# From Visual Simulation to Virtual Reality to Games

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**Leveraging technology from the visual simulation and virtual reality communities, serious games provide a delivery system for organizational video game instruction and training.**

During the past two decades, the virtual reality community has based its development on a synthesis of earlier work in interactive 3D graphics, user interfaces, and visual simulation.[1] Doing so let developers create a more open technology than the visual simulation community could, increased the number of people working in 3D, and developed a science, technology, and language considerably beyond that of the earlier field.

Beginning in 1997 with the publication of an NRC report titled "Modeling and Simulation—Linking Entertainment and Defense,"[2] the video game community has pushed into spaces previously the domain of the VR community. Clearly, the VR field is transitioning into work influenced by video games and thus now influences that industry as well. Because much of the research and development being conducted in the games community parallels the VR community's efforts, it has the potential to affect a greater audience.

Given these trends, VR researchers who want their work to remain relevant must realign to focus on game research and development. Research in the games arena affects not just the entertainment industry but also the government and corporate organizations that could benefit from the training, simulation, and education opportunities that serious games provide.

## DEFINING SERIOUS GAMES

People respond differently to the emotionally charged term *game* depending on whether they played or did not play video games while growing up. This is basically a generation-gap issue because children who have grown up since the 1980s have been exposed to video games their entire lives.

Before we can seriously tackle the issue of what a games research agenda might be, we must define what the term means. Dictionaries tend to define a game as a physical or mental contest, played according to specific rules, with the goal of amusing or rewarding the participants. When seeking a definition of the more specific term *video game*, we are likely to encounter a description such as "a game played against a computer," which would more accurately be worded as "a game played with a computer." To fully flesh out this definition, we might propose the following: "*Video game*: a mental contest, played with a computer according to certain rules for amusement,

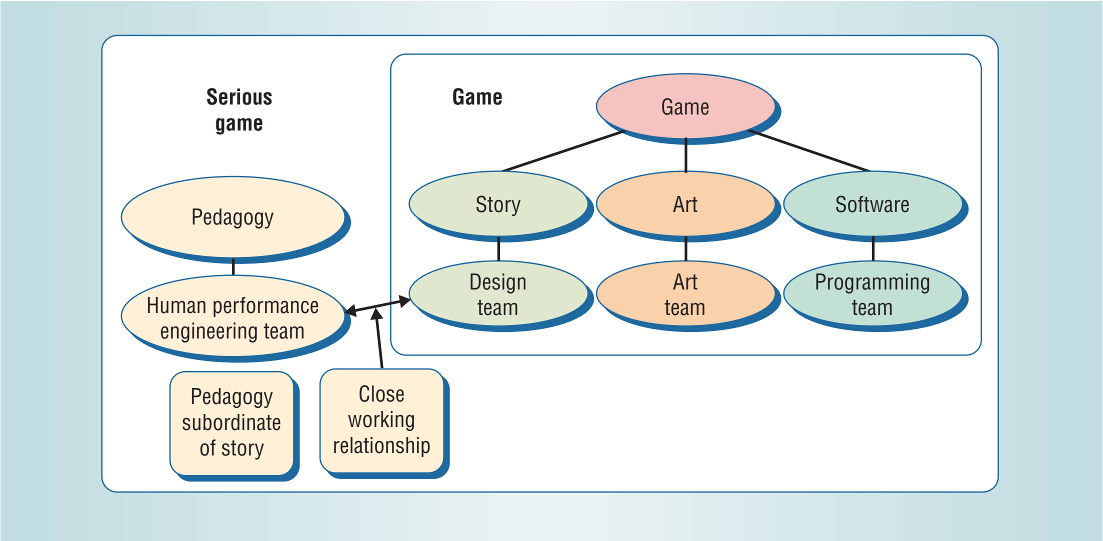


***Figure 1. From game to serious game. Unlike their entertainment-only counterparts, serious games use pedagogy to infuse instruction into the game play experience.***

Developing a science of games opens up a huge potential for the wider application of games in governmental and corporate arenas. The formal definition might read as follows: "*Serious game*: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives."

Bing Gordon, chief creative officer of video and computer games developer Electronic Arts, once told me that he defines video games as "story, art, and software."

When designing a game, the development team blends these elements into a finished product. The design team crafts the story, which provides the game's entertainment component. The art team provides the game's look and feel. The programming team develops the code that implements story requirements, interface features, networking, Web connectivity, scoring systems, AI scripting, game engine changes, and just about anything technical or programmatic that the entire development effort requires.[3]

Serious games have more than just story, art, and software, however. As Figure 1 shows, they involve pedagogy: activities that educate or instruct, thereby imparting knowledge or skill. This addition makes games serious. Pedagogy must, however, be subordinate to story—the entertainment component comes first. Once it's worked out, the pedagogy follows.

A human-performance engineering team works closely with the design team to oversee this peda- scientist and part subject-matter expert for the domain around which the teams are building the serious game.

