Chapter 2

Good Videogames, the Human Mind, and Good Learning

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Introduction

This chapter has two main points to make and, in turn, the chapter falls into two main parts. My first point—a point some will find startling at first—is that good videogames (by which I mean both computer games and games played on platforms like the Xbox, Cube, or PlayStation) represent a technology that illuminates how the human mind works. My second point follows, in part, from this first one. It is that good videogames incorporate good learning principles and have a great deal to teach us about learning in and out of schools, whether or not a videogame is part of this learning.

Videogames and the Mind

Videogames are a relatively new technology replete with important, and not yet fully understood, implications (Gee, 2003). Scholars have historically viewed the human mind through the lens of a technology they thought worked like the mind. Locke and Hume, for example, taking the technology of literacy as their guide, argued that the mind was like a blank slate on which experience wrote ideas. Much later, modern cognitive scientists argued that the mind worked like a digital computer, calculating generalizations and deductions via a logic-like rule system (Newell & Simon, 1972). More recently, some cognitive scientists, inspired by distributed parallel-processing computers and complex adaptive networks, have argued that the mind works by storing records of actual experiences and constructing intricate patterns of connections among them (Clark, 1989; Gee, 1992). So we get different pictures of the mind: mind as a slate waiting to be written on, mind as software, mind as a network of connections.

Human societies get better through history at building technologies that more closely capture some of what the human mind can do and getting

these technologies to do mental work publicly. Writing, digital computers, and networks each allow us to externalize some functions of the mind.

Though they are not commonly thought of in these terms, videogames are a new technology in this same line. They are a new tool with which to think about the mind and through which we can externalize some of its functions. Videogames of the sort I am concerned with—games like *Half-Life 2*, *Rise of Nations*, *Full Spectrum Warrior*, *Morrowinds: The Elder Scrolls*, and *World of WarCraft*—are what I would call "action-and-goal-directed preparations for, and simulations of, embodied experience." A mouthful, indeed, but an important one.

To make clear what I mean by the claim that games act like the human mind and are a good place to study and produce human thinking and learning, let me first briefly summarize some recent research in cognitive science, the science that studies how the mind works (Bransford, Brown, & Cocking, 2000). Consider, for instance, the remarks below (in the quotes below, the word "comprehension" means "understanding words, actions, events, or things"):

> . . . comprehension is grounded in perceptual simulations that prepare agents for situated action. (Barsalou, 1999a, p. 77)

> . . . to a particular person, the meaning of an object, event, or sentence is what that person can do with the object, event, or sentence. (Glenberg, 1997, p. 3)

What these remarks mean is this: Human understanding is not primarily a matter of storing general concepts in the head or applying abstract rules to experience. Rather, humans think and understand best when they can imagine (simulate) an experience in such a way that the simulation prepares them for actions they need and want to take in order to accomplish their goals (Barsalou, 1999b; Clark, 1997; Glenberg & Robertson, 1999).

Let's take weddings as an example, though we could just as well have taken war, love, inertia, democracy, or anything. You don't understand the word or the idea of weddings by meditating on some general definition of weddings. Rather, you have had experiences of weddings, in real life and through texts and media. On the basis of these experiences, you can simulate different wedding scenarios in your mind. You construct these simulations differently for different occasions, based on what actions you need to take to accomplish specific goals in specific situations. You can move around as a character in the mental simulation as yourself, imaging your role in the wedding, or you can "play" other characters at the wedding (e.g., the minister), imaging what it is like to be that person.

You build your simulations to understand and make sense of things, but also to help you prepare for action in the world. You can act in the simulation and test out what consequences follow, before you act in the real world. You can role-play another person in the model and try to see what motivates their actions or might follow from them before you respond in the real world. So I am arguing that the mind is a simulator, but one that builds simulations to purposely prepare for specific actions and to achieve specific goals (i.e., they are built around win states).

Videogames turn out to be the perfect metaphor for what this view of the mind amounts to, just as slates and computers were good metaphors for earlier views of the mind. To see this, let me now turn to a characterization of videogames and then I will put my remarks about the mind and games together.

Videogames usually involve a visual and auditory world in which the player manipulates a virtual character (or characters). They often come with editors or other sorts of software with which the player can make changes to the game world or even build a new game world. The player can make a new landscape, a new set of buildings, or new characters. The player can set up the world so that certain sorts of actions are allowed or disallowed. The player is building a new world, but is doing so by using and modifying the original visual images (really the code for them) that came with the game. One simple example of this is the way in which players can build new skateboard parks in a game like *Tony Hawk's Pro Skater*. The player must place ramps, trees, grass, poles, and other things in space in such a way that players can manipulate their virtual characters to skate the park in a fun and challenging way.

Even when players are not modifying games, they play them with goals in mind, the achievement of which counts as their "win state" (and it's the existence of such win states that, in part, distinguishes games from simulations). These goals are set by the player, but, of course, in collaboration with the world the game designers have created (and, at least in more open-ended games, players don't just accept developer's goals, they make real choices of their own). Players must carefully consider the design of the world and consider how it will or will not facilitate specific actions they want to take to accomplish their goals.

One technical way that psychologists have talked about this sort of situation is through the notion of "affordances" (Gibson, 1979). An "affordance" is a feature of the world (real or virtual) that will allow for a certain action to be taken, but only if it is matched by an ability in an actor who has the wherewithal to carry out such an action. For example, in the massive multiplayer game *World of WarCraft* stags can be killed and skinned (for making leather), but only by characters that have learned the skinning skill. So a stag is an affordance for skinning for such a player, but not for one who has no such skill. The large spiders in the game are not an affordance for skinning for any players, since they cannot be skinned at all. Affordances are relationships between the world and actors.

