TECHNOLOGY EDUCATION-A RESOURCE FOR TEACHING MATHEMATICS
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*The Technology Teacher;* May/Jun 2004; 63, 8; ProQuest
pg. 20

FEATURE ARTICLE

# TECHNOLOGY EDUCATION—A RESOURCE FOR TEACHING MATHEMATICS

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**Mathematics is the language of the technological world.**

*Standards-based testing* is a major issue impacting public education around the world. Educational publications and daily newspapers cite instances where schools are accredited, or other instances where teams of educators are being assigned to failing schools, to suggest changes for improving student learning and subsequent test scores. In some instances, the state government has taken control of poorly performing schools.

Department of Education reports are also comparing urban, suburban, and rural schools within states. State and national governments are increasing the funds that are directed toward improving education. In the U.S., *No Child Left Behind* (2001) legislation has demanded that all children meet educational standards before they are promoted to the next grade level.

Many educators are suggesting that freedom and enjoyment are being removed from children's and adolescents' daily school activities because there is not time left in the curriculum for exploration (a general education). Schooling's main focus is on the core subjects and the resultant standards-based test scores. Families are choosing where to live, so their children can attend accredited (quality) schools.

Since technology education is an elective course in many schools, as are the other career and technical education components of the school curriculum, state leaders have made administrators and teachers aware of the importance that career and technical education subjects have in reinforcing academic content within a contextual environment. At the state level, technology educators have worked to show the linkages of the courses to the state standards for language arts, science, social studies, mathematics, and educational technology. They state that they have aligned the career and technical subjects to support instruction and learning of the academics.

The history of technology education will show that for many years the profession has said that one of its programmatic goals is to assist in *applying other school subjects* (ITEA, 1985). From a practical perspective, students must use reading to develop knowledge from our textbooks and read plans on using tools and materials to solve technological problems. Often, technical vocabulary is taught. Students are required to apply scientific principles to both understand and to design solutions to problems. We do this with heat, flight, propulsion, simple machines, etc. Since technology changes society, many projects undertaken by students in technology education laboratories require that students become familiar with the history of the period and contributions that technological developments have made to society. Some teachers have students bring in magazine and newspaper articles that show new developments in technology and their potential use in everyday activities.

Mathematics is the language of the technological world. Students measure in technology education. They also solve equations to analyze circuits. They figure areas when purchasing needed construction materials. They analyze statistics on the projects they build, such as the weight held by a bridge or the seconds that a plane was able to fly. They modify their designs, trying to improve their statistics. In a way, technology education is a multidisciplinary subject that applies all subjects in its study and applications.

While articles could be written about the contribution that technology education has made to all school subjects, the authors have chosen to analyze mathematics in this writing. One reason for this choice is that when schools are reviewed for their accreditation, they are often found not performing well in mathematics at the middle school level.

## U.S. Statistics on Mathematics

The National Assessment of Educational Progress (NAEP) mathematics assessment gauges student mathematics achievement in Grades 4, 8, and 12. The NAEP mathematics assessment is a nationally ongoing assessment of mathematics achievement, using a representative sample of thousands of public and private school students. The framework guiding the NAEP mathematics assessment was revised in 1990 to be in accordance with the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). Subsequent adaptations have been made to be in accordance with the *Principles and Standards for School Mathematics* (NCTM, 2000). Since 1990, the NAEP

Figure 1. Description of the Five NAEP Mathematics Content Strands

### Description of the Five NAEP Mathematics Content Strands

**Number Sense, Properties, and Operations**

This content area focuses on students' understanding of numbers (whole numbers, fractions, decimals, integers, real numbers, and complex numbers), operations, and estimation, and their applications to real-world situations. Students are expected to demonstrate an understanding of numerical relationships as expressed in ratios, proportions, and percents. Students are also expected to understand properties of numbers and operations, generalize from numerical patterns, and verify results.

**Measurement**

This content area focuses on an understanding of the process of measurement and on the use of numbers and measures to describe and compare mathematical and real-world objects. Students are asked to identify attributes, select appropriate units and tools, apply measurement concepts, and communicate measurement-related ideas.

**Geometry and Spatial Sense**

This content area extends beyond low-level identification of geometric shapes into transformations and combinations of those shapes. It focuses on informal constructions and demonstrations, along with their justifications. Geometry and spatial sense area includes the demonstration of reasoning within both formal and informal settings. Proportional thinking to similar figures and indirect measurement is an important connection in this area.

