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## HARNESSING THE POWER OF GAMES IN EDUCATION

Kurt Squire and Henry Jenkins

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*The video game industry has been a major influence on students' lives in recent years. Now researchers consider how games might be used in pursuit of engaging, effective learning experiences. Kurt Squire and Henry Jenkins describe five detailed scenarios designed to illustrate the pedagogical potential of computer and video games. In the Leadership section, Borjana Mikic, Kara Callahan, and Domenico Grasso discuss two initiatives under way in the Picker Engineering Program at Smith College. These projects focus on the design of games and toys to enhance science and engineering education for K-16 students.*



# 1

## V I S I O N



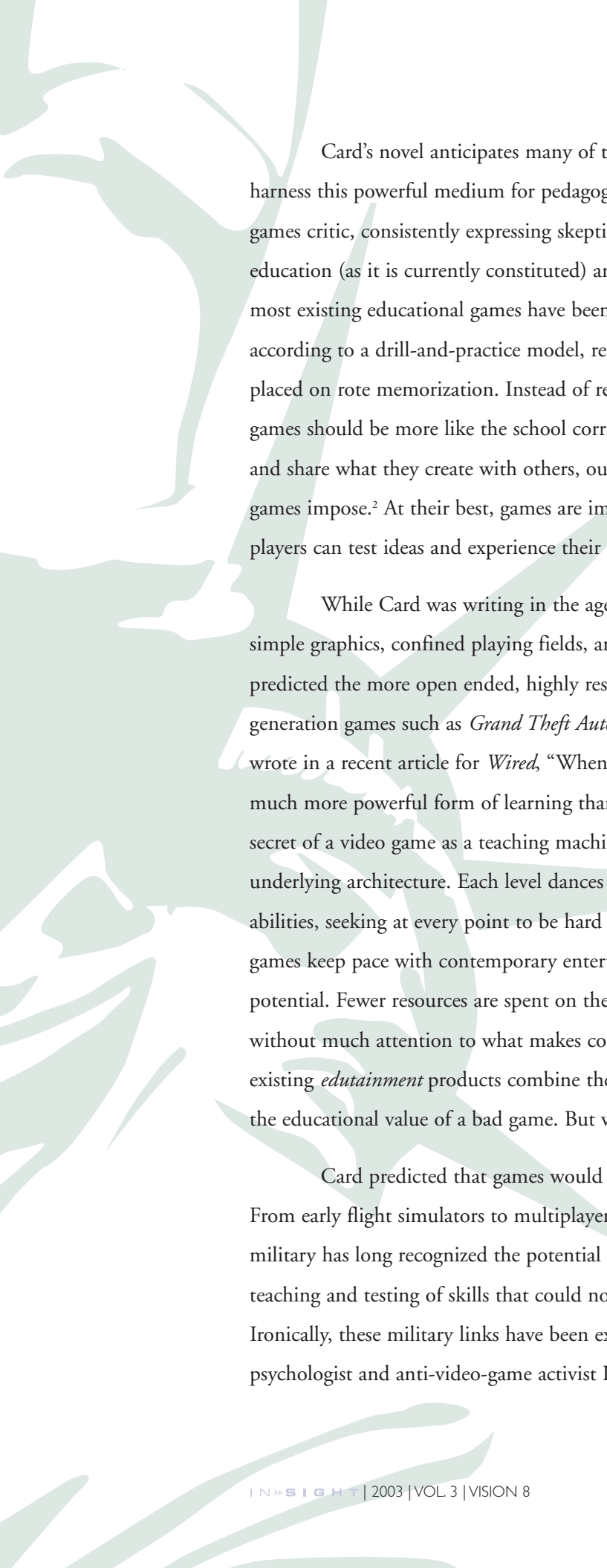
# HARNESSING THE POWER OF GAMES IN EDUCATION

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## **Card's Prophecy: Imagining the Future in Ender's Game**

In Orson Scott Card's 1985 science fiction novel *Ender's Game*, the Earth is facing a life-and-death battle with invading aliens.<sup>1</sup> The best and brightest young minds are gathered together and trained through a curriculum that consists almost entirely of games—both electronic and physical. Teachers play almost no overt role in the process, shaping the children's development primarily through the recruitment of players, the design of game rules, and the construction of contested spaces. Games become the central focus of the students' lives: they play games in classes, in their off-hours, even as part of their private contemplation. Much of the learning occurs through participation in gaming communities, as the most gifted players pass along what they have learned to the other players.

In Card's world, games teach by encouraging competition, experimentation, exploration, innovation, and transgression. Card's school is a constructivist utopia -in that nobody teaches kids what to do in these games; they are left on their own to experiment and solve compelling problems, and as they do so, they master strategies and tactics they will eventually apply to the world beyond the games. The teachers monitor the game play to increase their grasp of each student's potential. The teachers are counting on the holding power of games to push these already gifted students to their limits. And the games automatically adjust to the skill level and objectives of each student.



Card's novel anticipates many of the challenges and opportunities we face as we harness this powerful medium for pedagogical purposes. Card himself worked as a games critic, consistently expressing skepticism of any real-world alignment between education (as it is currently constituted) and games (as they currently exist). For Card, most existing educational games have been little more than “flashcards” that operate according to a drill-and-practice model, reflecting the value schools have traditionally placed on rote memorization. Instead of replacing the textbook, he argued, educational games should be more like the school corridors, where kids experiment, interact, create, and share what they create with others, outside the rigid structures that contemporary games impose.<sup>2</sup> At their best, games are imaginary worlds, hypothetical spaces where players can test ideas and experience their consequences.

