Competitive Impact of Game Technologies on Five Industry Segments

Roger Smith
Chief Scientist and CTO
U.S. Army Simulation, Training, and Instrumentation
roger.smith@peostri.army.mil

Abstract

This paper explores the impact that game technologies are having on five different industry segments. As they have matured, these technologies have proven to be very useful for a number of tasks that are different from their gaming origins. In this paper we explore the adoption of game technologies into the areas of entertainment, training, scientific analysis, decision making, and marketing. Each of these has found a use for game technologies that is unique and that is having a significant impact on the market positions of companies in these industries. Like the computer, Internet, World Wide Web, and IT services of the late 20th century, game technologies are empowering companies to create unique products and services in this early part of the 21st century. We explore how this is occurring and expose some of the reasons that it is happening. The changes that this fosters may significantly impact the market positions of established and emerging companies in these areas.

Author:

Dr. Roger Smith is the Chief Scientist and CTO for all U.S. Army Simulation, Training, and Instrumentation. He has been an active and visible member of the military simulation and training community for 20 years and has worked on crossover projects with game companies and game conferences since 1999. In his current position he collects, researches, and promotes innovative technologies that can be applied to military training and experimentation. Game technologies has been a central focus of this office for several years and Dr. Smith has published a number of papers explaining the impact that games are having on “serious industries”. Through the course of his career, Dr. Smith has published over 100 technical papers in the areas of simulation, games, business strategy, and mathematics. He holds degrees in computer science (Ph.D.), statistics (M.S.), mathematics (B.S.), and management (M.S. and MBA).

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Previous Waves of Technology Disruptions

In his Nobel Prize winning work, Robert Solow demonstrated that the advancement of technology has been responsible for 50% of the economic growth of nations in the 20th century. The application of these new technologies created new businesses and transformed established institutions, allowing them to be significantly more productive than they had been prior to applying the technology (Solow, 1957).

Computers have been one of the most significant technologies introduced into all institutions. Computers are computational, information handling, and telecommunications devices, all of which have brought significant innovations to the 20th century. Newspapers had been around for centuries as a primary means of sharing information with a large audience. But this all changed around 1920 when our understanding of the properties of radio waves allowed us to create radio broadcasting stations and news was suddenly turned into an electronic form that could be transmitted almost immediately into people's homes. Similarly, the performance theater lost its place as the primary delivery vehicle for acting when film and radio joined forces to enable broadcast television. Digital signal processing and miniaturized data storage transformed the music industry by creating Internet downloadable music and digital MP3 players.

Detailed computer graphics and animation had been relegated to academic laboratories and major military programs until companies like Evans & Sutherland, Silicon Graphics, 3dFX, and Nvidia introduced the computer graphics processors. Their success in the market and improvements in computer chip manufacturing led to the creation of a number of affordable graphic devices for all forms of computers. Today anyone can install a major graphic processor in their computer for less than $100. This has enabled the visualization, animation, texturing, shadowing, and lighting of a three dimensional world for use in any application with a need. The leading users of this capability have not been scientific researchers, but instead it has created explosive growth in the computer game industry. In a single decade it has risen from relative obscurity to a size that rivals that of the motion picture industry. Zyda (2006) estimates that the worldwide game industry was $33.5 billion in 2005 and may grow to $58.4 billion by 2007. As the industry has grown, the tools and technologies have struggled to overcome their stigma as a game or toy for entertainment. In spite of this, we are in the early stages of adoption of graphics and game technologies into a number of mainstream industries. Drawing from the 1970 book by Charles Abt, these applications of game technologies are known as "serious games" (Abt, 1970).

The early stages of adoption of such a powerful technology are attracting the attention of business, academic, and government leaders. It has also become a popular focus in the media in the last few years. It is not uncommon to see a new story on the use of game technologies for serious purposes in leading business publications every week, such as

the recent announcement by IBM of their foray into the Second Life online community (Konrad, 2007). This trend and the changes it promises appear to be poised to significantly impact the economies of a number of developed and developing countries. Just as India has become a serious player in providing information services, some country or cluster of countries is going to become a provider of serious game technologies. Currently this expertise is emerging in the United States, but once the business model has matured and a solid market is identified, other countries will focus their intellectual energies on this market as well. Several Eastern European countries, former Soviet states, possess significant intellectual talent and low operating costs that have allowed them to create some very successful game titles and to build a reputation as a potential development cluster for game technologies.

In this paper we will explore the application of game technologies to other industries, focusing specifically in five categories – entertainment, training, scientific analysis, decision making, and marketing. Figure 1 illustrates a path of technical innovation and transformation that has created the commercial and serious games industries. The evolution of technology has brought us the television, main frame computer, personal computer, and Internet. As they became available to large audiences, each of these have been applied to electronic entertainment, first in the form of game consoles, then as PC games, and finally as multiplayer games leveraging the Internet. These game technologies are being adopted by the industries listed above. The entertainment industry includes much more than games. Game technologies are appearing in major movies, television programming, news broadcasts, and sporting events. The military has always be a user of leading computer technologies, but as they adopted computer games they laid the groundwork for the applications of games to a number of other serious applications – specifically in training, analysis, decision making, and marketing.

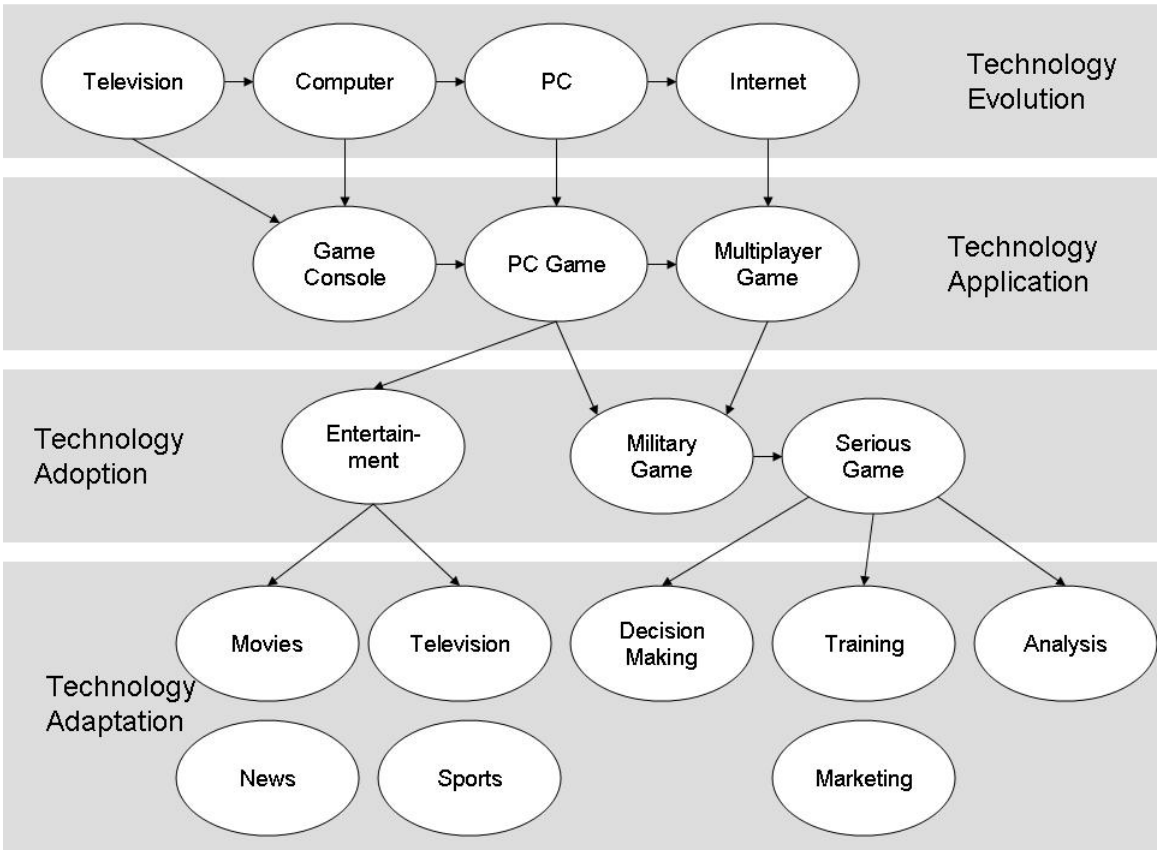

Figure 1. The emergence and adoption of necessary technologies to create and drive the global explosion in game products and services.
Source: Created by the author

