Citation: Gee, James Paul. "Learning and Games." *The Ecology of Games: Connecting Youth, Games, and Learning.* Edited by Katie Salen. The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning. Cambridge, MA: The MIT Press, 2008. 21–40. doi: 10.1162/dmal.9780262693646.021

Copyright: © 2008 Massachusetts Institute of Technology. Published under Creative Commons Attribution-Noncommercial-No Derivative Works Unported 3.0 license.

Learning and Games

James Paul Gee

Arizona State University, Literary Studies

Experience and Learning

In this chapter, I want to argue that good video games recruit good learning and that a game's design is inherently connected to designing good learning for players.[1] Good game design has a lot to teach us about good learning, and contemporary learning theory has something to teach us about how to design even better and deeper games. Let's start with contemporary learning theory.[2] When today's learning scientists talk about the mind, it sometimes seems as if they are talking about video games. Earlier learning theory argued that the mind works like a calculating device, something like a digital computer. On this view, humans think and learn by manipulating abstract symbols via logiclike rules. Newer work, however, argues that people primarily think and learn through *experiences* they have had, not through abstract calculations and generalizations.[3] People store these experiences in memory—and human long-term memory is now viewed as nearly limitless—and use them to run simulations in their minds to prepare for problem solving in new situations. These simulations help them to form hypotheses about how to proceed in the new situation based on past experiences.

However, things are not quite that simple. There are conditions experiences need to meet in order to be truly useful for learning.[4] Since I will later argue that video games offer players experiences and recruit learning as a form of pleasure and mastery, I will argue as well that these conditions are properties of a well-designed game.

First, experiences are most useful for future problem solving if the experience is structured by specific goals. Humans store their experiences best in terms of goals, and how these goals did or did not work out.

Second, for experiences to be useful for future problem solving, they have to be interpreted. Interpreting experience means thinking—in action and after action—about how our goals relate to our reasoning in the situation. It means, as well, extracting lessons learned and anticipating when and where those lessons might be useful.

Third, people learn best from their experiences when they get immediate feedback during those experiences so that they can recognize and assess their errors and see where their expectations have failed. It is important too that they are encouraged to explain their errors and why their expectations failed, along with what they could have done differently.

Fourth, learners need ample opportunities to apply their previous experiences—as interpreted—to similar new situations, so they can "debug" and improve their interpretations of these experiences, gradually generalizing them beyond specific contexts.

Fifth, learners need to learn from the interpreted experiences and explanations of other people, including both peers and more expert people. Social interaction, discussion, and sharing with peers, as well as mentoring from others who are more advanced, are important. Debriefing after an experience—that is, talking about why and how things worked in the accomplishment of goals—is important. Mentoring is best done through dialogue, modeling, worked examples, and certain forms of overt instruction, often "just in time" (when the learner can use it) or "on demand" (when the learner is ready).

One way to look at what is going on here is this: When the above conditions are met, people's experiences are organized in memory in such a way that they can draw on those experiences as from a data bank, building simulations in their minds that allow them to prepare for action.[5] They can test out things in their minds before they act, and they can adjust their predictions after they have acted and gotten feedback. They can play various roles in their own simulations, seeing how various goals might be accomplished, just like a gamer playing a video game. The simulations we humans run—and there are various neural accounts of how this works[6]—are composites of our interpreted experiences built to prepare us to predict, act, and assess. Interpreted experiences are the engine from which we build simulations.

A Piece of Research: Action, Simulation, and Reading

One interesting line of research that exemplifies these points is Glenberg et al.[7] This study describes an experiment in which young children read a passage and manipulate plastic figures so that they can portray the actions and relationships in the passage. By manipulating the figures, the children get a structured, embodied experience with a clear goal (portray the action in the text). After some practice doing this, the children were asked to simply imagine manipulating the figures. This is a request to engage in simulation in their heads. As a posttest, the children read a final passage without any prompting.

Children who completed the sequence of embodied experience then simulation were better at remembering and drawing inferences about the new passage, as compared to children who received no training. They were better as well, compared to children who were instructed to only imagine the passage. And, most interestingly, they were better compared to children who manipulated the figures without the intermediate instructions to imagine manipulating. Encouraging simulation through the initial use of physical enactment helped the children learn a new reading comprehension strategy, namely a strategy whereby they called on their experiences in the world to build simulations for understanding a text in specific ways.

Social Identity and Learning

Modern learning theory tends to stress the social and cultural more than I have done so far.[8] The reason for this is that the elements of good learning experiences—namely goals, interpretations, practice, explanations, debriefing, and feedback—have to come from someplace. In fact, they usually flow from participation in, or apprenticeship to, a social group, or what are sometimes called "communities of practice"[9] or affiliation groups.[10] For instance, I am a bird-watcher and I have lots of experience looking for birds. But my experiences in this domain have been greatly shaped by other people and institutions devoted to birds and bird watching.

What we might call a "social identity" is crucial for learning. For example, consider learning to be a SWAT team member. The sorts of goals one should have in a given situation; the ways in which one should interpret and assess one's experiences in those situations; the sorts of feedback one should receive and react to; the ways in which one uses specific tools and technologies—all of these flow from the values, established practices, knowledge, and skills of experienced SWAT team members. They all flow from the identity of being or seeking to become such a person.

What is true of being a SWAT team member is equally true of being a bird-watcher, teacher, carpenter, elementary school student, scientist, community activist, soccer player, gang member, or anything else. Social groups exist to induct newcomers into distinctive experiences, and ways of interpreting and using those experiences, for achieving goals and solving problems. Today, of course, social groups can engage in interactions at a distance via the Internet and other technological devices, so the role of face-to-face interaction is, in many cases, changing, and new forms of social organization around identity are emerging.[11]

Good learning requires participation—however vicarious—in some social group that helps learners understand and make sense of their experience in certain ways. It helps them understand the nature and purpose of the goals, interpretations, practices, explanations, debriefing, and feedback that are integral to learning.

Having discussed good learning, I now turn to good game design, arguing that game design is also design for good learning, since good games are, at their heart, learning and problem-solving experiences.

Game Design

What's a video game? In many cases—for example, in the case of games like *SWAT4*, *Deus Ex*, *Half Life*, or *Chibi Robo*—a video game is a set of experiences a player participates in from a particular perspective, namely the perspective of the character or characters the player controls. Of course, not all games offer the player an avatar; although this fact is important, I will deal with it later, where we will see that having an avatar is just one way of achieving "microcontrol," one of the defining features of video games. For the moment, I will stick with games played from a first- or third-person perspective.

Video games like those I have just mentioned are designed to set up certain goals for players, but often leave players free to achieve these goals in their own ways. The game may also allow players to construct their own goals, but only within the rule-space designed into the game (e.g., you can interact with enemies in different ways in *Thief*, but robust hand-to-hand combat is not one of them). Level design ensures that players get lots of practice applying what they have learned earlier both in similar situations (within a level) and in somewhat less similar situations (across levels). Feedback is given moment by moment, and often summarily at the end of a level or in boss battles, which require players to integrate many of the separate skills they have picked up in prior battles with lesser enemies. Within such a structure, a number of our learning conditions are met as a matter of the basic design of the game.

