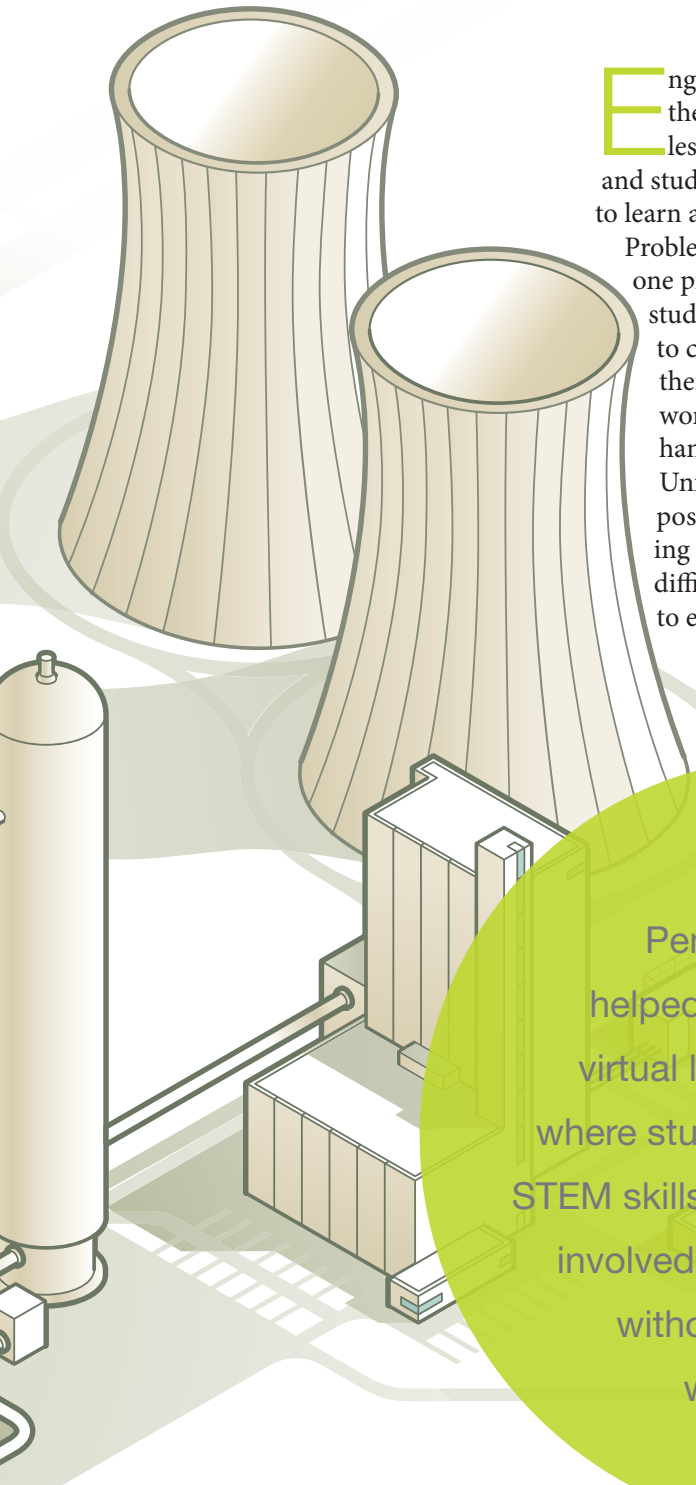
By John Branson and Diane Thomson

Hands-On Learning in the



Engagement is a big piece of the learning puzzle. Make lessons fun and interesting, and students are much more likely to learn and retain them.

Problem-based learning (PBL) is one proven method for engaging students, because it allows kids to connect the dots between their school work and the real world while participating in hands-on learning actvities. Unfortunately, this is not always possible. Some of the most exciting real-world activities are too difficult, expensive, or dangerous to expose children to.

Enter immersive simulations. The U.S. military has long understood the value of this type of learning. Before the Navy entrusts a ship to a crew, crew members must first practice and demonstrate their competency in a fully immersive, simulated environment. Why not teach students in the same way?

K–12 educators in Pennsylvania, USA, recently did just that when they partnered with the U.S. Navy in the Real World Navy Challenge (RWNC, www.rwnc.org). A joint project coordinated by the Navy, the Chester County Intermediate Unit, and Delaware Valley Industrial Resources Center, the RWNC uses immersive learning to give students real-world problem-based scenarios requiring science, technology, engineering, and mathematics (STEM)

Teachers in Pennsylvania, USA, helped build an immersive virtual learning environment where students could apply their STEM skills to the real-world issues involved with nuclear power—without any of the real-world dangers.

