Introduction

Theodore Koterwas, New Media Director, Exploratorium

Games are hot. The hype is that the commercial game industry will soon be bigger than Hollywood. Kids and hard-core gamers are glued to their game consoles, personal computers, and PlayStation portables. Conferences are springing up right and left about how to capitalize on their popularity in other disciplines and pursuits, including education and social progress. I doubt there will be a conference this summer that does not discuss games in some way. Professor James Gee has become almost a celebrity in education circles by describing video games in constructivist terms. Everybody seems to want to build a game. (I bet they're even talking about it at the James Joyce Conference at Cornell right now—no one really understands the rules, but ...)

It may sound like I'm setting this up as overblown in order to tear it down, but despite the knee-jerk desire to critique what has become almost comically fashionable, I think the issue bears serious consideration. There are a lot of very smart people who believe in games and yes, they are mostly gamers themselves—one of Gee's central points is that you must actually play games and even make them to really understand their power. Coe Leta Stafford, Brent Lowrie, David Schaller, and Jake Cressman are gamers who are making games or looking at them to inform their practice.

What Makes a Learning Game?

David Schaller, Principal, Educational Web Adventures

Games have broad appeal, making it tempting to call almost any computer learning interactive a game. But although games take many different forms, there are fundamental characteristics that distinguish a true game from other types of interactives. Thoughtful analysis of these characteristics in relation to any particular interactive will help clarify its true nature, and provide honest branding for users. Such analysis can also suggest its potential as a learning game, although user evaluation is necessary to truly understand its effectiveness.

Malone and Lepper (1987) provide valuable guidance with their list of key characteristics of a learning game:

Key Characteristics of a Learning Game

Malone and Lepper (1987)

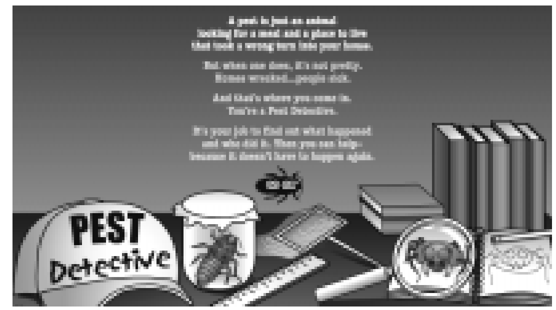
a) **Challenge** is created by having clear, fixed goals that are relevant for the learner. Uncertain outcomes provide challenge by offering variable difficulty levels, hidden information, and randomness. Feedback on performance should be frequent, unambiguous, and supportive. Lastly, the activity should promote feelings of competence for the person involved.

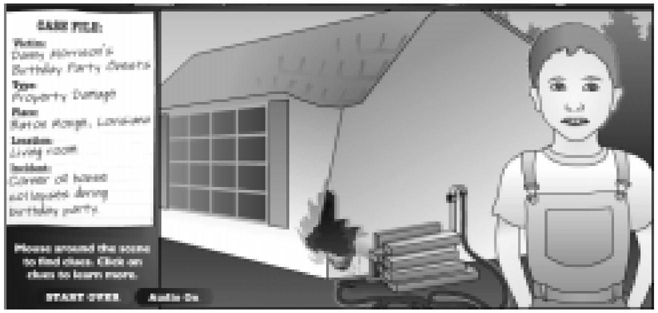
b) **Curiosity** exists in two different forms: sensory curiosity and cognitive curiosity. Audio and visual effects, particularly, in computer games may enhance sensory curiosity. When learners are surprised or intrigued by paradoxes, or incompleteness, it arouses cognitive curiosity.