Such games also encourage players to interpret their experiences in certain ways and to seek explanations for their errors and expectation failures. Such encouragement works through in-game features like the increasing degrees of difficulty that a player faces as the levels of a game advance, or when facing a boss that requires rethinking what one has already learned. However, it is precisely here that talking about "games"—and not "gaming" as a social practice—falls short. A good deal of reflection and interpretation stems from the social settings and practices within which games are situated.

Reflection and interpretation are encouraged, not just through in-game design features, but also through socially shared practices like FAQs and strategy guides, cheats, forums, and other players (in and out of multiplayer settings). Gamers often organize themselves into communities of practice that create social identities with distinctive ways of talking, interacting, interpreting experiences, and applying values, knowledge, and skill to achieve goals and solve problems. This is a crucial point for those who wish to make so-called serious games: to gain these sorts of desired learning effects will often require as much care about the social system (the learning system) in which the game is placed as the in-game design itself.

Because this last point is crucial, let me distinguish between what I will call the *game*, with a little *g*, and the *Game*, with a big *G*.[12] The "game" is the software in the box and all the elements of in-game design. The "Game" is the social setting into which the game is placed, all the interactions that go on around the game. I will write "game/Game" when I mean both together.

Both games and Games are crucial for good learning and, I would argue, good game design. But let me first talk directly about game design (in-game design), not Game design (the design of the interactions around the game). Video games offer people experiences in a virtual world (which, we will see below, is linked tightly to the real world), and they use learning, problem solving, and mastery for engagement and pleasure. It should be noted that humans and other primates find learning and mastery deeply, even biologically, pleasurable under the right conditions, though often not the ones they face in school.[13] Thus, I want to argue that game design is not accidentally related to learning, but rather that learning is integral to it. Game design is applied learning theory, and good game designers have discovered important principles of learning without needing to be or become academic learning theorists.

The Situated Learning Matrix

One way in which game design and modern learning theory come together is in what I will call the "Situated Learning Matrix." First, consider that any learning experience has some *content*, that is, some facts, principles, information, and skills that need to be mastered. So the question immediately arises as to how this content ought to be taught? Should it be the main focus of the learning and taught quite directly? Or should the content be subordinated to something else and taught via that "something else"? Schools usually opt for the former approach, games for the latter. Modern learning theory suggests the game approach is the better one.[14]

One version of the game approach is what I call the Situated Learning Matrix. To see what I mean by this term, let's take a concrete case, the game *SWAT4*. There is a lot of content to be mastered in learning to be a SWAT team member, some of which is embedded in *SWAT4*. This content involves things like how a team should form up to enter a room safely, where to position oneself in an unsafe environment, how to subdue people with guns without killing them, and facts about the range and firing power of specific weapons, ammunition, grenades, and much else.

But the game does not start with or focus on this content, save for a tutorial that teaches just enough of it so that players can learn the rest by playing within the Situated Learning Matrix, which is the game itself. Rather, the game focuses first and foremost on an *identity*, that is, being a SWAT team member. What do I mean by calling this an "identity"? I mean a "way of being in the world" that is integrally connected to two things: first, characteristic *goals*, namely—in this case—goals of the sort a SWAT team characteristically has; and second, characteristic *norms* (composed of rules or principles or guidelines) by which to act and evaluate one's actions—in this case, these norms are those adopted by SWAT teams.

In some games—and this is true of *SWAT4*—the norms amount, in part, also to a value system, even a moral system (e.g., Don't shoot people, even if they have guns, until you have warned them you are a policeman). Without such norms, one does not know how to act and how to evaluate the results of one's actions as good or bad, acceptable or not. Of course, norms and goals are closely related in that the norms guide how we act on our goals and assess those attempts. In a game like *SWAT4*, I am who I am (a SWAT team member) because I have certain sorts of goals and follow certain norms and values that cause me to see the world, respond to the world, and act on the world in certain ways.

To accomplish goals within norms and values, the player/learner must master a certain set of skills, facts, principles, and procedures—must gain certain sorts of *content* knowledge. However, in a game like *SWAT4*, players are not left all alone to accomplish this content mastery. Rather, they are given various tools and technologies that fit particularly well with their goals and norms, and that help them master the content by using these tools and technologies in active problem-solving contexts. These tools and technologies mediate between—help explicate the connection between—the players' identity (goals and norms), on the one hand, and the content the player must master, on the other. The SWAT team's doorstop device (yes, it's just a little rubber doorstop) is a good example. This little tool integrally connects the team's goal of entering rooms safely and norm of doing so as nonviolently as possible, with the content knowledge that going in one door with other open doors behind you can lead to being blindsided and ambushed from behind—an ambush in which both you and innocent bystanders may be killed. Using the doorstop in specific situations enacts these connections. In turn, players have to reflect on these connections as they think of better and better ways of using the doorstop.

Let me be clear, though, what I mean by tools and technologies. I am using these terms expansively. First, in *SWAT4*, tools and technologies include types of guns, ammunition, grenades, goggles, armor, lightsticks, communication devices, doorstops, and so forth. Second, tools and technologies also include one's fellow SWAT team members—artificially intelligent nonplayer characters (NPCs)—to whom the player can issue orders and who have lots of built-in knowledge and skills to carry out those orders. This allows players initially to be more competent than they are all by themselves. (Players can perform before they are fully competent and attain competence through performance.) Further, it means that the NPCs model correct skills and knowledge for the player.

Third, tools and technologies include forms of built-in collaboration with the NPCs and, in multiplayer versions of the game, forms of collaboration, participation, and interaction with real people, at different levels of skill. These forms of collaboration go further when the player enters Web sites and chat rooms, or uses guides, as part of a community of practice built around the game. Thus, I am counting NPCs as smart tools—and real people as tools too—when players can coordinate themselves with other players' knowledge and skills.

So, tools and technologies (in all these senses) mediate the relationship between identity and content, rendering that content meaningful. I know why, for instance, I need to know about open doors behind me. This knowledge is not just a matter of isolated and irrelevant facts. It's a matter now of being and becoming a good SWAT team member. And as a player, I have the tool to connect the two—the doorstop.

But this mediation means, of course, that players always learn in specific contexts. That is, they learn through specific embodied experiences in the virtual world (the player has a bodily presence in the game through the character or characters he or she controls). And, indeed, one hears a lot these days about learning in context. However, contexts in a game like *SWAT4* are special. While they are richly detailed and specific, they are—in reality—not just any old contexts, but richly *designed problem spaces* containing problems that fall into a set of similar, but varied, challenges across the levels of the game.