Playing *World of WarCraft*, or any other videogame, is all about such affordances. The player must learn to *see* the game world—designed by the developers, but set in motion in particular directions by the players, and, thus, co-designed by them—in terms of such affordances (Gee, 2005). Broadly speaking, players must think in terms of "What are the features of this world that can enable the actions I am capable of carrying out and that I want to carry out in order to achieve my goals?"

So now, after our brief bit about the mind and about games, let's put the two together. The view of the mind I have sketched, in fact, argues, as far as I am concerned, that the mind works rather like a videogame. For humans, effective thinking is more like running a simulation than it is about forming abstract generalizations cut off from experiential realities. Effective thinking is about perceiving the world such that the human actor sees how the world, at a specific time and place (as it is given, but also modifiable), can afford the opportunity for actions that will lead to a successful accomplishment of the actor's goals. Generalizations are formed—when they are—bottom-up from experience and imagination of experience. Videogames externalize the search for affordances, for a match between character (actor) and world, but this is just the heart and soul of effective human thinking and learning in any situation.

As a game player you learn to see the world of each different game you play in a quite different way. But in each case you see the world in terms of how it will afford the sorts of embodied actions you (and your virtual character, your surrogate body in the game) need to take to accomplish your goals (to win in the short and long run). For example, you see the world in *Full Spectrum Warrior* as routes (for your squad) between cover (e.g., corner to corner, house to house) because this prepares you for the actions you need to take, namely attacking without being vulnerable to attack yourself. You see the world of *Thief* in terms of light and dark, illumination and shadows, because this prepares you for the different actions you need to take in this world, namely hiding, disappearing into the shadows, sneaking, and otherwise moving unseen to your goal.

When we sense such a match, in a virtual world or the real world, between our way of seeing the world, at a particular time and place, and our action goals—and we have the skills to carry these actions out—then we feel great power and satisfaction. Things click, the world looks as if it were made for us. While commercial games often stress a match between worlds and characters like soldiers or thieves, there is no reason why other games could not let players experience such a match between the world and the way a particular type of scientist, for instance, sees and acts on the world (Gee, 2004). Such games would involve facing the sorts of problems and challenges that type of scientist does, and living and playing by the rules that type of scientist uses. Winning would mean just what it does to a scientist: feeling a sense of accomplishment through the production of knowledge to solve deep problems.

I have argued for the importance of videogames as "action-and-goal-directed preparations for, and simulations of, embodied experience." They are the new technological arena—just as were literacy and computers earlier—around which we can study the mind and externalize some of its most important features to improve human thinking and learning. But games have two other features that suit them to be good models for human thinking and learning externalized out in the world. These two additional features are: (a) they distribute intelligence via the creation of smart tools, and (b) they allow for the creation of "cross-functional affiliation," a particularly important form of collaboration in the modern world.

Consider first how good games distribute intelligence (Brown, Collins, & Dugid, 1989). In *Full Spectrum Warrior*, the player uses the buttons on the controller to give orders to two squads of soldiers. The instruction manual that comes with the game makes it clear from the outset that players, in order to play the game successfully, must take on the values, identities, and ways of thinking of a professional soldier: "Everything about your squad," the manual explains, "is the result of careful planning and years of experience on the battlefield. Respect that experience, soldier, since it's what will keep your soldiers alive" (p. 2). In the game, that experience—the skills and knowledge of professional military expertise—is distributed between the virtual soldiers and the real-world player. The soldiers in the player's squads have been trained in movement formations; the role of the player is to select the best position for them on the field. The virtual characters (the soldiers) know part of the task (various movement formations) and the player must come to know another part (when and where to engage in such formations). This kind of distribution holds for every aspect of military knowledge in the game.

By distributing knowledge and skills this way—between the virtual characters (smart tools) and the real-world player—the player is guided and supported by the knowledge built into the virtual soldiers. This offloads some of the cognitive burden from the learner, placing it in smart tools that can do more than the learner is currently capable of doing by him- or herself. It allows the player to begin to act, with some degree of effectiveness, before being really competent—"performance before competence." The player thereby eventually comes to gain competence through trial, error, and feedback, not by wading through a lot of text before being able to engage in activity. Such distribution also allows players to internalize not only the knowledge and skills of a professional (a professional soldier in this case) but also the concomitant values ("doctrine," as the military says) that

shape and explain how and why that knowledge is developed and applied in the world. There is no reason why other professions—scientists, doctors, government officials, urban planners (Shaffer, 2004)—could not be modeled and distributed in this fashion as a deep form of value-laden learning (and, in turn, learners could compare and contrast different value systems as they play different games).

Finally, let me turn to the creation of "cross-functional affiliation." Consider a small group partying (hunting and questing) together in a massive multiplayer game like *World of WarCraft*. The group might well be composed of a Hunter, Warrior, Druid, and Priest. Each of these types of characters has quite different skills and plays the game in a different way. Each group member (player) must learn to be good at his or her special skills and also learn to integrate these skills as a team member within the group as a whole. Each team member must also share some common knowledge about the game and game play with all the other members of the group—including some understanding of the specialist skills of other player types—in order to achieve a successful integration. So each member of the group must have specialist knowledge (intensive knowledge) and general common knowledge (extensive knowledge), including knowledge of the other member's functions.