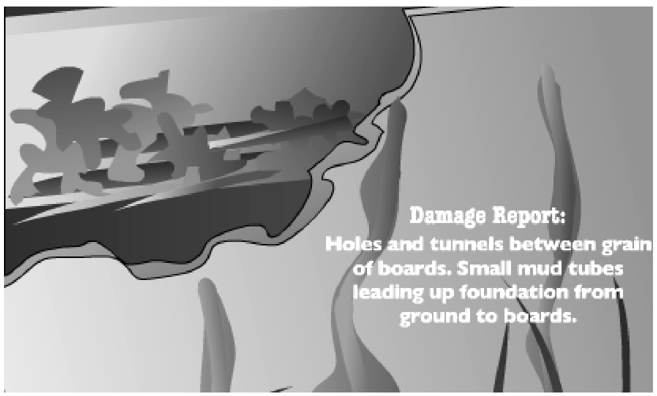
c) **Control** is experienced as feelings of self-determination and control on the part of the learner. The ingredients of contingency, choice, and power contribute to the control feature of the learning experience. When the individuals face choices that produce powerful effect, it increases their sense of personal control.

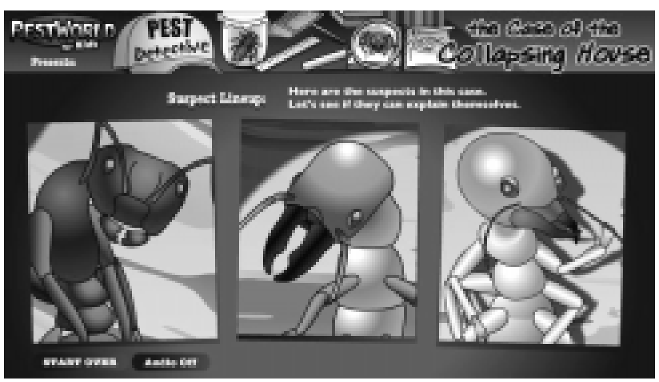
d) **Fantasy** encompasses both the emotions and thinking process of the learner. Fantasies should appeal not only to the emotional needs of learners, but should provide relevant metaphors or analogies. Lastly, fantasies should have an integral relationship to the material covered. (Dodge 2000)

How do these characteristics manifest themselves in something that claims to be a learning game? This first example interactive is an interactive mystery called *Pest Detective*, from the National Pest Management Association's *Pestworld for Kids* Web site (http://www.pestworldforkids.org). (Although the subject matter may seem pejorative towards the natural world, the site defines pests as "animals out of place" and thus explores pest ecology rather than pest elimination.)





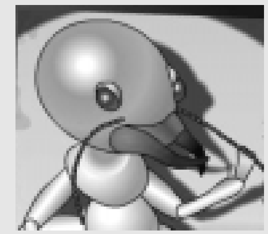




So is *Pest Detective* a game? It clearly has some gamelike qualities:

- The **challenge** is to find the explanation for an event (a bug bite or house damage).
- Cognitive **curiosity** is stimulated by this precipitating event, and sensory curiosity by the animations and particularly by the anthropomorphized insects.
- The program gives players some superficial degree of **control** (they can choose the order in which to view clues and suspects, and in which to complete the analysis worksheet), but the player cannot deviate from the throughpath of the mystery. (This limited degree of control was intentional given the learning goals and the age of the target audience.)
- **Fantasy** elements are strong: the "enhanced reality" nature of the scenarios and illustrations and the anthropomorphized insects foster an emotional connection with players, yet closely follows a scientific-deduction method that explains the cause of the problem posed. Thus the gameplay process is not arbitrary but addresses and embodies the actual content to be learned.

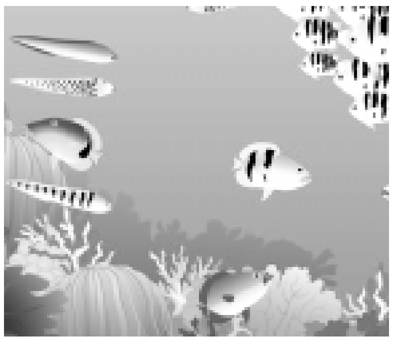
So *Pest Detective* has several attributes of a game, but doesn't fully qualify as one. It is better described as content delivery with gamelike qualities. Its convergent storyline also limits its game potential. Not all games allow multiple outcomes (although even a mystery game like Clue has many possible outcomes upon replay), but replayability signals the greater control that a true game gives its players.



