Mathematics is not just a collection of isolated facts, it is more like a landscape. The user of mathematics walks only the well-trod parts of the mathematical territory. The creator of mathematics explores its unknown mysteries, maps them, and builds roads through them to make them more easily accessible to everybody else.

Ian Stewart, 1995

Math and Science

The Culture of Mathematics: Slaying the Dragon

"Does any word strike greater fear in the hearts of American ninth-graders—and their parents—than algebra?" asked a 1998 front-page article in the *Wall Street Journal*. "Students dread algebra, approach it as if it were toxic and, not surprisingly, do badly at it."[1]

Clearly, most American students do not share Ian Stewart's eloquent view of mathematics. Most mathematics curricula and teachers do not present the subject as real and usable in today's setting. As a result, fear, anxiety, dislike, ambivalence, and low self-confidence are pervasive in mathematics classrooms. Mathematics is perceived as irrelevant. Students see it as merely a collection of rules to be memorized and manipulated. Such experiences create the myth that math is only for the fortunate few who "get it."

Why do students so disdain the prospect of venturing down Stewart's well-trod path through the jungle? Is the jungle too ominous and intimidating, or does the path simply need better lighting and friendlier guides?

Math in U.S. Schools

- In a study of fifth-grade math students, an overwhelming number of students who said they dislike mathematics also believed they were not good at it and that they performed worse than their classmates.[2]
- The Third International Mathematics and Science Study (TIMSS) found that:[3]
  - Most eighth graders in the United States study topics that students in many other countries encounter a year earlier.
  - U.S. math lessons seem to place greater emphasis on definitions of terms and less emphasis on the underlying rationale.
  - U.S. instructional materials for math attempt to cover more ground at less depth than the materials in the other countries. U.S. lessons also contain significantly more topics than do Japanese lessons.
  - The number of definitions presented in a U.S. mathematics lessons is about twice as many as in Germany or Japan.
  - U.S. lessons contain significantly more switches from topic to topic than do both Japanese and German lessons. German lessons scored at least four times as high as U.S. lessons in both complexity and connectedness. Japanese lessons scored six times as high.
- According to results of the National Assessment of Educational Progress (NAEP), only about 1 in 7 high school seniors is proficient in math.[4]
- Seventy-five percent of Americans stop studying math before they complete their career or job prerequisites. [5]

- Sixty percent of college mathematics students enroll in courses that are taught in high school.[6]
- Almost 40 percent of all 17-year-olds do not have the necessary math skills to hold down a production job in manufacturing. As a result, today's manufacturers now often must seek out college graduates for work that high school graduates should be able to perform.[7]
- Major industry and businesses are spending billions of dollars each year training a workforce that is becoming more reliant on computers and technology, while becoming less knowledgeable about how they work. In 1991, employers spent about $63 billion training their workers. By 2005, it is estimated that employers will have to increase training expenditures by more than $15 billion to match 1991 training levels for professional and technical workers.[8]

The Math Gap

U.S. mathematics education at all levels performs poorly, resulting in a less than mathematically literate nation. Why is "math anxiety" such a common condition in the U.S.? Why can't American teachers and schools interest and motivate students in mathematics as teachers in other countries do?

The following is a comparison of what is being taught about math in our schools, and what mathematics really is:[9]

In Schools	As a Discipline
Mathematics is neat and concise. It is about memorizing correct procedures or algorithms for solving well-defined problems.	Mathematics is messy. It involves a search for sense and order from complex, ill-defined situations.
Speed and correct answers are emphasized.	Persistence and flexibility are essential to mathematical pursuits. Mathematicians often spend years trying to solve a single problem.
Answers are validated by the teacher or answer book.	There is no answer book. Often there are no "best" answers or even a guarantee that an answer will be found.
Calculators may be used only once basic skills are mastered. Computers and other technologies are useful primarily for drill but also for enrichment.	Tools (manipulatives, computers, calculators) are continuously used to examine and represent ideas or extend thinking. Tedious computations are done by machines. Thinking and reasoning are done by people.
Math is done in isolation, working quietly from a textbook or a worksheet.	Math is a collaborative endeavor with mathematicians and others working together, communicating their ideas and building on one another's ideas and experiences.

Routes and Destinations

It is not unreasonable to argue that the responsibility for the prevailing level of math literacy of our students falls squarely on the shoulders of the American education system and ultimately our teachers. The system has put forth tremendous resources toward reform; however, it is not clear that there has been much change in the culture of teaching. Teachers as a group continue to teach mathematics in much the same way they always have taught it.

Successful math teachers are not only those with expertise in mathematics, but also those with expertise in teaching[10] and further expertise in teaching mathematics. Expert teachers with expertise in pedagogy and mathematics know what is easier for students to master in mathematics and what is harder, and they adjust their teaching accordingly.[11]

Successful math teaching:

- Gets students involved with the ideas and concepts behind mathematics.
- Capitalizes on their capacity for making connections.
- Defines and connects their work to critical pieces of accepted arithmetic, algebraic syntax, and historical knowledge.
- Assesses students' knowledge of skills, content, and mathematical process.

To the typical mathematics student, math is a beast to be feared—a dragon from which to run. An equally difficult dilemma, however, faces the math teacher who stands before a classroom of students who don't want to be there. The teacher is most likely armed with knowledge of math, and perhaps even knowledge of teaching, but is he or she adequately prepared to break down the barriers that separate students from the desire not just to learn but to understand?[12]

Endnotes

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12. Some teachers and schools are adequately prepared to do so, such as the math and science classes at Bedford Road Collegiate Institute in Saskatoon, Canada, described in *Scientific American, 281*(4), p. 91, October 1999.

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This work was produced in whole or in part with funds from the U.S. Department of Education under Eisenhower grant number R168R50003. The content does not necessarily reflect the position or policy of the Department of Education, nor does mention or visual representation of trade names, commercial products, or organizations imply endorsement by the federal government.