Creative Destruction

In 1942 Charles Shumpeter wrote *Capitalism, Socialism and Democracy* in which he discussed the long-term viability of a capitalistic economy (Shumpeter, 1942). In that book he also described the impact that change has on business and the economy.

> "We must now recognize the further fact that restrictive practices … as far as they are effective, acquire a new significance in the perennial gale of creative destruction, a significance which they would not have in a stationary state or in a state of slow and balanced growth."

This description and one phrase in particular, have become famous among modern economists and business leaders. Shumpeter cast a positive light on "creative destruction", the impact that change, technology, and knowledge have on the current state of the economy. An economy that remains static or grows slowly is not in the clutches of the forces of growth. When significant growth is occurring it will lead to the destruction of existing structures and the devaluation of skills that were previously essential. This is a positive force that creates more opportunities than it destroys. However, it can also be very painful because most people and businesses cannot clearly see where the new value

is being created and must often suffer the loss of income and jobs before they can enjoy the fruits of renewal and growth.

Shumpeter's ideas were reinforced by the writings of David Wells, who insisted that:

> "It seems to be in the nature or natural law that no advanced stage of civilization can be attained, except at the expense of destroying in a greater or less degree the value of the instrumentalities by which all previous attainments have been affected." (Perelman 1995)

Like Schumpeter, Wells recognized that advancement required the destruction or abandonment of practices, skills, and endeavors that were the basis for previous attainments.

Smith et al (2001) studied the impacts that changes have on the competitive positions of companies. He found that, "A creative action carried out by challengers disrupts the competitive status quo and forces industry leaders to respond and also to be creative." Further study indicated that, "The more new competitive actions a challenger takes, the greater is the competitive uncertainty on the part of industry leaders, which will cause a delay in their reactions." This indicates that maintaining the status quo in a business can lead to the loss of a leadership position to a competitor who is willing to race from one change to another. Those who change slowly will find themselves reacting to the change leader and may find that they lose their market leadership to the change leader. Smith demonstrates this through studies of a number of companies in different industries. Figure 2 compares the market shift between Reebok and Nike in the sports shoe business. In the late 1980's Reebok held a significantly larger market share than Nike. However, Nike began to introduce innovations to its products, partnering, and marketing. It made more changes per year than Reebok. During this time there was a corresponding shift in market share away from Reebok and toward Nike until by 1993 the two had nearly reversed their positions from 1987. This illustrates Smith's point about the significant impact that business innovations can have on the balance of leadership in an industry.

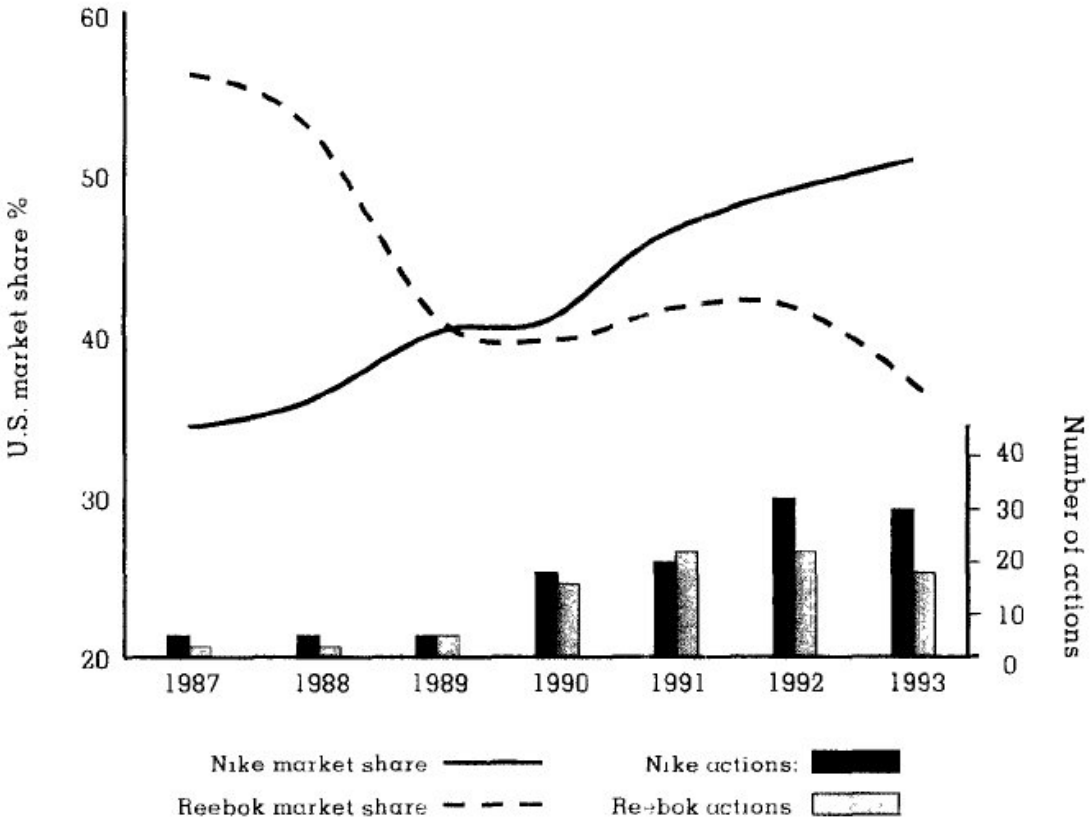

Figure 2. Action aggressiveness between Nike and Reebok
Source: Smith et al 2001

Reinganum (1985) also points out that challengers always invest more in innovation and changes than do incumbents. This means that monopolies are often short lived because a challenger will soon innovate and spend their way into a leadership position. She applies the Nobel winning "Nash Equilibrium" from Game Theory to demonstrate that these innovators are more likely to win competitions among "n" players in business competition.

Popular authors in the business press often turn to Shumpeter's ideas to both justify and explain the temporary negative impacts that come from technological change. These explanations will soon need to be applied to industries falling under the influence of game technologies.

Spread of Game Technologies

One of the earliest published books on "serious games" came out in 1970 from Clark Abt, an MIT graduate who was focused on improving the educational system. In that book, Dr. Abt introduced the term "serious games" which has been adopted more recently in reference to computer-based games. Though Abt's games were all based on manual role playing or traditional board games, the concepts behind using entertainment techniques for a more serious purpose was identical to the transformation that is emerging from computer game technologies today. Abt describes "serious games" in this way:

> "Reduced to its formal essence, a game is an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context. A more conventional definition would say that a game is a context with rules among adversaries trying to win objectives.
>
> "We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement." (Abt, 1970, p.9)

As computer games became more common as tools for serious industries, a number of authors attempted to create more descriptive definitions for the term. Zyda (2005, p.25-26) approached the challenge with a series of definitions leading up to one for serious games.