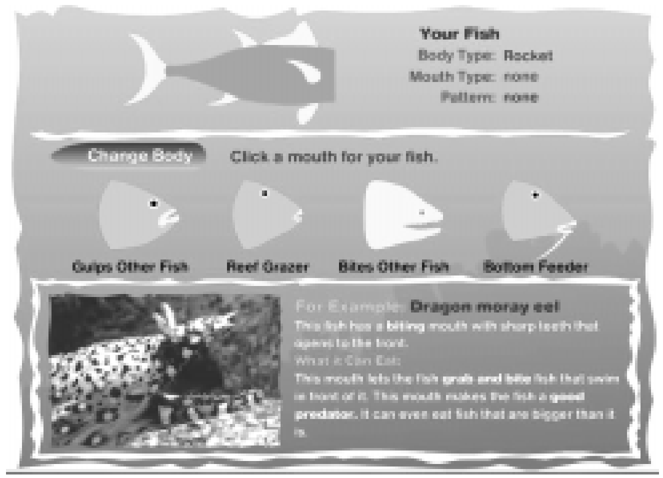
What did you learn?

"Bugs are cool!"

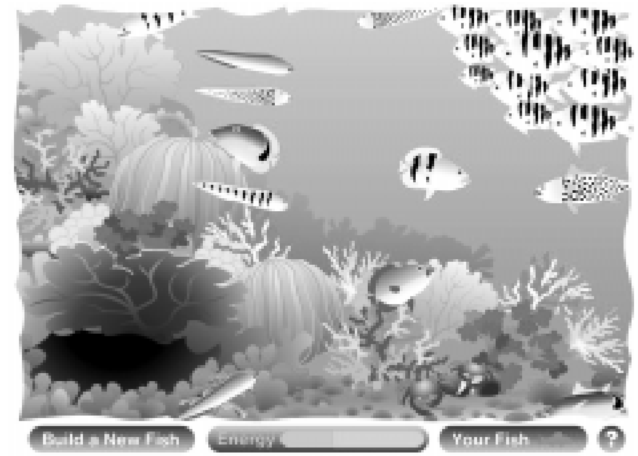
"How to prevent termites from getting into your house—turn off the water, move the wood away. That's their favorite habitat."



A divergent learning interactive such as *Build-a-Fish* from the John G. Shedd Aquarium takes a step farther toward gamehood. In *Build-a-Fish*, players design a mongrel fish (choosing from three body shapes, three mouth types, and three colorations) and swim it around the reef in an effort to eat and avoid being eaten. So is it a game?



- The **challenge** is to design a fish that will survive on the reef.
- Sensory **curiosity** is stimulated by the variety of shapes and colors of the fish parts, and by the cause-and-effect of swimming one's fish on the reef. The first time one's fish dies (from starvation or predation) creates a discrepant event or disequilibrium in the player, fostering cognitive curiosity.
- Some **control** is granted with the fish design choices (with 27 possible combinations); even more control comes from the ability to move one's fish around the reef and try to eat other fish.
- The **fantasy** aspects (designing a fish and controlling its behavior on the reef) foster an emotional connection while tightly integrating the gameplay with the subject matter.



Build-a-Fish embodies all four of Malone and Lepper's characteristics and thus qualifies as a true learning game. But that isn't the end of the matter. Even a true learning game doesn't automatically create an effective learning experience for players. Because of the game's open-ended constructivist approach, players are responsible for making connections between selected physical adaptations and the success or failure of their fish on the reef.

In the summative evaluation of *Build-a-Fish* (conducted by Selinda Research Associates as part of its evaluation of the larger Shedd Educational Adventures project), one teacher reported, "Some of them have figured it out….They know exactly what combinations to get. And others of them still—it still hasn't sunk in that if this animal eats coral, you've got to choose a body that's going to work when you have it down in the coral reef." (Gyllenhaal *et al*. 2003). But evaluators found that the game was usually effective:

"The first few times through *Build-a-Fish*, [third grade] students often faced difficulties figuring out how to get their fish to 'behave' in ways appropriate to its adaptations—swimming in the right place, and so forth. As they gained experience, students often paid more attention to the 'Best Habitat/Best Food' hints screen, so they could start the game with their fish behaving in appropriate ways…After several sessions, [students] had begun to master both the game itself and some of the ecological concepts that were designed into the game." (*Ibid.*)

