Using an inexpensive Xbox Kinect video game motion sensor, electrical engineering students at Drexel University were able to create an interactive virtual nuclear power reactor simulator.

Video games in the classroom

By Tim Gregoire

Instructors are exploiting the interactive qualities of modern video games to teach complex nuclear concepts.

Generating more than $25 billion in computer and software sales in 2011 alone, the video game industry is one of the fastest growing sectors of the U.S. economy, according to the Entertainment Software Association, a trade association serving businesses that publish video games for game consoles, personal computers, and the Internet. With all that economic power behind it, video game technology continues to grow at an exponential pace. By taking advantage of developments in game software and hardware, some educators are creating innovative new tools to teach and train future nuclear professionals.

Using computer simulations and games as pedagogical instruments is nothing new, and much of the technology found in video games—motion sensors, three-dimensional graphics, virtual environments—is not unique to the entertainment industry. A few savvy educators, however, have found that the ubiquitous and relatively inexpensive gaming systems are ideal platforms upon which to build custom teaching and training aids, quickly and on a minuscule budget.

For instance, the Microsoft Kinect is a motion-sensing device made to be used with the Xbox 360 game console as a natural user interface, allowing game players to control and interact with the system without having to use a controller. The small device contains an array of sensors, including an RGB camera, a depth sensor, and a microphone array, all of which provide full-body 3-D motion capture, facial recognition, and voice recognition capabilities. The unit itself costs less than $150.

"It's a little piece of what I call technological heaven," said Christopher Peters, a professor in the Electrical and Computer Engineering Department of Drexel University, in Philadelphia, Pa.

As part of a senior design project within the university's new nuclear engineering minor program, four of Peters's electrical engineering students decided to integrate the Kinect into an interactive and immersive nuclear power reactor simulator. Peters provided an overview of the project at the 2012 ANS Annual Meeting, held in Chicago, Ill., in June.

When his students suggested the idea of creating a simulator using the game system, Peters said, he initially was hesitant. "But then I did a little bit of research on it and found that this piece of equipment is now being used to defuse bombs and to do surgery," he said. Seeing the Kinect capably being used for things it wasn't intended for, Peters realized the device's potential to become a low-cost "teaching mechanism" for power reactor operations.

"Mind you, these are students who have no background in nuclear engineering whatsoever," he said of the four students

who undertook the project: Paul Martin, Mike Lui, Paul Rua, and Josh Waldman. "They are all electrical engineers."

Despite the lack of a nuclear background, within a year the students were able to create and program an interactive, motion-sensitive simulator of a 2 MWt-pressurized water reactor using the Kinect and a personal computer running Windows software. The 2-MWt PWR model was adopted, Peters said, to simulate a hypothetical future power source that would provide electricity to the Drexel University campus. Using point kinetic equations, the reactor is purely a behavioral model and is not a simulation of any one reactor design, he said.

With the graphics display projected onto a screen, the user can manipulate controls on the simulated control panel using a custom "grab" feature the students designed. Peters said that it is the first time a grab feature has been used in an Xbox game program. Using hand motions, the user can also swipe between screens showing different reactor parameters in real time.

From the control panel, the user can initiate criticality by controlling the rod height, track temperature and electrical outputs, change the speed of the coolant pump, and open and close the steam generator valve. There is even a scram button. From the real-time graphing screens, users can then track temperatures, rod height, power output, neutron population, and group concentrations, as well as total and specific poison concentrations and reactivities.