**Data Analysis, Statistics and Probability**

This content area focuses on the skills of collecting, organizing, reading, representing, and interpreting data. These are assessed in a variety of contexts to reflect the use of these skills in dealing with information. Students are expected to use statistics and statistical concepts to analyze and communicate interpretations of data. Students are also expected to understand the meaning of basic probability concepts and applications of these concepts in problem-solving and decision-making situations.

**Algebra and Functions**

This content area extends from work with simple patterns, to basic algebra concepts, to sophisticated analysis. Students are expected to use algebraic notation and thinking in meaningful contexts to solve mathematical and real-world problems, addressing an increasing understanding of the use of functions as a representational tool. Other topics assessed include using open sentences and equations as representational tools and using the notion of equivalent representations to transform and solve number sentences and equations of increasing complexity.

mathematics assessment was administered in 1990, 1992, 1996, 2000, and 2003. The data that have been collected from these studies assist the authors in selecting mathematics topics that technology teachers can learn about and include as examples into their curriculum. In turn, this will assist students in their performance on subsequent mathematics standards tests.

Some information about NAEP is necessary to help the reader interpret both the mathematics content strand and composite scores reported in this article. NAEP uses a consistent 500-point scale for both the mathematics content strand and composite scores. The consistency of the scale enables score comparison across the testing years. The NAEP mathematics composite score is computed as a weighed average of the five mathematics strands: (a) number sense, properties and operations; (b) data analysis, statistics and probability; (c) algebra and functions; (d) geometry and spatial sense; and (d) measurement. Figure 1 is an adaptation of Orrill and French's (2002) descriptions of the five mathematics content strands.

## Eighth Grade Student Achievement on NAEP Mathematics Content Strands

Table 1 reports the achievement of eighth grade students across the five mathematics content strands in 1990, 1992, 1996, and 2000 (Mitchell et al, 1999; Lubienski, 2003). The data show that the overall average performance in each strand has steadily increased over the years, and the average mathematics composite score has increased. There is relative consistency across the five mathematics strands because of the relatively small difference in points across the mathematics strands. When ranking the five mathematics strands, geometry and measurement are the bottom two strands each year. In 2000, 1996, and 1992, eighth-grade achievement in geometry was the lowest strand. Further examination of the five mathematics content strands by race/ethnicity reveals severe disparities.

Table 2 shows the average number of points by which white students outscored African-American and Latino students (Mitchell et al, 1999; Lubienski, 2003). The table reveals that in 2000, 1996, 1992, and 1990, across every strand, the average score of white students was significantly higher than the average score for African-American and Latino students. In addition, the table reveals a consistent gap over time among composite scores. The strand in which the largest disparities exist between African-American and white eighth-grade students is measurement. This gap has increased from 40 points in 1990 to 58 points in 2000. Among Latino and white students, measurement, data analysis, and statistics and probability are the strands where the greatest disparities exist.

Lubienski (2003) reported that eighth-grade achievement in measurement reveals a similar deficiency when

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**Table 1.**
**NAEP Eighth Grade Achievement by Year and Mathematical Content Strands**

| | Number | Data | Algebra | Geometry | Measurement | Mathematics Composite |
|---|---|---|---|---|---|---|
| 2000 | 276 | 278 | 277 | **272** | 273 | 275 |
| 1996 | 274 | 272 | 273 | **69** | 270 | 272 |
| 1992 | 272 | 269 | 273 | **264** | 267 | 268 |
| 1990 | 267 | 263 | 261 | 260 | **259** | 263 |

examining the 2000 NAEP data by socioeconomic class. She found that measurement revealed the greatest disparity when comparing students who qualify for free or reduced lunch with those who do not. In 2000, the gap in the mathematics composite score between eighth grade students who do not qualify for free or reduced lunch and those who do qualify was 30 points. The gap in measurement achievement between the two groups was 40 points.