Context here then means a *goal-driven problem space*. As players move through different contexts—each containing similar but varied problems—this movement helps them to interpret and, eventually, generalize their experiences. They learn to generalize—but always with appropriate customization for specific different contexts—their skills, procedures, principles, choices, and uses of information. This essentially solves the dilemma that learning in context can leave learners with knowledge that is too context-specific, but that learning out of context leaves learners with knowledge they cannot apply. Players come to see specific in-game solutions as part of more general types of approaches.

Below I give a diagrammatic representation of the Situated Learning Matrix. The Matrix has "Experience" on top, listing the conditions that render experience efficacious for learning. Good games—together with their associated Games—ensure that these conditions are met. However, in an educational context, things need to go further, since we want to be certain that we create Games (social systems) that ensure that experiences will be well interrogated in the game (the in-game play). This is where "teachers" and mentors (not necessarily official teachers in the school sense) become crucial. Such teachers and mentors help create an effective Game and game/Game combination.[15]

Situated Learning Matrix Experience: Goals, Interpretation, Feedback, Explanation, Practice, Social Interaction (Mentoring, Sharing, Debriefing)

Identity ←→ Goals and Norms (sometimes including ethical or moral values) ←→ Tools and Technologies ←→ Context as Problem-Solving Space That Is One of a Set of Similar but Varied Problems ←→ Content

Why do I call this *a situated* learning matrix? Because content is rooted in experiences a person is having as part and parcel of taking on a specific identity (in terms of goals and norms stemming from a social group, like SWAT team members). Learning is situated in experience, but goal-driven, identity-focused experience.

Learning in video games—learning in terms of the Situated Learning Matrix—is not "anything goes," "just turn the learners loose to do their own thing."[16] There is a good deal of guidance in games: guidance from the game design itself, from the NPCs and the environment, from information given "just in time" and "on demand," from other players in and out of the game, and from the resources of communities of practice built up around the game.

Clearing Up Possible Misconceptions

By using *SWAT4* as my example, I may well have created a number of misconceptions. So, let me try to clear them up. All games have content, that is, facts, skills, and procedures that players must master. This content is crystal clear in *SWAT4* because the game is organized around a connection to a real-world domain. But consider a game like *Chibi Robo*. In this game, players take on the identity of a four-inch house-cleaning robot enjoined to make people happy. This identity defines and in turn flows from the goals of the game (e.g., solve problems in the house by cleaning and getting to hard-to-reach places where you can do or get something that will make people happy), and norms (e.g., you should do good, not bad, to the people and animated toys in the house; it is important to talk repeatedly to everyone; problems must be solved in a time-efficient way, since your battery—or "health"—lasts only so long). There are lots of skills and facts a player needs to master, all of them germane to being a four-inch robot, skills such as how to get to high places, and facts like falling from such high places will take a good deal off your allowable time to solve problems. And there are tools that connect your identity and these skills and facts, for example, a little rotor that you can use to soften your fall.

The same can be said of *Half-Life*, *Deus Ex*, *Civilization*, or any other such game. The skills and facts in these games are content, but usually not recognized as such unless they fall into a real-world domain like physics or SWAT teams.

Finally, using *SWAT4* as an example may lead to the conception that the Situated Learning Matrix is only germane to violence or, at least, to action-filled adventures. It can seem that content—knowledge—in a domain like science or art is much less connected to identities, goals, and values. However, ethnographic accounts of scientists learning and doing science, for instance, show this is not true.[17] And, for students in school, there is clear research that shows that content divorced from the Situated Learning Matrix is inert and unable to be applied in practice, however much the student may pass multiple choice tests.[18]

Models and Modeling

The Situated Learning Matrix leaves out one element that is crucial to both learning and games. What it leaves out is a particularly important type of knowledge-building and knowledge-transforming tool, namely "models."[19] A discussion of models also allows us to move beyond games played in the first- or third-person perspective with avatars.

I will be using the word *model* here in an extended sense from its everyday use, so let's start in familiar territory. Consider a child's model airplane. Real planes are big, complex, and dangerous. A child can safely play with the model plane, trying out things, imagining things, and learning about planes. Of course, models are always simpler than the things they model (since we use them to understand or deal with realities too complex or dangerous to deal with directly). Thus, different types of models capture different properties of the thing being modeled and allow different sorts of things to be tried out and learned. Even a child's toy plane may be more or less detailed.

Of course, model planes can be used by engineers and scientists as well. They can use the model plane in a wind tunnel, for example, to test things that are too dangerous or too expensive to do with real planes. They can make predictions based on the model and see if these procedures hold true for the real thing in real life. They can use the model to make plans about how to build a better real plane. The model plane is a tool for thought, learning, and action.

Models are just depictions of a real thing (like planes, cars, or buildings) or a system (like atomic structure, weather patterns, traffic flow, ecosystems, social systems, and so forth) that are simpler than the real thing, stressing some properties of the thing and not others. They are used for imaginative thought, learning, and action, when the real thing is too large, too complex, too expensive, or too dangerous to deal with directly.

A model plane usually resembles closely the thing it is modeling (a real plane). But models can be ranged on a continuum of how closely they resemble the things they are modeling. They can be, in this sense, more or less "abstract." One model plane may have lots of details. Another may be a simple balsa-wood wings-and-frame construction, no frills. Even more abstractly, the blueprint of the plane, on a piece of paper, is a model, useful for some purposes (e.g., planning and building) and not for others. The blueprint is a model that resembles the plane very little, but still corresponds to the real plane in a rule-governed way. It's an abstract picture.

We can go even further and consider a model of the plane represented as a chart. In the chart, each of the plane's different parts is listed in rows along the left column, with the remaining columns filled with numbers, representing degrees of stress. The intersection of a part and number would stand for the amount of stress each part is under during flight. For each part we can trace our finger along the row to find the corresponding number. This representation of the plane doesn't "look" like a plane, but is a model all the same. We can still map from pieces of the chart to pieces of the plane. The chart still represents some properties of the plane, though it offers a very abstract picture of the plane, indeed, one useful for a narrow purpose.

However, this type of model—at the very abstract end of the continuum of resemblance—shows us another important feature of models and modeling. The chart captures an invisible, relatively "deep" (that is, not so readily apparent) property of the plane, namely how parts interact with stress. Of course, we could imagine a much more user-friendly picture (model) of this property, perhaps a model plane all the parts of which are color coded (say, in degrees of red) for how much stress they must bear in flight. This is more user-friendly and it makes clear the mixture of what is readily apparent (the plane and its parts) and what is a deep (less apparent) property, namely stress on parts.

These are very basic matters. Models and modeling are basic to human play. They are basic to a great many other human enterprises as well, for example, science (a diagram of a cell), architecture (model buildings), engineering (model bridges), art (the clay figure the sculptor makes before making the real statue), video and film (storyboards), writing (outlines), cooking (recipes), travel (maps), and many more.

Models are basic to video games as well, and represent another point at which game design and the learning sciences intersect. Thinking about models brings us to the topic of how to think about different types of games. Earlier I mentioned that not all video games offer the player an avatar, but set that issue aside. There are scholars who believe that "video game" is a unitary concept, and they seek a uniform theory applicable to all video games.[20] I do not believe this. There are different types of video games, and they need to be understood in somewhat different, though linked, ways. Thinking about models in fact keys us in to two different large categories of video games (and, of course, there are still other categories). So let's look at these two different types of games.