While Card was writing in the age of *Pac-Man* and *Defender*—games with simple graphics, confined playing fields, and limited chances for customization—he predicted the more open ended, highly responsive environments represented by next-generation games such as *Grand Theft Auto 3*, *Morrowind*, or *Deus Ex*. As James Gee wrote in a recent article for *Wired*, “When kids play video games they experience a much more powerful form of learning than when they’re in the classroom. . . . The secret of a video game as a teaching machine isn’t its immersive 3-D graphics, but its underlying architecture. Each level dances around the outer limits of the player’s abilities, seeking at every point to be hard enough to be just doable.”<sup>3</sup> Few educational games keep pace with contemporary entertainment titles and thus fail to achieve this potential. Fewer resources are spent on their production, and they are developed without much attention to what makes commercial games compelling. Frankly, most existing *edutainment* products combine the entertainment value of a bad lecture with the educational value of a bad game. But what if we could turn that around?

Card predicted that games would enter education initially through the military. From early flight simulators to multiplayer games like *America’s Army* (see Figure 1), the military has long recognized the potential for games and simulations to enable the teaching and testing of skills that could not be rehearsed in real-world environments.<sup>4</sup> Ironically, these military links have been exploited by fearmongers, such as military psychologist and anti-video-game activist David Grossman, to drive a wedge between

games and schools. In an oft-repeated formulation, Grossman describes contemporary first-person shooters as “murder simulators,” suggesting that since the military uses such games to train troops to kill, they serve the same pedagogical functions in everyday life.<sup>5</sup> Already suspicious to some because of their ties to popular culture, games are even more threatening to many because of their links to the “military-entertainment complex.”

What Card got right—and Grossman gets wrong—is the importance of how games fit within the overall educational environment: how and why you play a game, who you are and who you hope to become, and how playing the game allows you to participate in social practices. When games are used in the military, they are not used in isolation from other learning activities; recruits go through boot camp, where they are



Figure 1. *Players collaborate in America's Army*

exposed to military values and become soldiers. Games are used in conjunction with real-world simulations (like rifle ranges). Learning is guided by more experienced members of the military community, and the meaning of these activities is negotiated through social interactions. There are real consequences if you don't master

the material or if you fail to apply it correctly to real-world situations. None of these factors apply when games are played at the arcade or in our living rooms.

Similarly, Card went to some lengths to describe the ways that games are woven through the entire learning context so that their lessons get leveraged by both students and teachers in their flesh-and-blood interactions. As we imagine games being put to other educational purposes, we have to always keep in mind how they will be shaped by their interaction with other pedagogical activities and by the social and cultural environment of the contemporary school.

Card's novel fits within a longer tradition of American science fiction that attempts to draw on genre conventions to motivate the working through of new ideas

**In this article, we respond to Card's challenge to think about how games might fit within an educational context. We present a series of vivid scenarios—some already happening, some pointing toward future developments - that illustrate the pedagogical potential of this rapidly evolving medium.**

and their implications. Hugo Gernsback, widely regarded as the father of American science fiction, saw the genre as encouraging popular science education by communicating innovative theories or compelling research results in a language that is more accessible to lay readers.<sup>6</sup> For generations, science fiction fans have used such stories as thought experiments, debating what aspects of a story were plausible within our current scientific understanding, imagining what steps would need to be taken to expand that knowledge, and debating the ethical and moral consequences of potential future developments. Researchers have found that such stories have often helped to influence students' decisions to pursue scientific training and careers.<sup>7</sup> The history of science fiction and its efforts to fuse entertainment and education may suggest why so many of us are excited about what games might offer to American education. Like science fiction, games promise to stimulate the imagination, spark curiosity, encourage discussion and debate, and enable experimentation and investigation.

In this article, we respond to Card's challenge to think about how games might fit within an educational context. We present a series of vivid scenarios—some already happening, some pointing toward future developments -that illustrate the pedagogical potential of this rapidly evolving medium. These scenarios reflect the work of MIT's Comparative Media Studies Program. Collaborating with a variety of partners, ranging from Microsoft to the Royal Shakespeare Company and Colonial Williamsburg, we have developed gaming scenarios designed to add some concreteness to our current discussions about the relationship between games and education. These scenarios cut across different game genres, different academic fields, different pedagogical models, and different strategies for integrating games into the classroom. Small-scale games can be used for quick demonstrations in the midst of a classroom lecture; more ambitious games might be deployed over one or more class periods as central learning activities. Games can function as homework assignments, allowing students to work through challenges on their own. They also can be imagined as possible problems on a final examination, testing what the student learned by applying it to a specific task or activity. With this article, we want to suggest the versatility of games as a pedagogical medium, rather than identify a single best practice or ideal approach. It represents less a lab report on work done than an account of the vision that governs this research and an incitement for educators elsewhere to contribute to this process of thinking through the future potentials of game technologies.

## **Scenario I: Replaying History with Civilization III**

After Sputnik's launch, Bell Laboratories funded a series of documentaries designed to encourage popular science literacy. Directed by Frank Capra and animated by Chuck Jones, these films coupled Hollywood showmanship with cutting-edge research on such standard school topics as the solar system, meteorology, and the human body. Initially aired on prime-time network television, they circulated throughout the American education system for more than a decade—much to the delight of school children of my generation. These productions were part of a larger strategy—what one executive called “Operation Frontal Lobe”—to demonstrate the educational value of the then-emerging medium of television.

Suppose we wanted to launch a similar effort today—a new Operation Frontal Lobe. Suppose we offered a new generation of high-quality content within an equally engaging format. What medium would we choose?

### ***Our answer is clear: video and computer games.***

A survey of some 650 MIT freshmen found that 88 percent of them had played games before they were 10 years old, and more than 75 percent of them were still playing games at least once a month.<sup>8</sup> Sixty percent of MIT students spend an hour or more a week playing computer games. By comparison, only 33 percent spend an hour or more a week watching television, and only 43 percent spend an hour or more per week reading anything other than assigned textbooks. On the one hand, one would expect these technologically advanced students to be early adapters and enthusiastic users of new media. On the other hand, given the bad reputation that gaming has in some circles, it may be news that so many students can play games and keep up the GPA needed to get into a place like MIT.

