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This colorful image depicts an infinite tube with various portals on its boundary. The construction is meant to represent a three-dimensional manifold, an important structure in topology that captures the abstract notion of a curved surface. All art courtesy of Richard Schwartz.

For one Brown professor, merging math with art results in gallery-worthy visualizations

Richard Schwartz is not only a renowned mathematician, but a writer and illustrator of children's picture books — his secret is bringing math and art together.

PROVIDENCE, R.I. [Brown University] — To most people, math and art feel like two completely different subjects. But for Richard Schwartz — a mathematician who often creates colorful visualizations alongside his mathematics — the disparate fields go hand in hand.

Schwartz, a professor of mathematics at Brown University, is known for his work in geometry and dynamical systems — work that describes in mathematical terms repeated processes like a superball bouncing around inside a pyramid. Schwartz has also garnered acclaim for his artistic side — based on his use of graphical interfaces to help with his research, and also for his publication of illustrated math books.

Q: When you merge math and art in your work, which comes first?
They go hand in hand. The graphical user interfaces I program are investigative tools for me. They're my experimental apparatus. They sometimes help me discover new mathematical results by helping me organize the information, keep track of data and mathematical constructions. Sometimes the things I discover using the programs lead to papers, while the program itself ends up being separate from the actual publication — just a sort of demonstration of the math.

This is something I've always done. I just always had this style. I like things with bright, flashy colors and interesting patterns. I try to make programs to effi-

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ciently answer the math questions I have, and I want the design of the interface to reflect the underlying mathematical structure. As a bonus, these interfaces sometimes produce beautiful pictures. The nature of the programs depends on what I'm working on. For example, different subfields of mathematics lend themselves more naturally to visual things.

Q: As both a mathematician and an artist, what are some similarities you see between the two fields?
It's an interesting question and I was thinking about this a lot recently because of the gallery exhibit. For one, both generate many types of images, albeit through different means. Many mathematicians use algorithms

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When people read my math papers, I want them to understand exactly what I'm thinking. With my artwork, it is different. I might want to evoke a general kind of feeling without forcing the viewer into a specific interpretation. When it comes to the pieces I made for the gallery, I tried to make videos that people would find beautiful and striking without them having to know exactly what they mean.

RICHARD SCHWARTZ — Chancellor's Professor of Mathematics

and equations. An artist has many different methods, of course. I talked in depth with the owner of the gallery about how another commonality is the repetitive motion you see in both. Artists will retrace things over and over again and make sketches and explore things before the final piece comes out. Mathematicians are like that, too. They'll draw the same picture over and over again and gradually mutate it. Practitioners from both disciplines seem to go through this iterative drawing process.

Of course, there's also a common theme of creativity. On the art side, the creativity part is pretty obvious, but people often think of math as being set in stone — there are just these equations, and they're either right or they're wrong. That's true, in a sense, but the way you discover the truth is often through creative attempts that involve a level of choice and risk similar to what you see in art.

Q: Speaking of the exhibit, can you share details about the pieces you created for display?
Over the years, these computer programs I've written end up having an extensive visual interface. For the show I made videos of the interfaces in action. I ended up making about 18 of them, and the exhibit shows about a dozen. One of them looks like an Alka-Seltzer. It is a bunch of dots in the middle and they diffuse out, filling up a region. This one was just for fun, meaning it isn't so closely related to my research but I liked the mixture of chaos and order shown in the video.

Another shows this structure known as a tetrahedra in a curved four-dimensional space. We want to see that all the building blocks of the individual tetrahedra do not overlap. Imagine designing a building out of bricks. You might make a mistake and specify that two bricks be put down in a way that overlaps — a physical impossibility. The structure I created is like a building, except that it lives in four-dimensional space and the "bricks" are these tetrahedra. The computer program goes around and checks pair-by-pair that the bricks fit and do not overlap. The projection of each pair is colored red and the other yellow. The video shows this happening in real time.

I also did a demonstration of a famous theorem in geometry called the Poncelet porism. The setup for this theorem is that you have a small ellipse surrounded

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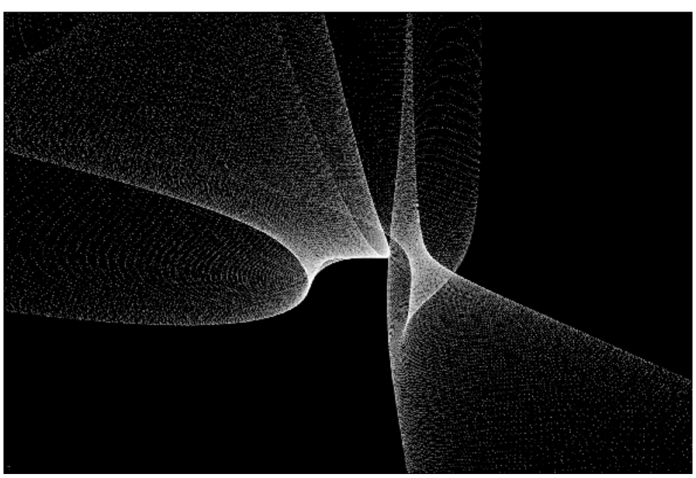
by a larger circle. You start with a point on the outer circle and then draw a line that just kisses the inner ellipse and continues back to the outer circle. Then you move the initial point to the new intersection point. Now, you repeat. Suppose you come back to where you started after some number of steps— say 17. The theorem says that no matter which point you start at, you will always come back to that point after 17 steps. My video animates this process, moving the inner ellipse around and changing its shape to give a dramatic effect.

Q: Is there a piece you're particularly proud of?
The one I like the best shows a sampling of surfaces in space. The levels show something called a completely integrable system, a process that starts with one point in space and moves it to another in such a way that lots of properties of the point are conserved. Think of the layers of an onion or maybe a bunch of parallel flat sheets, but they're not just straight, they're wavy. The program I created shows what each layer looks like, and I rendered them by putting lots of points on them. As you go through it, you see these cool interference patterns that look a little bit like when you put two grids in front of each other and twist them around. To me, it is really beautiful:



Q: When people look at your work — whether it is art or math or both, what is it you hope they take away?
Well, whatever the work is, I hope that they like it! I've always been pretty confident in my math abilities, but that hasn't been so with art. I often think: 'Am I a hack?' I don't have formal training in art, so I worry that people will find my artwork amateurish.

When it comes to math, there is always some precise idea I want to get across. When people read my math papers, I want them to understand exactly what I'm thinking. With my artwork, it is different. I might want to evoke a general kind of feeling without forcing the viewer into a specific interpretation. When it comes to the pieces I made for the gallery, I tried to make videos that people would find beautiful and striking without them having to know exactly what they mean.