has served as the anchor, though strongly supported and buttressed with simulation and gaming characteristics. Gaming, in particular, seems to offer important implications to microworld designers. This discussion has been rooted in instructional technology, hence, it has been aimed primarily at design issues. However, it is impossible and undesirable to divorce these design issues from the philosophical assertions on which they rest.

Despite the popularity of pitting one philosophical position against another, this paper has tried to bring together some of the best ideas from several philosophical positions. As a field, instructional technology is in a unique position to champion such a blending of different philosophical positions because of its eclectic and pragmatic nature, a position going back to Dewey (Garrison, 1994). Besides, epistemological differences of what it means to know something have consumed philosophers for hundreds of years without adequate resolution (Casti, 1989). Educational technologists are generally more interested in solving problems than they are in establishing barriers, philosophical or otherwise. Consequently, considerable value is placed on practical instructional applications that actually work in practical situations, rather than espousing one theoretical or philosophical position over another. The relationship between theory, research, and practice in instructional technology is dynamic and interdependent, not causal. Research in education, psychology, and anthropology makes play an attractive choice if one's goal is consistency between theory, research, and practice.

An interesting metaphor for efforts in instructional technology to reconcile theory with practice is the story of the Wright Brothers' invention of the airplane (Moolan, 1980). Their success appears to have been based on just the right mix of ingenuity, discovery, experience, and theory combined with mastery of the technology of their day (Crouch, 1992). Ready or not, theorists all over the world had to reconcile the fact that the Wright Brothers designed a plane that actually flew.

Like the Wright Brothers, most instructional technologists do not aim primarily to refine existing theory, but rather to design and develop instruction that works—instructional "planes" that really fly. Most have been trained to use theory as the foundation of their work, but few ever resolve the dilemma of dealing with the many discrepancies that arise between existing theory and actual practice. The relationship between design and theory is usually muddled in the minds of both practitioners and researchers. Theory and practice should continually provide feedback to each other in order to help identify and resolve discrepancies or inconsistencies. The blending of the characteristics of microworlds, simulations and games based on play comes close to achieving the goal of reconciling theory, research, and practice. Just like the Wright Brothers' first Flyer, this approach seems to work in the real world while being consistent with much of the theoretical framework currently espoused by both objectivists and constructivists. □

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