Games were clearly their preferred medium of entertainment, but they remained suspicious of their educational use. As one student explained, “The biggest qualm with educational software is the quality. Most look like infomercials, showing low quality, poor editing, and low production costs.” Another noted, “If people are going to learn from the games and want to play them, they'd better be damn good games (on par

with commercial console games in terms of graphics, sound, and playability). I played ‘educational’ type games for the computer a long time ago in middle school (remember *Math Blaster?*) and they sucked.” Despite such skepticism, 210 respondents in the survey took time to write detailed comments about what they saw as the educational potential of games and how they might be best achieved.

Game designers, educators, and students are all intrigued by the pedagogical potential of games, and yet, for somewhat different reasons, they are skeptical that the potential has been fully realized by the products currently on the market. How do we move beyond this impasse?

While industry has long sought the “sweet spot” in what looks like a potentially vast education market, they have largely focused on early childhood (e.g., *Reader Rabbit*, *The Magic School Bus*, *Math Blaster*, and *States and Traits*); but there has been no sustained exploration of how to create more sophisticated educational experiences for late adolescents, the core game market. Some of the most successful game franchises—*Civilization*, *SimCity*, *Railroad Tycoon*—have demonstrated how games can model complex social, scientific, and economic processes. Their designers are explicit about the degree to which they base the games on significant new theories of how cities work or how civilizations evolved. Interestingly, these games ranked high when the MIT students we surveyed were asked to identify their favorite titles. Made primarily for entertainment purposes, these products sometimes convey misinformation or foster misconceptions. *SimCity*, for example, exaggerates the mayor’s power and ignores issues of race. Some teachers have built classroom activities around such titles, encouraging critical reflection about their underlying models and their basis in reality.<sup>9</sup>

*Civilization III* (the third game in Sid Meier’s best-selling *Civilization* series) allows players to lead a civilization from 4000 BC to the present. (See Figure 2 for screen shots of *Civilization III*.) Students can win the game several different ways, roughly lining up with political, scientific, military, cultural, or economic victories. Players seek out geographical resources, manage economies, plan the growth of their civilization, and engage in diplomacy with other nation-states. Many educators take interest in *Civilization III*’s elaborate “technology” tree (see Figure 3), which organizes



6,000 years of technological innovation into a web of interrelated civilization advancements, linking together developments in science, religion, and the arts.



Figure 2. Political negotiations during Civilization III on a world map.

Over the last year, Kurt Squire has been studying what kinds of things game players learn about social studies through playing *Civilization III* in classroom environments.<sup>10</sup> Playing *Civilization III* seems to be a powerful way of introducing students to concepts such as monotheism or monarchy, but it may be an even better way of helping them tie together the disparate periods of history. A challenge of teaching world history is how to present students with thousands of years of developments across all civilizations without being Western-centric. *Civilization III's* scope extends well beyond the Greco-Roman realm and thus invites us to take a global perspective on historical developments.

Exactly what students learn from the game-playing experience depends heavily on the goals they set for themselves. Imagine one player picking the ancient Egyptians

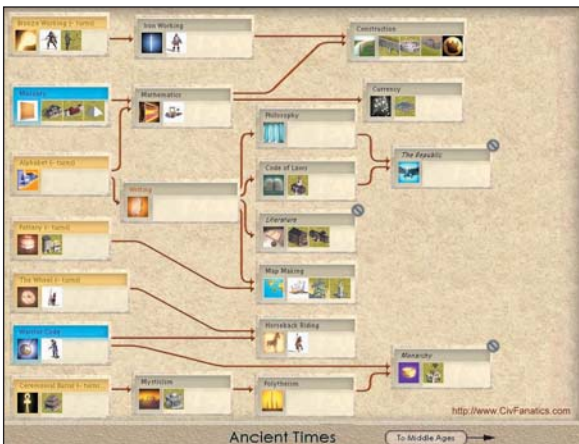


Figure 3. Technology tree in Civilization III.

in order to write a paper on the influence of the Nile on ancient history, compared to another whose only goal is to conquer the world. Open-ended games such as *Civilization III* allow for the use of games to pursue different questions and ideas.

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These questions are also driven by the students' personal histories. Squire's research has focused on minority and low-income students, often those who are currently performing well below grade level expectations. Like many marginalized students in America, Squire's subjects largely hated social studies and resisted standardized school curricula they saw as propaganda. Several minority students were totally uninterested in playing the game until they realized that it was possible to win playing as an African or Native American civilization. These kids took great joy in studying hypothetical history, exploring the conditions under which colonial conquests might have played out differently. What if smallpox disease hadn't wiped out millions of Native Americans? What if they had resisted the first wave of European settlers rather than embracing them?

*Civilization III* players encounter history not as a grand narrative but as the product of several dynamic interrelated forces. Students might learn about the role of horses or the interplay between economics and foreign policy. Students can use the game as a form of transgressive play, playing out fantasies of overturning established social orders. "What if?" questions can motivate further reading or discussion, helping them to refocus on why the actual events unfolded the way they did.

Geographical terminology became a tool for students to talk about the game (e.g., "You are on an island that is isolated from any trade networks. So, you need to be careful to develop allies so that you're not taken over for your strategic resources."). Some students started studying maps to find out where oil is located or how Rome's borders evolved. As one student said, "Losing over and over made me realize that I needed to know more about geography if I was going to be any good at the game." Games are not replacements for traditional resources such as maps, texts, or educational films; rather, students are motivated to return to those media to do better in the games. They don't memorize facts; they mobilize information to solve game-related problems.

