REVIEWS

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The chalk-covered overhead projector in the classroom corner has a story to tell. So does the pitted blackboard. Even the abandoned scrap of graph paper has a tale. These objects find their voice in *Tools of American Mathematics Teaching*. Other, less familiar or forgotten devices such as cube-root blocks and Cuisenaire rods get the occasion to speak as well.

Tools of American Mathematics Teaching is divided into four parts: Tools of Presentation and General Pedagogy; Tools of Calculation; Tools of Measurement and Representation; Electronic Technology and Mathematical Learning. The impatient reader can dip in anywhere without fear of getting lost, since the chapters are independent. Careful references and generous notes at the end make this book a valuable supplement for a course in history of mathematics, especially one designed for education students. Briefly, *Tools of American Mathematics Teaching* is a highly unusual, well-written book that will entice those who have been on either side of the lectern.

"When do you suppose blackboards were introduced in the United States?" I eavesdropped as one of the authors, Peggy Kidwell, posed the question to a dinner table full of mathematicians attending a conference. Her account of indignant Yale students whose resistance to such an innovation led to the Conic Section Rebellion of 1830 (and their ultimate dismissal) now often intrudes on my subconscious when I drag an eraser across a board.

Ostensibly, mathematical tools are the focus of the book. They are treated carefully, even lovingly. One chapter is titled "The Slide Rule," another "The Protractor." More than 80 black and white photographs aid the reader's imagination. However, *Tools of American Mathematics Teaching* is in fact a catalog of enthusiasms. Each of the chronicled devices embodies someone's hopes. Consider, for example, this early 19th-century description of the abacus: "Suffice it to say, that it was one of the best instruments that was ever introduced into an infant school." Or this later assertion: "The single most important catalyst for today's mathematics education reform movement is the continuing exponential growth in personal access to powerful computing technology."

The most common teaching tools of our day are textbooks. They were not always common. Textbooks were rare and expensive in the early United States. When *A New and Complete System of Arithmetic* was published in 1786 by a Newbury-Port schoolmaster, Nicholas Pike, the weight of the event was recognized by the former commander of the Continental Army, George Washington. "I flatter myself," he wrote, "that the idea of its being an American production, and the first of its kind which has appeared,

will induce every patriotic character to give it all the countenance in his power" [**2**, pp. 181–182]. Those who traded in anchors of brandy, pipes of water, or butts of ale were thankful for Pike's book. So great was its need that it remained in general use for more than 50 years.

Other authors followed Pike's example. Both Jeremiah Day of Yale and John Farrar of Harvard made handsome profits from their textbooks. Yet both continued to regard themselves primarily as university professors rather than successful authors.

Charles Davies was different. A hasty product of the United States Military Academy at West Point, he returned after the War of 1812 as an assistant professor of mathematics. Perhaps it was his depressing salary of ten dollars a month that motivated Davies to begin writing mathematics textbooks. He would churn out fifty books during the same number of years from 1826 to 1876. His dealings with various publishers suggest that he was equally fond of business. Davies created a new, lucrative career that would survive longer than his writing.

A sense of civic duty also propelled most mathematical authors and inventors. However, another, more alarming motive was gaining strength. As schools and students multiplied, cries for uniform standards and assessment became loud. By the end of the nineteenth century, testing had become an industry that would survive recessions and even the Great Depression.

When knowledgeable enthusiasm for teaching gives way to other concerns, trouble follows. Administrators and psychologists soon began a symbiotic relationship, the former dreaming of more efficient classrooms, the latter of huge classroom-laboratories. Together they began to transform teachers into data gatherers. Some of the tests, such as those designed by Stuart Appleton Courtis which timed students' arithmetic computations, were at best a waste of time. One series of "diagnostic tests," designed by Courtis for the schools of Cleveland and Grand Rapids, required nearly six hours for completion. A colleague, Walter Scott Monroe, warned, "Any series of classroom tests must not require a large amount of time if they are to be used by any besides the most enthusiastic workers." Schools today must be full of enthusiastic workers.