Building serious games takes more than simply handing their development to a traditional game team, however. The team must interact with the instructional scientists and subject matter experts that comprise the human-performance-engineering team. To thrive, this new organization must have a university's facilities and support or similar research organization. A research agenda that supports serious games also benefits the entertainment industry, one of the US's largest economic sectors.

## CREATING A SCIENCE OF GAMES

The development and wide release of the *America's Army* game began a revolution in thinking about the potential role of video games for nonentertainment domains. It also sparked a discussion about how to advance game technology's state of the art to support future entertainment and serious games.[4] This, in turn, promoted interest in creating a science of games and an allied educational program. Experiences with *digital-game natives*—those who have grown up playing games—indicated that a game-centered research and educational program could offer many positive benefits. While much speculation regarding these benefits is anecdotal, substantive evidence shows that game experiences affect digital-game natives positively. If researchers construct and perform their studies carefully, they may be able to harness these positive affects for societal gain.

The announcement of *America's Army*, shown

Expo prompted the US Army to commission a study of the game to see if it could be used for training. In the summer of 2002, a US Army captain from Fort Benning, who was tasked with spending about a week playing the game, reported that he was unimpressed. Although he deemed the game a good recruiting tool, he indicated that there "was insufficient fidelity in the game for it to be of any use in training."

Cyberpunk author William Gibson once noted that the street finds its own uses for things.[5] We saw this effect in action in October 2002, when a staff sergeant from Fort Benning approached the *America's Army* booth at the Army's annual AUSA Conference in Washington, DC. An enthusiastic gamer who had played *America's Army* from day one, he and told the staff, "We love this game at Benning. We use it for training."

The sergeant had bypassed the Army's requirements documents and formal studies and deployed the game on his own initiative. He went on to explain that when new recruits had trouble with the rifle range or the obstacle course, his team had those recruits play *America's Army* and required them to complete those levels in the game, as shown in Figure 3. When the recruits did so, they then went back to the range and usually passed the range tests. This made us wonder what other applications would benefit from game-based instruction—especially after we developed a revised version of *America's Army* with new levels for a variety of Department of Defense, Army, and Secret Service training needs.

Six to nine months after its release, mothers would meet me and complain that "my son is playing *America's Army* five to six hours a day, seven days a week. What is going to become of him?" I would usually answer that these children would be twice as likely to consider a career in the US Army as those who didn't play the game, something the Army counts on with respect to the game's recruiting mission. When I asked the mothers if their children knew a lot about the US Army, the mothers usually responded that "they know everything about the Army, having learned it from the game. Wouldn't it be nice if playing games could teach them something more useful?"

These comments led us to wonder how much of K-12 science and math education could be taught via games and how we might exploit students' capability for *collateral learning*—the learning that happens by some mechanism other than formal teaching. Ultimately, we wondered if we could

***Figure 2. America's Army. The most widely used and successful serious game to date, this title initially served as a recruiting tool.***

***Figure 3. Training simulator. Despite the initial evaluator's skepticism, America's Army proved to be an effective military training simulator. Soldiers who played the rifle range segment of the game, for example, earned improved scores on the real-life rifle range.***

in a highly immersive, highly addictive game—we called this our "first person education" grand challenge, a play on the phrase "first person shooter".[6]

Given the many anecdotes about digital-game natives being better surgeons and displaying exceptional business skills, it became clear that creating a science of games—a scientific and engineering method for building them and understanding and

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## GAME PRODUCTION CHALLENGES

Today, game production poses some incredible challenges. Teams come together to build a single game, then dissolve. Training times on game engine toolsets increase steadily. Code modules, crafted for specific games, offer less than 30 percent reuse in subsequent efforts. First-person shooters are currently the only games that have reusable engines. These engines are proprietary, however, used for a few games only, licensed at exorbitant expense, cost more than $6 million, and take more than a year to develop. Game production times increase steadily as graphics cards provide more visual capabilities and the game-playing public demands more interactivity and verisimilitude.

The demand for better computer characters and story increases with the complexity of visual displays and with the release of each new, more complex-than-ever game. Game play innovation is becoming a competitive necessity. The big hits have been sports, first-person shooters, adventure, and *Sims*-type games. For the game industry to continue to grow, additional genres must become more sophisticated, with better backstories and thoroughly researched, developed, and deployed foundational game-play technologies.

The game-playing public is becoming ever more enamored of portable entertainment platforms, and computing speeds are becoming ever faster. These trends pose the critical challenge of providing well-designed interfaces, ever-increasing storage capacity, and expanded wireless network bandwidth. Efficient streaming of content to wireless portable devices and for game downloads from the Web will also become priorities.

## GAMES RESEARCH AGENDA

To influence the future of both serious and entertainment games, developers must create a research and development agenda that transforms the game production process from a handcrafted, labor-intensive effort to one with shorter, more predictable production timelines that still manage to provide innovations and increased complexity. This research agenda has three components: the infrastructure, cognitive game design, and immersion.