In the post-interviews Squire conducted after the world history unit, students used geographic and historiographic concepts to explain hypothetical scenarios such as why China did not colonize South America. One student described to the class what he learned after playing *Civilization III*: "Geographic location affected the civilization's resources, which affected its economy as well as its politics." As he tried to tease out the

causal influence of these factors, he finally gave up, saying, “They all affect each other. What this game teaches you is that history, politics, economics . . . they are all related.”<sup>11</sup>

Games are not simply problems or puzzles; they are microworlds, and in such environments students develop a much firmer sense of how specific social processes and practices are interwoven, and how different bodies of knowledge relate to each other. In that sense, they resemble classic word problems, where students are invited to separate out the data they need from a much more complex field of information and then apply it toward specific tasks. In the classic word problem, however, most of that additional information is regarded as clutter or distraction that throws students off from their pursuit of what they need to respond to an assigned problem. Here, students can draw meaning from every element in their environment to solve problems that grow organically from their own goals and interests.

## Scenario 2: Historical Thinking Through Revolutionary Role Playing

*Civilization III* represents one way of helping students understand the forces shaping world history on broad scales. There are a number of other good ways for thinking about games as they relate to history education. Similar games such as *Railroad Tycoon* and *Gettysburg* allow players to explore historic time periods by managing resources. Other lesser-known games, such as the Marxist-inflected *Hidden Agenda*,



Figure 4. Screen shots from *Tropical America*, *OnRamp Project*.

show that games can adopt entirely different orientations. Groups like OnRamp Arts ([www.onramparts.com](http://www.onramparts.com)) in Los Angeles have worked with kids to design their own flash games for the Web, helping them to

represent complex historical topics, such as the colonization of Latin America (see Figure 4), with simple yet powerful images and activities.

We believe that multiplayer historical role-playing games represent a very promising area for educational design. Imagine this scenario: A classroom of 25 students enters the computer lab. Each student assumes the role of a towns person living in a middle-sized town in Colonial America that he or she has been researching for several weeks. Some are blacksmiths, some scullery maids, and some bankers. Each has their own responsibilities, daily routines, and political allegiances as the town works through the events surrounding the American Revolution. Some actively support the coming Revolution, some remain loyal to the Royal governor, and others are trying to keep their heads down and avoid having to pick sides for as long as possible. The game world is big enough so that each student can play an important part, small enough that their actions matter in shaping what happens. The game unfolds through a series of short episodes, each playable within about 40 minutes, each designed to stage an event or debate and play out its consequences for the different factions within the community. Keeping the game's duration short will allow time at the end of the typical class period for the teacher to pull back, reflect on the events, and debrief the students.

We are describing *Revolution* (see Figure 5), one of 15 game concepts to emerge through the MIT-Microsoft Games to Teach Project. *Revolution* is being developed in

collaboration with the Colonial Williamsburg Foundation with advice from award-winning historian Pauline Maier (*American Scripture*).<sup>12</sup>



Figure 5. *Revolution*: A multiplayer role-playing game where players experience the intermingling social and political forces contributing to the American Revolution.

Role-playing activities are hardly alien to the social science classroom. Students involved in the Model United Nations program, for example, research national cultures, choose fictional identities, and play out conflicts and compromises between national delegations. Teachers lucky enough to live in the regions may take their classes to living history museums, allowing them to see firsthand how they made candles in Colonial Williamsburg, how they built ships in the Mystic Seaport, or how the Industrial Revolution impacted everyday life in Sturbridge Village. We describe such experiences as making history “come alive,” as immersing students intellectually and emotionally in another political or historical context. Role-playing games such as *Revolution* carry this process to the next level. You do not simply visit Williamsburg for an afternoon; you become part of that community. You do not simply discover what daily life was like in Colonial America; you watch the process by which the coming Revolution impinged upon and impacted those routine practices.

A central assumption underlying the game is the interplay between personal and local concerns (making a living, marrying off your children, preparing for a party) and the kinds of national and very public concerns that are the focus of American history classes (the Stamp Tax, the Boston Tea Party, the shots fired at Lexington, the winter at Valley Forge). *Revolution* invites us to think about how resistance to British rule got staged at the most grassroots level by citizen soldiers who saw political activism as a disruption to their daily routines but who felt a larger commitment to fight for freedom or defend the crown. Deploying a multiplayer framework allows the town to become a real social community, reflecting the differing opinions and competing interests that shaped how people up and down the eastern seaboard responded to what were, for them, current events.

Because each student has a somewhat different play experience, each brings something vital to the class discussion. Because those play experiences intersect each other, the game provides a common framework for discussion. Imagine classroom discussions where students try to identify the causes of the American Revolution, each speaking for a different class or faction, with all participants functioning much like a group of historians, adopting different points of view, building narrative accounts, and debating the meaning of different events. Bringing the game into the classroom forces

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students to pull back from the immediate play experience and reflect on the choices they have made. In this case, that process can help students to better understand how and why historical agents made the decisions they did.

Part of what can often be deadening about the teaching of American history is the sanctimonious tone with which we respond to certain defining moments in our national tradition. It isn't simply that the outcomes are predetermined; it is also that our identifications with those events are prestructured and their meanings absolutely dictated by longstanding mythologies. But what if learning about the American Revolution meant becoming a revolutionary—sneaking out in the middle of the night to throw tea in the harbor, or burn an effigy of the Royal governor from a liberty tree, or smuggle a message past the British guard post and into the hands of the revolutionaries at the local tavern? As with controversial games like *Grand Theft Auto*, students take pleasure in transgression, but now transgressing the rules helps them to understand the risks involved in overthrowing Colonial rule.

