Mixed-Reality Game Teaches Geotechnical Engineering Concepts

TEACHING methods are evolving as instructors and researchers embrace the knowledge that there is more than one way for students to learn. We are rapidly moving toward an educational landscape in which the mastery of professional skills—such as teamwork, communication, ethical judgment, and critical thinking—is just as important as the mastery of technical ones. What’s more, employers are looking for candidates who have these technical and professional skills, but they are also looking for those who have practical experience, and engineering programs are often challenged by balancing accreditation requirements and attempts to infuse these elements into their curricula.

Technology is playing a role in these shifts in curricula as well. Smartphones, tablets, virtual reality, gaming, and other technologies are increasingly infiltrating classrooms, just as they have the rest of the world. The need for technology in higher education has perhaps never been more apparent than in the past three months, as instructors across the country pivoted to an online mode of instruction in response to the COVID-19 pandemic.

Enter GeoExplorer, an immersive, mixed-reality game designed for geotechnical engineering students that makes it possible for them to obtain practical experience, build their technical skills, exercise engineering judgment, and learn from failure—all in a stress-free and engaging environment.

Funded by a multimillion-dollar grant from the National Science Foundation, a team of researchers from Rensselaer Polytechnic Institute (RPI), in Troy, New York; Northeastern University, in Boston; and Olin College of Engineering, in Needham, Massachusetts, are hoping to “fundamentally transform engineering education with mixed-reality, game-based learning” in civil engineering curricula at more than 20 colleges and universities across the country, including historically black colleges and universities and Hispanic-serving institutions, according to Tarek Abdoun, Ph.D., M.ASCE, in written comments to Civil Engineering.

Leading the curriculum design team are Abdoun, who is the Thomas Iovino chaired professor in RPI’s Civil and Environmental Engineering Department and a Global Distinguished Professor at New York University Abu Dhabi (United Arab Emirates), and Victoria Bennett, Ph.D., A.M.ASCE, an assistant professor in the same department at RPI. Together, they are responsible for developing the technical content for GeoExplorer, spearheading its classroom implementation, assessing student learning outcomes, and hosting professional development workshops for early adopter faculty. The game development effort is led by Casper Harteveld, Ph.D., an associate professor of game design at Northeastern University. Yevgeniya V. Zastavker, Ph.D., an associate professor of physics at Olin College, is leading the education research and evaluation effort.

GeoExplorer is a comprehensive tool, one that the team hopes will motivate and engage students in science, technology, engineering, and mathematics (STEM) education. Now under development to expand beyond a field testing module, the final GeoExplorer activity will combine “actual lab testing, virtual field testing (cone penetration test [CPT]), theoretical system design, and virtual inspection of flood-protection systems during extreme events [in a] mock internship experience,” Abdoun explained.

The appeal for students is that it uses technology they are familiar with and simultaneously gives them the opportunity to apply the knowledge they have garnered in class and develop their engineering judgment skills as they complete the missions—all in an environment in which they have the freedom to learn by failing. Activities in the virtual environment include conducting a CPT site investigation, inspecting a levee system, and testing student-designed levees to failure.

Many students find it fun, Abdoun noted. “We designed four sites for site investigation and asked students to complete only two of them as their assignment,” he said. However, 40 percent wished to complete all the sites. “You know you have a very successful learning tool when your students tell you they want to do more assignments!”

And they should find it fun, because they have been integral to the game’s development since it was first introduced four years ago at RPI and Southern Methodist University, in Dallas. In the early phases of this project, students completed surveys before and after they played the game. These questions were designed to test what they learned on a technical level as well as the game’s quality and their perception of its effectiveness as a learning tool. “The results showed that over 80 percent of students agreed or strongly agreed that this computer-based game was an effective way to learn about field testing,” he noted.

Students are still heavily involved in the research four years later. “Students—undergraduates and graduates—are the core of the game development, as the majority of our research team members are students,” said Abdoun. He and Bennett use student feedback—from those on the research team as well as the 500 or so students who have played it since its first implementation in 2016—to craft and fine-tune the missions and make it more appealing for players.

The research team is not resting on what has already been accomplished with the game. Team members hope it will be an integral tool in geotechnical engineering courses in the United States and abroad. “I believe virtual
and mixed-reality gaming will be the core of effective STEM learning,” Abdoun stated. Although they are pleased with the results and its reach so far, they hope for more: within five years they would like to see Geo-Explorer “fully developed, tested, and broadly used by engineering universities on the national and international level.”

And perhaps it may someday be broadly used by employers as well. During a summer internship, one of the students performed a CPT in the field (a task she had done virtually in class). She completed the task so well and her boss was so amazed that he contacted Abdoun wanting to know if the company could make the game part of the training for new hires, which, he says, he and Bennett readily agreed to.

Immersive and mixed-reality educational games are the “next generation” in delivering innovative, engaging, and effective learning, Bennett said in written comments to Civil Engineering. GeoExplorer provides the platform needed to “teach and assess engineering concepts when students might not have access to a physical laboratory or field testing,” she said.

“For engineering education, in particular, this is an important point since many of us believe that a quality engineering education is marked by hands-on learning, interdisciplinary and teamwork experiences, integrated learning opportunities, design, and many other components that are difficult to achieve through traditional online education.”

—MARGARET M. MITCHELL

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