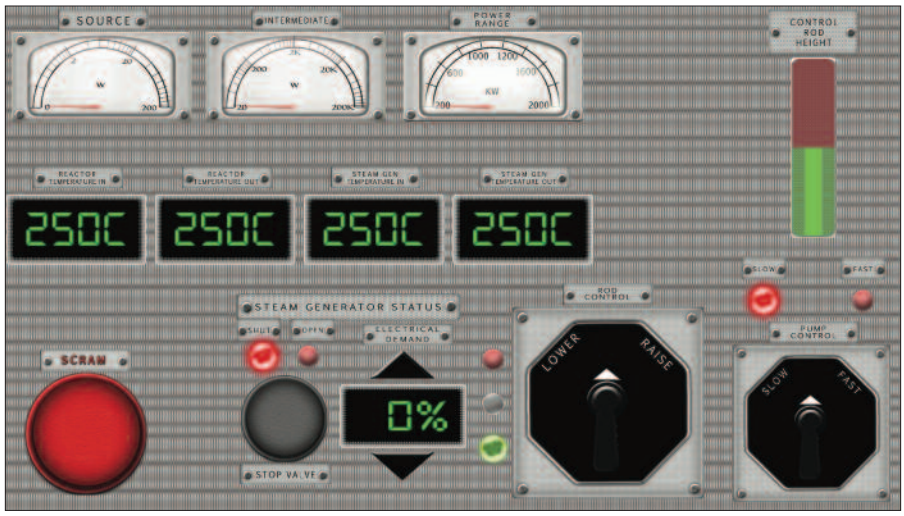
According to Peters, a six-factor formula enables the simulator to use poison concentrations and temperature effects to change reactivity. With the steam generator connected, the simulator will then model temperature changes in the reactor as load demand changes, which helped his students comprehend differential integrated rod worth, he said.

"Getting electrical engineers to understand rod worth and cross sections was itself a chore, but they did it and now understand it," he said.

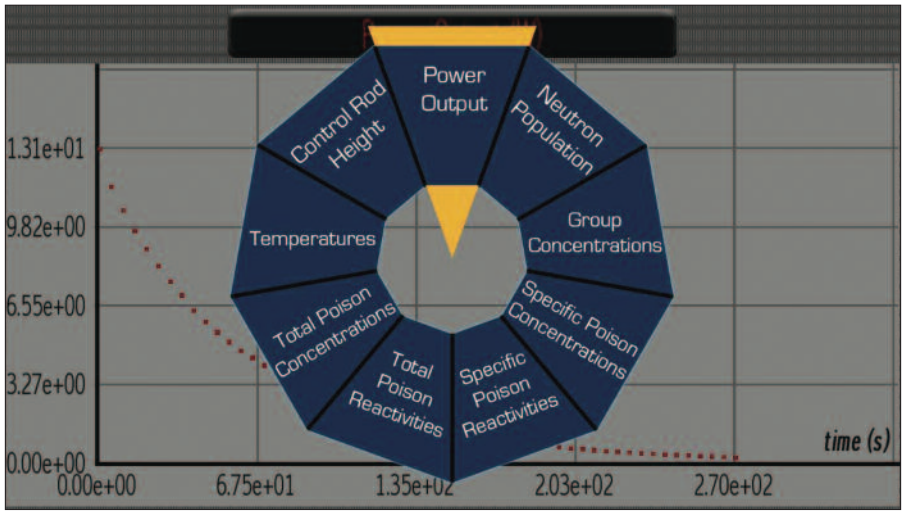
In addition to being an educational vehicle for demonstrating "basic, normal reactor behavior," Peters said that the beauty of the Kinect simulator is that it is expandable and can be further developed to create a valuable tool for universities or institutions that want to teach reactor operations but do not have or cannot afford a research reactor.

Currently, Drexel students are working on building a physical reactor simulator using a simple microprocessor and Matlab software. The whole system, Peters said, including computers and monitors, can be built for under $1000.

Adopting video game technology into classroom tools works, Peters said, because younger students are increasingly becoming visual learners. "This generation of students has a different learning modality," he



From the control panel of the Drexel simulator, users can control criticality, cooling, and electrical demand.



Drexel's virtual simulator allows real-time graphing of reactor operations.

Photo: NPRE Illinois

University of Illinois Prof. Rizwan Uddin walks students through the use of the virtual lab.

Graphic: Scivle

The Scivle virtual lab allows students to complete their work from any computer with Internet access.

said. "They're more visual. They like to be interactive and have the immersive effect."