The video games discussed thus far are simulations in which the player is inside the simulation, thanks to the presence of an avatar. And, of course, all simulations are models of what they are simulating. *World of Warcraft* simulates (models) a world of mountains, lakes, roads, buildings, creatures, and so forth that, although fantasy, is meant to resemble aspects of the real world. However, players (for the most part) pay very little attention to this modeling aspect of *World of Warcraft*, because it usually plays no important role in the game play. Rather, players concentrate on the embodied experiences of play, problem solving, and socialization that *World of Warcraft* offers. By and large, the fact that it models environments does not matter all that much to the game play, beyond providing a spatialized context in which to act.

However, sometimes in *World of Warcraft* this is not true; sometimes the modeling aspect comes to the fore. For example, when I get stuck trying to walk up the inclines and crevices of a mountain in *World of Warcraft*, I begin to think about how the game's mountain is representing (modeling) gravity and resistance in the real world. Sometimes this reflection is tinged with anger, because I realize the game does not model mountains well enough to ensure that I can climb them successfully. In other games, where one's character seems more than tall enough to jump over an obstacle, but can't, the player is well aware the model is a model and isn't working well. In games like *World of Warcraft*, the modeling aspect comes to the fore only when there are problems with being able to act in the world. Of course, models and modeling are present throughout the game, but are rarely the focus.

There are other games in which the modeling aspect of the simulation is crucial. Players in these games are having experiences, just as they are in *World of Warcraft* or *Half-Life*, but the modeling aspect is crucial at nearly all points, not just intermittently. In a game like *Civilization*, for instance, the depictions of landscapes, cities, and armies are not very realistic, not nearly as realistic as in *World of Warcraft*. For example, in *Civilization*, a small set of soldiers stands for a whole army and the landscape looks like a colorful map. However, given the nature of game play in *Civilization*, these components are clearly meant to be models of real things stressing only some of their properties (to see how game play works in *Civilization*, see videos at http://media.pc.ign.com/media/620/620513/vids_1.html). They are clearly meant to be used for quite specific purposes in the game—for example, modeling large-scale military interactions across time and space, and modeling the roles of geographical features in the historical development of different civilizations.

Models and modeling are integral to game play in *Civilization*—it's the point of the game, in one sense. Since a game like *Civilization* stresses modeling, it is not surprising that it is played with a top-down god's eye view, rather than the first-person, world-internal view of *Half-Life*. However, not all games that stress modeling as integral to game play have such a top-down view (though many do, e.g., *Zoo Tycoon*, *Rise of Nations*, and *The Sims*). A game like *SWAT4* is played with a first-person, world-internal view, and modeling is crucial to the game. The player is very aware that it matters how and why the game designers modeled the SWAT team members, their equipment, their social interactions, and the sorts of environments with which and in which they interact. This is after all a "toy" SWAT team in very much the way a model airplane is a toy. But it is more than a toy team—just as a model airplane can be more than a toy—since it models aspects of SWAT teams that are serious and interestingly complex. The game models not just objects, but behaviors as well, in support of the articulation of values. *Full Spectrum Warrior* is an example of another modeling-intensive game, like *SWAT4*, that is played from a close-in top-down perspective, much closer to the action than, say, in *Rise of Nations* or *Civilization*.

So we can distinguish between video games that stress player experiences but not modeling, and other games that, while offering experiences, stress modeling as well. Games in the first category are usually played in a first- or third-person up-close perspective, while those in the latter category can be played from such perspectives (as in *SWAT4*), but can also be played in a middle-distance top-down view (as in *Full Spectrum Warrior*) or a god's eye farther-distance top-down view (as in *Civilization* or *Rise of Nations*).

However, even in games where, at the "big picture" level, modeling is not integral to game play in terms of their overall virtual worlds—games like *World of Warcraft* or *Half-Life*—very often models appear ubiquitously *inside* the game to aid the player's problem solving. For example, most games have maps that model the terrain (and maps are pretty abstract models) and that allow players to navigate and plan. The bottom part of *World of Warcraft*'s interface screen includes a set of stats which provides an abstract model of the player's abilities and skills. Lots of games allow players to turn on and off a myriad of interface screens, which display charts, lists, and graphs depicting various aspects of game play, equipment, inventories, abilities, skills, histories, and accomplishments. In a first-person shooter, the interface displaying an inventory of all the guns a player has, their firing types, and their ammunition is a model of the game's weapon system, an abstract picture of it that is made for planning, strategizing, predicting, and problem-solving purposes.

Models inside games go further, much further. Players and player communities often build modifications of games that are models used to solve certain sorts of problems. For example, *World of Warcraft* players can download a model that displays a chart (during actual fighting) listing each player's class (e.g., Druid, Priest, Warrior, Mage, Paladin, etc.) and the amount of damage he or she is doing in a group raid inside a dungeon. This chart can be used to check—publicly—that each player is holding up his or her end of the group task (so Warriors better be doing lots of damage and healing Priests better not be—they had better be concentrating on healing rather than attacking). This is one of several models (almost all of them made by players) that help players solve a very real world problem, namely the problem of individuals attempting to take a free ride in a group or attempting to hide their lack of skill.

Models and modeling reach a new pitch in games like *Tony Hawk's Pro Skater 4* or *Tony Hawk's Underground*. First, in these cases, the whole game is a model of the practices and culture of skateboarders. Within that larger model, there are a myriad of models of boards, dress styles, tricks, and environments. However, players can readily design their own skaters, clothes, boards, tricks, points for tricks, and skate parks. That is, they can build their own models. When they build a model skate park, they interact with a set of more abstract models of environments (screens made up of grids and rotatable objects) that help them build the more specific and realistic-looking model skate park they want (like a toy plane). Indeed, as skating styles in the real world change, the models in the game and those made by players change in turn, each iteration trying to capture things that are seen by players as important or essential, all the while balancing a variety or criteria about fidelity to different things and systems. This is modeling with a vengeance. Here modeling is integral to game play at all levels.

So why, in the end, are models and modeling important to learning? Because while people learn from their interpreted experiences—as we have argued above—models and modeling allow specific aspects of experience to be interrogated and used for problem solving in ways that lead from concreteness to abstraction.[21] This is not the only way abstraction grows—we have already seen through several game examples that it grows as well from comparing and contrasting multiple experiences. But modeling is an important way to interrogate and generalize from experience. This is readily apparent in a game like *Tony Hawk's Underground*. Surely, players of this game, if they have made skate parks and shared them, have both an embodied experiential understanding of skating (as least as an in-game simulated activity) and a more abstract take on properties and features of skating and skate parks. Indeed, these two forms of understanding constantly interact with and feed off of each other.

