Editorial

The Integration of Science, Technology, and Mathematics
Myth or Dream?

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The achievement level of U.S. science students does not compare favorably with other countries. According to the National Science Foundation (NSF), the United States ranked 8th out of 15 countries on a 5th grade science achievement test. However, by the 9th grade, students in the United States ranked 15th out of 16 countries rated.

As students enter high school, achievement continues to be low in all areas of science. Physics students ranked tenth among 14 countries rated. In biology, the U.S. ranked 14th out of 14 countries (NSB, 1987).

Table 1
Ranking of U.S. Students in Science

Grade	Subject	Rank	Number of Countries Ranked
5th	Science	8th	15
9th	Science	15th	16
High School	Physics	10th	14
High School	Chemistry	12th	14
High School	Biology	14th	14

The low U.S. student performance may be related to the time spent on task. According to the National Science Teachers Association (NSTA Report, April 1989), high school students spend far less time in science courses than their counterparts in the Soviet Union and the People's Republic of China.

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Technology education can provide an integrated methodology for science and increase the time on task of our students in science and technology.

Table 2
Time Spent on Biology, Chemistry, and Physics

	U.S.	USSR	PR China
Biology	180 hrs. 1 year	321 hrs. 6 years	256 hrs. 4 years
Chemistry	180 hrs. 1 year	323 hrs. 4 years	372 hrs. 4 years
Physics	180 hrs. 1 year	492 hrs. 5 years	500 hrs. 5 years

Everybody Counts: A Report to the Nation on the Future of Mathematics Education and *Project 2061: Science for All Americans*, clearly details the value of the integration of science, technology, and mathematics:

> There are certain thinking skills associated with science, mathematics, and technology that young people need to develop during the school years. These are mostly, but not exclusively, mathematics and logical skills that are essential tools for both formal and informal learning and for a lifetime of participation in society as a whole. (AAAS, 1989, p. 133)

From middle school to the university level, the data indicate a loss of interest in science and mathematics. According to the National Research Council (NRC), approximately one-half of the students leave the mathematics pipeline each year. The National Science Foundation indicates that out of the 4 million high school sophomores in 1977 only 750,000 indicated an interest in natural sciences or engineering. That same pipeline will lead to less than 10,000 Ph.D.s in 1992. NSF predicts a shortage of over 450,000 B.S. degrees in natural sciences and engineering in the year 2,000 (NSB, 1987). About 7 out of 1,000 U.S. students receive an engineering degree, while in Japan, the figure is 40 out of 1,000.

Technology education can help students learn the "doing part" of engineering and natural sciences. It is necessary for instruction to include relevant "real world" problems that cause students to practice and extend their mathematics and science skills. This approach will address the assertion by the National Council of Teachers of Mathematics (NCTM) that knowledge should emerge from experience with real life problems (NCTM, 1989). To help accomplish these objectives, *technology education has the opportunity and obligation to integrate science and mathematics into technology activities.*

Vocational Education Responds

National vocational consortium projects such as *Principles of Technology, Applied Mathematics,* and *Applied Biology/Chemistry* not only discuss the need for such integration but demonstrate ways in which the integration can take place. Similarly, the Carl D. Perkins Vocational and Applied Technology Education Act of 1990 requires that such academics be integrated into vocational education.

Technology Education

Technology education programs such as the ones in Pittsburg, Kansas and Eagle Crest and Delta, Colorado have effectively demonstrated the value of integrating technology with science and mathematics. Technology education programs have shown that such integration is successful. Yet our profession is slow to change.

Roadblocks

The many national and state reports have documented the need to integrate science, technology, and mathematics. There are model programs and complete curriculum packages available to provide such integration. *Then why doesn't more integration take place?* I believe that several roadblocks occur due to the inability of universities and state departments to support and model such integration.

As an example, most people who have reviewed the Principles of Technology curriculum realize the value that Principles of Technology brings to the student. The student uses mathematics, physics, and technology to better understand society in much the same way that an engineer would use that knowledge. Yet, very few universities will accept Principles of Technology as a science credit toward entrance into the university. This roadblock is communicated to counselors and administrators. Many students fear that the university of their choice might frown upon such "integrated knowledge" and not admit them. Similarly, universities have to deal with a transcript that lists "technology education." In most cases technology education credit does little to excite university admission officers. We, the technology teacher educators, must educate the admission offices on our campuses.

Leading By Example

Universities provide few examples of the integration of science, technology, and mathematics. Most frequently, engineering, science, and mathematics departments are run as theoretical units with little knowledge of "doing." Similarly, many practical arts fields such as industrial technology, technology education, occupational therapy, and vocational education promote the doing with little emphasis on the scientific and mathematical base behind the doing.

