CancerSpace: A Simulation-Based Game for Improving Cancer-Screening Rates

Can playing a video game help save lives? It might seem unlikely, especially if the first image that comes to mind at the word “gamer” is that of an overstimulated, underdeveloped teenager who desperately needs a suntan and a girlfriend. However, like many of today’s gamers, video games are moving out of their parents’ basement and into the real world. Video games are maturing and facing adaptation to serious applications. Such serious games are seeing use in a variety of fields, from the military to corporate management, and are finally being employed in healthcare. One of the biggest, most challenging areas is modeling simulations for medical training, particularly for managing chronic illness and providing system-level population-based care (see the sidebar for more information).

The Educational Gaming and Simulation Design group (EG&SD), part of the US National Cancer Institute (NCI) Office of Communications and Education, has been researching principles of gaming and simulation design and applying them to an educational program developed to help increase cancer-screening rates among low-income and minority populations. The burden of cancer falls inordinately hard on these populations, and the need to reduce the disparity is great. In particular, the EG&SD group is working closely with the Oak Ridge Institute for Science and Education to develop CancerSpace (Cancer: Simulating Practice and Collaborative Education), an interactive, Web-based learning application in a game format.

CancerSpace’s design encourages self-directed learning by presenting the players with real-world situations about which they must make decisions similar to those they would make in clinics. To accomplish this, our EG&SD group needed to choose and often adapt certain features of various software packages and platforms and then combine them. One development process that might be of particular interest to the computer graphics and animation community was our need to simulate the clinical environment, primary care providers, and organization staff with a level of fidelity acceptable to users.

Background
William McGaghie defines a simulation as a person or device that attempts to mimic problems occurring in the physical world. Learners must solve the problems as they would under natural conditions, frequently receiving feedback as they would in a real situation. Research has shown that such technology can effectively educate personnel. Simulations offer the opportunity to practice such real-world skills and help workers learn to solve problems by making their mental processes and problem-solving skills explicit. They let healthcare workers practice and hone skills before performing medical procedures and allow educators full control over clinical scenarios without risk to patients.

Simulations can also train healthcare workers to improve day-to-day functions or the workflow of their hospital, office, or clinic. To meet such a training need, the EG&SD group was asked to create an educational tool to disseminate a curriculum designed to help primary-care organizations, providers, and staff improve their clinical processes for cancer screening. One challenge quickly presented itself: the curriculum had to be disseminated online to reach the broadest number of people in the most cost-effective manner. This requirement started us down the path of creating an e-learning tool.

Target-audience research indicated that in the FQHCs, the specific audience that responded most favorably to the e-learning concept was training...
coordinators and quality improvement managers. They had two problems to solve for which a solution such as CancerSpace seemed suited. First, the current lecture method took too much of the allotted time for staff in-service education. Second, didactic lectures aren’t usually interactive or engaging, and the trainees’ retention of information seemed a problem. The need became apparent for a self-paced, interactive, engaging, easily disseminated learning tool that would increase retention and facilitate behavior changes among practitioners and staff.

Prototype Development Challenges
Throughout development of successive prototypes of the game, the EG&SD group made a progression of graphical-design decisions and changes to meet our intended user group’s domain-specific requirements. Of primary interest are how the graphical representation of the clinical decision-making process evolved to reflect the user’s perception and what tools and techniques were required to render it effectively.

Prototype 1: Too Much Information
With the first prototype (see Figure 1), the game was text-heavy and the limited graphics were less than state of the art and more of the 2D, geometric variety.

In many ways, this reflected our group’s primitive understanding of the challenge at the time. Usability testing showed that players weren’t interacting with the game as intended. For example, players were ignoring certain aspects of play, such as the “Check the Evidence” feature, which encouraged the player to read research published on a certain question or problem before making a decision. Testing data showed players were also ignoring game directions and skipping over feedback.

This taught us that we had basically designed a fancy interface for a multiple-choice test. The game didn’t present data in ways that users responded to or that would integrate into their clinical practices. To engage the player and deliver the cancer-screening information more effectively, we needed to greatly reduce the delivery of information through text. We also needed to present the game in a more immersive, visually stimulating way, one that more closely reflected a real-world clinic.

Prototype 2: Diverse Characters, Static Environment
The next challenge was finding the right platform to use to simulate the clinical environment. Research on practitioner information needs and usage patterns has shown that, in primary-care environments, interpersonal information exchange is a primary input into clinical decision-making. So, the development team began looking for tools related to this area.