> Game: "a physical or mental contest, played according to specific rules, with the goal of amusing or rewarding the participant."
>
> Video Game: "a mental contest, played with a computer according to certain rules for amusement, recreation, or winning a stake."
>
> 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."

Michael and Chen (2006, p.17) defines it this way:

> "a serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment"

Michael and Chen also provide a definition from Bernard Suits' book, *Grasshopper: Games, Life, and Utopia*:

> "To play a game is to engage in activity directed towards bringing about a specific state of affairs, using only means permitted by rules, where the rules prohibit more efficient in favor of less efficient means, and where such rules are accepted just because they make possible such activity." (Michael, 2006, p.18)

As early as 1970, Abt was able to identify a number of industries within which to apply games.

> "Education, industrial and governmental training, planning, research, analysis, and evaluation are all rich fields for the use of serious games" (Abt, 1970, p.10)

In a previous paper I compiled a list of industries that were known to be using games and game technologies to push their products and services forward. That compilation is shown in Table 1.

Table 1. List of industries impacted by games and game technology.

Industry	Game Technology Impact
Military	Training soldiers and leaders in the tactics and strategies of war. Three dimensional modeling of equipment to illustrate or explore its capabilities.
Government	Ethics training for NASA. Project management training for the State of California.
Education	Augmenting classroom instruction in nearly every subject – English, math, physics, history, etc.
Emergency Management	Training emergency responders, firefighters, FEMA agents, and others to deal with disasters.
Architecture	Visually promoting major hotel, casino, and office spaces to potential clients.
City & Civil Planning	Lay out and experimentation with public services for a population of constituents.
Corporate Training	Orienting people to company products, facilities, and policies. Pilot and safety training.
Health Care	Educating patients on treatments, rehabilitation, and managing anxieties. The next generation of workout videos.
Politics	Presenting political issues and consequences of political decisions. Promoting candidates.
Religion	Interactive versions of sacred texts. Tools to teach religious history.
Movies & Television	Tools for creating animation and 3D worlds. Alternative form of storytelling known as “machinima”.
Scientific Visualization & Analysis	Rapid display of objects under experimentation and physical forces acting on them. 3D display of data collected and analyzed.
Sports	Recreate live sporting events for review and for prediction of potential outcomes. Design and rehearse critical “one time” events like Olympic ceremonies. Fantasy sports leagues in 3D.
Exploration	Prepare missions for NASA Mars Lander. Recreate environments around deep sea probes.
Law	Illustrate crime scene activities for judge and jury. Analyze crime scene data.

Sources: Compiled from Michael & Chen, 2006; Bergeron, 2006; Casti, 1997; Maier & Grobler, 2001

In his 1968 work, Elmagharaby identified five applications of simulation techniques and technologies. At that time, and from Elmagharagy’s perspective in operations research, the term “simulation” largely referred to languages for discrete event simulation and mathematical techniques for optimization. However, in spite of that, these five areas continue to be very descriptive of the modern use of simulation and can be applied to the

serious games business as well. Figure 3 illustrates Elmagharaby's uses for simulation and adds one that was perhaps not viable in 1968.

- Aid to Thought. They apply a computer's memory and ability compute on a massive scale to the human's very limited ability to do these same operations. As a result, humans are able to think about larger problems while maintaining accuracy and consistency.
- Communication. Simulations can assist in communicating ideas from one person who understands them to another person who is seeking understanding.
- Prediction. The accuracy and logical construction of simulations makes them a valuable tool in predicting the future state of a system or a problem.
- Experimentation. Simulations are often used as a computer-based laboratory in which experiments are conducted. Many problems cannot be pursued in the "real world" because of safety limitations or our inability to collect data in all circumstances.
- Training. Simulations are an engine for replicating a situation and presenting it to a human audience as a challenge to be solved. Many authors point to the repeatability of simulation as an ideal environment in which to learn with feedback.

The sixth application of simulation that is added here is as a tool for entertainment. As technologies become affordable, the consumer entertainment industry always adapts them to games, toys, movies, and other forms of entertainment. Today we find simulation in a number of computer games and in all animated movies.

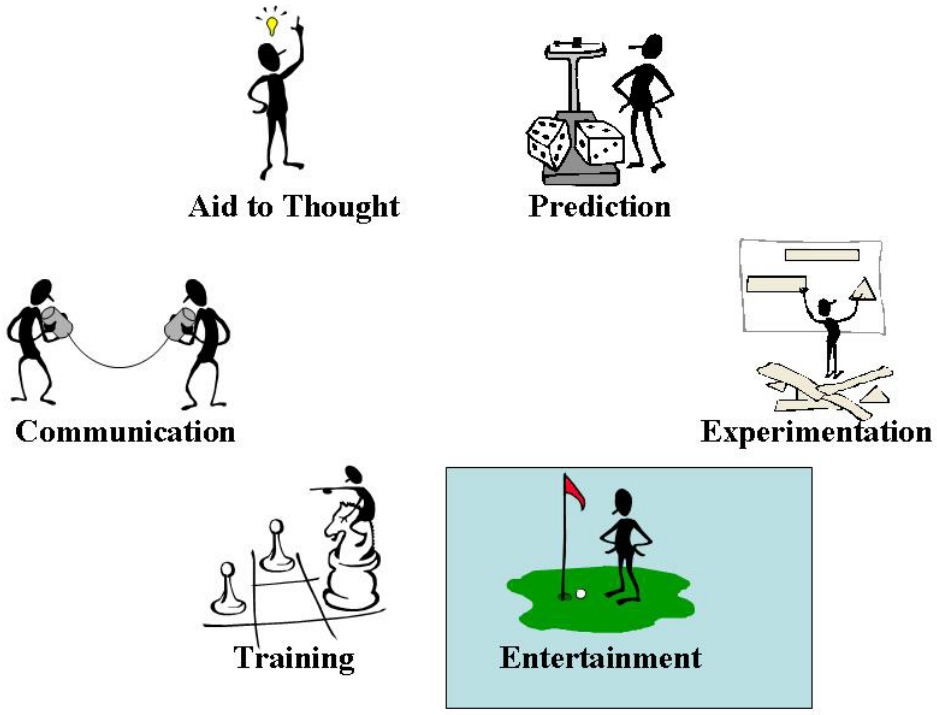

Figure 3. Elmaghraby identified five major categories of the application of computer simulation. Entertainment is added as a sixth category.

Source: Created by the author based on Elmaghraby, 1968.

Though games emerged much later as a useful application of computers and simulation techniques, they have progressed so rapidly that game technologies are now returning to their roots to offer improvements to a number of more serious applications.

Core Game Technologies

In a previous research project I identified six core technologies upon which games are built, and which offer significant value to serious industries (Figure 4). These technologies are:

- 3D Engine for visualizing the virtual world,
- Graphical User Interface for control and management of the simulation/game,
- Physics Models for realistically representing actions and interactions of physical objects,
- Artificial Intelligence for representing the reasoning powers of characters or objects,
- Global Networking to connect multiple players together in a shared virtual world, and
- Persistent Worlds to allow experiences to be cumulative from one session to another and to provide coherency across numerous player experiences.