College Entrance Exams

College entrance exams also work as roadblocks toward the integration of math, science, and technology. ACT and SAT exams are departmentalized and focus on theoretical knowledge with very little, if any, real world application. Many universities across the country are clamoring for the integration of science, technology, and mathematics, but at the same time there is a reluctance to appreciate the value of high school programs that are already accomplishing such integration through technology education, Principles of Technology, Applied Mathematics, and other integrated programs.

Roadblocks to Technology Teacher Education

As university technology education programs try to keep up with the times, they often face the following realities:

- a decreasing undergraduate student population
- decreasing university budgets
- an older tenured staff that is reluctant to change
- old, large, and outdated equipment that is bolted to the floor with emotional ties
- a federal budget of $62 billion of which two-tenths of one percent support educational research (AERA, 1990, p. 5).

Compounding the above problem is the fact that technology education has not found its home in the K-12 system. As Rustum Roy pointed out in a recent article in this journal, (Roy, 1990):

> In the American public's belief system 'Science' is a uniform good. The American credo affirms 'more scientific research' is certain to be good for the nation. In economic terms, it fails to distinguish between a 'consumption' and an 'investment good.' Without any thought or reflection, the U.S. public and its leaders base action on the proposition that the supply of 'basic science' is infinite, that science leads to applied science which in turn leads to technology and jobs.

Yet, Roy gives the following as a more accurate description of the science and technology relationship:

1. Technology leads to science more often than science leads to technology.
2. Technology and science are not in the same hierarchical plane in human learning. Technology integrates science's results with half a dozen other inputs to reach a goal.
3. Teaching technology and about technology is important for all citizens, while science is an equally important addition for a small (10-15%) subset. (Roy, 1990, p. 11)

Solutions for Our Profession

Professors in the field of technology education must stand up for the value of the content. The integration of science, technology, and mathematics

will require that technology teacher educators work hand-in-hand with the other academic areas. In fact, many times the technology teacher will need to lead the other academic areas to rational decisions.

For example, at Colorado State University we are fortunate that our Admissions Office recognizes the value of Principles of Technology and accepts Principles of Technology as a science course for entrance into the University. Colorado State accomplished this by assembling the faculty from the College of Engineering and the Department of Physics and demonstrating to the faculty the value of the Principles of Technology curriculum. The department chair for Physics and the associate dean for the College of Engineering then wrote a letter to Admissions supporting Principles of Technology as one way of obtaining scientific knowledge.

Financial Support

Over the past year, the National Science Foundation and the U.S. Department of Education have supported a wide variety of initiatives that encourage and require the integration of science, technology, and mathematics. Leadership from our national organization has helped establish the Technology Education Demonstration Program. Even with the political pressure to balance the budget, there will be increased support for innovative programs that demonstrate to the country how to produce a person who can understand and use the technological tools of our time. Teacher education institutions that are successful at acquiring federal and state funds will find it easier to overcome the roadblocks that face technology education.

Carl D. Perkins Vocational and Applied Technology Education Act of 1990

For most states it is clear that the single largest impact on technology education will come in the form of the authorization of the Carl D. Perkins Vocational and Applied Technology Education Act of 1990. The new act emphasizes the importance of technology education and the integration of academics into occupational education. We must work together to meet the needs of all youth and give them the education they deserve.

The Accreditation Opportunity

Recently, our national organization (ITEA), through the Council for Technology Teacher Education (CTTE), established specific criteria which are used when the National Council for Accreditation of Teacher Education (NCATE) evaluates teacher education programs. The new NCATE guidelines clearly emphasize the importance of the integration of science, technology, and mathematics. This peer pressure forces technology teacher education institutions to evaluate how they can better integrate science and mathematics into their technology programs. In addition, the NCATE review causes universities to assemble documentation that may be used to assist in acquiring additional funds and provide support for change.

Summary

Although there are many obstacles to the integration of science, technology, and mathematics, there has never been a more exciting time for our profession to embrace such integration. Nearly every national and state report on education highlights the importance of that integration. This emphasis on education is causing an increase in federal and state funds for technology education and its academic counterparts. We have the challenge to follow the CTTE's NCATE guidelines and embrace change and, most importantly, to provide the leadership for the integration of science, technology, and mathematics.

Myth or dream? The integration of science, technology, and mathematics will become reality if we, the technology teacher educators, respond to federal and state requests for proposals, seek the support of science and mathematics educators on our campuses, and focus on the needs of the middle school, high school, and university students. We must be leaders in ensuring that students of all ages, gender, and ethnic backgrounds can participate in society as "doers and thinkers." Technology education provides a hands-on, minds-on approach to science and mathematics. The words of Calvin Woodward, from more than a century ago, are relevant today:

> Hail to the skillful cunning hand!
> Hail to the cultured mind!
> Contending for the world's command,
> Here let them be combined. (Barlow, 1967, p. 36)

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