COMMUNICATION

Mathematics at the Airport? Why Sure!

David Eisenbud, Nicole Mullen, and Cliff Stoll

Figure 1. Cliff Stoll, with Klein bottle variations.

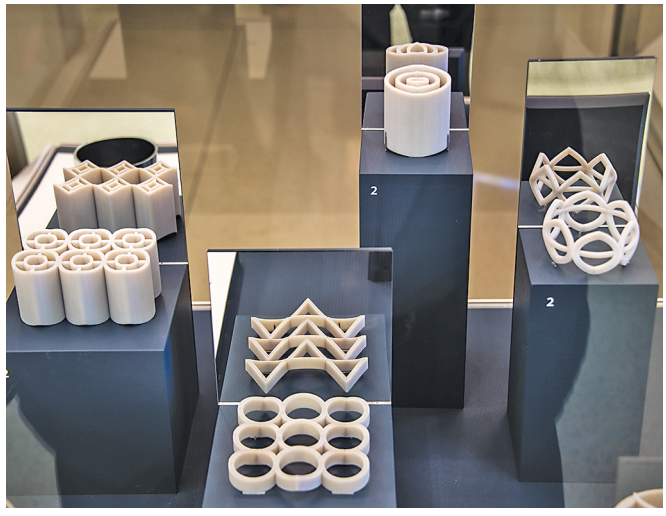

Figure 2. Kokichi Sugihara's Ambiguous Objects, seen from two points of view (note the flat mirrors; there is no trickery).

Passengers traveling through San Francisco International Airport have long been intrigued and delighted by SFO Museum's exhibitions. These displays have included cultural icons like surfboards, wallpapers, and even toasters. An exhibition of hundreds of typewriters attracted worldwide accolades. Might there be space for an exhibit on mathematics?

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In 2019, one of us (Cliff Stoll—astrophysicist, author, purveyor of Klein bottles) found himself with some oddball Klein bottles and not enough closet space. Perhaps the Mathematical Sciences Research Institute might display them? A chat with David—MSRI director—dashed any hopes: "Nope, we just don't have the room, but let's check around—perhaps a museum would be interested." Emails to local museums, high-tech businesses, and community centers weren't answered: it looked like the one-sided glassware would stay in the closet. But persistence paid off: David called SFO and eventually reached Nicole Mullen—then curator of SFO Museum. "Why sure," she said. "We're thinking about displaying some slide rules and other mathematical objects. Can you help out?"

So began a two-year collaboration amongst the three of us. At the beginning, David and Cliff learned SFO Museum's rules: only vetted artifacts are shown and these

Figure 3. A Sierpiński curve development, with maker Henry Segerman.

must be treated as art objects. No computer displays or videos. Posters were possible, but discouraged. Everything's behind glass for a year, so no motorized mechanisms. Nicole broadened her view of what the exhibit might represent.

On the other hand, since SFO Museum adheres to rigorous museum rules, it was easy to work with other museums and galleries, such as the Computer History Museum and the National Cryptological Museum. Nicole researched mathematical exhibitions, such as Charles and Ray Eames' Mathematica, and studied the Smithsonian National Museum of American History's mathematical collections, seeking artifacts to attract the attention of airport visitors. Meanwhile, David and Cliff thought about how to show modern mathematics, and put out calls to mathematical artists.

Throughout the selection process, there was tension between what displays well to the public, and what has mathematical content. A written proof isn't likely to turn the head of a harried passenger; a glitzy display of dancing digits hasn't much math. The experience of the museum staff gave insight into what to avoid; commentary from the math community helped keep us on track.

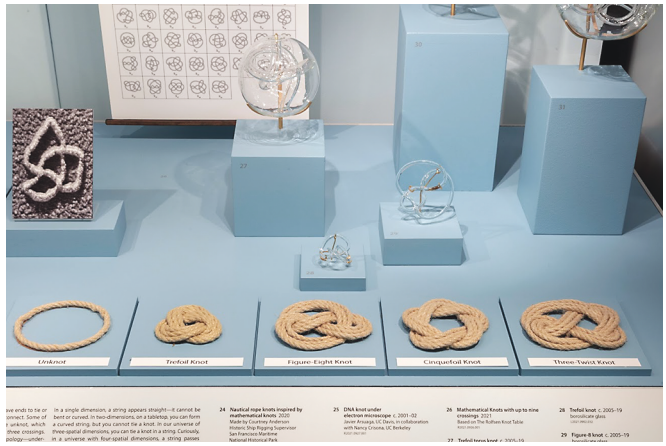


Figure 4. Knots in DNA, glass and, yes, rope.

Figure 5. Two uses of the term "computer."

In choosing objects, we tried to reach both the curious and the indifferent. We wished to include simple objects as well as some mathematically challenging concepts. Ideally, we wanted to show a world of mathematics that stretches the imagination.