Players—who are interacting with each other, in the game and via a chat system—orient to each other not in terms of their real-world race, class, culture, or gender (these may very well be unknown or if communicated made up as fictions). They must orient to each other, first and foremost, through their identities as game players and players of *World of WarCraft* in particular. They can, in turn, use their real-world race, class, culture, and gender as strategic resources if and when they please, and the group can draw on the differential real-world resources of each player, but in ways that do not force anyone into pre-set racial, gender, cultural, or class categories.

This form of affiliation—what I will call cross-functional affiliation—has been argued to be crucial for the workplace teams in modern "new capitalist" workplaces, as well as in modern forms of social activism (Beck, 1999; Gee, 2004; Gee, Hull, & Lankshear, 1996). People specialize, but integrate and share, organized around a primary affiliation to their common goals and using their cultural and social differences as strategic resources, not as barriers.

Good Videogames and Good Learning

So videogames, though a part of popular culture, are, like literacy and computers, sites where we can study and exercise the human mind in ways that may give us deeper insights into human thinking and learning, as well as new ways to engage learners in deep and engaged learning. And, in fact, one of the biggest contributions the study of good videogames can make is to illuminate ways in which learning works when it works best for human beings. In part because they externalize the way in which the human mind thinks, good videogames often organize learning in deep and effective ways.

Many good computer and videogames, games like *Deus Ex*, *The Elder Scrolls III: Morrowind*, or *Rise of Nations*, are long, complex, and difficult, especially for beginners. As we well know from school, young people are not always eager to do difficult things. When adults are faced with the challenge of getting them to do so, two choices are often available. We can force them, which is the main solution schools use. Or, a temptation when profit is at stake, though not unknown in school either, we can dumb down the product. Neither option is open to the game industry, at least for the moment. They can't force people to play and most avid gamers don't want their games short or easy games. Indeed, game reviews regularly damn easy or short games.

For people interested in learning, this raises an interesting question. How do good game designers manage to get new players to learn their long, complex, and difficult games and not only learn them but pay to do so? It won't do simply to say games are "motivating." That just begs the question of "Why?" Why is a long, complex, and difficult videogame motivating? I believe it is something about how games are designed to trigger learning that makes them so deeply motivating.

So the question is: How do good game designers manage to get new players to learn long, complex, and difficult games? The answer, I believe, is this: The designers of many good games have hit on profoundly good methods of getting people to learn and to enjoy learning. They have had to, since games that were bad at getting themselves learned didn't get played and the companies that made them lost money. Furthermore, it turns out that these learning methods are similar in many respects to cutting-edge principles being discovered in research on human learning (for details, see Gee, 2003, 2004, 2005 and the references therein).

Good game designers are practical theoreticians of learning, since what makes games deep is that players are exercising their learning muscles, though often without knowing it and without having to pay overt attention to the matter. Under the right conditions, learning, like sex, is biologically motivating and pleasurable for humans (and other primates). It is a hook that game designers own to a greater degree—thanks to the interactivity of games—than do movies and books.

But the power of videogames resides not just in their present instantiations but in the promises the technologies by which they are made hold

out for the future. Game designers can make worlds where people can have meaningful new experiences, experiences that their places in life would never allow them to have or even experiences no human being has ever had before. These experiences have the potential to make people smarter and more thoughtful.

Good games already do this and they will do it more and more in the future. *Star Wars: Knights of the Old Republic* immerses the player in issues of identity and responsibility: What responsibility do I bear for what an earlier, now transformed, "me" did? *Deus Ex: Invisible War* asks the player to make choices about the role ability and equality will or won't play in society: If we were all truly equal in ability would that mean we would finally have a true meritocracy? Would we want it? In these games, such thoughtful questions are not abstractions, they are part and parcel of the fun and interaction of playing.

I care about these matters both as a cognitive scientist and as a gamer. I believe that we can make school and workplace learning better if we pay attention to good computer and videogames. This does not necessarily mean using game technologies in school and at work, though that is something I advocate. It means applying the fruitful principles of learning that good game designers have hit on, whether or not we use a game as a carrier of these principles. My book *What Video Games Have to Teach Us About Learning and Literacy* (2003) lists many of these principles. Science educator Andy diSessa's book *Changing Minds: Computers, Learning, and Literacy* (2000) offers many related principles without ever mentioning videogames (see also chapter 9 by diSessa in this book).

There are many good principles of learning built into good computer and videogames. These are all principles that could and should be applied to school learning tomorrow, though this is unlikely given the current trend for skill-and-drill, scripted instruction, and standardized multiple choice testing. The principles are particularly important for so-called "at risk" learners, students who have come to school under-prepared, who have fallen behind, or who have little support for school-based literacy and language skills outside of school.

The principles are neither conservative nor liberal, neither traditionalist, nor progressive. They adopt some of each side, reject some of each, and stake out a different space. If implemented in schools they would necessitate significant changes in the structure and nature of formal schooling as we have long known it, changes that may eventually be inevitable anyway given modern technologies.