The need for greater classroom efficiency also spurred the use of many of the devices found in the pages of *Tools of American Mathematics Teaching*. Perhaps the oddest instance involved the overhead projector.

As the Second World War began, the United States military discovered that it was now in the business of teaching. Thousands of new recruits needed training in technical matters, and many had little education. While movies and filmstrips were helpful, one such device, the overhead projector, was drawing special attention and funding of the U.S. government.

Before the war, overhead projectors were more likely to be bathed in beer than chalk. The "Tel-E-Score," manufactured in Chicago by the Brunswick-Balke-Collender Company, projected written bowling scores on screens at the head of the alley. After the war ended, aggressive marketing combined with government grants promoted "bowling-alley projectors" to the classroom. Unlike blackboards, overhead projectors permitted teachers to remain facing unruly students, thereby satisfying needs of both pedagogy and protection. "Projectuals," devices specifically designed for the projectors, offered teachers the opportunity to present material in a dynamic fashion. One such device that is still available for purchase used iron filings in a soft bag of viscous fluid together with magnets to help students visualize magnetic fields.

While some teaching tools promoted more efficient teaching, others demanded precious time. Cube-root blocks (a visual aid for cube root extraction) and Cuisenaire rods (colorful manipulatives for demonstrating basic arithmetic operations, reciprocal

numbers, proportion, and other elementary concepts) are two examples. As early as the mid 1800s we find educators contending that children should discover mathematical principles for themselves. I do not know if the use of such tools initiated the teaching debate between "traditionalists" and "reformers," the former emphasizing manipulation of symbols, the latter objects. Certainly, it accelerated this ongoing fight.

The slide rule was a different sort of device. It was invented by a seventeenth-century Anglican minister and mathematician, William Oughtred. Specialized rules for tradesmen quickly followed. One such "gauging rule" was used to determine excise taxes on wine, ale, and spirits contained in barrels. When in the late nineteenth century the slide rule was introduced to American college classrooms, it arrived as a tool only for advanced calculations. Nevertheless, there was unease among some educators. The authors of *Tools of American Mathematics Teaching* might have included the following warning of Oughtred, reported in 1916 by mathematics historian Florian Cajori [**1**, p. 93].

> A boy may learn to use a slide rule mechanically and, because of his ability to obtain practical results, feel justified in foregoing the mastery of underlying theory; or he may consider the ability of manipulating a surveying instrument quite sufficient, even though he be ignorant of geometry and trigonometry; or he may learn how to operate a dynamo and an electric switchboard and be altogether satisfied, though having no grasp of electrical science. Thus instruments draw a youth aside from the path leading to real intellectual attainments and real efficiency; they allure him into lanes which are often blind alleys. Such were the views of Oughtred.

Many of the devices described in *Tools of American Mathematics Teaching* were made possible by new or improved materials. The commercial success of the overhead projector, for example, was dependent upon cellophane, invented in 1912 and later used to make inexpensive transparencies. The popularity of graph paper depended on production methods that could ensure large supplies at low cost.

However, one innovation had a greater impact on mathematical tools than all previous ones combined. With the introduction of miniaturized electronic circuits in 1959, the shore of a previously unimagined, virtual world was glimpsed. As affordable handheld calculators arrived in the 1970s, traditional mathematics curricula and attitudes about teaching began to change. Fifty years later we are still struggling in the ocean currents, making our way to an uncertain shore.

It is fitting that the final quarter of *Tools of American Mathematics Teaching* is devoted to electronic technology. Computers have made possible new educational tools. More significantly, they have changed the way we discover and, arguably, the way we think. (Today it is easier to find a slide rule "app" for an iPod Touch than to purchase the real thing.) The search during the past two centuries for new tools of teaching is now carried to the jungles of our virtual world. I can't wait to read the sequel to this extraordinary book 200 years from now.

REFERENCES

1. W. Cajori, *William Oughtred, A Great Seventeenth-Century Teacher of Mathematics*, Open Court, Chicago, 1916.
2. G. E. Littlefield, *Early Schools and School-Books of New England*, The Club of Odd Volumes, Boston, 1904.

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