There’s an established and growing evidence base documenting the effectiveness of simulation-based learning in surgical and acute care. The da Vinci surgical-system simulator (www.davincisurgery.com) and Laerdal’s SimMan (www.laerdal.com/document.asp?docid=1022609) are popular examples in the healthcare community.

Over the past few decades, simulations increasingly have been providing medical training in a safe environment, thereby improving medical professionals’ skills. For example, Stephen Abrahamson and his colleagues examined the effectiveness of a computer-controlled patient simulator in training anesthesiology residents on the endotracheal-intubation procedure. Residents who received this training achieved proficiency more quickly than those who didn’t. However, evidence supporting simulation-based training in chronic care is only just emerging as organizations implement pilot projects such as CancerSpace (see the main article) to improve such care’s delivery.

References

Figure 1. The first prototype (2006) of CancerSpace (Cancer: Simulating Practice and Collaborative Education) used static geometric graphics without animation. This prototype wasn’t visually stimulating and didn’t reflect a real-world clinic closely enough.
Graphically Speaking

Graphically Speaking to render the graphical environment necessary to simulate interpersonal communication. Initially, the team explored a simulation-authoring software package that incorporates live-action video clips into a simulation design template. Simulations developed with this tool looked excellent, but using real video proved cost-prohibitive. The amount of content needed for CancerSpace to be a truly comprehensive training tool was significant and precluded this package as a viable option.

Animated characters, which are more easily edited and rerendered, were logically the next step. At this point during development, the team began compiling a list of the characteristics and technical specifications required if we were going to meaningfully simulate interactions between patients and providers as well as between members of our virtual staff. From a technical perspective, we needed to be able to model animated characters in the round, render them, and export them in a format convertible to flash animation. We also wanted a package that would let us manipulate the characters’ environment to simulate activities taking place in a clinical space. This required software that let developers render characters on a chromakeyed backdrop (also called a “green screen”). Most important, the characters had to be expressive, especially in terms of conveying messages through body language and facial cues, and had to represent a wide cross section of the patient population. In short, the models needed to include individuals of many different races or ethnicities, genders, and ages.

For animated-character creation, the team first explored a popular software package that allowed for real-time animation of talking characters. These characters were more readily adaptable to dialogue changes and were more cost-effective than shooting live video. However, the software didn’t allow for the animation of a character’s entire body (it shows only the head and shoulders). It was also incompatible with the game’s bandwidth, causing the animation to lag when the audio was synced to the video animation.

Further searching for an appropriate solution led us to a company that created and delivered digitally rendered, 3D virtual characters and the software that would allow for customization of characters, gestures, voice, and movements. We can customize these characters to reflect the diversity in race, age, and gender of FQHC patients and employees. They can speak and gesture (including sign language) with fully animated bodies, interacting with the player much as the other staff members of a clinic would. Incorporating these characters let us reduce much of the text and the need for excessive reading on the user’s part. Figure 2 shows the results.

Although this prototype was a definite improvement over the first, integrating the 3D characters presented new challenges. The animated characters seemed out of place, and users perceived interactions with them as too artificial. At first, we superimposed these animated characters over backgrounds developed from photographs of real clinics. However, not only did the static backgrounds limit the ability to pan and zoom, the characters’ outlines became quite pixelated. The real photographs also limited the variety of the rooms in which we could place the characters. We needed to be able to build and customize virtual rooms to simulate the look and feel of a clinical environment that was also compatible with the animated characters.

Prototype 3: A More Immersive Experience

The third prototype (see Figure 3) incorporated the 3D-modeling tool used in a popular online networked virtual environment, with which we built a virtual clinic in which the characters would operate. The virtual clinic became a kind of “cyber-studio” for the developers, who used the virtual rooms and objects as the background or “set” for capturing short clips of characters. This capability to set the virtual characters in the virtual clinic reinforced the concepts behind the gameplay. With a fully developed virtual clinic, the player becomes more immersed, and we could give the simulated experience contextual relevance that had otherwise been missing.

The integration of the animated characters with the virtual background met with approval from a review panel of users and healthcare education experts. The combination of social cues from the character animations, sounds, and other graphic effects seemed to create an emotional connection between the user and the learning environment.
We anticipate that planned evaluations of CancerSpace will confirm that, by creating an engaging simulated environment, we’ve given users a more effective and efficient learning experience than they would receive from traditional didactic methods.