I list a baker's dozen below. We can view this list as a checklist: The stronger any game is on more of the features on the list, the better its score for learning. The list is organized into three sections: I Empowered Learners;

II Problem Solving; III Understanding. Under each item on the list I first give a principle relevant to learning, then a comment on games in regard to that principle, as well as some example games that are strong on that principle. I then discuss the educational implications of the principle. Those interested in more ample citations to research that supports these principles and how they apply to learning things like science in school should consult the references in cited in Gee (2003, 2004, 2005). I should point out as well that the first part of this chapter has already discussed some of learning principles that we don't need to discuss further below, since distributed knowledge and cross-functional affiliation are themselves powerful forms of social organization for learning and knowledge building. So is the way in which good videogames teach players to look for and build affordances into their learning environments.

I Empowered Learners

1 Co-design

Principle: Good learning requires that learners feel like active agents (producers) not just passive recipients (consumers).

Games: In a videogame, players make things happen. They don't just consume what the "author" (game designer) has placed before them. Videogames are interactive. The player does something and the game does something back that encourages the player to act again. In good games, players feel that their actions and decisions—and not just the designers' actions and decisions—are co-creating the world they are in and the experiences they are having. What the player does matters and each player, based on his or her own decisions and actions, takes a different trajectory through the game world.

Example: The Elder Scrolls: Morrowind is an extreme example of a game where each decision the player makes changes the game in ways that ensure that each player's game is, in the end, different from any other player's. But at some level this is true of most games. Players take different routes through *Castlevania: Symphony of the Night* and do different things in different ways in *Tony Hawk's Underground.*

Education: Co-design means ownership, buy-in, engaged participation. It is a key part of motivation. It also means learners must come to understand the design of the domain they are learning so that they can make good

choices about how to affect that design. Do student decisions and actions make a difference in the classroom curriculum? Are students helping to design their own learning? If the answers are no, what gives students the feeling of being agents in their own learning? Forced and enforced group discussions are about as far as interactivity goes in most classrooms, if it goes that far. The whole curriculum should be shaped by learners' actions and react back on the learner in meaningful ways.

2 Customize

Principle: Different styles of learning work better for different people. People cannot be agents of their own learning if they cannot make decisions about how their learning will work. At the same time, they should be able (and encouraged) to try new styles.

Games: Good games achieve this goal in one (or both) of two ways. In some games, players are able to customize the game play to fit their learning and playing styles. In others, the game is designed to allow different styles of learning and playing to work.

Example: Rise of Nations allows players to customize myriad aspects of the game play to their own styles, interests, and desires. *Deus Ex* and its sequel *Deus Ex: Invisible War* both allow quite different styles of play (and thus learning, too) to succeed.

Education: Classrooms adopting this principle would allow students to discover their favored learning styles and to try new ones without fear. In the act of customizing their own learning, students would learn a good deal not only about how and why they learn, but about learning and thinking themselves. Can students engage in such customization in the classroom? Do they get to reflect on the nature of their own learning and learning in general? Are there multiple ways to solve problems? Are students encouraged to try out different learning styles and different problems solutions without risking a bad grade?

3 Identity

Principle: Deep learning requires an extended commitment and such a commitment is powerfully recruited when people take on a new identity they value and in which they become heavily invested—whether this be a child "being a scientist doing science" in a classroom or an adult taking on a new role at work.

Games: Good games offer players identities that trigger a deep investment on the part of the player. They achieve this goal in one of two ways. Some games offer a character so intriguing that players want to inhabit the character and can readily project their own fantasies, desires, and pleasures onto the character. Other games offer a relatively empty character whose traits the player must determine, but in such a way that the player can create a deep and consequential life history in the game world for the character.

Example: Metal Solid Gear offers a character (Solid Snake) that is so well developed that he is, though largely formed by the game's designers, a magnet for player projections. *Animal Crossing* and *The Elder Scrolls: Morrowind* offer, in different ways, blank-slate characters for whom the player can build a deeply involving life and history. On the other hand, an otherwise good game like *Freedom Fighters* offers us characters that are both too anonymous and not changeable enough by the player to trigger deep investment.

Education: School is often built around the "content fetish," the idea that an academic area like biology or social science is constituted by some definitive list of facts or body of information that can be tested in a standardized way. But academic areas are not first and foremost bodies of facts, they are, rather, first and foremost, the activities and ways of knowing through which such facts are generated, defended, and modified. Such activities and ways of knowing are carried out by people who adopt certain sorts of identities, who adopt certain ways with words, actions, and interactions, as well as certain values, attitudes, and beliefs.

Learners need to know what the "rules of the game" are and who plays it. They need to know how to take on the identity of a certain sort of scientist, if they are doing science, and operate by a certain set of values, attitudes, and actions. Otherwise they have no deep understanding of a domain and will surely never know why anyone would want to learn or even spend a lifetime of learning in that domain in the first place.

Ironically, when learners adopt and practice such an identity and engage in the forms of talk and action connected to it, facts come free—they are learned as part and parcel of being a certain sort of person needing to do certain sorts of things for one's own purposes and goals (Shaffer, 2004). Out of the context of identity and activity, facts are hard to learn and last in the learner's mind a very short time indeed.

4 *Manipulation and distributed knowledge*

Principle: As I suggested in the first part of this chapter, cognitive research suggests that for humans perception and action are deeply interconnected

(Barsalou, 1999a, b; Clark, 1997; Glenberg, 1997; Glenberg & Robertson, 1999). Thus, fine-grained action at a distance—for example, when a person is manipulating a robot at a distance or watering a garden via a webcam on the Internet—causes humans to feel as if their bodies and minds have stretched into a new space (Clark, 2003). More generally, humans feel expanded and empowered when they can manipulate powerful tools in intricate ways that extend their area of effectiveness.

