Teaching Math in America: An Exhibit at the Smithsonian

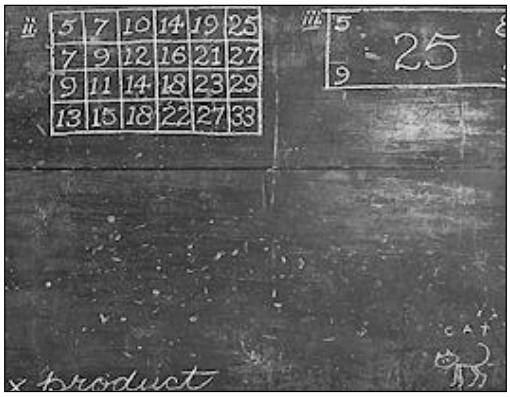
How to teach mathematics well is a problem educators in the United States have struggled with for a long time. Some aspects of this struggle come to life in an exhibit at the National Museum of American History, part of the Smithsonian Institution, in Washington, DC. With around thirty objects that were used in mathematics classrooms from the early 1800s to the present day, the exhibit shows how mathematics teaching evolved as the United States changed over the past two centuries. "The exhibit is an attempt to put mathematics teaching into the context of American history," explains Peggy Kidwell, a museum curator who created the exhibit.

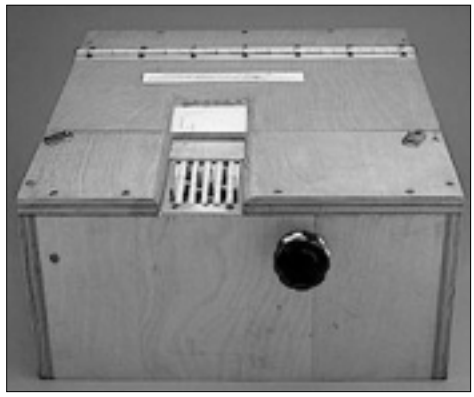
In the early 1800s any man who was free could vote. This was at a time when most nations tied voting rights to property ownership and there were concerns in the United States about whether voters would be sufficiently educated to be able to vote intelligently. This concern led to the establishment of "common schools", later called elementary schools, which taught the basics of reading and arithmetic. And they were not just for boys: it was thought that women needed to be educated too so that they could teach their own children. Kidwell points out that although much of the instruction in mathematics at this time was rote teaching of arithmetic, one can perceive echoes of the present-day concern about how to make math appealing for a diverse student population. Teachers tried various means to make math interesting to students, including using what are today called "manipulatives".

One example on display in the exhibit is a box of wooden models of geometric objects, such as spheres, cones, and cubes, created by Josiah Holbrook in the 1830s. His motto "Good enough for the best and cheap enough for the poorest" reflected the populist ideal of education for all. Similarly low-tech is one object that may be the most mathematically satisfying item in the exhibit: a set of flat wooden tiles, made in 1890 by W. W. Ross, that fit together to provide a proof of the Pythagorean Theorem. More sophisticated models generally came from Europe, often imported by American mathematicians who got their Ph.D.'s from European universities. In contrast to the wooden models that were used to teach the masses, the European models reached only the elite. A few of these models appear in the exhibit, such as a collection of models, dating from 1893, of projections of polytopes, created by the German mathematician Victor Schlegel and distributed by the German publisher Ludwig Brill.

That indefatigable constant of all mathematics classrooms, the blackboard, was introduced in the United States in the early 1800s. A blackboard from this era is in the exhibit, and it is literally a board that had been painted black. Sometimes sand was mixed with the paint in order to create a gritty surface that would hold the chalk. As a result of their successful use in math classes, blackboards began to be used in teaching other subjects. Kidwell tells the story of the curious backlash that occurred when math classes at Yale University began using blackboards. When solving a problem involving a figure, students had been allowed to look at the figure in their textbooks while solving the problem. After blackboards were introduced, the students were expected to solve the problems at the board while recalling any needed figures from memory, without referring back to the book. When this way of working problems at the board was required for geometry examinations in sophomore courses at Yale in 1830, the students refused to take the exams. As a result of the so-called "Conic Sections Rebellion", over forty students, comprising nearly half the entire class of 1832, were expelled.

In the early 1800s students brought to class whatever mathematics textbooks their families happened to own, and some students had no textbooks. Thus the blackboard was especially important for unifying the presentation of explanations





Left to right above: early blackboard, Josiah Holbrook's geometric models from the early 1800s, B. F. Skinner's teaching machine (1954). Below: (top) Cuisenaire rods from the 1950s; (bottom) one of the first graphing calculators, introduced in the United States by Casio in 1986.

of mathematics and for assigning problems to the students. At this time, textbooks were distributed locally: a text would be taken to different printers in different cities, each of which would typeset and print its own edition. Starting in the 1840s, improvements in transportation allowed textbooks to be distributed around the country from a central printing site. These improvements, as well as innovations in printing, were steps leading to the mass marketing of mathematics textbooks.

The stranglehold that rote learning has held on mathematics teaching is evident in the exhibit. One of the strangest objects is a prototype mathematics teaching machine built by the Harvard psychologist B. F. Skinner. A demonstration of the machine took place at a meeting in 1954, but it was never actually used in a classroom. The machine is a wooden box with a set of levers on the top and a handle jutting out of the front. There are numbers running alongside the tracks of the levers so that, for example, having one lever in the 7 position and another in the 2 position indicates one is supposed to perform the operation $7 - 2$. One gives an answer by moving another lever into position, then turning the handle. If the answer is right, the handle turns and one goes on to the next problem. If the answer is wrong, the handle will not turn. The device simply tests calculation skills; there is no attempt to develop the intuition behind those skills. "It's really dippy," Kidwell says of the device. Skinner and others went on to build more sophisticated devices for what came to be known as "programmed learning".

Much better for developing intuition are Cuisenaire rods, invented by the Belgian educator Émile-Georges Cuisenaire. The exhibit has a set of the rods dating from 1965. The various lengths of the rods represent different numbers; by placing the rods end-to-end and comparing the lengths, students have a visual and tactile representation of arithmetic problems. The colors of the Cuisenaire rods also have significance: they are meant to indicate multiples of numbers, so that, for example, the reddish rods represent multiples of two. As Kidwell explains it, Cuisenaire's theory holds that children learn best when they are able to manipulate objects and also have strong associations with color. For this reason his theory is sometimes called "numbers in color". The exhibit also has some examples indicating the revival of the use of manipulatives in mathematics classes in the 1990s.

And what of mathematics education today? The exhibit ends on a rather colorless note, with a display of hand-held calculators and manuals for mathematical and educational software. Compared to the hands-on manipulatives and colorful numeral boards of the past, these manuals seem dour indeed, though presumably the software itself is more exciting. Kidwell points out how cheap, easy-to-make tools like Holbrook's wooden models came to be replaced by more expensive and sophisticated tools like software. In this way, the exhibit reveals the increasing influence of commercialism in the mathematics classroom. The objects in this exhibit remind us that, while the problems of teaching and learning mathematics will never be definitively solved, a historical perspective can provide new insight into the best and most useful teaching methods.

Note: The exhibit, entitled "Slates, Slide Rules, and Software: Teaching Math in America", is on display in the National Museum of American History in Washington, DC. It is anticipated that the exhibit will remain at least through the duration of the Joint Mathematics Meetings in January 2003, which will take place in Baltimore. More information can be obtained by visiting the exhibit's website, `http://www.americanhistory.si.edu/teachingmath/` or by sending email to `mathematics@si.edu`.

—Allyn Jackson

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