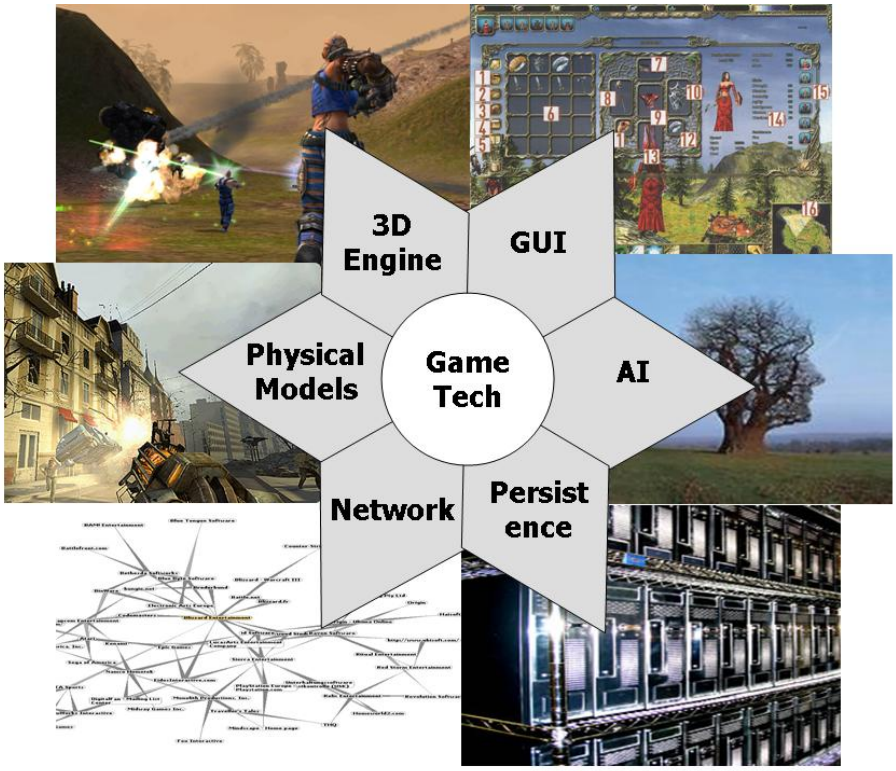

Figure 4. Six core technologies that drive computer games.
Source: Smith 2006

These core technologies play an important role in the spread of games to other industries.

Disruption of Established Industries

There have been a number of technologies that have significantly changed many industries in the last two decades, including computers, the Internet, business information technologies, and cellular communications. The changes wrought by these may provide clues to changes that lie ahead in the adoption of game technologies. Following in the steps of the dot.com boom, the game industry presents a powerful value proposition for adopting them. Bergeron (2006) identified five benefits of adopting game technologies in serious industries:

- Economics. These tools have lower costs, broader dissemination potential, and wider accessibility.
- Educational Effectiveness. Games have the ability to illustrate ideas clearly and to communicate to large audiences. Games are an infinitely patient tutor that can repeat material until the student grasps it.
- Efficacy. They connect with students through visual, auditory, tactile, and emotional stimuli. Combined, these are more effective in games that attempt to change behaviors or change implicit self-image.
- Emergent Behavior. Sufficiently rich games create an environment with multiple logical paths and unforeseen advantages to player cooperation. These allow emergent and unpredicted behavior from the players.
- Social Impact. Multiplayer games create a social space in which players create a community with standards, mores, ethics, relationships, and extensive conversation. These social spaces often transcend the boundaries of the game environment and extend into the physical world.

Using the works summarized in the tables and figures above, we have identified five major categories for the application of game technologies. These are:

- Entertainment,
- Training,
- Scientific Analysis,
- Decision Making, and
- Marketing

Establishing and specifying these categories will be the focus of the rest of this paper.

Entertainment

Computer games began as research experiments in university labs. The first is considered to have been “Spacewar!” developed by scientists at MIT on a DEC PDP-11 computer (Figure 5). That game represented two spaceships that fire small missiles at each other. Each ship was controlled by a joystick input device and displayed on a circular screen. The similarities with the arcade game of Asteroids are very clear (Dodsworth, 1998).

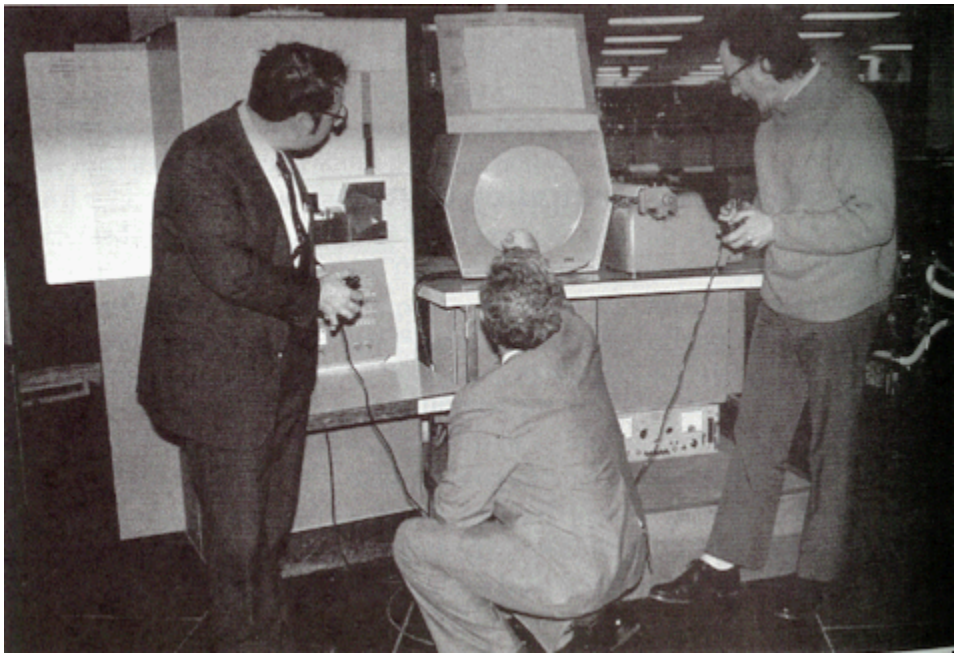

Figure 5. Researchers at MIT working with the first computer games – Spacewar!
Source: Dodsworth 1998

Gaming Arcades vs. Pinball & Shopping

Commercially the first arcade game was PONG which was delivered to pinball arcades, pool halls, and bowling alleys in 1972. Developed by Nolan Bushnell and distributed through his newly formed Atari Corp., this game began the transformation of analog pinball games into digital arcade games. At the same time, Magnavox released the Odyssey home gaming system. This included the game of PONG which they claimed Bushnell had copied and Magnavox filed a law suit claiming patent infringement (Sheff, 1999 and DeMaria & Wilson, 2004).

In 1972, the digital computer game moved into pinball arcades and into people's homes simultaneously. The popularity of the new devices created a rush of imitators and began the growth of game arcades and home entertainment consoles. DeMaria and Wilson (2004) provide a clear history of the emergence of arcade games. In this paper we are most interested in the business disruption impacts of those games.

Pinball machines had been in existence since 1871 and a number of companies had been founded upon them. Pacific Amusements added electricity and a ringing bell in 1933 and more complex electrical bumpers, gates, and flippers began to appear in 1947. These devices continued to evolve, adding minor computerization in the 1970's. But their form was largely fixed by then (DeMaria and Wilson, 2004).