On the other hand, why are models and modeling important to a game's design? Because in-game models are tools to facilitate, enrich, and deepen the problem solving the game designer is building. And because games like *Civilization*, *SWAT4*, *The Sims*, and *Tony Hawk's Underground*—games that stress modeling even at the larger level of the game-play experience—allow for a quite deep form of play. This is play-connected in complicated ways with the real world, though this is not to say, of course, that such games are necessarily more "fun" than other games. One can take note here as well of the beautiful video game *Okami* that models, in a myriad of ways, Japanese spiritual, cultural, and historical perspectives on the relationship between drawing (e.g., in writing in characters) and the world.

Games and Simulations: Microcontrol and Empathy for a Complex System

Simulations are regularly used at the cutting edge of science, especially to study complex systems—things like weather systems, atoms, cells, or the rise and fall of civilizations. This raises the question of what differences exist between simulations and video games. There are two key differences: one is that most (but not all) video games have a win state, and the other is that gamers don't just run a simulation, they microcontrol elements inside the simulation (e.g., an avatar in *Doom*, squads in *Full Spectrum Warrior*, armies and cities in *Rise of Nations*, and shapes and movement in *Tetris*).

Microcontrol has well-known cognitive effects.[22] Humans feel their bodies extend only so far as the space over which they have small-scale control, which for most of us is a space quite close to the body. Blind people have the feeling that their bodies extend out to the end of their canes, since the cane extends their space of small-scale control. When people use webcams to water plants in a far away place via the Internet, they feel that their bodies have extended into space—a novel feeling for humans, since it is one unavailable for most of human history. Video games also offer humans a new experience in history, namely microcontrol over objects in a virtual space. This gives us the feeling that our bodies and minds have extended into this virtual space and that the spaces of the real and the virtual are joined.

While scientists often do not have such microcontrol over elements in their simulations and graphs, it turns out that many scientists often talk and think *as if* they were inside not only the simulations they build, but even the graphs they draw and the models they build. They do this to gain a deeper feel for how variables are interacting in the system. For example, consider the following remark from a physicist talking to other physicists while looking and pointing to a graph (an abstract model) on a blackboard:[23] (Points to the right side of the diagram) "When (moves finger to left) I come down (moves finger to right) I'm in (moves finger to left) the domain state."[24]

Notice the "you's" and "I's." The scientist talks and acts as if he and his colleagues are moving their bodies not only inside the graph, but inside the complex system it represents as well. This is much like gamers who say "I died" in *Doom* or "my army was crushed" in *Rise of Nations*.

In science education too, research shows that students often find it helpful to identify with individual elements in a model, and then view phenomena from the perspective of this element. For example, Wilensky and Reisman[25] mention that a student building a model to understand how fireflies synchronized their light patterns found it useful to try to "think like" an individual firefly in the model.

Video games, under the right circumstances, may well be able to encourage (and actually help players to enact) an "attitude" or "stance" similar to the one taken by scientists studying complex systems. This stance involves a sort of "embodied empathy for a complex system" wherein a person seeks to enter imaginatively into a system, all the while seeing and thinking of it as a system, rather than as a group of local or random events. This does, indeed, seem similar to the stance players take when they play as Garrett in a game like *Thief* and seek to figure out the rule system that underlies the virtual world through which Garrett (and they) move. We can go on to ask whether video games could create such empathy for the sorts of complex systems relevant to academic and other domains outside of entertainment (e.g., urban planning, space exploration, or global cooperation among competing societies).

Distributed Intelligence and Cross-Functional Teams

The modern learning sciences have stressed the ways in which human thinking and learning go beyond the processes going on inside people's heads. One way in which they have done this is to focus on "distributed cognition" or "distributed knowledge."[26] These terms are meant to describe the ways in which people can act smarter when they combine or integrate their own individual knowledge with knowledge that is built into tools, technologies, environments, or other people. We have already seen in the discussion of *SWAT4* how some video games can distribute intelligence between the player and artificially intelligent virtual characters.

By distributing knowledge and skills between the virtual characters and the real-world player, a game like *SWAT4* guides and supports the player through the knowledge built into the virtual policemen. This off-loads some of the cognitive burden from the learner, placing it in smart tools (the virtual policemen) 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."[27] The player thereby eventually comes to gain competence through trial, error, and feedback. Of course, when real people are involved in multiplayer games, this becomes a condition for a well-functioning team that can apprentice new members and guide new learning for each. This suggests an important question: whether and how we could model other "professions"—scientists, doctors, government officials, urban planners, political activists—and distribute their knowledge and skills as a deep form of value-laden learning. Learners could in turn compare and contrast different value systems as they play different games. Shaffer's[28] "epistemic games"—games which model sorts of professional practices—already give us a good indication that even young learners, through video games embedded inside a well-organized curriculum, can be inducted into professional practices as a form of value-laden deep learning that transfers to school-based skills and conceptual understandings.

Another way in which the modern learning sciences have stressed that thinking and learning go beyond individuals' isolated thought processes is in regard to the social and collaborative nature of learning and knowledge building. Indeed, researchers of the modern workplace have become intensely interested in how people can work together as a group to be and act smarter than any individual in the group.[29] This is really a question of how people can distribute knowledge and learning between themselves, requiring them to move beyond tools and technologies to include as well the organization of the group itself as a tool to leverage deep learning and high performance.

One form of group organization has played a major role in modern workplaces, so-called cross-functional teams.[30] They have also played a major role in activist groups like Greens, advocating for particular causes. On such teams, each member must have deep expertise in a specific area, that is, specialized knowledge (their "function"). At the same time, each team member must have a good knowledge of each other team member's special skills, both so that he or she can integrate with that person smoothly in practice and so that he or she can carry out some of the team member's functions even if one or another team member is missing (crossing functions). That is, each team member must have extensive knowledge in addition to intensive knowledge.

One of the fascinating things about modern video gaming is that game designers have discovered that people find great pleasure, excitement, and fun in organizing themselves into cross-functional teams, however boring the concept sounds at an institutional level. Though such teams have given rise to high stress and a lot of tensions in workplaces, millions play on such teams for pleasure in games like *World of Warcraft*.

In *World of Warcraft*, a hunting group might be composed of a Hunter, Warrior, Druid, Mage, and Priest. Each of these types of characters has quite different skills and plays the game in a different way. Each group member must learn to be good at his or her special skills and also learn to integrate these skills as a team member into the performance of 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.

Anyone who has played *World of Warcraft* knows that a good many groups have solved a major social problem that crops up in business and education: the free-rider problem—that is, the problem that, in groups, individuals can try to take a free ride by letting all the others do the work. Free riders in a *World of Warcraft* dungeon quest get noticed, castigated, and removed quickly. There are readily available information tools (as we saw above) that can display quite clearly what contribution each member of the group is making, and each group member is well aware of whether the others are effectively using their specialized skills to good purpose for the group as a whole. They know this, not just because of the information available to them through such tools, but also because they have "cross-functional" understandings learned through play. Many a Druid, for instance, has also played as a Priest or Mage and knows what Priests or Mages ought to be doing.

