# The Educational Potential of Electronic Games:

# From Games–To–Teach to Games–To–Learn

## Playing by the Rules

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If someone were to write the intellectual history of childhood—the ideas, the practices, and the activities that engage the minds of children—it is evident that the chapter on the late 20th century in America would give a prominent place to the phenomenon of the video game. The number of hours spent in front of these screens could surely reach the hundreds of billions. And what is remarkable about this time spent is much more than just quantity. Psychologists, sociologists, and parents are struck by a quality of engagement that stands in stark contrast to the half-bored watching of many television programs and the bored performance exhibited with school homework. Like it or not, the phenomenon of video games is clearly a highly significant component of contemporary American children's culture and a highly significant indicator of something (though we may not fully understand what this is) about its role in the energizing of behavior.

Most software designers and commercial companies have sought to capitalize on this energizing of behavior by making games for learning. Building on the motivating nature of games, they hope to make the learning of hard core academic matters more fun, if not easier. Far fewer people have sought to turn the tables: making games for learning instead of playing games for learning. As one should expect different educators think of using games in different ways, reflecting their different philosophies of education. The most relevant of these differences is the split between predominantly instructionist philosophies and predominantly constructionist ones (see Papert, 1993).

The instructionists, accustomed to thinking in terms of making instructional educational materials, turn naturally to the concept of designing instructional games. This central idea has venerable antecedents. Teachers did not have to wait for the computer to "make a game of" practicing the multiplication tables, the rules of grammar, or the quirks of spelling. And when the computer did come, the advocates of using it in education did not have to wait for the specific format of the "video game" to begin exploring the advantages of embedding school-like exercises in a computer game. An elegant and influential early example was *How The West Was Won* (Burton and Brown, 1982)—a computer-based game in which players "throw" dice, then perform various arithmetic operations on the numbers to determine how far to advance a token on a board.

Without wanting to deny the value of instructional games, constructionists have focused their efforts in a very different direction. Rather than embedding "lessons" directly in games, their goal has been to provide students with greater opportunities to construct their own games—and to construct new relationships with knowledge in the process (see Kafai, 1995). In the world of educational games such constructionist approaches have received far less attention than their instructionist counterparts, but it is conceivable that they hold far more potential for engaging children's enthusiasm for games in the service of learning.

## The Instructionist Approach: Games–To–Teach

While there are now thousands of instructional computer games on the market, including popular titles like *Math Blaster*™ and *Where in the World is Carmen SanDiego*™, we know little about which features make an educational game good for learning. Early research has documented the motivating features of educational games with a view on their potential educational value (e.g., Malone, 1981; Lepper & Malone, 1987). What Malone and Lepper called intrinsic motivation describes an integration of the game idea with the content to be learned. To date, this research conducted on two-color screens in the late 70's is still one of the more systematic investigations of different features such as sound, graphics and combinations thereof in an educational game.

A survey of the last twenty years of educational publications reveals a rather sparse bounty; in particular if one is interested in hard core academic benefits rather than motivational or social aspects of playing games for learning. A common feature in nearly all those games is that they sport what we might call intrinsic integration in alliance with Malone and Lepper (1987). That is, integration of the game idea with the content to be learned. Such instructional game contexts could be found across content domains: learning Boolean logic while building machines with particular characteristics; learning city planning while designing a city; learning about equations while designing graphs that intersect with points on a grid; learning about the physics of motion while controlling the

movement of a spaceship and firing of missiles; and learning about geometry while solving Tangram puzzles to name but a few. Assessment of students' learning found in most cases produced beneficial effects such as increased motivation and also a better understanding of the content matter under investigation. What we learn from the few available studies is far from being comprehensive to provide us with a list of successful design features for good educational games (Kafai, in preparation).

This rough summary is also plagued by customary concerns of research compilations: Too few studies in one domain, with a focus on one concept, or on one age group are available to provide a substantial foundation for recommendations. Further complicating the issue are the different intervention periods and assessments; also what counts as a game is rather loosely defined in most studies. There is a near absence of commercial game evaluations, the one exception being a case study on *Where in the World is Carmen SanDiego*™ (Honebein, Carr & Duffy, 1993). Most available research covers games on early platforms; thus neglects to take into account recent technological advances. One should note that this situation is not limited to research on computer game playing. There are also few comprehensive studies in the area of game playing off the computer (one notable exception is Bright, Harvey & Wheeler, 1986). For those interested in the study of non-electronic games, the review about multiple uses and functions of games in a variety of contexts compiled by Avedon and Sutton-Smith (1966) is still unique. Some more recent updates published by Goldstein (1994) and Cassell & Jenkins (1998) cast a wider net with more attention to digital media.

## The Constructionist Approach: Games–To–Learn

Far less prominent has been any research on the instructionist counterpart—making games for learning. We know that as many children enjoy playing games according to given rules, they are also constantly modifying rules and inventing their own. Piaget (1951) claimed that these modifications reflected children's growing understanding of the world. The process of game construction represented for Piaget the ultimate effort by children to master their environment in creating their representations of the world. Turkle (1984) pointed out an interesting parallel between the attractions of playing games and of programming computers. She saw programming as a way for children to build their own worlds. Within this context, children could determine the rules and boundaries governing the game world and become the makers and players of their own games. In contrast, when children play a video game, they are always playing a game programmed by someone else; they are always exploring someone else's world and deciphering someone else's mystery. Turkle saw that what she called the holding power of playing purchased video games could be applied to the making or programming of video games.