Computer arcade games like PONG eliminated the metal ball and the use of gravity as a primary power source. They opened the door to create many new forms of games incorporating sports themes like ping pong, tennis, and handball; space themes like Space Invaders, Asteroids, and Defender; and abstract themes like PacMan, Tempest, and

Tetris. These games introduced computer graphics, human interfaces, and audio to the general populace and to the entertainment business (Bushnell, 1996).

Arcades created a casual part-time customer. They could be used to attract crowds to businesses like bowling alleys, restaurants, and shopping malls. In the latter case, arcades added a child attraction to the shopping mall experience that was geared around adults. In a survey of the connection between entertainment and shopping behaviors in 500 large malls, Kim et al (2005) determined that "a good amusement area for children" was a desirable feature in the mall environment. However, those authors did not specifically investigate the role of the game arcade. Bloch et al (1994) report that 21% of people in a mall are there to "consume services" such as movie theaters and game arcades. But only 7.2% report that they have played a video game at the mall. Compared to other non-shopping activities carried out in the mall environment, this is relatively low and suggests that games do not contribute significantly to mall revenues. But games are part of the "habitat" described by Bloch that encourages people to spend their time in the mall. A habitat is an environment which meets people's needs, effectively creating an alternative to their home. Both Barnes (2005) and Bloch et al (1994) admit that relatively little research is done specifically on mall shopping behavior. Therefore, it may not be possible to quantify the impact that game arcades have had on behavior and shopping in these environments.

Home Consoles vs. Television

Consoles like the Magnavox Odyssey and the Atari 2600 moved the casual arcade game into the home. This meant that customers could play the games as often as they liked and without feeding a constant stream of quarters into a machine. However, rather than replacing the demand for the larger, more powerful, and more colorful arcade versions, they seem to have increased the appetites of customers for the more advanced arcade games and for the social environment that was growing up around the arcades.

Home console gaming became a popular leisure activity like watching television. It was always accessible, required little physical activity, and could be played alone or with other people. This began the current 35 year incursion of gaming into the space previous held almost solely by the television. As gaming has grown more popular, this has become a serious threat to the advertising revenue that drives television programming (Bushnell, 1996).

Home PC vs. Web Surfing

Games on the home PC extend entertainment to a machine that was previously purchased for "serious" applications like online communications, banking, and education. In moving to this machine, games became instantly accessible to professionals who may not have been inclined to purchase a game-specific console. This move leverages the already developed expertise that the audience has with the PC to smoothly transition them into gaming.

Each move to a new venue or a new device extends the circle of users and the time spent on games. The trend in the game industry is to find an opportunity for people to access computer games any time and any place, following similar previous patterns for cellular communications, computing, and Internet access.

Portable Handheld Gaming vs. Radio and Digital Music

The introduction of portable handheld gaming devices like the Gameboy series (Standard, Color, Advance, SP, DS, and DS Lite) and the Playstation Portable (PSP) moved gaming from a fixed site activity to one that is portable and accessible in any environment. These devices are to casual activity what the Blackberry and Treo are to mobile business activities. They displace other activities that filled spaces while traveling or away from a desktop computer. In business, mobile computing and communication devices encourage people to be constantly connected to the electronic web of relationships. They no longer use travel and waiting time to read, think, or relax. Instead this enables them to do traditional office work in the mobile environment. Portable gaming devices extend electronic entertainment to these same spaces. They allow the displacement of previous non-digital activities with "always on" gaming.

The newest Gameboy DS device also contains an 802.11 wireless connection that allows a player to interact with others who are playing Gameboy DS titles anywhere in the world. This means that multiplayer gaming has also moved to the mobile spaces.

Cellular Gaming vs. Cellular Communication

The success of cellular telephones has been driven by an increasingly busy and mobile lifestyle and by their ability to sustain networks of relationships via voice conversations and text messaging. As these devices have become more powerful, their larger color screens, computer processors, and network bandwidth have made them attractive devices for gaming applications. Shuster (2003) estimates that games for cellular phones is a $350 million business. Manufacturers and service providers see gaming as a means of selling devices and advanced services. Just as people once upgraded their computers to be able to play the newest games, the cellular providers are hoping that games will drive this trend in their space as well.

In many ways, cellular gaming is socially similar to portable game devices. However, the major difference is in the ubiquity of cellular phones and the access to an audience that is not limited to those who invest in a game-specific device. The trend is similar to the move from home game consoles to the home PC - both allow the gaming industry to access people who purchase an electronic device primarily for serious purposes, but who are willing to add games to that device.

Hybrid Devices vs. Physical Activity

Interesting combinations of devices are being created to explore a less passive application for games. The largest category of hybrid devices is in exercise equipment, or

"exergames" (Michael, 2006). The first step was when game arcades introduced dancing games that required a player to stand on a platform and control the game with very basic dance moves. The success of these devices in Japan spread to America and Europe and demonstrated that physical activity in conjunction with gaming was acceptable to the customer base. Games like *Dance Dance Revolution* have been very successful titles in the arcades and on home consoles, and have driven the sale of peripherals like the electronic floor mats that are the controllers for game consoles.

The Eye Toy for Playstation 2 uses a camera as an input device. Given the right lighting and background, the camera can identify the movements of a player in its field of view. Those movements are then applied in the game to kick a soccer ball, slap balloons into the air, or knock down plates and other objects in the virtual world.

Specialty exercise machines have been created for the game consoles and for home PCs. These devices often mimic the movements of a treadmill, stair climber, rowing, bicycle, or cross country skiing machine. Working with the exercise equipment causes the scene in the game to change so that an exercise bicyclist may experience a virtual ride through the countryside. Hills in the virtual world can be translated into increased pedal resistance on the exercise equipment and turning to the left or right with the bicycle causes the virtual rider to veer off of the trail and into the woods (Michael, 2006).

Each of these devices demonstrates the penetration of computer games into activities that traditionally include physical exertion. Games are becoming a ubiquitous part of society and our lifestyles. Just as computer scientists predicted that their hardware would become ubiquitous in society, it appears that gaming applications are a significant part of the reason that people adopt new computer equipment.

Technology Insertion

Many industries are adopting game technology to other forms of entertainment, but without keeping specific game characters or storylines. Television weather reports are now animated with game-like tools. They are no longer limited to the simple two-dimensional artwork of just ten years ago. The weather is now animated and three-dimensional. Similarly, sportscasts can be enhanced through the use of games like Madden NFL and College Day. These games can portray specific teams and even specific players in near-perfect renderings. They allow a sportscast to recreate specific plays, examine them from a number of angles, and even create variations that cannot be accomplished by replaying film footage. Major League Baseball commissioned a game development team to recreate entire real world baseball games using the tools and environment of Second Life (Carella, 2006).

Experiments are underway to cross print, television, and gaming advertising. Promotions are being created to move the advertising audience from a television commercial, to the purchase of a magazine, to visiting a web page, to entering a game for points or clues that allow people to compete for prizes. These treasure hunt stories have been used for years,

even going back to radio advertising, but their extension to game environments is new and untested.

Figure 6 summarizes the growth of games and their impact on a number of previously established entertainment formats.