If *Civilization III* emphasizes large-scale and long-term historical change, Revolution stresses short-term historical events and individual agency within constrained contexts. Each character has differing degrees of freedom and flexibility to act, depending on his or her social status within the community. If *Civilization III* pays particular attention to the ways that geographic location and access to natural resources shapes the power relations between nation-states, *Revolution* explores how the flow of information impacts the choices that were made by geographically dispersed communities within Colonial America. It is difficult for people raised in an era of instantaneous global communication to grasp the disjunctions and delays in information flow that shaped the events of the American Revolution and that needed to be overcome if the 13 colonies were going to think as a national unit. The game makes real the different modes and temporalities of communication in Colonial America—from the covert oral culture of the slaves, to the committees of correspondence deployed by the revolutionaries, to the more official realm of proclamations and newspapers. *Revolution* embeds primary documents from the period in the game. It is one thing to ask a student to read authentic letters or diaries for clues of cultural assumptions; but imagine if this interpretive exercise becomes a critical component of game play, as

players try to discern the motivations of other players and understand the unfolding events. Historical agents are often forced to act on imprecise or dated information to make decisions in the field that may or may not reflect the direction the nation as a whole is taking. If one player decides to check out a history book to find out what is coming next, all the better.

### Scenario 3: Role Playing and Literary Analysis on Prospero's Island

Historical games are already on the market and are already being deployed in classrooms around the country. What if we were to extend what we have learned to new subject areas and disciplines—for example, to the study of literature? In her book *Hamlet on the Holodeck*, Janet Murray invites us to imagine the coming era of the “cyberbards”—when creative and expressive works may look and feel more like games than like traditional novels or plays. She asks us whether a game can create a character as complex and compelling as Hamlet, using Shakespeare as the limit case for examining the current state and future potential of the medium.<sup>13</sup> Murray’s claims have proven controversial among game theorists who believe there are profound differences between



Figure 6. Prospero's Island "Cabinet Sequence." In this series, Tom Piper, associate designer with the Royal Shakespeare Company, has imagined a moment when the player encounters the "cabinet of curiosities" that opens the game. Here it has washed ashore on the island, emptied of all its previous treasures. Piper illustrates how the player might place a piece of red coral into the cabinet and see the entire world morph into a surreal landscape of twisted scarlet coral trees.

(All images of Prospero's Island, copyright © 2003, by the Massachusetts Institute of Technology and Royal Shakespeare Company. Used with permission.)

games and traditional storytelling media. To retell Shakespeare via a game, they contend, would be to detract from the agency of game players who want more open-ended structures and who want to see the outcome emerge from their own choices and

actions.<sup>14</sup> What if, however, we sought not to reenact Shakespeare's stories through games but rather to allow players to explore and have their own adventures in the richly detailed worlds where those stories unfold?

The Royal Shakespeare Company (RSC) is collaborating with the MIT Comparative Media Studies Program to develop a single-player game (*Prospero's Island*) to provide a "gateway" into Shakespeare's *The Tempest*.<sup>15</sup> (See Figure 6 for screen shots of the "Cabinet Sequence" and Figure 7 for screen shots of the "Text Sequence.") The game is not simply a literal-minded adaptation of Shakespeare's play; it doesn't simply play out the plot with limited roles for player intervention. Rather, the game is a deconstruction or interpretation of the play as rich and original as the RSC's provocative stage performances.

While it was important that *Revolution* be a multiplayer game since it represents the social, economic, and political life of a particular community, *Prospero's*



Figure 7. Prospero's Island "Text Sequence." In this series, Tom Piper, associate designer with the Royal Shakespeare Company, suggests one way the player may interact with text from *The Tempest*. As she moves through the play space, the player may come across a "tear" in the image that appears on screen. She rips one corner and reveals an entire canvas of text behind the island scenery.

*Island* must be a single-player game since, like the play on which it is based, it is centrally about the process of self-discovery. The game can be consumed by individual students on their own time and then brought into the classroom as an object for analysis and interpretation. As the game opens, the player begins by choosing a

costume to wear. The costume determines the player's role (servant, sailor, courtier), what goals she adapts, and how other characters respond to her. The player is shipwrecked on a fantastical island, the look and feel of which is inspired by the artifacts



found in Renaissance curiosity cabinets. Her interactions with the Shakespearian characters—especially Caliban; Ariel; and, ultimately, Prospero—reshape the world and rework the narrative of the original play. Sometimes the other characters perform predetermined actions, but at other times they become pawns in an elaborate puppet theater. *Prospero's Island* is a space of dreams and magic, and students are encouraged to decipher symbols, manipulate language, and uncover secrets (in short, to perform literary analysis).

There has been a significant movement in recent years away from conceiving the Shakespearian plays as sacred and unchanging texts, and toward studying Shakespeare as part of a living performance tradition.<sup>16</sup> Each time these plays get restaged, this argument goes, they are not only reinterpreted but also rewritten. Indeed, there may never have been a stable Shakespearian text at all, given the significant contradictions and inconsistencies between the earliest surviving editions of his texts. And in any case, Shakespeare himself was reworking stories with a much older history. In the case of *The Tempest*, Shakespeare built the play from fragments of existing stories, borrowing from Ovid and Montaigne, Italian ducal intrigues, New World voyages, and Greek romances and their Renaissance reworkings. Any given production may recognize and foreground some of these borrowings while remaining ignorant of or disinterested in others.

This focus on the performance process suits a nonlinear, more open-ended medium where no two players will have exactly the same experience. *Prospero's Island* encourages students to experience the plays not simply as readers or spectators but as players, directors, and authors. As students become immersed in this world, they learn more about the play, they experience embodiments of central metaphors in the text, they master the core characters' desires and relationships, and they learn about the role magic and dreams play in the Renaissance imagination. Yet, they also learn something about themselves, the choices they make, the identities they play, and the ways they are seen by other people—issues that are central to the experience of adolescence.

