

From Tic-Tac-Toe to the Geometry of the Universe

MacArthur Fellow Jeff Weeks helps teachers explore the “Shape of Space” at an EDC workshop



Jeff Weeks at an EDC workshop

Last June, NASA sent up a probe to gather information on the shape of the universe. Last week, Jeff Weeks showed a group of Massachusetts secondary math teachers how tic-tac-toe and other familiar games can help students explore similar questions.

Weeks, a MacArthur Fellow “genius” winner, works at the intersections of geometry, cosmology, and topology. His EDC workshop combined hands-on mathematical activities, computer games, and his award-winning Shape of Space video to walk the teachers through the mathematics of various alternative universes.

Reading Topological Maps

Outlining his two-week Exploring the Shape of Space curriculum, Weeks began with a tribute to traditional Euclidean geometry, calling it “extremely beautiful” and the right focus for geometry lessons. “But kids need to see that humanity’s understanding of geometry continues to evolve,” he added.

To start everyone thinking beyond traditional Euclidean space, he distributed paper cylinders with a tic-tac-toe game drawn around each one—which creates a sort of continuous game board as you move around the cylinder. Attendees plunged into this novel version, with much amusement.

Now imagine folding that same piece of paper into a cylinder in two directions—so that the right and left sides come together and the top and bottom sides. That shape is

called a torus and it's nearly impossible to create with a real piece of paper. However, Weeks has designed a simple computer model to represent a torus.

With the visual model of the torus in their heads, teachers at the workshop tried their hands at new, complex versions of mazes, crosswords, word searches, and even chess.

Studying the Universe's Shape

Beyond the fun and challenge of the games, Weeks drew the connections between the torus and the shape of space, which he studies in his day job in Canton, New York.

"We don't know if the universe is finite or infinite," he noted. In fact, it might, like a torus, be finite but without boundaries.

If the universe is finite, scientists might expect to see repeating patterns as light or radiation travels around space. His current research is focused on searching for patterns in microwave radiation that can be detected throughout the universe. Some early data on this background radiation may show that its temperature patterns are duplicated on either side of the earth, as it would be in a three-dimensional torus.

Much better data are expected from the Microwave Anisotropy Probe (MAP), which the National Aeronautics and Space Administration shot into space last June. This will be followed in 2007 by the European Space Agency's even more advanced Planck satellite. So within a few years, if the universe is not too large to be observed, "we will learn the shape of space," Weeks concluded.

Bringing It Back to the Classroom

The culminating event of two EDC professional development courses (PROMYS for Teachers and Building Regional Capacity) offered in partnership with graduate mathematics programs at Boston University and UMASS Lowell, the Weeks session drew an enthusiastic response from the Massachusetts teachers.

"The teachers in both of these courses have been working for years to sharpen their mathematics skills by exploring complex problems," noted Al Cuoco, senior scientist and director of EDC's [Center for Mathematics Education](#). "This kind of professional development helps teachers become expert in the mathematics they teach and explore how that content connects to the key ideas that underlie the structure of mathematics and the process of mathematical thinking."

"It was interesting to go through different aspects of topological math at a nice leisurely level," said Bob Mastorakis, a math teacher at Mohawk Trail Regional High

School in Buckland. “Computer graphics make it much easier to visualize. I can see where it might be put into the curriculum.”

“It’s definitely something you could use,” agreed Megan Gerstenzang, who teaches at Gibbons Middle School in Westborough. “The activities would challenge the student, and help them understand why people would study all of the things we’ve been talking about.”

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