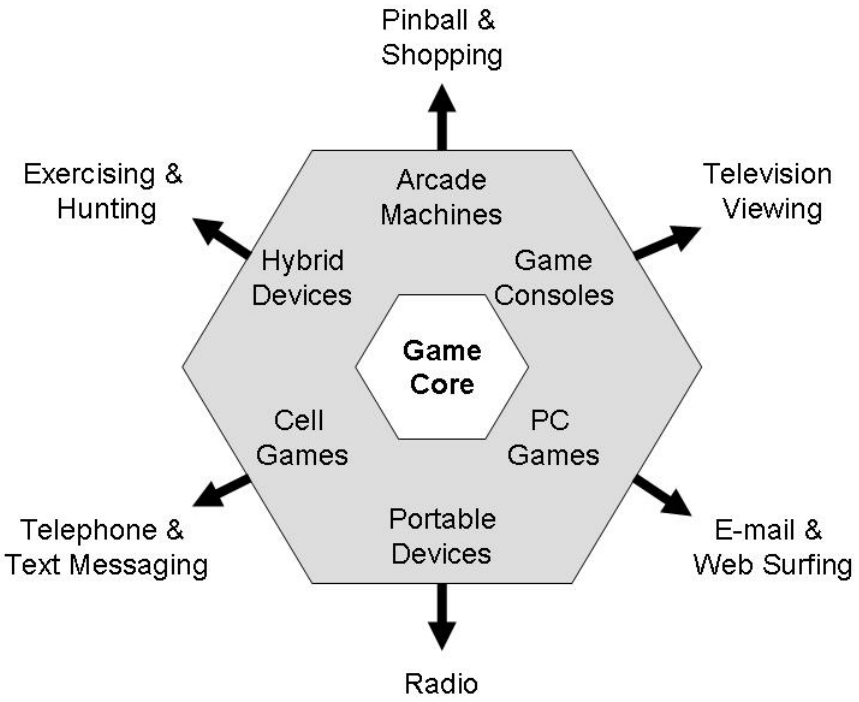

Figure 6. As games appear on a new electronic device, they compete with established activities.
Source: Created by the author.

Training

Training is an essential function within all organizations. Distinct from education, training focuses on conveying or mastering specific skills that will be used for specific jobs by specific people. Public and university education prepare people to learn to work in a profession, providing more of a broad foundation of knowledge. Specific applications require unique knowledge and skills, often unique to a single company or job position. Conveying the necessary knowledge is an expense to the organization in both time and money. The cost of instructors, instructional materials, classrooms, and student time can be significant. Games appear to be able to reduce the costs of training and to improve its effectiveness in some cases.

Bloom (1984) has shown that one-on-one tutoring can improve a student's test scores by as much as two standard deviations. This can effectively move a student from the 50^{th} percentile of a class to the 96^{th} percentile. Though tutoring is extremely effective, it is also very expensive and time consuming. Even if there were no financial costs for a tutor,

there are not enough domain experts available to serve all of the students seeking instruction. Because of the costs and limited availability, self-directed study has always been an option to formal classroom or tutored study. Correspondence learning requires that the student learn at his/her own location and often on his/her own time. This extends learning to a much broader set of students and it reduces the cost of delivering the training. Computer-based training (CBT) and web-based training (WBT) have become a very large business because of the significant cost savings involved. Computer games offer a richer environment in which to host computer-based training and student collaboration.

Like all learning materials, games attempt to communicate information in a form that is accessible to the student and that motivates the person to learn. A study by The Learning Federation (2006) identified a number of themes that are driving the training business to a game-based solution. These are:

- Accessibility. Games have lower costs for materials and staffing.
- Believability. Games present a 3D environment that is so similar to the real world that lessons fit well into their natural environmental context and are more believable.
- Engagement. Games can interact with the student in more ways than simple online tests. These engagements keep the students' attention and increase their learning experience.
- Accuracy. Given a richer environment, games can create a more accurate representation of the real situation than can materials like textbooks and 2D images.
- Variability. Games can present situations in many different forms and in various contexts to reinforce lessons and to show special cases.
- Measurability. Games allow the numeric collection of performance data. These measurements enable scoring and identification of the tasks that the student has not mastered.
- Repeatable learning loop. Games are infinitely patient. They can take a student through identical or similar scenarios as many times as it takes for them to learn the lessons.

Though the advantages described above do exist, there remains some question as to the effectiveness of game-based training. Like all other forms of training before it, we expect this method to be less effective that real "on the job training", but we do not know how it compares to older forms of training. A recent study by the Federation of American Scientists emphasized that games may develop higher order thinking, but they were careful not to assume that this was true in spite of potential advantages like those listed above (FAS 2006a).

In another document generated by that same study, the Federation of American Scientists identified some specific learning advantages of games (FAS, 2006b):

- Contextual bridging. Students are able to apply lessons from 3D games much more readily to the real world because of the similarity of the two environments.

- High time-on-task. Because of the high level of immersion and interactivity, students spend a significantly larger amount of time on tasks in a game environment than with other learning materials.
- Motivation and goal orientation, even after failure. Students are highly motivated to complete tasks successfully. Failure in game situations does not seem to discourage students, but encourages them to try different tactics.
- Providing learners with cues, hints, and partial solutions to keep them progressing. Game environments can subtly provide students with hints on how to perform tasks. Like a good tutor they can be programmed to recognize when a student is choosing an incorrect path and give hints as to why they should change direction or tactics.
- Personalization of learning. Games allow the student to personalize their avatar in the game. This customization builds a stronger relationship between the student and the materials. Given some basic information, the game can also address the student by his/her preferred name and make references to other personal interests.
- Infinite patience. Games do not become irritated or impatient with students who learn at different rates. The game does not insist that people learn within a specific number of iterations or in a specific order. They present an ever-present environment that can be explored.

The Learning Federation has observed that the "expense and related challenges often cause both formal education and corporate training to rely on strategies that ignore the findings of learning research" (TLF, 2006). Like computer-based training before it, games have the potential to bring additional learning techniques into an affordable range for industry, government, and academia. Moving more of the knowledge and skills of human instructors and tutors into an interactive, self-directed environment like a game can potentially extend this limited resource to a much higher number of students and spread the costs of the tools broadly enough to make them affordable.

However, TLF also observed that the training and education market is highly fractured. Public schools are divided into independently funded counties, companies structure their own internal training, and government spending is divided into thousands of small offices. They concluded that this audience is divided into too many small pieces to be able to afford the high development costs of building a game from scratch. Their recommendation is that federal funding be used to create the foundation for many of these potential customers. However, in contrast to this perspective, an entire "serious games" industry is springing up to leverage game engines, tools, and artwork that have already been created for entertainment. Serious games companies license these after the development costs have been recovered by their creators through the marketing of a successful game. These companies operate with very limited budgets, often encouraged by the generous licensing arrangements from the game product creators. Many of the major game development companies allow smaller companies to use the tools for free up to the point that they create a commercial title. This means that small studios can build their expertise, create demonstrations, and win clients before paying for licenses.

This approach has been working very well for companies focused on a wide variety of customers. In the training space, successful projects have been created for customers in the military, emergency management, government, education, health care, airlines, and heavy industries.

Scientific Analysis

The 3D engine that creates the visualization for games is a powerful graphic processor known generically as a scene-graph. The images that it produces are simply game specific versions of 3D scenes that are created in a number of different scientific disciplines. Computer Aided Design (CAD) tools allow engineers to create digital models of physical products like automobiles, aircraft, and kitchen appliances. Movie animation tools do the same for computer generated movie characters like those introduced in Pixar's Toy Story and the evolutions that have followed. In games, CAD, and animated movies there are two essential tools for creating the 3D world. Modeling tools are used to design static 3D representations of physical objects. Graphics engines or scene-graphs animate the static models by driving interactions between the objects and with other items in the environment.

