Seventh-graders learn astrophysics through mixed-reality computer simulation

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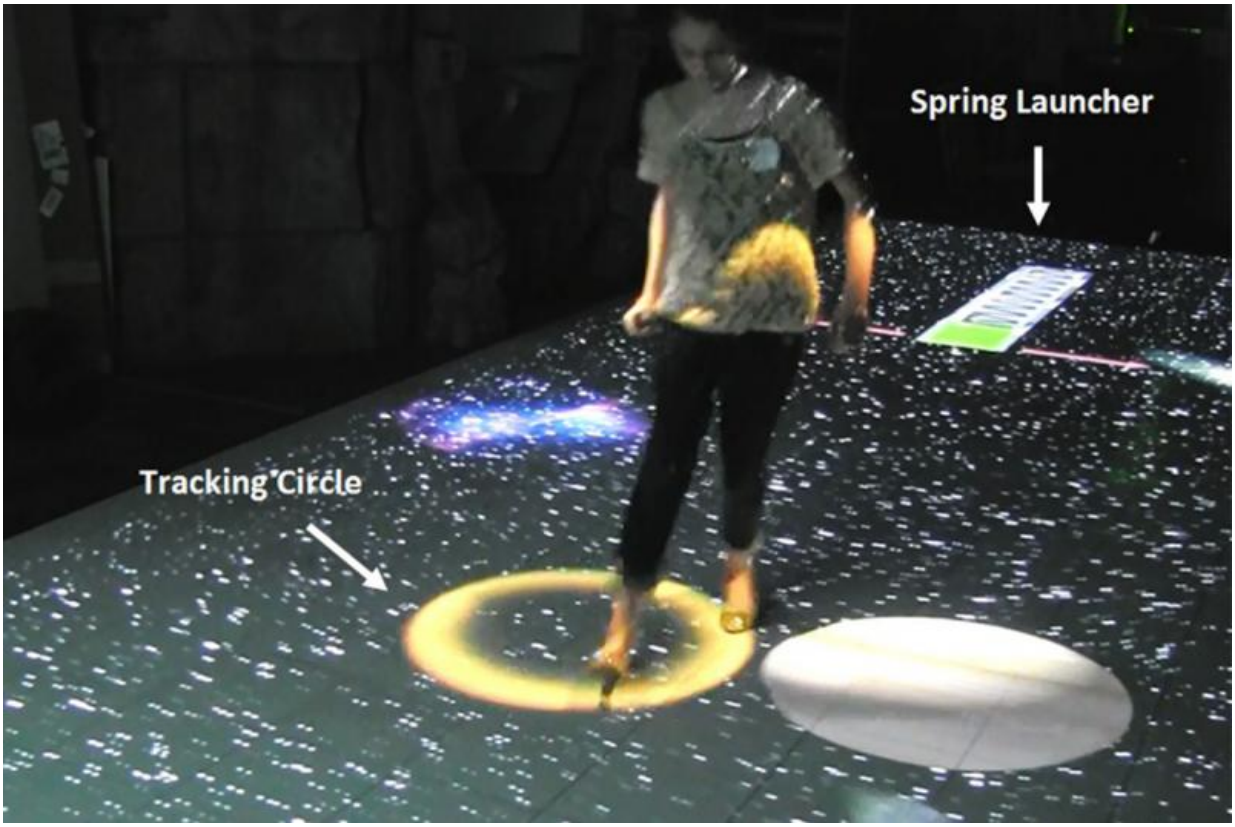


After launching the asteroid, a participant walks across the simulation field to predict the asteroid's path to the target. The tracking circle shows the participant's position; however, a planet's gravitational field has caused the asteroid to accelerate and curve around the planet. Credit: Used with permission of Robb Lindgren