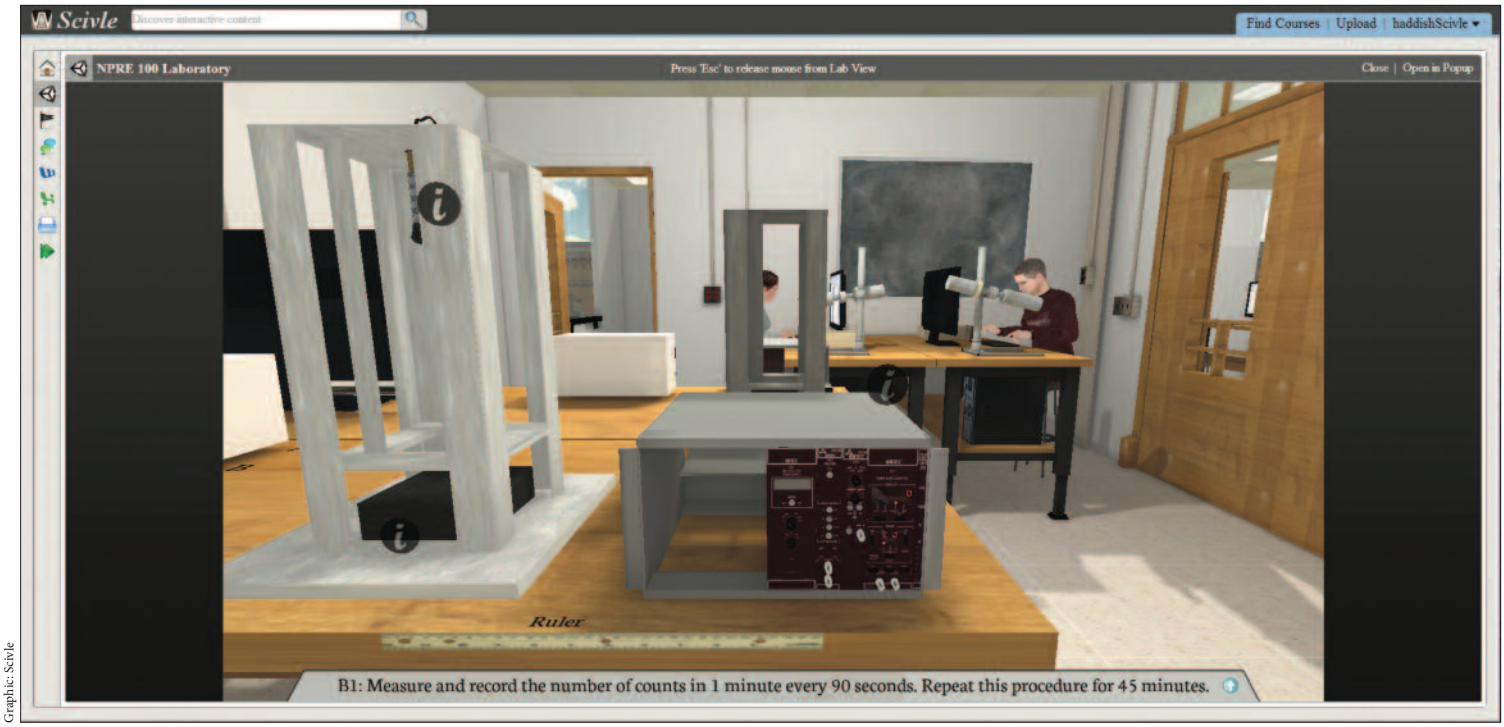
A video of Drexel students demonstrating the Kinect reactor simulator is available on YouTube at <www.youtube.com/watch?v=uIEPfK537U8>.