Choices have consequences here, not simply on the local level in terms of how certain events play out, but on a more cosmic level in terms of the nature of the world itself. Rebooting the game has a cost: each time the player “dies” or pulls out of the

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game, something gets lost. The computer's memory card drains away color, hue, or texture, so that the world feels increasingly impoverished. Actions that lead to greater insights may, on the other hand, restore some of the clarity of the world, enabling players to look on it with fresh perspectives.

We imagine that if Shakespeare were alive today he would be a game designer, given his fascination with the conventions of theater and the mechanics of staging and plot development. Of all of Shakespeare's plays, *The Tempest* seems the most interested in encouraging audiences to reflect on the nature of theater. Prospero, whose magic creates the world and dictates the actions of its inhabitants, albeit imperfectly, stands in for Shakespeare himself. *Prospero's Island* is designed to make us more reflective about the kinds of role playing found in other games and about the relationship between games and theater.

Every game element is carefully designed to convey symbolic as well as literal meaning. *Meta-gaming*, the conversation that goes on around the game, becomes a form of literary analysis. The player seeking more information about the game world, such as how she might tame Caliban, finds herself drawn back to the play; the once forbidding text now functions as a cheat sheet.

In the end, should the student go from playing the game to watching a performance of *The Tempest*, she will be in roughly the position of an original spectator at the Globe—she will know some aspects of the story, be familiar with the world in which it is set, have some access to the information on which its central metaphors operate, and perhaps be able to more fully enjoy the immediate experience of the performance. The game does not displace the play. Rather, game playing enhances the experience of watching the play, much the way students reading part of the text aloud or enacting scenes in their classrooms historically has.

## **Scenario 4: Freeing Computer Games from the Desktop in Environmental Detectives**

Ubiquitous gaming is one of the most exciting ideas to emerge from the games industry in recent years. Ubiquitous games can be played anytime, anywhere and often play out across multiple media. For example, Electronic Arts' *Majestic* uses cell phones,

desktop computers, and fax machines (among other technologies) to immerse players in a multiplayer conspiracy theory game. Such games motivate players to investigate, weigh evidence, compare notes, test hypothesis, and synthesize information as they draw conclusions about what has occurred and why. We use the terms *enhanced reality* or *augmented reality* to refer to virtual experiences being played out in real-world spaces. While such game experiences may seem prohibitively expensive, recent handheld technologies, which can now combine cellular phone, GPS, Bluetooth, wireless Internet, multimedia capabilities, and infrared technologies into one machine, make such experiences possible even on the level of an individual school.<sup>17</sup>

*Environmental Detectives* (see Figure 8) capitalizes on the location-aware and intercommunication capabilities, context sensitivity, and portability of handheld computers to put teams of players in a game that is played in real locations in real time but is augmented by data from their PDAs.<sup>18</sup> The player is an environmental scientist representing one of several different factions researching a chemical spill on a college campus. Players walk about the campus using their PDAs to take virtual readings of the contaminant in the soil, interview virtual informants, and access intranets of information. Players must prepare a presentation for the president of the university,

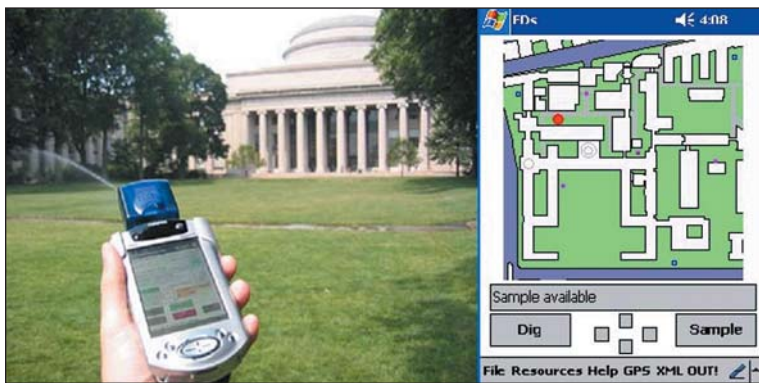


Figure 8. *Environmental Detectives: Augmented reality on PDAs.* On the left is a player calibrating her GPS unit. The image on the right displays the player's location on the MIT map.

describing the problem as they understand it, and suggest a course of action for the university.

*Environmental Detectives* is designed to

combine the pedagogical potential of simulations in science education with the motivational appeal of games.<sup>19</sup> Past research on participatory games has shown that role playing as part of a physical system can help students better understand scientific concepts such as predator—prey relationships, evolution, or latency.<sup>20</sup> Research on simulations and microworlds has shown that games can produce deeper conceptual

understandings, particularly in physics.<sup>21</sup> *Environmental Detectives* takes and extends these affordances by situating them within an augmented reality game format.

Game play requires making decisions about what kinds of data to collect and how to best organize the investigation within a limited time frame. Students must balance the need for hard scientific data about the concentration of the contaminant in the soil with the need for information gathered from experts and found in documents (stored on the PDA and unlocked by visiting virtual libraries) that helps them interpret the data. Successful players must also use the information to rethink the problem itself, evaluating what they know and building a feasible strategy to answer the most urgent questions. For example, as students find that there is a relatively even concentration of the contaminant on campus, it might be more pressing to find out just how hazardous the chemical is, or who uses the chemical on campus, before wasting hours trying to pinpoint its exact origin through sampling techniques alone. Because there is a limited amount of time, players must prioritize information based on the most pressing questions. Because the players are members of teams (see Figure 9), they are forced to articulate their observations and conclusions at every stage of the process, enabling a high level of peer-to-peer teaching. We leave it up to teachers how much they want to emphasize cooperative versus competitive gaming.

*Environmental Detectives* is in its first testing phases, and our initial results suggest that augmented reality games might be a powerful way of exposing students to learning experiences not otherwise possible.<sup>22</sup> Students enjoy seeing their living environments turned into the site of a disaster, the hub of a grand conspiracy, or a base of international intrigue. Students use information both from their



Figure 9. Students collaborating while playing *Environmental Detectives*.