The workings of *World of Warcraft* groups can get to be pretty stressful. Groups can often have very high performance expectations, which they enforce in a range of ways (e.g., by not grouping with someone who has misbehaved in the past). The game itself sets problems for small groups and larger one (raids) that can sometimes be extremely demanding in terms of the need for tight organization, the expression of specific and well-executed individual skills, and the quick and smooth integration of those skills.[31] While it doesn't sound like much fun, millions pay to do it.

At a more general level, widely popular games like *World of Warcraft* and *GuildWars* have made a game out of social planning and organization itself. For example, in *World of Warcraft*, small groups organize into larger groups to go on challenging raids in dungeons. Each large group is composed of five-person cross-functional teams, and each of these teams has to function well as a team while also integrating quickly and smoothly with other teams in the group to produce a well-choreographed raid. Raids require intricate preplanning, lots of practice, and skilled orchestration. They require levels of leadership from top-level planners to team leaders, and they demand both excellent vertical (top-down) and horizontal (across all participants) communication.

In part because of these demands, people very often organize into large guilds of dozens or several hundred people in games like *GuildWars* or *World of Warcraft*. (How guilds and groups work has changed somewhat with *World of Warcraft's* expansion, *The Burning Crusade*.) Guilds orchestrate organization, planning, and the enforcement of norms and values at a high level—for example, choosing who goes on what raids and how specialized skills (like being a Priest) are to be learned and played-out in practice. From guilds to raids to hunting parties (groups), *World of Warcraft* is all about social organization for high performance of just the sort that workplaces pay consultants to refine, and workers find stressful. Such games hold out the potential for the discovery of new forms of social organization, new ways of solving social problems (e.g., the free-rider problem), and new ways of researching and testing collaborative learning, knowledge building, and performance.

We saw above that what is important for learning—and, indeed, for mastery in game play—is not just the game (software) but also the Game (the social system in which the game is embedded). The identities, goals, norms, tools, and technologies that form the core of the Situated Learning Matrix flow from social groups (e.g., SWAT teams). In massively multiplayer games like *World of Warcraft*, social groups organically grow their own identities, norms, tools, and technologies, which intersect with and transform those built into the game.[32] Big "G" Game and little "g" game become evermore tightly knit together, as the game/Game becomes a learning, knowledge building, design community.

Motivation and Ownership

An issue that comes up repeatedly when considering games and learning is the fact that video games appear to be deeply motivating to young people in ways in which much of school, say, is not. It is clearly a profoundly important subject for research to understand the source (or sources) of this motivation.

There are certainly features connected to video games that help explain both the motivation they recruit and the learning they enable. One key feature is the role of failure. The role of failure is very different in video games than it is in school. In good games, the price of failure is lowered—when players fail, they can, for example, start over at their last saved game. Furthermore, failure—for example, a failure to kill a boss—is often seen as a way to learn the underlying pattern and eventually to win. These features of failure in games allow players to take risks and try out hypotheses that might be too costly in places where the cost of failure is higher or where no learning stems from failure.

Every gamer and game scholar knows that a great many gamers, including young ones, enjoy competition with other players in games, either one-on-one or team-based. It is striking that many young gamers see competition as pleasurable and motivating in video games, but not in school.[33] Why this is so ought to be a leading question for research on games and learning.

One thing that seems evident is that competition in video games is seen by gamers as social and is often organized in ways that allow people to compete with people at their own levels or as part and parcel of a social relationship that is as much about gaming as about winning and losing. Furthermore, gamers highly value collaborative play, for example, two people playing *Halo* together to beat the game, or the grouping in massive multiplayer games like *World of Warcraft*. Indeed, collaboration and competition often seem to be closely related and integrated in gaming, though not in school.

Many have connected the motivation video games recruit with their status as interactive, and hence *active*, systems. But, from a learning perspective, what is important about video games is not interactivity per se, but the fact that in many games players come to feel a sense of agency or ownership. In a video game, players make things happen; they don't just consume what the "author" (game designer) has placed before them. In good games, players feel that their actions and decisions—and not just the designers' actions and decisions—cocreate the world they are in and shape the experiences they are having. Their choices matter. What they do matters. I would argue that all deep learning involves learners feeling a strong sense of ownership and agency, as well as the ability to produce and not just passively consume.

Emotion

Traditional work on learning viewed human thinking in almost entirely rational and intellectual terms, ignoring the role of emotion. However, recent research in neuroscience has clearly demonstrated that both thinking and learning depend on emotions.[34] Learning involves not just the cortex (or "higher" intellectual functions), but the whole brain, including the amygdalae, the limbic system, and the cortex. Emotion appears to be a key source of motivation for driving thinking, learning, and problem solving. Video games, as a form of entertainment, are good at attaching emotion to problem solving, just as films are good at attaching emotion to stories.

Emotion plays a variety of important roles in thinking and learning. First, when we are processing information, we store it more deeply and integrate with our prior knowledge better when that new information has an emotional charge for us, when we feel something is at stake or matters. Thus, emotion plays an important role in the organization of long-term memory. Second, emotions can often help us to both focus our attention on what is important or matters to us and retrieve information from long-term memory.

Third, emotions assist us in evaluating information and action. When we act in the world, we get feedback from the world, and something happens. But we have to know how to evaluate or assess the meaning, import, and usefulness of this result. While this most certainly involves rational judgments based on norms, it also involves weighted choices of what to do next in terms of how we feel, what we care about among those choices. If a person has no such emotional weighting, he or she can be paralyzed in choosing among equally good possibilities and left unable to act or decide.

Of course, while emotions can facilitate thinking and learning, they can also frustrate thinking and learning. High stress, too much frustration, powerful anger, or intense fear can overwhelm our thinking and shut down our learning. Some theorists have talked about people having an "affective filter"[35]—that is a filter that shuts out input from the world when a person is fearful, emotionally resistant, frustrated, or otherwise emotionally overburdened. When this happens, input does not become intake for learning in the human mind (e.g., when someone is trying to learn a foreign language, but is fearful of failing and looking silly).

Good game design gives an emotional charge to the thinking, problem solving, and learning it recruits. This is sometimes done partly in terms of players' attachment to the identities of their avatars—characters they come to care about. It is sometimes done through elements of storytelling, as well as the norms and values the game associates with identity and action (as in *SWAT4*). It is sometimes done as well through the player's caring about accomplishing goals, not dying or otherwise failing, and winning the game. At the same time, good games keep the player below a level of frustration that will trigger an affective filter to go up. Failure is not so consequential that the player is so fearful of failure that he or she can't act and explore. Help is available in a variety of forms (difficulty levels, hints, FAQs, cheats, other players, and forums).

Situated Meaning

Video games deal with language and literacy in ways that also tie to research on deep learning in the learning sciences. One concern of this research is that so many students in school cannot apply the knowledge they are learning in practice, even when they can pass verbal paper-and-pencil tests.[36] One reason for this is that students very often do not know what the words (and other symbols) in an area like physics mean at the level of application to real problem solving, rather than just as words they can define in terms of other words (as in a dictionary).