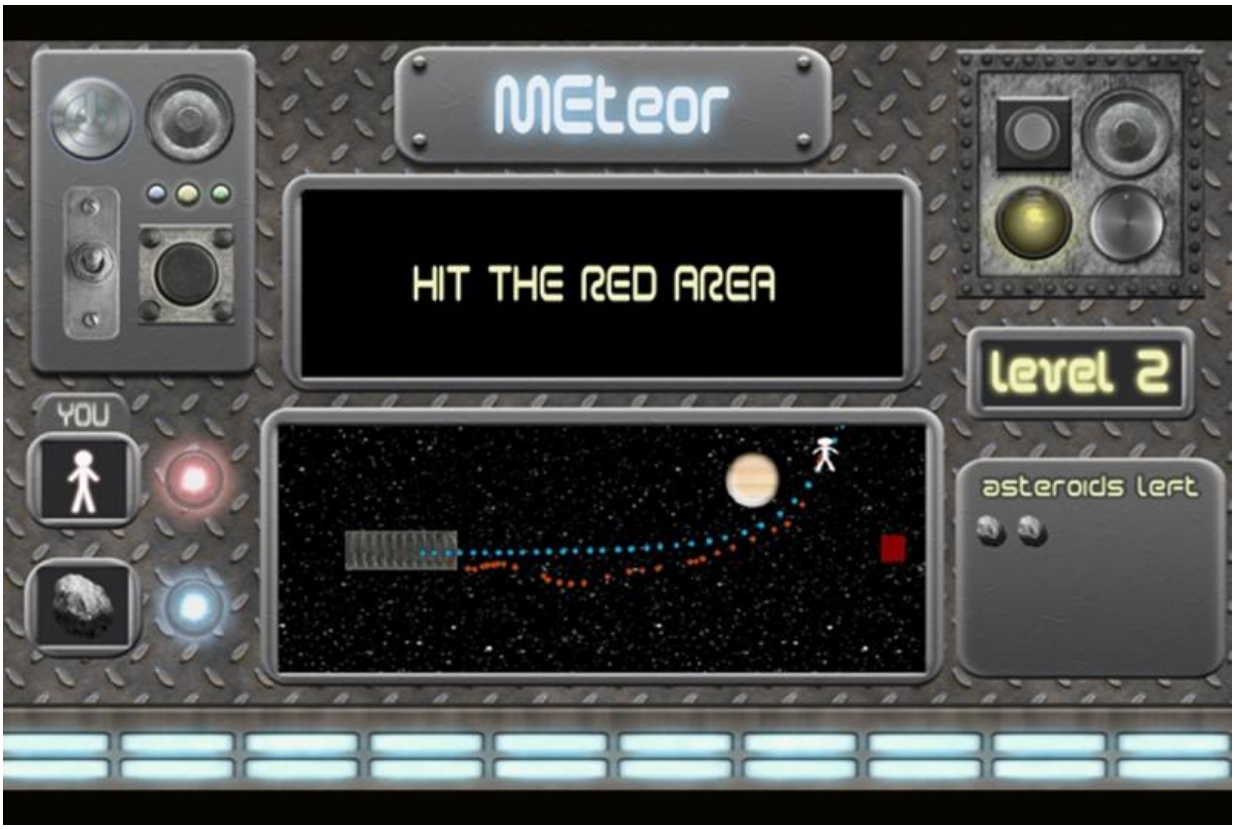
Had the "learn'd astronomer's" charts and theorems inspired the 19th century writer Walt Whitman as much as strolling under the nighttime sky, Whitman might have become an astrophysicist instead of a stargazing poet.

Researchers at the University of Illinois hope to inspire greater numbers of young people to become astronomers - or at least to embrace learning science - with a new computer simulation that engages children's bodies as well as their minds in learning about how objects move in space.

MEteor is a mixed-reality computer simulation that teaches middle school students concepts of physics such as planetary motion and gravitational acceleration by having students physically act the part of an asteroid traveling through space.

Mixed-reality simulations such as MEteor merge virtual reality with the physical world so that participants interact physically with digital objects, said curriculum and instruction professor Robb Lindgren, the principal investigator on the project.

"There's a lot of potential with these types of experiences to motivate students to pursue science education at the primary, secondary and university levels and to undertake science careers," said Lindgren, who also holds an appointment in educational psychology. "Unfortunately, science instruction has typically not gotten science students up and moving - until now. These types of fully immersive experiences have the potential to transform students' identities when it comes to how they see themselves related to the profession of science."