PDA and the real world when playing the game, using the slope of the ground to predict water flows, or their knowledge of the campus to predict where the spill might have originated. One team even made the computer lab their first stop so they could “Google” information about the contaminant.

Most students, though, spend inordinate amounts of time trying to track down the precise location of the spill, failing to gather enough desktop research. Even though most students recognize this issue as they are playing the game, they often opt to “just keep drilling.” This tendency to fail at the game may be its most educational feature. Trish Culligan and Heidi Nepf, the environmental engineers who consulted on the game design, suggest that students frequently fail to understand that environmental investigation is a social process constrained by real-world issues such as a lack of time or resources. It is one thing for a teacher to lecture about scientific processes, another for students to learn about scientific processes and problem solving through experience. Cognitive scientists often talk about the importance of causing perturbations in students’ thinking, helping them see where their current knowledge and beliefs break down, and only then providing them with structured information such as lectures or readings. In the best cases, the constraints of the game make flaws in the students’ thinking visible to both teachers and students, enabling students to learn from the consequences of their actions. Unlike most academic experiences, where everyone is expected to succeed, we intuitively understand that games can be won or lost. If a team loses, then members can reflect on the experience and figure out what went wrong.

Some might pit games against more “authentic” investigations, but we think that there is a natural overlap between exploring hypothetical scenarios and conducting “real” investigations. Students can rapidly play out imaginary scenarios in game space that would unfold over longer periods of time in the real world. Students can master skills, test theories, and then apply them to authentic problem-solving activities. Students may encounter phenomenon in game spaces that would be unlikely to arise during any given real-world observation. The real trick is finding ways for educators to use simulation technologies to inform the design of real investigations and vice versa.

We hope to incorporate even more of the unique capabilities of handheld computers and ubiquitous computing technologies in our future augmented reality

**In the best cases, the constraints of the game make flaws in the students’ thinking visible to both teachers and students, enabling students to learn from the consequences of their actions.**

designs. Our immediate task is to build a tool set so that educators around the world can localize augmented reality games to their own facilities. Our studies of computer game players suggest that there is a natural crossing over between game play and game design. Much the way the “mod” game developers used the tools of the game *Half-Life* to create the popular online action game *CounterStrike*, we hope students will take these basic technologies and run wild with them. Imagine students creating historical role-playing games based on their hometowns. Or, imagine playing augmented reality games set around popular vacation attractions such as the Boston Freedom Trail, where players investigate mysteries, trade information, or post clues to the Internet.

## Scenario 5: Mastering Essential Skills through Biohazard: Hot Zone

*Biohazard: Hot Zone* (see Figure 10 for a screen shot) was originally designed by MIT Comparative Media Studies as a way to help students learn introductory college biology and environmental science.<sup>23</sup> Through collaboration with Jesse Schell and a team of students in Carnegie Mellon’s Entertainment Technology Center, *Biohazard* has evolved into a game to help emergency first responders deal with toxic spills in public locations (including those caused by the deployment of weapons of mass destruction).<sup>24</sup> As in the novel *Ender’s Game*, *Biohazard* features play activities to help us prepare for potentially catastrophic situations. Emergency responders work in teams to organize the response to a gas attack in a crowded suburban shopping mall. Players race against the clock to save as many civilians as possible. The game play involves quickly scanning and



Figure 10. Screen shots of *Biohazard: Hot Zone*.

assessing the situation, dividing into teams, and coordinating efforts so that the likely point source is identified and isolated before more civilians (as well as the player) become sick. Students can thus practice recognizing the signs of different chemicals and viruses, examining victims’ symptoms, and observing how different chemicals spread in differing conditions.

The advantages of a simulation such as *Biohazard* is fairly obvious: Actually releasing deadly agents into the environment is too dangerous. By changing only a few simple variables, players can experiment with a multitude of different conditions, examining how strategies should differ, depending on whether the mall is crowded or vacant, whether the contaminant is released near an air vent, whether the air conditioning is on or off, or how much of the contaminant is released. Players can try dozens of variant conditions, sharpening their ability to read emergency situations, and predict likely outcomes. Players can also experiment with different team configurations, seeing how having large teams or small teams affects the strategies they can deploy.

Teams of responders can also compete against other teams. The game, in this case, serves as both a motivational tool and an “anchor” for instruction. Players can develop a sense of how teammates react in situations, refining their interactions before facing an emergency. Trainers can see what mistakes players make and then use the game as a focus for discussion. Trainers might use the game for assessment purposes, putting individuals or teams into a simulation game where they face an unknown toxin in a new environment and using the game to test how they respond. Initial evaluation reports show that playing *Biohazard* produced increased communication, better problem solving, and new opportunities for trainers to examine firefighters’ thinking during game play.<sup>25</sup>

*Biohazard* still has its limitations. People can be unpredictable, particularly in highly stressful, emergency situations. Dealing with a panicked public demands a type of interpersonal skill expressed through voice, gestures, and demeanor that contemporary game interfaces cannot capture. Despite the many advances in artificial intelligence in games, characters still can’t express a full range of emotional responses in dynamic reaction to events. Clearly, *Biohazard* is no replacement for experience—or even field trials and manuals. Rather, it is a tool that responders can use to explore ideas and talk about their practice.

## Conclusions

As Orson Scott Card prophesied, games have tremendous educational potential. A good educational game can enable players to explore ideas in virtual worlds.