Games: Computer and videogames inherently involve action at a (albeit virtual) distance. The more and better a player can manipulate a character, the more the player invests in the game world. Good games offer characters that the player can move intricately, effectively, and easily through the world. Beyond characters, good games offer the player intricate, effective, and easy manipulation of the world's objects, objects which become tools for carrying out the player's goals.

Example: Tomb Raider, Tom Clancy's Splinter Cell, and *ICO* allow such fine-grained and interesting manipulation of one's character that they achieve a strong effect of pulling the player into their worlds. *Rise of Nations* allows such effective control of buildings, landscapes, and whole armies as tools that the player feels like god. *Prince of Persia* excels both in terms of character manipulation and everything in its environment serving as effective tools for player action.

One key feature of the virtual characters and objects that game players manipulate is that they are "smart tools." The character the player controls—Lara Croft, for example—knows things the player doesn't, for instance how to climb ropes, leap chasms, and scale walls. The player knows things the character doesn't, like when, where, and why to climb, leap, or scale. The player and the character each have knowledge that must be integrated together to play the game successfully. This is an example of distributed knowledge, knowledge split between two things (here a person and a virtual character) that must be integrated.

A game like *Full Spectrum Warrior* takes this principle much further. In this game, the player controls two squads of four soldiers each. The soldiers know lots and lots of things about professional military practice, for example, how to take various formations under fire and how to engage in various types of group movements in going safely from cover to cover. The player need not know these things. The player must learn other aspects of professional military practice, namely what formations and movements to order, when, where, and why. The real actor in this game is the player and the soldiers blended together through their shared, distributed, and integrated knowledge.

Education: What allows a learner to feel that his or her body and mind have extended into the world being studied or investigated, into the world of biology or physics, for example? Part of what does this is "smart tools," namely tools and technologies that allow the learner to manipulate that world in a fine-grained way. Such tools have their own in-built knowledge and skills that allow the learner much more power over the world being investigated than he or she has unaided by such tools.

Let me give one concrete example of what I am talking about. Galileo discovered the laws of the pendulum because he knew and applied geometry to the problem, not because he played around with pendulums or saw a church chandelier swinging (as myth has it). Yet it is common for liberal educators to ask children innocent of geometry or any other such tool to play around with pendulums and discover for themselves the laws by which they work. This is actually a harder problem than the one Galileo confronted—geometry set possible solutions for him and led him to think about pendulums in certain ways and not others. Of course, today there are a great many technical tools available beyond geometry and algebra (though students usually don't even realize that geometry and algebra are smart tools, different from each other in the way they approach problems and the problems for which they are best suited).

Do students in the classroom share knowledge with smart tools? Do they become powerful actors by learning to integrate their own knowledge with the knowledge built into their tools? The real-world player and the virtual soldiers in *Full Spectrum Warrior* come to share a body of skills and knowledge that is constitutive of a certain type of professional practice. Do students engage in authentic professional practices in the classroom through such sharing? Professional practice is crucial here, because, remember, real learning in science, for example, is constituted by *being a type of scientist doing a type of science* not reciting a fact you don't understand. It is thinking, acting, and valuing like a scientist of a certain sort. It is "playing by the rules" of a certain sort of science.

II Problem Solving

5 Well-order problems

Principle: Given human creativity, if learners face problems early on that are too freeform or too complex, they often form creative hypotheses about how to solve these problems, but hypotheses that don't work well for later problems (even for simpler ones, let alone harder ones). They have been "sent down a garden path." The problems learners face early on are crucial

and should be well designed to lead them to hypotheses that work well, not just on these problems, but as aspects of the solutions of later, harder, problems as well.

Games: Problems in good games are well ordered. In particular, early problems are designed to lead players to form good guesses about how to proceed when they face harder problems later on in the game. In this sense, earlier parts of a good game are always looking forward to later parts.

Example: Return to Castle Wildenstein and *Fatal Frame 2: Crimson Butterfly*, though radically different games, both do a good job of offering players problems that send them down fruitful paths for what they will face later in the game. They each prepare the player to get better and better at the game and to face more difficult challenges later in the game.

Education: Work on connectionism and distributed parallel processing in cognitive science has shown that the order in which learners confront problems in a problem space is important (Clark, 1989; Elman, 1991a, b). Confronting complex problems too early can lead to creative solutions, but approaches that won't work well for even simpler later problems. "Anything goes"—"just turn learners loose in rich environments"—"no need for teachers"—these are bad theories of learning; they are, in fact, the progressive counterpart of the traditionalists' skill-and-drill.

Learners are novices. Leaving them to float amidst rich experiences with no guidance only triggers human beings' great penchant for finding creative but spurious patterns and generalizations that send learners down garden paths (Gee, 1992, 2001). The fruitful patterns or generalizations in any domain are the ones that are best recognized by those who already know how to look at the domain, know how the complex variables at play in the domain relate and interrelate to each other. And this is precisely what the learner does not yet know. Problems spaces can be designed to enhance the trajectory through which the learner traverses them. This does not mean leading the learner by the hand in a linear way. It means designing the problem space well.

6 Pleasantly frustrating

Principle: Learning works best when new challenges are pleasantly frustrating in the sense of being felt by learners to be at the outer edge of, but within, their "regime of competence." That is, these challenges feel hard but doable. Furthermore, learners feel—and get evidence—that their effort is paying off in the sense that they can see, even when they fail, how and if they are making progress.