This parallel provided the rationale for investigating game making as a new avenue for children's learning with interactive technologies. In one study, which may serve as an example, a class of 10-year-old children made their own educational video games (Kafai, 1995). The children met everyday to design their own games, create all their own characters, story lines, and game themes, and interactions over a period of six months. As the students were trying to give meaning to the task of designing a game (by finding out what game they would design and what features it would include), they were also involved in understanding what they were learning (i.e., constructing the meaning of fractions and how to make an educational game), while they were implementing their games (by thinking about what fractions to represent, by writing and using Logo programming, and by thinking about teaching strategies). Designing a complex piece of software such as a computer game to teach younger students about fractions was an effective way of learning the programming language. The analyses of the programming processes and products showed that students were able to master complex programming concepts, to create sophisticated products, and to develop efficient programming strategies. Furthermore, programming games allowed students to construct their own fraction representations. Students thought about and dealt with fractions in their games through invented stories and fantasies—contexts that are rarely promoted in mathematics textbooks or worksheets.

We also witnessed that making video games emphasized the gender differences found in playing purchased video games but with an interesting difference: the stories, characters, and worlds created by girls were different from those created by boys (Kafai, 1996). The influence of commercially available games was especially strong in the case of boys' games. Many game designers started out with ideas taken from popular video games such as *Super Mario Brothers*™ or *PacMan*™. The boys' game implementations included violent aspects as documented in the design of their feedback to player interactions. Violence is one of the most prominent features in commercial video games (Provenzo, 1991). Hence, popular media offered models on how to organize the game design (at least for the boys). This might offer an explanation of why more boys chose to end in the narrative form as compared to girls, even though in the beginning an equal number of boys and girls started using narrative. Popular media did not provide similar models to emulate for girls (the study was conducted several years before the appearance of pink software). Female game figures are rarely cast in the main role. The thematic embedding of video games in hunts and adventures are not necessarily appealing to girls' tastes. Many girls compensated for this by creating their own world in which they included familiar spaces and characters from their households. These results allow some conjectures about why girls lack involvement in video game play. It simply seems that most commercially available video games do not appeal to girls. However, a second study on children as game designers found that these gender differences are not always as consistent as one believes (Kafai, 1998a).

Most of the fraction games could be divided into two categories: extrinsic and intrinsic integration of subject matter in games following a distinction proposed by Malone and Lepper (1987). The former was exemplified most simply in games where the player had to answer a question in order to proceed in the game. In contrast, intrinsic integration was exemplified in a game where the designer took care of integrating the subject matter with the game idea. It is a strength and a weakness of the extrinsic integration that domains of knowledge become almost interchangeable. It is a strength because the integration is relatively easy: Answering a question correctly is what allows the next move in a game, the question can be on any topic. But this is also a weakness, because it causes the designer to loose the incentive to think deeply about the particular piece of knowledge.

In follow-up research (Kafai, Franke, Ching & Shih, 1998c), we focused more closely on the initial game design stage and analyzed instructional games designed by teachers and students. We were interested in how these groups conceptualized the task of creating virtual game learning environments for others, in which ways they integrated their understanding of fractions, and how they could develop meaningful fraction contexts. In our analysis, we found that most teachers and students, when left to their own devices, create instructional games to teach fractions that are very much like drill-and-practice and incorporate little of their knowledge. The idea that teaching is asking questions and learning is giving answers was a deeply rooted belief held by both students and teachers. We found that when we provided teachers and students with design directives such as to design games that do not ask questions we could facilitate an intrinsic integration of content and game context. Students and teachers were able not only to create intrinsically integrated games but also to generate constructivist game ideas. Here players were provided with a game that allowed them to design their own fractions. Furthermore, the games and teachers' and students' thinking increased in sophistication.

## Final Thoughts

We have only begun to build a body of experience that will make us believe in the value of game activities for learning. Obviously, the image of children building their own games is as much a "knee-jerk reflex" for constructionists as making instructional games is for instructionists. In the case of instructional games, a great deal of thought is spent by educational designers on content matters, graphical representations, and instructional venues. The greatest learning benefit remains reserved for those engaged in the design process, the game designers, and not those at the receiving end, the game players. After all, the game player is not partial to the discussions involved in developing valid instructional game ideas, designs and strategies. What finds its way into the final designs is only a substrate of those discussions.

Moreover, a deeper philosophical issue is hidden within the premise of instructional games: that we need games to "sweeten" the learning of difficult ideas. There is no doubt that learning is a demanding enterprise for students who strive hard to understand knowledge valued in our society. But do we need instructional games to make difficult ideas easy and fun to learn? One may wonder what messages about learning we are sending to students playing these games.

In the case of constructionist games the learner is involved in all the design decisions and begins to develop technological fluency. Just as fluency in language means much more than knowing facts about the language, technological fluency involves not only knowing how to use new technological tools, but also knowing how to make things of significance with those tools, and (most important) develop new ways of thinking based on use of those tools. There is no question that such game making activities are a tall order for most students. After all, students need to engage with content matter, learn software design skills, and develop perseverance in implementing their game designs. Such game-related activities are a promising context for developing technological fluency because of the special role of games in contemporary children's culture, and the deep sense of engagement common in game-related activities. Beyond that, they offer an entry point for young game designers into the digital culture not just as consumers but also as producers.

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