*Civilization III* allows students to play with historical forces on grand scales, while *Revolution* allows them to see the world through the eyes of a Colonial America. Learning through these games is more than just accumulating a body of historical facts. Students draw on that knowledge to solve problems and draw on the challenges of game play to master core geographical or historical principles. Educators have long acknowledged what Whitehead termed the *inert knowledge* problem, whereby students routinely fail to apply the information learned in school contexts to their lives.<sup>26</sup> John Bransford and colleagues at Vanderbilt have shown that students learning in the context of solving complex problems not only retain more information but tend to perform better in solving problems.<sup>27</sup> Games have the power to compel players to engage in disciplinary practices, such as planning scientific investigations in *Environmental Detectives* or reading primary documents in *Revolution*. We hope these practices will help learners overcome the inert knowledge problem. Although games are fantasy systems, we believe that by creating compelling goals, they have the *potential* to make learning very real for players.

Games are unique in that they have rules that constrain action, forcing players to manage resources and make trade-offs. Good games are about choices and consequences, and good educational games force players to form theories and test their thinking against simulated outcomes. Games encourage role playing, which can, in the case of *Prospero's Island*, help students to better understand the nature of theatricality, and, generally, to adopt different social roles or historical subjectivities.

Author Mary Louise Pratt has described how her son's fascination with baseball card collecting opened him to a much broader range of knowledge and experiences: "He knows something about Japan, Taiwan, Cuba, and Central America and how men and boys do things there. Through the history and experience of baseball stadiums, he thought about architecture, light, wind, topography, meteorology, and the dynamics of public space. He learned the meaning of expertise, of knowing about something well enough that you can start a conversation with a stranger and feel sure of holding your own. . . . Literacy began for Sam with the newly pronounceable names on the picture cards and brought him what has been easily the broadest, most varied, most enduring, and most integrated experience of his thirteen-year-old life."<sup>28</sup> Learning, from this



perspective, is about much more than memorizing names or dates for a test; it is about finding joy and fascination in the world, asking questions and engaging in inquiry, developing expertise and participating in social practice, and developing an identity as a member within a community.

We view games-based learning through a holistic lens similar to Pratt's depiction of the baseball card collector. A good game can function as a gateway through which students can explore a much broader range of knowledge. The properties and processes of a well-designed game may motivate them to turn to textbooks with the intention of understanding rather than memorizing. And, in some cases, games may inspire players to read more broadly across a range of other related fields. Learning occurs not just in the game play but as players move back and forth between games and other kinds of activities; that is, when they are motivated by playing *Prospero's Island* to reread *The Tempest* or to watch it in performance, when they draw on physical observations alongside imaginary data to solve the mysteries posed by *Environmental Detectives*, or when they discuss in class the actual outcome of the historical confrontations depicted in *Civilization III*.

As Card reminds us, games encourage collaboration among players and thus provide a context for peer-to-peer teaching and for the emergence of learning communities. Popular digital games do this already. Look up any popular game on the Internet and you find robust communities of game players debating games, sharing game tips, or offering critiques to designers. Game theorists use the term *meta-gaming* to refer to the conversations about strategy that occur around the actual game play itself as players share what they know, ask questions of more expert players, and put their heads together to resolve vexing challenges. This kind of critical engagement with the game can resemble what education psychologists call *meta-cognition*, the process of reflecting on learning itself. In the case of *Civilization III*, Squire saw players exchanging not just game experiences but critical stances toward the game. In *Prospero's Island*, we have tried to extend this reflection further, enabling the player to experiment with different readings of a text. Through these conversations about the game, players can become engaged in what Jim Gee has called "critical learning."<sup>29</sup> Gamers are learning not just to play the game but to become members of game playing communities where

**As Card reminds us, games encourage collaboration among players and thus provide a context for peer-to-peer teaching and for the emergence of learning communities.**

gaming knowledge is shared among and across players. Ultimately, educational game design is not just about creating rules or writing computer codes; it is a form of social engineering, as one tries to map out situations that will encourage learners to collaborate to solve compelling problems.

To move educational gaming to the next level will require hard work and a real commitment of resources. We believe the best results will come through collaboration between educators and game designers. Educators acting alone are unlikely to fully grasp what makes contemporary commercial games so compelling for their players; game designers acting alone may not fully grasp the challenges of designing problems and activities that will fully achieve pedagogical objectives. The games that emerge can't be seen cynically as rewards for learning. Rather, they need to be considered from the outset as organic to the educational process. Given the history of new media technologies being oversold, only to produce disappointment and frustration when they fail to yield predicted results, we need to remain clear about which games can do well and which can't. We do not put them forward as a substitute for all traditional learning practices. Throughout this article, we have stressed ways that they can be linked to real-world experiences and to textbook knowledge to create a richer learning environment—one that goes on “outside the box” as much as inside it.

As we move forward, the big challenges won't be technological. We are a long way from having tapped the full pedagogical potentials of existing game hardware and design practices. Nobody has produced an educational environment as immersive and open ended as *Grand Theft Auto 3*, or a simulation as compelling and nuanced as *The Sims*. The real problem is that the kind of immersive, experiential learning that games support runs directly counter to contemporary trends in education. Games may be seen as suspect in an era of standardized tests, where knowledge is considered measurable by scan-tron sheets, where teachers are held in suspicion for their practices, and where education debates center around what instructional methods produce the largest increases in standardized test scores. The kinds of learning gains we have seen with game-based learning environments have much less to do with increases in factual recall or the ability to choose correct answers and more to do with making complex ideas accessible to a different kind of student. These gains build students' identities as learners

in new areas and increase their ability to participate in discipline discourses. Using games to create rich learning environments in schools may mean changing the “game” of school itself so that routinized knowledge of facts or high performance on standardized tests are not the ultimate end goal. Instead, students’ ability to participate in complex social practices; learn new knowledge; and perform well in novel, changing situations needs to be considered valuable learning. Unfortunately, many school superintendents today would be happy to settle for games that are, in Card’s assessment, merely digital “flashcards.”



## *About the Authors*

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