Games: Good games adjust challenges and give feedback in such a way that different players feel the game is challenging but doable and that their effort is paying off. Players get feedback that indicates whether they are on the right road for success later on and at the end of the game. When players lose to a boss, perhaps several times, they get feedback about the sort of progress they are making so that at least they know if and how they are moving in the right direction towards success.

Example: Ratchet and Clank: Going Commando, Halo, and *Zone of the Enders: The Second Runner* (which has different difficulty levels) manage to stay at a doable but challenging level for many different sorts of players. They also give good feedback about where the player's edge of competence is and how it is developing, as does *Sonic Adventure 2 Battle. Rise of Nations* allows the player to customize many aspects of the difficulty level and gain feedback of whether things are getting too easy or too hard for the player.

Education: School is often too easy for some kids and too hard for others even when both are in the same classroom. Motivation for humans lies in challenges that feel challenging but doable and in gaining continual feedback that lets them know what progress they are making. Learners should be able to adjust the difficulty level while being encouraged to stay at the outer edge of, but inside, their level of competence. They should gain insight into where this level is and how it is changing over time. Good games don't come in grade levels that players must be "at." They realize that it doesn't matter when the player finishes or how he or she did in comparison to others—all that matters is that the player learns to play the game and comes to master it. Players who take longer and struggle longer at the beginning are sometimes the ones who, in the end, master the final boss most easily.

There are no "special" learners when it comes to videogames. Even an old guy like me can wander the plains of Morrowind long enough to pick up the ropes and master the game. The world doesn't go away, I can enter any time; it gives me constant feedback, but never a final judgment that I am a failure; and the final exam—the final boss—is willing to wait until I am good enough to beat him.

7 *Cycles of expertise*

Principle: Expertise is formed in any area by repeated cycles of learners practicing skills until they are nearly automatic, then having those skills fail in ways that cause the learners to have to think again and learn anew (Bereiter & Scardamalia, 1993). Then they practice this new skill set to an automatic level of mastery only to see it, too, eventually be challenged. In

fact, this is the whole point of levels and bosses. Each level exposes the players to new challenges and allows them to get good at solving them. They are then confronted with a boss that makes them use these skills together with new ones they have to learn, and integrate with the old ones, to beat the boss. Then they move on to a new level and the process starts again.

Games: Good games create and support the cycle of expertise, with cycles of extended practice, tests of mastery of that practice, then a new challenge, and then new extended practice. This is, in fact, part of what constitutes good pacing in a game.

Example: Ratchet and Clank: Going Commando, Final Fantasy X, Halo, Viewtiful Joe, and *Pikmin* do a good job of alternating fruitful practice and new challenges such that players sense their own growing sophistication almost as an incremental curve as the game progresses.

Education: The cycle of expertise has been argued to be the very basis of expertise in any area. Experts routinize their skills and then challenge themselves with the new problems. These problems force them to open up their routinized skills to reflection, to learn new things, and then to integrate old and new. In turn this new integrated package of skills, a higher level of mastery, will be routinized through much practice. Games let learners experience expertise, schools usually don't. The cycle of expertise allows learners to learn how to manage their own lifelong learning and to become skilled at learning to learn. It also creates a rhythm and flow between practice and new learning and between mastery and challenge. It creates as well a feeling of accumulating knowledge and skills, rather than standing in the same place all the time or always starting over again at the beginning.

8 *Information "on demand" and "just in time"*

Principle: Human beings are quite poor at using verbal information (i.e., words) when given lots of it out of context and before that can see how it applies in actual situations. They use verbal information best when it is given "just in time" (when they can put it to use) and "on demand" (when they feel they need it).

Games: Good games give verbal information—for example, the sorts of information that is often in a manual—"just in time" and "on demand" in a game. Players don't need to read a manual to start but can use the manual as a reference after they have played a while; by this time too the game has already made concrete much of the verbal information in the manual through the player's experiences.

Example: System Shock 2 spreads its manual out over the first few levels in little green kiosks that give players—if they want it—brief pieces of information that will soon thereafter be visually instantiated or put to use by the player. *Enter the Matrix* introduces new information into its "on demand" glossary when and as it becomes relevant and useable and marks it clearly as new. The first few levels of *Goblin Commander: Unleash the Hoard* allows the player to enact the information that would be in manual, step by step, and then the game seamlessly moves into more challenging game play.

Education: If there is one thing we know, it is that humans are not good at learning through hearing or reading lots of words out of contexts of application that give these words situated or experiential meanings. Game manuals, just like science textbooks, make little sense if one tries to read them before having played the game. All one gets is lots of words that are confusing, have only quite general or vague meanings, and are quickly forgotten. After playing the game, the manual is lucid and clear because now every word in it now has a meaning related to an action-image, can be situated in different contexts of use for dialogue or action. The player even learns how to readjust (situate, customize) the meanings of game-related words for new game contexts. Now, of course, the player doesn't need to read the manual cover to cover but can use it as reference work to facilitate his or her own goals and needs.

Lectures and textbooks are fine "on demand," used when learners are ready for them, not otherwise. Learners need to play the game a bit before they gets lots of verbal information; they need to be able to get such information "just in time" when and where they need it and can see how it actually applies in action and practice. Since schools rarely do this, we all familiar with the well-known phenomenon that students with A gradess because they can pass multiple choice tests can't apply their knowledge in practice.