People acquire what I will call "situated meanings"[37] for words—that is, meanings that they can apply in actual contexts of use for action and problem solving—only when they have heard these words in interactional dialogue with people more expert than themselves[38] and when they have experienced the images and actions to which the words apply. Dialogue, image, experience, and action are crucial if people are to have more than just words for words ("definitions")—if they are to be able to relate words to actual experiences, actions, functions, and problem solving. As they can do for more and more contexts of use, they generalize the meanings of the word more and more, but the words never lose their moorings in dialogue, embodied experience, action, and problem solving.

Video games are good at putting language into the context of dialogue, experience, images, and actions. They are not textbooks full of words and definitions. They allow language to be situated. Furthermore, good video games give verbal information "just in time"—near the time it can actually be used—or "on demand," when the player feels a need for it and is ready for it.[39] They don't give players lots and lots of words out of context before they can be used and experienced or before they are needed or useful. This would seem to be an ideal situation for acquiring new words and new forms of language for new types of activity, whether this takes the form of being a member of a SWAT team or a scientist of a certain sort.

Given the importance of oral and written language development (e.g., vocabulary) to school success, it is crucial that this assumption be tested both in terms of the complex specialist language players pick up from commercial games (e.g., young children playing *Yu-Gi-Oh*, a card and video game that contains very complex language, indeed) and in terms of how games can be made and used for the development of specifically school-based (or other institutional) language demands, such as the language of biology or history.

Conclusion

We started with an argument that people learn from experiences stored in long-term memory. We then stated the conditions experiences need to meet in order to enhance deep learning. Since video games are virtual experiences centered on problem solving, they recruit learning and mastery as a form of pleasure. The conditions experiences need to meet to enhance deep learning therefore translate into design principles for good games. We saw that these conditions go beyond the individual to include the individual's participation in social groups that supply meaning and purpose to goals, interpretations, practice, explanations, debriefing, and feedback, conditions necessary for deep learning from experience. This led us to make a distinction between a game (software) and the Game (social system in which the game is embedded) and to see both as crucial for good learning design and good game design.

The Situated Learning Matrix—which I illustrated through the game *SWAT4*—was one way in which good games work out learning based on the conditions necessary for experiences to be good for learning. In the Situated Learning Matrix, learning moves from identity to goals and norms, to tools and technologies, and only then to content. The notion of "identity" at play in the Situated Learning Matrix shows one way in which learning and playing games tie, in part, either to vicarious or to real participation in social groups and their values: SWAT teams in *SWAT4*, real members of professions in Shaffer's[40] "epistemic games," organically formed social groups in *World of Warcraft*. Here again the issue of the Game raises its head.

Beyond learning from problem-based, goal-driven experiences, I argued that some games stress models and modeling, not just as part of game play—as lots of games do—but as the very nature of their game play as a whole—for example, games like *SWAT4* or *Civilization*. Such games often dispense with avatars, allowing the microcontrol of many units. Models and modeling are inherently tied to learning and exploration, since they simplify complex phenomena in order to make those phenomena easier to deal with for the accomplishment of goals, problem solving, and action. They also allow for learning from experience—which is in danger sometimes of being too concrete—to be rendered more abstract and generalized.

I also discussed several things games do well that enhance learning—namely, recruiting distributed intelligence, collaboration, and cross-functional teams for problem solving; offering players "empathy for a system"; marrying emotion to cognition; being challenging while still keeping frustration below the level of the affective filter; giving players a sense of production and ownership; and situating the meanings of words and symbols in terms of actions, images, experiences, and dialogue, not just "definitions" and texts read outside of contexts of use. There are several other things, in this respect, I could have discussed had space allowed: for example, the ways in which games order their problems in effective ways so that earlier problems and levels lead to good hypotheses about how to approach later problems and levels.[41]

In the end, my "take home" message is, I admit, relatively abstract: the language of learning is one important way in which to talk about video games, and video games are one important way in which to talk about learning. Learning theory and game design may, in the future, enhance each other.

Notes

1. James Paul Gee, *What Video Games Have to Teach Us About Learning and Literacy* (New York: Palgrave Macmillan, 2003); and idem., *Why Video Games Are Good for Your Soul: Pleasure and Learning* (Melbourne: Common Ground, 2005).

2. John Bransford, Allen L. Brown, and Rodney R. Cocking, *How People Learn: Brain, Mind, Experience, and School*, expanded ed. (Washington, DC: National Academy Press, 2000); and R. Keith Sawyer,

Analyzing Collaborative Discourse, in *The Cambridge Handbook of the Learning Sciences*, ed. R. Keith Sawyer (Cambridge, UK: Cambridge University Press, 2006), 187–204.

3. Lawrence W. Barsalou, Language Comprehension: Archival Memory or Preparation for Situated Action, *Discourse Processes* 28 (1999): 61–80; idem., Perceptual Symbol Systems, *Behavioral and Brain Sciences* 22 (1999): 577–660; Patricia S. Churchland and Terence J. Sejnowski, *The Computational Brain* (Cambridge, MA: Bradford/The MIT Press, 1992); Andy Clark, *Associative Engines: Connectionism, Concepts, and Representational Change* (Cambridge, UK: Cambridge University Press, 1993); idem., *Being There: Putting Brain, Body, and World Together Again* (Cambridge, MA: The MIT Press, 1997); James Paul Gee, *The Social Mind: Language, Ideology, and Social Practice* (New York: Bergin & Garvey, 1992); idem., *Situated Language and Learning: A Critique of Traditional Schooling* (London: Routledge, 2004); J. Hawkins, *On Intelligence* (New York: Henry Holt, 2005); and Roger C. Schank, *Dynamic Memory Revisited* (New York: Cambridge University Press, 1999).

4. Andrea A. diSessa, *Changing Minds: Computers, Learning, and Literacy* (Cambridge, MA: The MIT Press, 2000); Gee, *Situated Language and Learning*; Janet L. Kolodner, *Case Based Reasoning* (San Mateo, CA: Morgan Kaufmann, 1993); idem., Educational Implications of Analogy: A View from Case-Based Reasoning, *American Psychologist* 52 (1997): 57–66; idem., Case-Based Reasoning, in *The Cambridge Handbook of the Learning Sciences*, ed. R. K. Sawyer (Cambridge, UK: Cambridge University Press, 2006), 225–42; Roger C. Schank, *Dynamic Memory* (New York: Cambridge University Press, 1982); idem., *Dynamic Memory Revisited*. See especially Kolodner, Case-Based Reasoning, 227.

5. Arthur M. Glenberg, What Is Memory For? *Behavioral and Brain Sciences* 20 (1997): 1–55; and Arthur M. Glenberg and David A. Robertson, Indexical Understanding of Instructions, *Discourse Processes* 28 (1999): 1–26.

6. Barsalou, Language Comprehension; idem., Perceptual Symbol Systems; Clark, *Associative Engines*; and Hawkins, *On Intelligence*.