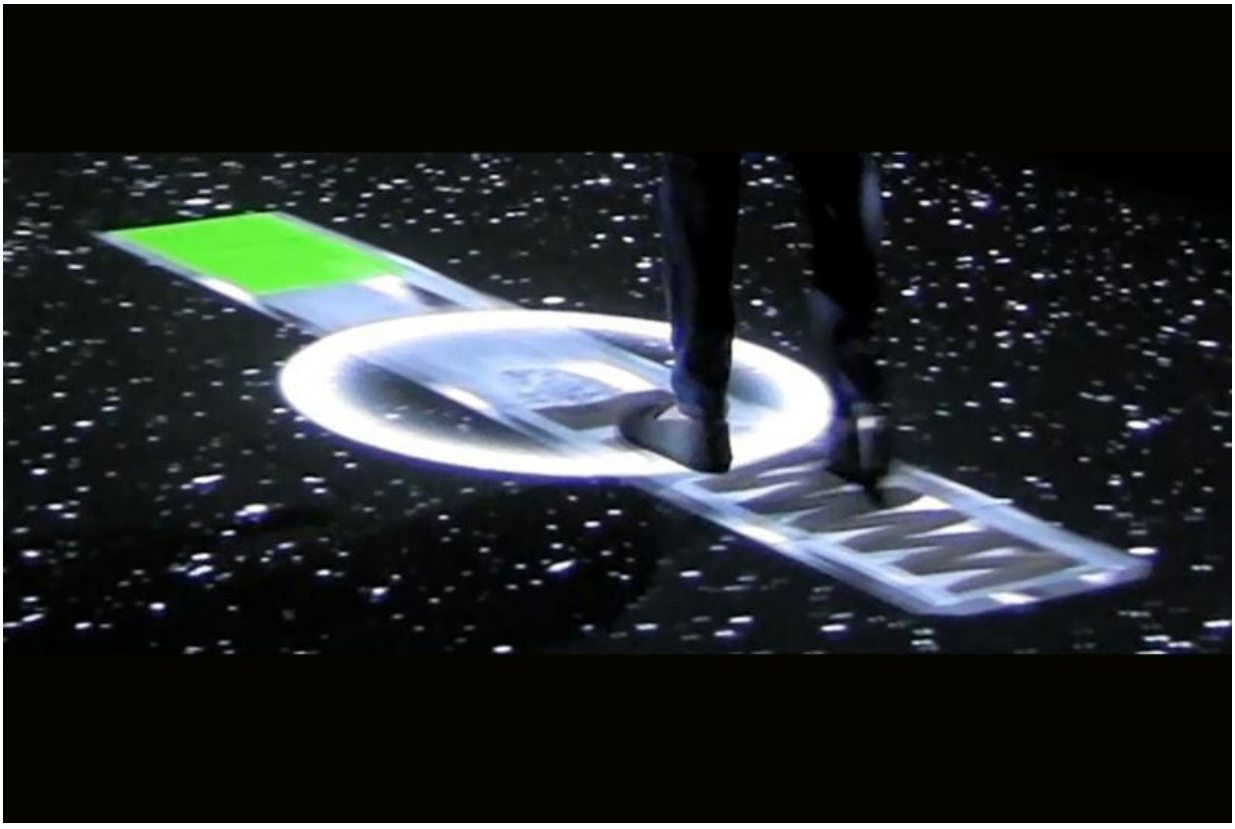
The MEteor wall display shows a graphical replay of the participant's previous launch. Credit: Used with permission of Robb Lindgren

Lindgren's research is focused on the emerging field of embodied learning, which blends physical activity and computer interaction with instruction and is based on the theory that nearly everything people learn and know is grounded in their bodies and the physical world.

Along with Michael Tscholl of Vanderbilt University, Emily Johnson of the University of Central Florida, and Illinois graduate student Shuai ("Sam") Wang, Lindgren recently published a study that compared the impact of the immersive mixed-reality version of MEteor with a version that students used on a standard desktop computer.

In the mixed-reality version, a simulation of planetary astronomy is projected onto a 30 feet by 10 feet floor surface in the researchers' lab. The four levels of the simulation lead students through a series of challenges, including hitting a target near a large planet with the asteroid and putting the asteroid in a sustained orbit around a medium-sized planet.

Participants select the speed and angle for the asteroid to travel using a virtual spring launcher that they control with their entire bodies or with a computer mouse on the desktop version. In the mixed-reality simulation, laser-scanning technology tracks each participant's position as they move across the platform. Real-time data on the student's performance are projected onto an adjoining wall along with basic instructions, providing cues about how the asteroid will respond to the gravitational fields of nearby planets.



A participant loads the asteroid by stepping onto the spring launcher. Credit: Used with permission of Robb Lindgren

To succeed at the full-body simulation, students must be able to predict the asteroid's movements in advance and move naturally with the correct trajectory, according to the study, published in *Computers and Education*.

Students who participated in the mixed-reality simulation showed significant gains in their understanding of physics, higher levels of engagement, more positive attitudes toward science and enjoyed the lessons significantly more than the students who used the desktop version, said Wang, a doctoral student in educational psychology.

Students in both groups were asked to answer a set of challenging college-level questions about concepts of force and motion that were addressed in the simulation, and those who participated in the full-body simulation scored significantly higher on the assessment, "adopting more expert-like knowledge of science concepts" than their counterparts, according to the study.

Using familiar, everyday physical motions such as those used in MEteor's interactive simulation may make physics concepts that students perceive to be difficult to understand seem more accessible and relevant to everyday life than conventional classroom physics instruction, Lindgren said.

"I think we showed in this study that there are significant advantages to embodied interaction in instructional environments if we want to create a generation of students who are interested in and knowledgeable about

science," Lindgren said. "Even short interventions like this can trigger additional questions and curiosities that can lead students to pursue them in a more dedicated, sincere way. That's really exciting, and I think it suggests that more research and experimentation with these kinds of immersive, interactive environments is going to be important if we want to increase the science, technology, engineering and mathematics workforce."

The researchers are working with seven middle schools and high schools in Champaign, Urbana and Danville, Illinois, to explore whether embodied learning and computer simulations can be used to teach abstract scientific concepts such as molecular heat transfer and air pressure, Lindgren said.

More information: Robb Lindgren et al, Enhancing learning and engagement through embodied interaction within a mixed reality simulation, Computers & Education (2016). DOI: 10.1016/j.compedu.2016.01.001

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