### Infrastructure

The underlying software and hardware necessary for developing interactive games include massively multiplayer online game architectures, game tion consoles, and wireless and mobile devices.

Many application domains use massively multiplayer online game architectures, including the military, security and homeland defense, and online education. MMOGs pose the fundamental research question of how to develop dynamically extensible and semantically interoperable software architectures. This functionality requires building game or simulation clients that can connect to a running MMOG, download the appropriate code for display and interaction, then operate with other online players. This work, of interest to gaming in general, has special relevance for the large governmental game-based simulation sector.

Currently, only static solutions that dramatically drive up the cost of large-scale simulation and gaming have been developed—no dynamic solutions are available. Developers must solve the MMOG architecture problem not just for game clients but also for large-scale computational architectures such as grid computing. Game engines and tools will be vital to researchers bent on attacking the lack-of-reuse problem in gaming. They can also provide the technology for moving games from crafted systems built by the game industry gnomes to engineered systems used widely in the government and corporate sectors.

The *America's Army* project has made some attempts to broaden first-person-shooter game engine reuse to other domains, but all such uses have suffered from major limitations.[3] For example, many game engines lack support for large terrain boxes and can only handle a 1 km × 1 km area even though most real-world applications require much larger spaces. Other limitations include onerous and expensive game-engine licenses and the general unavailability of these engines for R&D and to the serious games community at large.

Thus, developers need an open source game engine that includes a development toolset as widely available and utilized as Linux. With an open source engine, developers could explore additional capabilities, including a larger terrain box, dynamic terrain, physical modeling, and other requirements that the entertainment world ignores. In addition, an open source engine would make feasible exploring many other directions, including the modeling and simulation of computer characters, story, and human emotion.

Streaming media will play a prominent role in the delivery of dynamic content to PC-based games and mobile devices. This will gain more importance in games as computing becomes smaller, faster, and encourage research into the proper interfaces for such devices and in determining how to best deploy them for serious and entertainment purposes.

## Cognitive game design

Taking a cognitive approach to game development will give developers the tools to create theories and methods for

- modeling and simulating computer characters, story, and human emotion;
- analyzing large-scale game play;
- innovating new game genres and play styles; and
- integrating pedagogy with story in the interactive game medium.

Computer-generated autonomy involves modeling human and organizational behavior in networked games, for example, deploying the technology from a game like *The Sims* for a serious purpose, such as a training aid for nursing. Developers can use this approach to model and simulate hospital operations in game form, providing an immersive experience for the nurse trainee.

Creating a compelling computer-generated story has long been a game development challenge. To overcome this challenge, developers must computationally model story by deploying engines and tool suites that dramatically simplify the construction of networked game storylines.

The modeling and simulation of human emotion lies at the frontier of networked games and simulations. For the entertainment world, the future of gaming includes developing an experience so immersive that it engages the players' emotions on a visceral level. The military, homeland security, defense, and hospital trauma sectors need a similar game-based simulation capability that spans the spectrum of entertainment and serious game developers. This capability must be thoroughly researched to determine in advance its potential human impact.

Understanding and analysis will play a key role in the games research agenda. When researchers place humans in large-scale MMOGs or single-player modules, they must determine what happens during game play and how the experience affects the players. Current serious game usage and large-scale simulation require human monitors to watch networked play. When the game ends, the human monitor tells the researchers which team won and

To refine this process, developers must acquire an automated understanding and analysis capability that can generate a high-level report of what happened during game play over a specified period, from a particular viewpoint, with the option to query the system for additional detailed information. Several defense, homeland security, and educational applications require such automated analyses if gaming is to make meaningful contributions to the serious game domain. In addition, the entertainment industry might find such analyses useful as a marketing and game-refinement tool.

**Defense, homeland security, and educational applications require automated analyses for gaming to make meaningful contributions to the serious game domain.**

Pedagogy and story integration involve determining theories and developing practices for inserting learning opportunities into story, such that participants find the story immersive and entertaining because the embedded instruction remains subordinate to it. The game industry has already witnessed the failure of *edutainment*, an awkward combination of educational software lightly sprinkled with game-like interfaces and cute dialog. This failure shows that story must come first and that research must focus on combining instruction with story creation and the game development process.

## Immersion

Creating technologies that engage the game player's mind via sensory stimulation and providing methods for increasing the sense of presence contribute to building a feeling of immersion. This work includes:

- computer graphics, sound, and haptics;
- affective computing—sensing human state and emotion; and
- advanced user interfaces.

Sensory channel research plays a fundamental role in games technology. As they develop more capable graphics engines, researchers need to know how to appropriately use that new capability for serious games as well as how to generate new technology that industry can put into the next-generation graphics chipsets it provides.

Spatial and immersive sound are key components for whatever training and educational systems researchers build with gaming. Developers must implement future engineering requirements and human-performance engineering to ensure that they can employ sound appropriately and effectively

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