Data Visualization

A number of research laboratories employ supercomputers to analyze the behavior of nuclear explosions, geologic movements, weather patterns, astrophysics, and other complex phenomena. These analyses typically begin with a numerical model that represents the movement and interactions of thousands or millions of subcomponents of an item or event. These computations generate extremely large volumes of numerical data that must be analyzed mathematically and statistically. Potentially, all of the insight embedded in this data can be extracted numerically. However, in practice scientists have found that visualization is an extremely powerful tool for understanding the behavior of the data and looking for anomalies in the models that created it.

Robert Rosner, the Director of Argonne National Laboratory, explained that he was originally skeptical of the real value of visualization in the work of the energy labs. However, in one case an Argonne project used a giant, high-resolution display to plot every single data point that had been calculated by their models. Prior to that, much smaller plots were created from a thinned or averaged data set. But when every point was visualized, the scientists noticed a pattern in which aberrant behavior appeared at repeating thresholds in their equations. This visually exposed inaccuracies in the model which were too subtle to be readily identified statistically. Understanding the importance of this, the director became a champion of data visualization and now supports its use whenever possible (Rosner, 2006).

Current game engines lack the fidelity to present the high resolution data that come from many scientific models. But they are a base from which to create such tools as part of a serious game project.

Graphing and Animation

Animations of solar systems, molecular arrangements, and chemical reactions represent small scale problems for which game engines can be readily applied. These tools present significant value in lowering the price of animation and in extending access to the tools due to their relative ease of use compared to traditional animation packages. Commercial quality game engines can be licensed for a few hundred dollars, where more traditional visualization tools cost many thousands of dollars for a similar license. Additionally, game engines are designed with an "application programming interface" that allows programmers to attach new software to the game engine to drive it. This means that the game engines can potentially be connected directly to scientific software that is generating data to be visualized.

Presentation

Both traditional science experiments and the more recent computational science contain information that is often difficult to grasp or to communicate. 3D visualization engines are a means for communicating this information to disparate audiences. Rather than creating traditional "science museum" plaster models of human organs, a game engine can create a moving 3D visualization of the inside of the body at work. It can also add the sounds that should be present in such a scene and inject virtual chemicals that will circulate through the system.

These visualizations can also be deployed on desktop computers rather than the more expensive scientific workstations that are called for by other tools.

Immersive Navigation

Science fiction authors have presented stories in which military, medical, scientific, and maintenance personnel navigate a real space by immersing themselves into a virtual representation of that same environment. This technique has become reality in many modern systems.

Maintenance personnel for the Boeing 777 aircraft have access to a virtual overlay repair manual. The repair person can don see-through display glasses and approach the aircraft. Projected on the glasses is a schematic of the aircraft engine that is superimposed over the real engine in front of him. The schematic may include labels to identify all of the parts and may color code the part that is to be worked on. When it comes time to do the operation, the schematic may even show an animated instruction sequence that indicates the best method of performing the operation. Potentially this can allow a repair person to work on a specific problem for which he has not received prior in-class training. In military environments this can allow a skeleton crew to work on a wide variety of equipment by learning specific information just as the skill is needed (Boswell, 1998).

Similar displays are being used to position radiation sources around a patient who is about to receive treatment. A 3D overlay augments a technician's native ability to

visualize the location of the tumor and the exact angle of alignment for equipment. The visualization also has the power to identify dangerous situations and to alert the technician to check for these before proceeding with treatment.

In these cases, it is the raw graphics processing power of the software game engine and the hardware graphics card that are desired. Older systems typically had to simplify the displayed information because of limited computing power and limited budgets. But as games and graphics cards have become more powerful, they have opened the door to much higher resolution than existing overlay/navigation systems based on older hardware and software technology.

Research Collaboration

When research is carried out in multiple facilities, a means is needed to exchange working data, leverage laboratory resources at each facility, and collaborate among all parties involved. The new generation of Massively Multiplayer Online Games (MMOGs) are designed to accomplish these types of needs for the entertainment community. An MMOG creates a shared virtual world that can be entered by a large number of participants from around the globe. The virtual world is persistent because actions taken there or objects deposited remain in those locations until acted upon by a participant.

For scientific research, this means that data, or an icon that represents and locates a data set, can be deposited in the virtual world by one player and retrieved, copied, or processed by any number of other players. Currently, Second Life is the environment that is most supportive of this type of operation. It allows participants to load graphics, textures, documents, presentations, and a number of digital data forms into the world. These can be viewed and manipulated in the world or downloaded to a local computer for manipulation (Figure 7).

Figure 7. The Second Life environment allows participants to upload and share digital files such as this Microsoft PowerPoint presentation that is being projected on a virtual screen within the game.

Source: http://freebeer.com.au/

Social structures have evolved within all MMOGs. Players have created teams, guilds, societies, and alliances that bring them together for a common purpose. These groups hold regular meetings to discuss their missions and to manage the operations of the group. Many of these are run like business operations, even to holding weekly teleconferences with participants to conduct group business and plan future quests (Steinkuehler, 2007).

Second Life has also become a popular venue for holding university classes, distributing assignments, and presenting work completed. It can be used in the same way to bring together researchers for collaboration or to partition work among remote participants.

Decision Making

Leaders in business, government, academia, military, and non-profit organizations are faced with the necessity of making large numbers of decisions every day. The study of decision making and the techniques employed in it is quite diverse. In general, people are guided by principles, objectives, and information. Establishing principles and objectives focuses a decision, but evaluating all information available tends to diffuse the process. Also, many decisions involve multiple parties with different objectives and principles. Therefore, decisions often must be compromises designed to partially meet the objectives of each party, rather than optimizing for any one party (e.g. Janis, 1989; Jennings and Wattman, 1998).

Historically, decision makers have turned to advisors and reliable sources of information to aid them. More recently, computers have been employed to organize large volumes of information and to present multiple perspectives on a problem. Within the field of artificial intelligence, computers are also programmed to provide advice. These programs attempt to codify a body of knowledge and process it according to specified rules. The value of the advice generated is proportional to the degree to which real world information and considerations can be encoded into a form that can be processed by a computer. However, limits in technology, time, and funds available to create such systems impacts their ability to provide actionable advice. These limitations apply to games and the decision making systems that are derived from them.

Reasoning

Computer games contain simplified artificial intelligence (AI) algorithms that enable computer controlled characters to act somewhat intelligently in a very restricted environment. Typically, the AI is custom designed for the physical space in which the action is taking place and with prior knowledge of all of the relevant objects that will be involved. Game reasoning is not general purpose or universal. It attempts to mimic intelligence in a limited space, not be intelligent in a number of different circumstances.

Understanding this limitation indicates that, to be effective, a game may need to be based on a knowledge base of prior situations that were very similar to the one in which a

current decision maker is involved. Because game reasoning is so customized, it may not be appropriate for unique new situations for which prior data is not available. This is similar to the requirement for medical expert systems which are designed to assist doctors in making a diagnosis.

Illustration and Demonstration

Games can provide a valuable environmental context into which data is injected from other programs. Just as maps are used to provide background and context for reports on the movement of military units on the battlefield, creating a realistic environment in which to portray facts that are relevant to a decision maker can make valuable contributions to understanding those facts.

The animating power of games is ideal for demonstrating the dynamic characteristics of data and to inject the results of specific actions taken at different times within this dynamic environment. A recorded interactive game session may be shared in the same way that a movie is shared. Setting up a situation and allowing a team of people to experience the same space in which decision makers are working can convey an appreciation for the complexities involved that is not possible with non-dynamic, non-interactive tools.