Virtual lab

Providing students with an interactive and immersive learning experience was just one of the motivating factors behind an online virtual laboratory developed by Rizwan Uddin, a professor in the Department of Nuclear, Plasma, and Radiological Engineering (NPRE) at the University of Illinois at Urbana-Champaign, and NPRE graduate Imran Haddish. Borrowing technology used in first-person, 3-D shooter-style video games, the virtual lab allows students to conduct nuclear engineering experiments outside the physical lab. Anywhere there is Internet access, students can do their lab work.

Haddish demonstrated the virtual lab at the 2012 ANS Winter Meeting and Nuclear Technology Expo, held November 11–15 in San Diego, Calif. According to Haddish, there was a real need for such a virtual lab as the number of students enrolling in the NPRE program grew.

"On the university level, we have budget constraints and increased enrollment, but the capacity has stayed the same," he said, noting that the NPRE department currently has 50 undergraduate students in a system that was set up for 15. Without enough



Graphic: Scivle

Students work at a computer-rendered lab desk modeled after a real lab at the University of Illinois.

lab stations to accommodate all of the students, they had to do labs in shifts.

Furthermore, Haddish said, on the global level, there is a growing interest in online education. "There's an initiative going on right now to bring more content to the Web, where students can access it freely," he said. "But the focus has remained more on Web lectures and video lectures. There really hasn't been a focus on lab work, [which] is interactive and involves hands-on interactions. We're trying to put together a platform to handle all these needs."

Haddish said that they first looked at readily available options for creating an online lab, but they found nothing on the market that they felt was realistic or had the desired level of interactivity. So Uddin and Haddish built the lab over the summer of 2012 using a game-building platform offered by Unity. The first NPRE 100 lab, hosted by Scivle, was first made available to students for the fall 2012 semester.

By using the Unity platform on the Scivle site, students are able to access the virtual lab using any Internet-enabled device. As the program is scalable to the device used, students can even use a mobile device to run the program. Everything a student would need to do the lab work in real life, including instruments and lab guides, is provided within the virtual lab, according to Haddish. Likewise, all the lab work, including data processing and report writing, can be done in the user's Web browser. There is also a feature that allows students to post questions and discuss their work with other students.

"Like all other major sites, Q&A forums are a big thing," Haddish said. "They allow students to interact with each other and share information back and forth. We essentially hope to create a very rich database of information in this lab as we progress."

As with Drexel's Kinect reactor simulator, Haddish sees the value of the virtual lab in its ability to provide a highly flexible, inexpensive teaching tool. "We can do anything we want," he said. "We can do any type of lab."

In terms of time and cost savings, Haddish noted that he is able to build a prototype lab in a two-week time frame, as opposed to the months it typically takes for a real-life lab to be designed, approved, and built—all of which costs money.

In addition to educating University of Illinois students, Haddish hopes that the virtual lab will reach a wider audience of potential nuclear engineers, enabling nuclear engineering to compete with other disciplines in the world of online education. The problem, Haddish said, is that most online course platforms, such as video lectures, are designed for large audiences. For the more popular, general interest course subjects, thousands of people often will be enrolled in a single course, whereas smaller programs such as nuclear engineering are often "shoved to the side" within the online learning world, Haddish said. The virtual lab will ensure that nuclear engineering is able to maintain a presence in the online environment, he added.

Uddin said that outside of academia, the nuclear industry has shown interest in using game technology for personnel training. One such application could be in the training of temporary construction workers and laborers for outage work. "With a room of 30 to 50 PCs, you could train 50 people in an hour," he said.

As for the future, Haddish said that Scivle is working to produce online video lectures in a digital format similar to the virtual lab. Rather than a one-dimensional recorded lecture that remains static and fixed, a code-based digital lecture would allow an instructor to add, delete, or swap files, changing the material to adapt the lecture to individual students. Haddish said it is a much more realistic way to learn. "You lose something just watching a video," he said.

Taking advantage of the rapidly expanding technology is key to creating and maintaining a robust online educational experience, Haddish said, noting that the technology used to create the virtual lab was only two months old before they adopted it. "That's how radically things change with education and technology," he said. NN