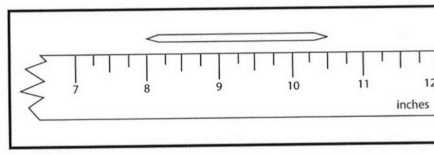
Although race/ethnicity and socioeconomic class patterns were similar, one should not conclude that race-related gaps in achievement were due to socioeconomic factors. Lubienski's (2001) secondary analysis of the 1990 and 1996 NAEP mathematics assessment indicated that, although class is a factor in the achievement gap between African-American and white students, race primarily accounts for the differences in mathematics achievement among these subgroups. She reported that, in both 1990 and 1996, white students in the lowest socioeconomic subgroup scored equal to or higher than African-American students in the highest socioeconomic subgroup. On the 1996 NAEP mathematics assessment, African-American eighth-grade students in the highest socioeconomic subgroup scored a significant 13 points lower than white eighth-grade students in the lowest socioeconomic subgroup (Lubienski, 2003).

The implications of the NAEP findings reveal that students from lower socioeconomic classes and students of color from all socioeconomic classes need more opportunities across all mathematics content strands, but especially in the measurement content strand. This tells us that if we teach students of color, we may need to work harder to have them better understand mathematics.

## Technology Education–A Resource for Teaching Mathematics

Since the NAEP data indicate that eighth-grade students need the most assistance with measurement, geometry and spatial sense, and data analysis, statistics, and probability, instructors of sixth-, seventh-, and eighth-grade technology education need to highlight these concepts when they are teaching in laboratories and modular environments.

Measurement at the middle grades focuses on the process of measuring and its application to real-world objects. Examples of problems students encounter in mathematics that involve measuring could include (National Center for Educational Statistics (NCES), 2004, January 13):




- What is the length of the toothpick in the figure above?
- A cereal company packs its oatmeal into cylindrical containers. The height of each container is 10 inches and the radius of the bottom is 3 inches. What is the volume of the box to the nearest cubic inch? (The formula for the volume of a cylinder is $V = \pi r^2 h$).
- A car odometer registers 41,256.9 miles when a highway sign warned of a detour 1,200 feet ahead. What will the odometer read when the car reaches the detour? (5,280 feet = 1 mile).

These are problems taken from the 1996 and 2000 NAEP mathematics questions released by NCES. These problems have practical and real-

**Table 2.**
**NAEP Eighth Grade Achievement Gap of the Five Mathematics Strands by Year and Race/Ethnicity**

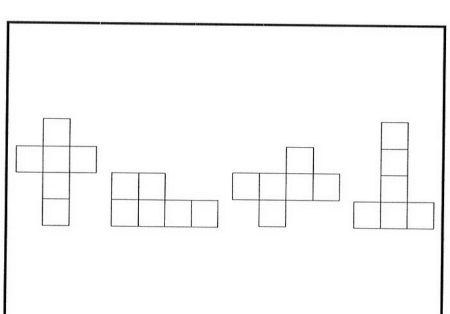
| | Number | Data | Algebra | Geometry | Measurement | Mathematics Composite |
|---|---|---|---|---|---|---|
| **2000** | | | | | | |
| Black/White Gap | 34 | 43 | 33 | 29 | **58** | 39 |
| Latino/White Gap | 31 | 39 | 30 | 26 | **44** | 33 |
| **1996** | | | | | | |
| Black/White Gap | 34 | 46 | 34 | 36 | 55 | 39 |
| Latino/White Gap | 29 | **41** | 27 | 25 | 39 | 31 |
| **1992** | | | | | | |
| Black/White Gap | 36 | 45 | 38 | 37 | **51** | 40 |
| Latino/White Gap | 29 | 27 | 31 | 25 | **34** | 31 |
| **1990** | | | | | | |
| Black/White Gap | 28 | **40** | 30 | 31 | **40** | 32 |
| Latino/White Gap | 25 | **33** | 26 | 24 | 30 | 26 |

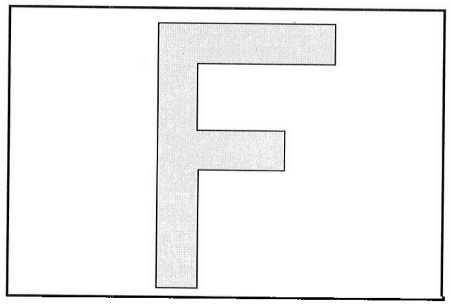
world applications in the technology education laboratory. Technology education teachers have many activities that use rules or scales for measuring. The problems also show the application of formulas that we commonly use in solving real-world problems. When we teach application of real-world measurement in real-world contexts, we are reinforcing skills students need to develop in order to pass mathematics courses and standardized tests.