Quantification and Comparison

As digital environments, games are able to record numerical results of actions taken. This can be processed objectively and remove much of the human bias that creeps into decision making that includes a number of people with varying agendas. There are a number of business games that achieve this. Tools like “Mike’s Bikes” place teams of business students into an environment in which they compete against each other to maximize the sale of bicycles and company share price (Figure 8). These games are formula driven, quantifying every decision and keeping a record of the results of each. In Mike’s Bikes the actions of each team have an impact on the results achieved by the others as well, creating an interactive competitive environment. All teams are developing, marketing, and selling products into a single virtual market with a defined level of demand for the product.

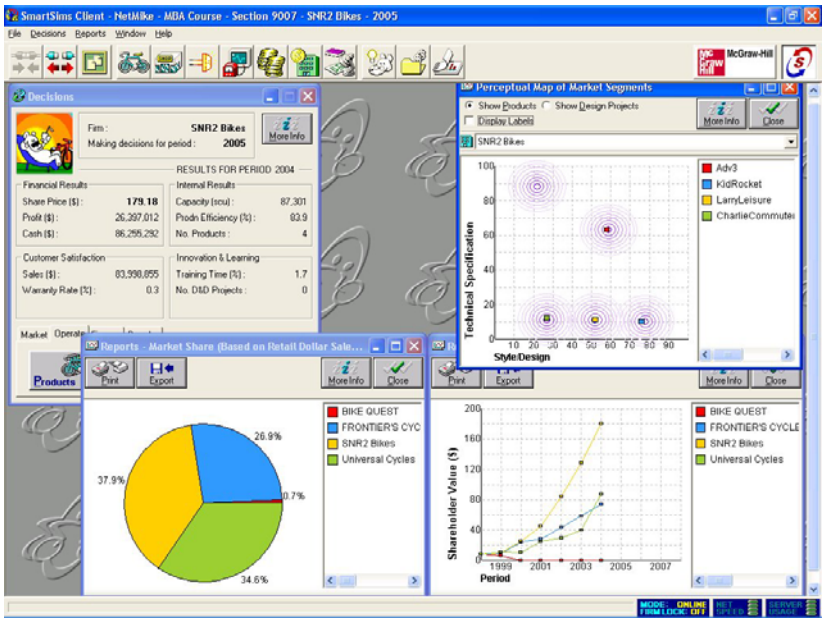

Figure 8. Mike's Bikes from Smart Sims is a game that emphasizes the importance of understanding competition in business decision making.

Given the quantification of multiple decision paths, computer systems can be used to compare the results of each and the consequences expected. Games, like business, usually portray a win-lose scenario that result in one or more companies winning a stake while others lose their stake.

Experimentation

Computer programs are ideal for experimentation with multiple options. When the computer can calculate results very rapidly, it is possible to explore dozens or even hundreds of variations on a decision before identifying the most promising combinations. This digital laboratory is rapid and private. It allows excursion without sharing ideas so widely that they become competitive intelligence.

Games contribute to this in that they are relatively inexpensive to modify, can be limited to a single computer with access restrictions, and display results in a visually memorable and comparable form.

Games and game technology for decision making have been employed in a number of industries to assist with decision making. These include architectural design, city planning, courtroom law, and leadership.

Marketing

Many of the applications described above involved convincing people that a specific perspective on a problem was correct. Though some of those are similar to marketing, there are a number of instances in which games are used purely to market products and

ideas. Since there was no other objective, such as making a decision or analyzing data, these cases demanded their own category.

Advertising

Games have been employed as advertisements. Web sites like Postopia.com present children with simple games that prominently feature company products and convey messages about those products. In this sense they are exactly like television advertisements. However, they improve on traditional advertising because the game engagement can keep a child connected to the product and its message for many minutes or even hours. This is impossible with television and print ads. This type of advertising via game is more closely aligned with event sponsorships, like the Nike logo that appears on football uniforms. Audiences fix their attention on the game and on the advertisement for hours at a time (Winkler and Buckner, 2006).

Activism

A number of games have been created to make the world aware of situations like starvation, genocide, discrimination, pollution, and conservation. These games create an accessible and interactive story. Like advertisements, the engagement can capture people's attention for significantly longer periods than traditional narration or printed stories. They convert statistics and data on the situation into realistic, interactive events that place the player in the position of the person at risk. This creates an empathy that cannot be matched in many other media. This application of games is not new. Hutchison (1997) reports on a game created by the Red Cross in 1920 to teach children how to reduce the chances of catching diseases.

Examples of some of these activist games are:

- Darfur Is Dying: http://www.darfurisdying.com/
- Food Force: http://www.food-force.com/
- A Force More Powerful: http://www.aforcemorepowerful.org/game/index.php
- Escape from Woomera: http://escapefromwoomera.com/

Politics

Games are used to convey political messages. These may be as simple as illustrating the dynamics of voting in Illinois or exploring the conflict between the Israelis and the Palestinians. In some cases, the game is designed to promote a specific point of view. In others it is meant to communicate multiple points of view so that a player can appreciate the difficulty of a situation.

Examples of these include:

- Peace Maker: http://www.peacemakergame.com/
- Howard Dean for Iowa: http://www.deanforamerica.com/
- Take Back Illinois: http://www.takebackillinoisgame.com/
- Under Ash/Under Siege: http://www.underash.net/en_download.htm

Religion

Religious games are usually designed to communicate the core message of the religion and to take advantage of the long-duration contact that people put into games. It also animates historical information that can easily become rote or dull to an audience that has heard it many times over.

Examples of religious games include:

- Left Behind: http://www.leftbehindgames.com/
- Interactive Parables: http://www.interactiveparables.com/
- Ominous Horizons: http://www.n-lightning.com/ominoushorizons.htm
- Catechumen: http://www.n-lightning.com/catechumen.htm

Conclusion

This paper explored five areas in which game technologies are being applied and in which they are impacting the behavior of customers and of companies that serve them. Understanding the potential for these new technologies to be used in areas beyond games is important for business leaders who are facing competition from them. The five application areas are summarized in Figure 9. The “New Sector” section of the figure indicates that game technologies may certainly continue to invade established business functions and markets and this paper does not define a bounded area to which they are limited.

Figure 9. A core set of game technologies have enabled the extension of games into a number of different industry categories.
Source: Created by the author

Game technologies are proving to be very flexible in adapting to industry needs outside of gaming. Entrepreneurs are launching companies to take advantage of this disruption. Because of their very specific focus on the visualization of environments and problems, games will probably never achieve the level of adoption that has come to the Internet or IT services. It may be fair to predict that the spread of game technologies is the first disruptive wave of computer technologies in the 21st century, and that it will be followed by others that will be larger.

It is important for companies to continue to evolve, which includes the adoption of new technologies. Companies that refuse to consider the uses of game technologies may very well hinder their ability to understand and appreciate the waves of technology that will follow. For example, game technologies carry important lessons regarding computer graphics, networking, shared data persistence, analysis of large volumes of information, and interoperability among disparate tools. Companies that do not learn these lessons now may be ill equipped to apply them to non-game-based applications in the future.

In the last few years, games and the technologies embodied in them have proven to be an undeniable force in changing the way many businesses operate. The ability to bring rich visualization and interactivity to every computer desktop adds value to a number of

different operations. In this paper we have explored the value of these in entertainment, training, scientific analysis, decision making, and marketing. The adoption of games in these areas is reminiscent of the use of the Internet and Web in the mid 1990's. Though there is some question as to the value of adopting these technologies, there is no doubt that they have been very effective in some industries and that they continue to push into new areas each year.

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