## *Untying Knots with Mathematics*

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INFORMATION

Jonathan Gross knew little about Celtic knots before he started studying them. “I knew one when I saw it. They are characterized artistically by repetitive patterns and symmetries,” he said. “Then, while browsing the Internet, I found a graphic artist’s description of them so precise, I could turn it into math.”

Gross uses computers to explore algebraic topology, the mathematics of translating geometric forms into algebraic expressions. “We calculate a polynomial from a picture of the knot. Once we represent the shapes with algebra, we can manipulate the math to learn fundamental truths about the shapes,” he explained.

“For example, Reidemeister proved that if you make new crossings in a knot without cutting the string, the resulting figure has the exact same polynomial as before. If you hand me a knot, I can either fumble for hours trying to untie it or I can calculate a certain polynomial and quickly know that the string is really knotted,” Gross said.

Gross is quick to point out that his research is theoretical. Yet some of his insights have worked their way into practical applications. “Some of my work is related to practical technology,” he said. “But what motivates me are mathematical problems that involve spatial visualization and deriving algebraic formulas to count mathematical objects far too numerous and/or too intricate to count by any elementary methods.”

Last year, for example, he collaborated with two colleagues in Texas to develop a computer graphics program to create designs in woven textiles. “We designed software whose mathematical models embody key principles of algebraic topology,” said Gross. “A graphic artist doesn’t have to know any of this to use the software to create a complicated woven pattern very quickly.”

Gross has also applied mathematical modeling to social anthropology. Anthropologists used to live with a people and describe what they saw. Their descriptions were typically highly subjective. Gross worked with a team that developed an objective way to measure and compare behavior.

They started with food systems. “There are differing levels of randomness in the way people eat,” he said. “When some people eat scrambled eggs, you know for sure it’s breakfast. Not quite so for others. To differing extents, meal content reflects the time of day, time of year, and festivities. By measuring the information content in these patterns, we could make comparisons between different peoples.”

To Gross, it was just another knot untangled by mathematics.

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