**The Data Visualization Challenge**

From a computer graphics and animation perspective, CancerSpace also tried to meet a data visualization challenge. The development team sought to visualize data collected on cancer mortality and risk and data related to the sensitivity and specificity of various screening modalities such as mammograms, in a way that would convey meaning to clinical practitioners. Although these concepts might appear unnecessarily complex and abstract for the clinical environment, they form the basis for whom, when, and how to screen for cancer. Because clinical nonadherence to screening guidelines has been cited as a contributing factor to suboptimal screening rates, we wanted to try an approach that would present the data in an engaging-enough way that clinicians might be more likely to adhere to screening guidelines more closely.

In our attempt, the development team produced a set of Java-based activities that let users group, select, manipulate, and filter data for breast, cervical, and colon cancers and that let users toggle through various views of the data associated with different screening modalities. Unfortunately, this data visualization component was one challenge our team couldn’t overcome. The approaches we used to visualize the data were insufficient to the task at hand and weren’t included in the final version of CancerSpace.

If we tried to rework this component for inclusion in a later version, our team would concentrate on two areas. First, focusing on research evaluating how effective data visualizations are at improving knowledge, skills, clinical decision-making, and clinical outcomes would give us an opportunity to craft visualizations optimized to convey cancer-screening information in a way that results in improved rates. Second, we would look for established data visualization algorithms—tree mapping is one popular algorithm—that we can tailor to convey cancer-screening information in a way consistent with gameplay and the simulated clinical environment. We certainly invite suggestions as to how we can meet this challenge.

**Gameplay**

What differentiates CancerSpace from a mere collaborative 3D e-learning environment is its embedded gameplay. At the game’s beginning, the user assumes the role of the Decider, a clinician at the All Hands Community Health Center. His or her job is to help the clinical staff evaluate the clinical literature, integrate the evidence into their clinical decision-making, plan changes to cancer-screening delivery, and accrue points correlating to increased cancer-screening rates. The user interacts with the game interface to implement decisions and observe whether the chosen course of action improves screening rates.

To introduce an element of chance, CancerSpace uses wildcards and decision trees. Wildcards function as they usually do in an entertainment device. Because CancerSpace takes place in a community health center, wildcards reflect certain unplanned events common to community health centers such as a budget cut, funding of a grant, or a staff member transferring to another clinic.

The game also provides four patient-provider interactions in which the Decider must talk with a patient reluctant to get screened, try to educate that patient, and hopefully get him or her screened. During the conversation, the Decider must negotiate cultural and language barriers as well as the patient’s changing attitudes toward screening. Through preprogrammed decision trees, the player’s choices lead to the patient either deciding or declining to get screened.

The use of audio elements such as buzzers, chimes, and other sound effects, combined with video elements such as quick animations indicating an incorrect answer and a mentor character showing emotions ranging from strong disapproval to strong approval, lend elements of entertainment to CancerSpace that are critical. Of course, CancerSpace would be a lot more entertaining if the user was vaporizing marauding aliens instead of...
trying to increase cancer-screening rates. However, in the context of an e-learning tool, a layer of entertainment was still important to successfully convey a sense of gameplay.

To stimulate gameplay, CancerSpace has adapted an award system. The targeted users, professionals working in community health centers, are professionally motivated to increase screening rates. The CancerSpace scenarios in which the Decider guides the virtual clinical staff are based on research-tested interventions and best practices. At each game’s conclusion, a summary screen (see Figure 4) indicates which decisions the player implemented and their effect on the clinic’s screening rate. Users receive points on the basis of their performance. This screen also lets the user print out descriptions of the interventions and practices demonstrated in each scenario. Our goal was to provide real-world users with real-world steps to take in their own community health centers.

To facilitate the gaming-and-simulation approach to improving cancer-screening rates, further research and collaboration are needed, because the evidence base in this area is quite small. We plan to release the final version of CancerSpace in January 2010; subsequent evaluation of the tool will, in turn, contribute to the evidence base.

Simulations’ effectiveness in acute care and other areas of healthcare are a call to action to explore their applicability and effectiveness in chronic care as well. Reflecting on our development experience, we believe that cross-disciplinary collaboration between graphic designers, animators, healthcare researchers, and educators could benefit many. The computer graphics and animation community has an important role in helping healthcare researchers design higher-fidelity educational games and simulations for improving the delivery of chronic care to the millions requiring it.

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References

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