It behooves the technology education teacher to review the National Center for Educational Statistics' Web site at http://nces.ed.gov/nationsreportcard/ and coordinate with the middle school mathematics teacher in teaching measurement. The review of this Web site will show past problems found on standardized tests and how students respond to these problems. If you are teaching a technological literacy course, or one on drafting or energy and power, you will see that mathematics is a measuring tool for technology and engineering, and you will see how closely what you are teaching students to do relates to the same concepts that the mathematics teacher is trying to develop in students.

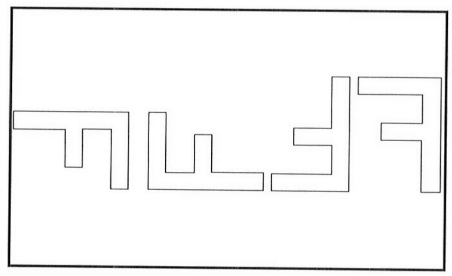
Mathematics teachers at the middle grades also teach geometry and spatial sense. This content focuses on mathematics beyond identification of geometric shapes, but transforms this information to real-world applications. Examples of problems middle schoolers encounter include (NCES, 2004, January 13):

Which of the following could NOT be folded into a cube?

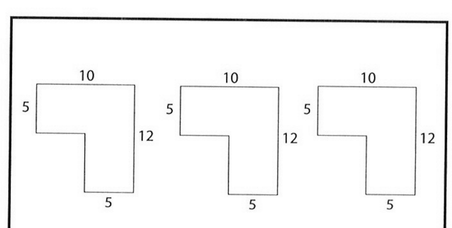




The figure above is shaded on the top side and white on the under side. If the figure were flipped over, its white side could look like which of the following figures?



Again, these are problems that both mathematics and technology education students should encounter. Often we have students draw geometric shapes, and at the high school level, drafting classes usually teach geometric projections. Again, by coordinating with the mathematics teacher, or surfing the National Report Card, we will see that our technology education problem-solving activities are closely related to the concepts being taught by the mathematics teacher.




Ted wants to purchase floor covering for his hallway. He knows there are many ways to find the area of the hallway. One way is to divide the hallway into the sections and then add together the area of each section. Use the figures above to show three ways that Ted can divide his hallway to find its area.

## Measuring Annual Contributions to Mathematics Improvement

Because of our closeness in content to mathematics, some technology teachers may become interested in the actual test results of their technology education students the next time school standards mathematics tests are given. Those of us in higher education are often contacted by technology teachers, asking for studies that show the value of technology education. This usually occurs when it is too late, and their school board or principal has decided to replace their elective courses with those that supposedly have more academic rigor.

As sports analysts often say, the best offense is a good defense. Why not begin collecting data on your students' performance in mathematics? Can you show that the teaching of technology education actually made a difference in the portion of the school's population that completed technology education courses? This is not a difficult task. Get the names or student numbers of your students who completed technology education classes. You might begin with just the eighth grade students. Calculate the average that they got on the mathematics standards test. Compare it to the average that the whole eighth grade class received.

You may then wish to separate the students who did not take technology education in the eighth grade and see if the average, or the non-technology education students, differed from the technology education students. It is suggested that band students be removed from the sample. In studies that the authors have seen, band students tend to be above the academic base of the school (often gifted).

You could also carry such studies further by analyzing students who had three years of technology education (Grades 6, 7, and 8, since all three grades contribute knowledge that comprises the eighth-grade mathematics standards test). Did the group averages lead to improved test scores for those who completed additional technology education classes?

For those who have completed master's degrees, there may have been a course in statistics. An excellent statistical tool to use to prove if there is a significant difference for your students who have taken technology education compared to populations who have not would be to calculate the t-ratio. It determines if there is a significant difference between the average of the group that had technology education and the group that did not. The mathematics teacher, or your university professors, may be able to assist you with this statistic if you are not familiar with it.

## Summary

Why would technology teachers want to begin to build a database of their students? The answer is informed decision making. With data in hand, you have tools available to prove the value of your studies in technology education. You can use it to get technology education as a required subject in your school system or state. You can position yourself as a member of the education team at your school. You can also use it as leverage to get more resources to support your program. What school board would deny you additional resources if you can show that your teaching in technology education can improve the test scores of students in your school system?

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