Learning by Design: good video games as learning machines

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ABSTRACT This article asks how good video and computer game designers manage to get new players to learn long, complex and difficult games. The short answer is that designers of good games have hit on excellent methods for getting people to learn and to enjoy learning. The longer answer is more complex. Integral to this answer are the good principles of learning built into successful games. The author discusses 13 such principles under the headings of 'Empowered Learners', 'Problem Solving' and 'Understanding' and concludes that the main impediment to implementing these principles in formal education is cost. This, however, is not only (or even so much) *monetary* cost. It is, importantly, the cost of changing minds about how and where learning is done and of changing one of our most profoundly change-resistant institutions: the school.

Introduction

Many good computer and video games, games like *Deus Ex*, *The Elder Scrolls III: Morrowind*, or *Rise of Nations*, are long, complex, and difficult, especially for beginners (from now on I will simply use the term 'video games' for both computer games and games on platforms like the *Playstation 2*, the *Xbox*, and the *Nintendo GameCube*). 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. 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 video game 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, 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 video games 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 video games. 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* (Gee, 2003) lists many of these principles. Science educator Andy diSessa's book *Changing Minds: computers, learning, and literacy* (diSessa, 2000) offers many related principles without ever mentioning video games.

Learning in Good Games

There are many good principles of learning built into good computer and video games. 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 underprepared, 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: Empowered Learners; Problem Solving; 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).

Empowered Learners

Co-design

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

Games: In a video game, players make things happen. They don't just consume what the 'author' (game designer) has placed before them. Video games 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 cocreating 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 the learner's actions and react back on the learner in meaningful ways.

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 problem solutions without risking a bad grade?

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 which 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, that is, 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 – and even spend a lifetime 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.

Manipulation and Distributed Knowledge

Principle: 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 video games 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 in terms of 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 the answer here is smart tools, that is, 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 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.

Problem Solving

Well-ordered Problems

Principle: Given human creativity, if learners face problems early on that are too free-form 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 Frame2: crimson butterfly*, although radically different games, each 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. Problem 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.

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 multiple 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 they 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 video games. 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.

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.

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 they 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 and the game has already made much of the verbal information in the manual concrete through the player's experiences in the game.

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 the 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 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 and 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 are all familiar with the well-known phenomenon that students with As because they can pass multiple-choice tests can't apply their knowledge in practice.

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 ecosystem 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*'s 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!).

Sandboxes

Principle: Sandboxes in the real world are safe havens for children that 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*'s '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', that is, 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.

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 that one wants and needs to carry out.

Sounding out letters, together with thinking of word families and looking for sub-patterns in words, work best when they are 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 et al, 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, each of which uses language far more complicated than our everyday vernacular forms of language. Learners need to know how skills translate into strategies for playing the game.

Understanding

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 can not 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 fit 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 amidst a myriad of complex systems, systems which interact with each other (Kelly, 1994). In such a world, unintended 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.

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 weddings 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 video games (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 video games work, since video games 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 not either 'conservative' or 'liberal', 'traditional' or 'progressive'. The progressives are right in that situated embodied experience is crucial. The traditionalist 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 (Kelley, 2003). For games, these designers are brilliant game designers like Warren Spector and Will Wright. For schools, these designers are teachers.

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