Virtual World

knowledge and skills, without requiring them to leave the classroom.

Some of the RWNC problem scenarios that students have participated in include a natural disaster that led to the relocation of the entire population of Philadelphia and issues associated with the hydraulic fracturing (known as fracking) process used to extract natural gas from shale. Middle and high school teachers in STEM subjects throughout southeastern Pennsylvania were eager to try their own scenario, and they got to be involved from day one.

Welcome to Boot Camp

Like new recruits to the Navy, the 21 educators who participated in the RWNC kicked off their experience with a boot camp. They gathered at the Philadelphia Navy Yard, where they took part in three days of rigorous training designed to change the way they teach and learn.

During the boot camp, the teachers toured the U.S. Naval Surface Warfare Center's Ship Systems Engineering Station so they could see how the Navy employs full-scale simulations in its training programs and get a glimpse into science and engineering research that will have significant implications far beyond the scope of the military.

But like any boot camp, this was not a spectator event. Teams solved complex logistical problems with limited tools and resources and came up with solutions requiring their collaboration, clear communication, and creativity.

There was class work and homework as well. Bootcamp participants learned the foundations of PBL from experts in the field. They studied new tools, such as a custom-designed team collaboration portal featuring a whiteboard, voice, and text chat; wikis; and journals. And they gained hands-on experience in an immersive virtual environment called NewWorlds (newworlds.paiunet.org), where much of their and their students' experience in the RWNC would take place.

NewWorlds, which uses the open source simulation platform OpenSIM, has built several learning environments for students. The RWNC training team provided a framework for the scenario they had in mind. It would have to:

- Connect to the students' local environment
- Require a knowledge of STEM concepts and skills
- Require collaboration
- Be relevant to the students' lives

The scenario selection process began with a whole-group brainstorming session. The educators agreed that the problem should involve something that is meaningful and relevant to all the students. Nine potential scenarios emerged, but the overwhelming favorite involved a simulated accident at a nearby nuclear power plant.

This challenge met all of the criteria. The school districts were within the evacuation zone of a nuclear power plant. And the scenario would encourage students to use and expand their STEM and collaboration skills. Even better, although no one knew it at the time, a version of the imaginary scenario was about to play out in real life and get worldwide attention.

Building the Virtual Environment

Once the teachers identified the problem scenario, the NewWorlds Development Team began designing and building the virtual environment, dubbed the Scarboro South Nuclear Power Plant. The development team, which included a programmer and several graphics and instructional designers from the Chester County Intermediate Unit, built the site over approximately six months using the Open SIM platform.

It was essential that the virtual power plant accurately re-create the structure and operation of the local nuclear power plant. Although students under 18 were not allowed onsite, the design team was able to tour the nuclear power plant, interview engineers, and procure detailed drawings to ensure the virtual environment's authenticity.

The team took painstaking care to faithfully depict a fully functioning nuclear power plant, including all safety and security features, such as ID scanners, an explosives detector, metal detectors, twin pressure-lock doors, personal contamination monitors, radiation scrubs, and other protective gear. They even designed the virtual nuclear reactor and core to allow students to "peel away" outer layers to reveal the fuel rods and turbines within.

The team used Google Earth to assist in the design of the plant's exterior, including the cooling towers, the spray pool, the switch yard, and the cask storage area. Google Earth provided excellent aerial views of the plant that allowed the designers to accurately depict the number, size, and proximity of buildings in relation to the Schuylkill River, which is the water supply for the plant.

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Virtual Reality Meets Real Life

Once the Scarboro South Nuclear Power Plant was completed in February, the teachers had considerable latitude in how and when they could implement the challenge. But, as fate would have it, real life had plans of its own.

On March 11, 2011, a powerful earthquake struck off the coast of Japan. The earthquake spurred a 46-foot tsunami that, one hour later, breeched the seawall at the Fukushima Daiichi nuclear power plant located 150 miles northeast of Tokyo. The raging waters overwhelmed the backup power and cooling systems at the plant, leading to one of the worst disasters in the history of the nuclear power industry.

When the disaster struck, Brenda Gelinas, an AP chemistry teacher at Downingtown East High School, immediately revised her implementation of the RWNC to incorporate the events unfolding in Japan. She challenged her students to act as a team of nuclear energy experts tasked with determining the implications of the Fukushima Daiichi disaster on the future of nuclear power generation in the United States.