With five display cases and thirteen windows, we thought we'd have plenty of space for the exhibition. Hah! We quickly realized that the allotted space was far too small to survey math. We decided to highlight works from mathematical artists in walk-around display cases. In eye-level wall cases we focused on mathematical models, calculators, and teaching manipulatives, reflecting the SFO Museum's original conception of the exhibit.

To give a sense of history, we devoted several windows to "computing before computers:" here, passengers see abacuses, slide rules, adding machines, and calculators from the past five centuries. Photos help with historical and cultural context: not long ago, a computer was a human turning a crank on a calculator.

Math is taught in every school, so we included numerical toys and manipulatives for elementary arithmetic, together with models from integral calculus—the method of disks and washers. An elegant photo (Fig. 6) shows a class confirming that the ratio of circumference to diameter is the same for (at least) many circular objects.

Figure 6. What is the value of π?

Figure 7. Surprising Rubik's cubes, and friends.

One window is devoted to delicate plaster models that depict cubic polynomials and the Weierstrass p-function. Such models were produced at the end of the 19th century, and collected by many math departments until World War I. They have been the subject of art photos by Man Ray that were exhibited by San Francisco's deYoung Museum not long ago.

Other parts of the exhibition focus on modern math, including topology, prime numbers, and cryptography. The historic ship rigging supervisor from the San Francisco Maritime Museum used sisal rope to create mathematical knots, to complement knots formed by DNA and knots made from glass tubing. (He was fascinated by mathematical knot charts and surprised that topological knots don't have ends.) We devote a window to Rubik's cubes, pointing out their connection to group theory.

We hand-scribbled "proofs without words" on two large backlit displays; these show the Pythagorean theorem and the summation of an infinite series. To indicate that math research continues we included a blackboard with syzygies—the Koszul complex—written with Hagoromo Fulltouch chalk, a box of which is also on view.

We had the good fortune to receive help from many mathematical artists. Professor Kokichi Sugihara of the Meiji Institute for Advanced Study of Mathematical Science generously lent several of his Ambiguous Objects. Passengers glance at his exhibit then stop, trying to understand a geometry that looks quite impossible.

Nearby, Scott Kim's anamorphic ambigram shows reflective geometry—the decoding of messages using a cylindrical mirror. His playful blend of math, art, and language brings out a curious and creative side of mathematics.

Chris Hamann contributed many hours of his expertise in calculator history as well as beautifully reconstructed calculators and slide rules.

Figure 8. This could be you..., and if you can't come in person, these links will show you more: `https://www.sfomuseum.org/exhibitions/mathematics-vintage-and-modern`, `https://photos.app.goo.gl/tpL6AEL2X1YfgtfRA`.

Stacy Speyer built several polyhedra to demonstrate Euler's convex polyhedral formula. While surprisingly simple, this isn't well known to the public; Stacy's sculptures let viewers use an elementary arithmetic relationship to connect a variety of geometric solids.

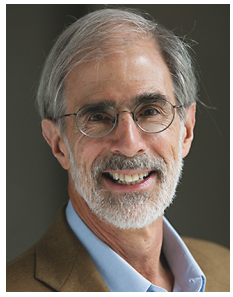
Henry Segerman lent two complex 3D printed objects—a Sierpiński Arrowhead and a Terdragon curve. These show the complexity of fractals; his sculptures are complemented by several related math puzzles.

Carlo Sequin displayed two sculptures: "Aurora Australis," a convoluted brass Mobius loop inspired by the earth's polar aurorae. His (3,5) torus knot attracts attention with its 5-fold symmetry and slightly triangular shape.

In other displays, passengers can see glass knots, Klein bottles, and a Thurston tripus made by glassblowers Lucas Clarke, Tom Adams, George Chittenden, and Xing Wei.

By the end of the exhibition in June 2022, about half a million passengers will have passed by these displays. Of course, many will hurry by, hardly noticing. Some will spend a few minutes; others will invest time understanding the displays and puzzles.

Too often, fascinating mathematics remains in academic corridors. As mathematicians, we're responsible for reaching the public to describe the wonders of both modern and historical mathematics, their beauty and power, and the fun to be had from them. As you walk through your neighborhood, think of ways to show your ideas and research: perhaps in an editorial, at a math circle, or even a chalk scribble on the sidewalk. And if you're flying through SFO, come visit the mathematics exhibition in Terminal 2.



David Eisenbud

Nicole Mullen

Cliff Stoll

Credits

Figures 1, 2, 4, 5, and 8 are courtesy of David Eisenbud.

Figures 3 and 7 and photo of Nicole Mullen are courtesy of SFO Museum.

Figure 6 is courtesy of Scurlock Studio Records, Archives Center, National Museum of American History, Smithsonian Institution.

Photo of David Eisenbud is courtesy of the Simons Foundation.

Photo of Cliff Stoll is courtesy of Cliff Stoll.