7. Arthur M. Glenberg, Tiana Gutierrez, Joel R. Levin, Sandra Japuntich, and Michael P. Kaschak, Activity and Imagined Activity Can Enhance Young Children's Reading Comprehension, *Journal of Educational Psychology* 96 (2004): 424–36.

8. John S. Brown, Allan Collins, and Paul Duguid, Situated Cognition and the Culture of Learning, *Educational Researcher* 18 (1989): 32–42; Gee, *Situated Language and Learning*; Edward Hutchins, *Cognition in the Wild* (Cambridge, MA: The MIT Press, 1995); Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (New York: Cambridge University Press, 1991); and Michael Tomasello, *The Cultural Origins of Human Cognition* (Cambridge, MA: Harvard University Press, 1999).

9. Etienne Wenger, *Communities of Practice: Learning, Meaning, and Identity* (Cambridge, UK: Cambridge University Press, 1998); and Etienne Wenger, Richard McDermott, and William M. Snyder, *Cultivating Communities of Practice* (Cambridge, MA: Harvard Business School Press, 2002).

10. Gee, *What Video Games Have to Teach Us*; idem., *Situated Language and Learning*.

11. Gee, *Situated Language and Learning.*

12. James Paul Gee, *Social Linguistics and Literacies: Ideology in Discourses* (London: Taylor & Francis, 1996); idem., Situated Language and Learning; and David W. Shaffer, *How Computer Games Help Children Learn* (New York: Palgrave Macmillan, 2007).

13. Deborah Blum, *Love at Goon Park: Harry Harlow and the Science of Affection* (Cambridge, MA: Perseus, 2002).

14. Gee, *Situated Language and Learning*; and Shaffer, *How Computer Games Help Children Learn*.

15. See Shaffer, *How Computer Games Help Children Learn*, for specific examples.

16. Paul A. Kirschner, John Sweller, and Richard E. Clark, Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching, *Educational Psychologist* 41 (2006): 75–86.

17. Bruno Latour and Steve Woolgar, *Laboratory Life: The Social Construction of Scientific Fact* (Los Angeles, CA: Sage, 1979); and S. Traweek, *Beamtimes and Lifetimes: The World of High Energy Physicists* (Cambridge, MA: Harvard University Press, 1988).

18. Michelene Chi, Paul Feltovich, and Robert Glaser, Categorization and Representation of Physics Problems by Experts and Novices, *Cognitive Science* 5, no. 2 (1981): 121–52.

19. diSessa, *Changing Minds*; Richard Lehrer and Leona Schauble, Modeling in Mathematics and Science, in *Advances in Instructional Psychology: Educational Design and Cognitive Science*, Vol. 5, ed. R. Glaser (Mahwah, NJ: Lawrence Erlbaum, 2000), 101–59; idem., Developing Modeling and Argument in the Elementary Grades, in *Understanding Mathematics and Science Matters*, eds. Thomas Romberg, Thomas P. Carpenter, and Fae Dremock (Mahwah, NJ: Lawrence Erlbaum, 2005), 29–53; idem., Cultivating Model-Based Reasoning in Science Education, in *The Cambridge Handbook of the Learning Sciences*, ed. R. Keith Sawyer (Cambridge, UK: Cambridge University Press, 2006), 371–87; and Nancy J. Nersessian, The Cognitive Basis of Model-Based Reasoning in Science, in *The Cognitive Basis of Science*, eds. Peter Carruthers, Stephen Stich, and Michael Siegal (Cambridge, UK: Cambridge University Press, 2002), 133–55.

20. For citations and discussion, see Jasper Juul, *Half-Real: Video Games Between Real Rules and Fictional World* (Cambridge, MA: The MIT Press, 2005).

21. diSessa, *Changing Minds*; Lehrer and Schauble, Cultivating Model-Based Reasoning.

22. Clark, *Being There*; and Gee, *Why Video Games Are Good*.

23. Elinor Ochs, Patrick Gonzales, and Sally Jacoby, When I Come Down I'm in the Domain State, in *Interaction and Grammar*, eds. Elinor Ochs, Emanuel Schegloff, and Sandra A. Thompson (Cambridge, UK: Cambridge University Press, 1996), 328–69.

24. Ibid., 330–31.

25. Uri Wilensky and Kenneth Reisman, Thinking Like a Wolf, a Sheep or a Firefly: Learning Biology Through Constructing and Testing Computational Theories—An Embodied Modeling Approach, *Cognition and Instruction*, forthcoming.

26. Brown, Collins, and Duguid, Situated Cognition; and Hutchins, *Cognition in the Wild*.

27. Gee, *What Video Games Have to Teach Us*; and idem., *Why Video Games Are Good*.

28. David W. Shaffer, Pedagogical Praxis: The Professions as Models for Post-Industrial Education, *Teachers College Record* 10 (2004): 1401–21; idem., Epistemic Games, *Innovate* 1, no. 6 (2005). http://www.innovateonline.info/index.php?view=issue&id=9. Accessed June 20, 2007; and idem., *How Computer Games Help*.

29. John Hagel and John S. Brown, *The Only Sustainable Edge: Why Business Strategy Depends on Productive Friction and Dynamic Specialization* (Boston, MA: Harvard Business School Press, 2005); and James Paul Gee, Glynda Hull, and Colin Lankshear, *The New Work Order: Behind the Language of the New Capitalism* (Boulder, CO: Westview, 1996).

30. Gee, Hull, and Lankshear, *The New Work Order*; and G. M. Parker, *Cross-Functional Teams: Working with Allies, Enemies, and Other Strangers*, 2nd ed. (San Francisco, CA: Jossey-Bass, 2002).

31. John S. Brown and Douglas Thomas, You Play World of Warcraft? You're Hired! *Wired Magazine* 14 (April 4, 2006). http://www.wired.com/wired/archive/14.04/learn.html.

32. Constance A. Steinkuehler, Massively Multiplayer Online Videogaming as Participation in a Discourse, *Mind, Culture, and Activity* 13 (2006): 38–52; and T. L. Taylor, *Play Between Worlds: Exploring Online Game Culture* (Cambridge, MA: The MIT Press, 2006).

33. Gee, *Situated Language and Learning*.

34. Antonio Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (New York: Penguin, 1994); idem., *The Feeling of What Happens: Body and Emotion in the Making of Consciousness* (Orlando, FL: Harvest Books, 1999); idem., *Looking for Spinoza: Joy, Sorrow, and the Feeling Brain* (Orlando, FL: Harvest Books, 2003).

35. Gee, *Social Linguistics and Literacies*.

36. Howard Gardner, *The Unschooled Mind: How Children Think and How Schools Should Teach* (New York: Basic Books, 1991).

37. Gee, *Situated Language and Learning*.

38. Tomasello, *The Cultural Origins of Human Cognition*.

39. Gee, *What Video Games Have to Teach Us*.

40. Shaffer, *How Computer Games Help*.

41. Gee, *What Video Games Have to Teach Us*; idem., *Situated Language and Learning*.