"I've decided to take advantage of the teachable moment with what is going on in Japan," Gelinas said. "I'm really excited about it! While the events in Japan are terrible, they do provide a wonderful backdrop for this project."

The students' engagement, both with the unit and with current events, soared. When news reporters covering the Fukushima disaster discussed the growing danger posed by the exposed spent fuel cooling pools, and the structure and safety features of a nuclear power plant became headline news, students in the RWNC could relate because they had already spent time in the Scarboro South plant and witnessed the virtual equivalent of the disaster.

Hands-On Learning

As would be expected in any good PBL experience, each implementation of the RWNC varied significantly, requiring the students to assume control of their learning.

Students formed teams to attack different aspects of the problem, including alternative energy, possible evacuation, past events, nuclear radiation, and radiation sickness. Real-life nuclear engineers visited the classrooms to explain nuclear power generation and to answer questions. The students engaged in brainstorming activities, collaborative research, debate, data analysis, and, finally, consensus building with a goal of determining implications for nuclear power generation in the United States.

Each student's avatar wore a virtual dosimeter that kept track of accumulated exposure to radiation. They recorded violations and safety hazards in their virtual notebooks as they inspected the plant, using checklists provided by the Nuclear Regulatory Commission. They also recorded their experiences in their journals and through video.

At the end of the program, teams of students presented their findings to their classmates and teachers, and one group reported on their experience to their district's school board members.

In addition to the class presentations, the students were evaluated on the quality of their journal entries and the sophistication of their problem-solving skills. They were assessed on several

criteria, including their collaborative efforts, the quality and content of their presentations, and completion of the virtual nuclear power plant inspection.

When asked what they thought of the project, the students' overwhelming response was positive. They felt touring the Scarboro South virtual nuclear power plant added a valuable dimension to their learning.

Almost all of the students surveyed felt that the collaboration portal enabled them to communicate with other team members more effectively and helped them to keep organized throughout the project. Overall, students said they preferred using the PBL approach to learning about nuclear reactions because it was "more fun," "hands on," and "interactive."

Some students expressed concerns that they did not learn to balance chemical equations during the project and felt that this method might not be appropriate for introductory classes. Others felt that the project would be difficult for students without previous collaboration experience.

The Next Frontier

As teachers learn about Scarboro South and other virtual learning environments within NewWorlds, they generally respond with enthusiasm and creativity.

When Laura Kowalski, a science teacher at Parkland High School, first saw NewWorlds at the Keystone Technology Summit at Bucknell University in July 2010, she immediately recognized the potential of the virtual environment to enhance her students' learning.

Kowalski had already used technology to create simulations for her classroom. She used PowerPoint to design a game called Leechyman to help students better understand protein synthesis. Students had to defeat the villain Leechyman, who planned to end the human race by altering the genetic structure of hemoglobin so it could no longer transport oxygen throughout the body.

Kowalski observed that the game greatly enhanced her students' understanding of a difficult concept and helped them retain what they learned. But she thought that NewWorlds could take Leechyman players to the next level of learning. Her game could not accurately depict the entire process of protein synthesis, but a 3D immersive virtual environment would allow students to see the process and actually experience it.

In the 3D version of Leechyman, students enter the body of one of the villain's victims. Traveling through the blood vessels, students are able to examine hemoglobin on the molecular level. Throughout their travels, they encounter mini-challenges that require them to demonstrate their knowledge and understanding of related concepts. Finally, they have to identify and correct the genetic anomaly that threatens all human life.

The Pennsylvania Department of Education provided funding through its E-Fund grant program to develop Leechyman, along with several other simulations, as NewWorlds immersive virtual learning environments for students throughout the state. Other virtual environments include an Asian language and culture program that provides immersive simulations of Asian architecture and artifacts, and a life-skills program featuring a functioning apartment and a simulated work experience to help students with special needs learn independent living skills.

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Despite the clear benefits of immersive virtual learning environments to student engagement, many schools have been reluctant to use them, mainly because of cost. But with the advent of open source environments, expense is no longer an issue.

Some educators avoid them because of their similarity to video games and their lack of alignment to academic standards. But the RWNC and Leechyman programs demonstrate how, with a little collaboration and creativity, these environments can be used effectively to achieve academic standards.

Bottom line, hands-on PBL has increased student engagement and learning. And virtual environments provide a way to get that hands-on experience for students, even when the logistics of the real world get in the way.

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