9 Fish tanks

Principle: In the real world, a fish tank can be a little simplified ecosystem that clearly displays some critical variables and their interactions that are otherwise obscured in the highly complex eco-system in the real world. Using the term metaphorically, fish tanks are good for learning: If we create simplified systems, stressing a few key variables and their interactions, learners who would otherwise be overwhelmed by a complex system (e.g.,

Newton's Laws of Motion operating in the real world) get to see some basic relationships at work and take the first steps towards their eventual mastery of the real system (e.g., they begin to know what to pay attention to).

Games: Fish tanks are stripped-down versions of the game. Good games offer players fish tanks, either as tutorials or as their first level or two. Otherwise it can be difficult for newcomers to understand the game as a whole system, since they often can't see the forest because of the trees.

Example: Rise of Nations' tutorial scenarios (like "Alfred the Great" or "The 100 Years War") are wonderful fish tanks, allowing the player to play scaled-down versions of the game that render key elements and relationships salient.

Education: In traditional education, learners hear words and drill on skills out of any context of use. In progressive education, they are left to their own devices immersed in a sea of complex experience, for example studying pond ecology. When confronted with complex systems, letting the learner see some of the basic variables and how they interact can be a good way into confronting more complex versions of the system later on. This follows from the same ideas that give rise to the well-ordered problems principle above. It allows learners to form good strong fruitful hypotheses at the outset and not go down garden paths by confronting too much complexity at the outset.

The real world is a complex place. Real scientists do not go out unaided to study it. Galileo showed up with geometry, ecologists show up with theories, models, and smart tools. Models are all simplifications of reality and initial models are usually fish tanks, simple systems that display the workings of some major variables. With today's capacity to build simulations, there is no excuse for the lack of fish tanks in schools (there aren't even many real fish tanks in classrooms studying ponds!).

10 Sandboxes

Principle: Sandboxes in the real world are safe havens for children which still look and feel like the real world. Using the term metaphorically, sandboxes are good for learning: If learners are put into a situation that feels like the real thing, but with risks and dangers greatly mitigated, they can learn well and still feel a sense of authenticity and accomplishment.

Games: Sandboxes are game play much like the real game, but where things cannot go too wrong too quickly or, perhaps, even at all. Good games offer players, either as tutorials or as their first level or two, sandboxes. You can't expect newcomers to learn if they feel too much pressure, understand too little, and feel like failures.

Example: Rise of Nations' "Quick Start" tutorial is an excellent sandbox. You feel much more of the complexity of the whole game than you do in a fish tank, but risks and consequences are mitigated compared to the "real" game. The first level of *System Shock 2* is a great example of a sandbox—exciting play where, in this case, things can't go wrong at all. In many good games, the first level is a sandbox or close to it.

Education: Here we face one of the worst problems with school: It's too risky and punishing. There is nothing worse than a game that lets you save only after you have gone through a whole long arduous level. You fail at the end and have to repeat everything, rather than being able to return to a save part-way through the level. You end up playing the beginning of the level perfectly over and over again until you master the final bits. The cost of taking risks, trying out new hypotheses, is too high. The player sticks to the tried and true well-trodden road, because failing will mean boring repetition of what he or she already well knows.

Good games don't do this. They create sandboxes in the beginning that make the player feel competent when they are not ("performance before competence") and thereafter they put a moratorium on any failures that will kill joy, risk taking, hypothesizing, and learning. Players do fail, of course; they die and try again, but in a way that makes failure part of the fun and central to the learning.

In school, learners, especially so-called "at risk" learners need what Stan Goto (2003) has called "horizontal learning"—time to "play around," to explore the area they are about to learn, to see what is there and what the lay of the land is, before they are forced up the vertical learning ladder of ever new skills. They need always to see failure as informative and part of the game, not as a final judgment or a device to forestall creativity, risk taking, and hypothesizing.

11 Skills as strategies

Principle: There is a paradox involving skills: People don't like practicing skills out of context over and over again, since they find such skill practice meaningless; but, without lots of skill practice, they cannot really get any good at what they are trying to learn. People learn and practice skills best when they see a set of related skills as a strategy to accomplish goals they want to accomplish.

Games: In good games, players learn and practice skill packages as part and parcel of accomplishing things they need and want to accomplish. They see the skills first and foremost as a strategy for accomplishing a goal and only secondarily as a set of discrete skills.

Example: Games like *Rise of Nations*, *Goblin Commander: Unleash the Hoard*, and *Pikmin* all do a good job at getting players to learn skills while paying attention to the strategies these skills are used to pull off. *Rise of Nations* even has skill tests that package certain skills that go together, show clearly how they enact a strategy, and allow the player to practice them as a functional set. The training exercises (which are games in themselves) that come with the *Metal Gear Solid* and *Metal Gear Solid: Sons of Liberty* are excellent examples (and are great fish tanks as well).

Education: We know very well that learning is a practice effect for human beings—the conservatives are right about that, we humans need practice and lots of it. But skills are best learned (often in sets) as strategies for carrying out meaningful functions.

Sounding-out letters, together with thinking of word families and looking for sub-patterns in words, works best when seen as functional devices to comprehend and use texts. It's not that one can't get reading tests passed by drilling isolated skills out of context—one certainly can. But what happens is that we then fuel the so-called "fourth-grade slump," the long-known phenomenon in which children seem to do all right learning to read (decode) in the early grades (at least in terms of passing tests), but then cannot handle the complex oral and written language they confront later in the content areas of school, e.g., science, math, social studies, etc. (Chall, Jacobs, & Baldwin, 1990; see the papers in the special issue of the *American Educator* 2003 devoted to what they call the "fourth-grade plunge").