Students who did master the gameplay indicated that they understood the ecological connections between adaptations and habitat, but in narrowly construed ways: "The rocket body makes it easy to swim. If you choose a rocket body, you should choose a mouth to eat other fish and a blue pattern to blend in with the water." Only during class discussion and reflection did students generalize these concepts to other settings. "Teachers gave examples of students (1) extending what they had learned about adaptation in coral reefs to adaptations of animals living in polar and desert habitats, and (2) generalizing camouflage concepts from fish to other vertebrates." (*Ibid.*)

The evaluators noted that *Build-a-Fish*'s effectiveness partially stemmed from the "close correspondence between mastering the game and understanding the basic concept of the relationship between physical adaptation and behavior," which is a key aspect of fantasy: "the integral relationship to the material covered." (Malone and Lepper 1987) Sherry Turkle calls this transparency: knowing why something is working by reference to an underlying process. (Turkle 1999) Transparency is a critical challenge in digital learning games, where the surface gameplay can easily mask the underlying content, structure, and rules. While children have an intrinsic need to understand, the gameplay can focus this need on understanding how to win the game, which is not necessarily the same thing as understanding the game content.

While players may overlook the intentional rules of the underlying system, they are also likely to draw meaning from other features of the game—design compromises or convenient assumptions which were not the ostensible content to be learned. Turkle has made famous one child's misconception generated by *SimCity*: "Raising taxes always leads to riots." (Turkle 1997) Even a highly complex and big-budget game like *SimCity* presents a simplified model of reality that reveals the designer's biases and assumptions. Yet without a critical view of the simulation model, players are likely to draw such unwanted conclusions. We have seen this happen with both simple and complex games (the simple games have more obvious compromises and simplifications, while more complex simulation games require assumptions deeper below the surface of the gameplay). Without evaluating the learning outcomes, game designers cannot know whether players are learning the intended or inadvertent content.

The *Build-a-Fish* evaluation suggests additional criteria for an effective learning game that extend Malone and Lepper's taxonomy.

Extending Malone and Lepper's Taxonomy

Original Criteria:
- Challenge
- Curiosity
- Control
- Fantasy

Added Criteria:
- Iteration
- Reflection

- **Iteration** is vital to learning. Whether it consists of small iterations within the activity sequence, or replaying the entire game to attempt alternate strategies, iteration supports the learning process by encouraging experimentation, hypothesis testing, and synthesis. With *Build-a-Fish*, only through iteration did students start to understand how fish adaptations worked within the reef ecosystem. Conversely, a story-driven interactive like *Pest Detective* relies on successful information transmission to be effective. (Of course, just because *Pest Detective* is not designed for replay doesn't mean that children don't do it repeatedly. As with their favorite books and movies, my own sons have played *Pest Detective* dozens of times, progressively learning more of the content, and in my younger son's case, gradually overcoming his fear of spiders. Thus a sufficiently engaging interactive can encourage repeat usage and lead to meaningful outcomes.)

- Ideally, **reflection** should happen during these iterations, as players test new hypotheses and synthesize the outcomes with their existing understanding. But this process can be sidetracked by transparency issues, or simply not occur at the level that the game designers wish. Student comments about *Build-a-Fish* reveal growing understanding of the system, but these did not develop into coherent understanding of the ecosystem until the teacher facilitated group reflection, even though the fish design process is meant to encourage reflection on various types of adaptations. In a twitch-speed game, reflection is even more unlikely. Gee (2003) cites external scaffolding in the form of discussion boards about gameplay strategies as a vital element in the larger game experience, but this assumes a game of sufficient length and complexity to drive players to such a resource. How do we build reflection into the gameplay experience itself?

The intrinsic appeal of gameplay makes games an attractive format for educational media developers, but the particular characteristics and challenges of a game magnify the usual concerns over design, intentionality, and outcomes that all educational designers deal with. Only through careful design and thorough evaluation can we hope to overcome these challenges and realize the potential that games offer.

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