These children aren't learning to "play the game"—and the game in school is ultimately using oral and written language to learn academic areas which all use language far more complicated than our everyday vernacular forms of language. Learners need to know how skills translate into strategies for playing the game.

III Understanding

12 System thinking

Principle: People learn skills, strategies, and ideas best when they see how they fit into an overall larger system to which they give meaning. In fact, any experience is enhanced when we understand how it fits into a larger meaningful whole. Players cannot view games as "eye candy," but must learn to see each game (actually each genre of game) as a distinctive semiotic system affording and discouraging certain sorts of actions and interactions.

Games: Good games help players see and understand how each of the elements in the game fits into the overall system of the game and its genre (type). Players get a feel for the "rules of the game"—that is, what works and what doesn't, how things go or don't go in this type of world.

Example: Games like *Rise of Nations*, *Age of Mythology*, *Pikmin*, *Call of Duty*, and *Mafia* give players a good feel for the overall world and game system they are in. They allow players to develop good intuitions about what works and about how what they are doing at the present moment fits into the trajectory of the game as a whole. Players come to have a good feel for and understanding of the genre of the game they are playing (and in *Pikmin*'s case, this is a rather novel and hybrid genre). *Metal Gear Solid* and *Metal Gear Solid: Sons of Liberty* come with training exercises that strip away the pretty graphics to make clear how the player is meant to read the environment to enhance effective action and interaction in the game. If players stare at the pretty fish in the island paradise of *Far Cry*, they'll die in a minute. Players have to think of the environment they are in as a complex system that must be properly understood to plan effective action and anticipate unintended consequences on one's actions.

Education: We live, in today's high-tech, global world, amidt a myriad of complex systems, systems which interact with each other (Kelly, 1994). In such a world, untended consequences spread far and wide. In such a world being unable to see the forest for the trees is potentially disastrous. In school, when students fail to have a feeling for the whole system which they are studying, when they fail to see it as a set of complex interactions and relationships, each fact and isolated element they memorize for their tests is meaningless. Further, there is no way they can use these facts and elements as leverage for action—and we would hardly want them to, given that acting in complex systems with no understanding can lead to disasters. Citizens with such limited understandings are going to be dangers to themselves and others in the future.

13 *Meaning as action image*

Principle: Humans do not usually think through general definitions and logical principles. Rather, they think through experiences they have had

and imaginative reconstructions of experience. You don't think and reason about weddings on the basis of generalities, but in terms of the wedding you have been to and heard about and imaginative reconstructions of them. It's your experiences that give weddings and the word *wedding* meaning(s). Furthermore, for humans, words and concepts have their deepest meanings when they are clearly tied to perception and action in the world.

Games: This is, of course, the heart and soul of computer and videogames (though it is amazing how many educational games violate this principle). Even barely adequate games make the meanings of words and concepts clear through experiences the player has and activities the player carries out, not through lectures, talking heads, or generalities. Good games can achieve marvelous effects here, making even philosophical points concretely realized in image and action.

Example: Games like *Star Wars: Knights of the Old Republic*, *Freedom Fighters*, *Mafia*, *Metal of Honor: Allied Assault*, and *Operation Flashpoint: Cold War Crisis* do a very good job at making ideas (e.g., continuity with one's past self), ideologies (e.g., freedom fighters vs. terrorists), identities (e.g., being a soldier), or events (e.g., the Normandy Invasion) concrete and deeply embedded in experience and activity.

Education: This principle is clearly related to the information "just in time" and "on demand" principle above. For human beings the comprehension of texts and the world is "grounded in perceptual simulations that prepare agents for situated action" (Barsalou, 1999a, p. 77). If you can't run any models in your head—and you can't if all you have is verbal, dictionary-like information—you can't really understand what you are reading, hearing, or seeing. That's how humans are built. And note, by the way, that this means there is a kinship between how the human mind works and how videogames work, since videogames are, indeed, perceptual simulations that the player must see as preparation for action or fail.

Conclusion

When we think of games, we think of fun. When we think of learning we think of work. Games show us this is wrong. They trigger deep learning that is itself part and parcel of the fun. It is what makes good games deep.

For those interested in spreading games and game technology into schools, workplaces, and other learning sites, it is striking to meditate on how few of the learning principles I have sketched out here can be found in so-called educational games. "Non-educational" games for young people, such as *Pajama Sam*, *Animal Crossing*, *Mario Sunshine*, and *Pikmin*, all use many of the principles fully and well. Not so for many a product used in school or for business or workplace learning. It is often said that what stops games from spreading to educational sites is their cost, where people usually have in mind the wonderful "eye candy" that games have become. But I would suggest that it is the cost to implement the above principles that is the real barrier. And the cost here is not just monetary. It is the cost, as well, of changing people's minds about learning—how and where it is done. It is the cost of changing one of our most change-resistant institutions: schools.

Let me end by making it clear that the above principles are neither "conservative" nor "liberal," "traditional" nor "progressive." The progressives are right in that situated embodied experience is crucial. The traditionalists are right that learners cannot be left to their own devices, they need smart tools, and, most importantly, they need good designers who guide and scaffold their learning (Kelly, 2003). For games, these designers are brilliant games writers like Warren Spector and Will Wright. For schools, these designers are teachers.

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