Technology Education's Role in the New National Science Standards

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One of the foundations of American democracy has been its emphasis on public education. Even so, as the American Association for the Advancement of Science (AAAS, 1990) pointed out in its publication *Science for All Americans*, "most American children are not science literate" (p. xv). In fact, students remain below the levels of the 1970s in their knowledge and understanding of both science and mathematics. This fact has been documented in a number of publications beginning with the National Commission on Excellence in Education's (1983) report entitled *A Nation at Risk: The Imperative for Educational Reform*. This report cautioned that unless we reform the entire educational system we are headed for a national educational crisis. The AAAS (1990) reinforced this prediction by pointing out that American students rank far behind those from other countries in problem solving and that the average performance for 17-year-olds is now worse than almost three decades ago.

In response to the immeasurable reports citing the poor performance of American students in science and mathematics, the AAAS initiated Project 2061 in 1985 to reform science, mathematics, and technology education for the 21st century. This project proposed "a fundamental reformation of science, mathematics, and technology education" (AAAS, 1995, p. 6). According to the AAAS (1995), current science textbooks and teaching methods do not encourage working together, sharing ideas and information, or using modern instruments to extend intellectual capabilities. The association believed that rather than teaching more and more content, it is more important to improve the effectiveness of teaching content that is essential for science literacy.

The AAAS (1990) considered science education to be "education in science, mathematics, and technology" (p. xiii). They believed that science education, therefore, should prepare students to "participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital" (p. xiii). This can be accomplished, in part, through the application of technology. As noted by the AAAS, despite the fact that many problems facing humanity, both globally and locally, originate with technology, it is technology itself that furnishes us with the tools for coping with the problems and also for discovering new knowledge.

The *Science for All Americans* project (AAAS, 1990) identified several teaching strategies that are crucial to science, mathematics, and technology education. Among the approaches cited were engage students actively, use a team approach, provide abundant experience in using tools, and emphasize group learning. The *National Science Education Standards* (National Academy of Science [NAS], 1995) address the shortcomings of science education in the United States and incorporate these approaches in its recommendations. Specifically, the new standards call for pregraduation science teachers to learn to teach in an applied, constructivist manner.

Seeking Technology Educators' Opinions

Since the new Science Education Standards (NAS, 1995) mandate, science teachers are learning to teach with a hands-on approach, one infused with constructivist ideas. Furthermore, many professionals in technology education (Bredderman, 1987; Shamos, 1995; Welty, 1996) have long felt that the study of technology facilitates the learning process in all subjects, particularly mathematics and science. Therefore, I sought to determine the opinion of teacher educators as to (1) the role that technology teacher education should play in preparing new science teachers and (2) whether we will be doing a service or disservice to technology education programs by getting involved.

All 258 individuals listed as department chairs, heads, or coordinators in the *Industrial Teacher Education Directory* (1998-99) and all 66 members of the Mississippi Valley Technology Teacher Education Conference (MVTTEC), a total of 324 people, comprised the original population. Chairs were chosen using purposive sampling (Fraenkel & Wallen, Prospective science teachers should:

1. Be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology, and other school subjects;
2. Be able to use scientific understanding and ability when dealing with personal and societal issues;
3. Understand the nature of scientific inquiry, its central role in science, and how to use the skills and processes of scientific inquiry;
4. Have the opportunity to engage in active learning that builds their knowledge understanding and ability;
5. Engage in the collaborative aspects of scientific inquiry;
6. Use a variety of technological tools, such as computerized databases and specialized laboratory tools;
7. Have direct contact with phenomena, gather and interpret data using appropriate technology, and be involved in groups working on real, open-ended problems;
8. Have opportunities to develop understanding of how students with diverse interests, abilities, and experiences make sense of scientific ideas and what a teacher does to support and guide all students;
9. Be introduced to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge;
10. Be involved in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding;
11. Develop a deep understanding of accepted scientific ideas and the manner in which they were formulated;
12. Be able to address problems, issues, events, and topics that are important to science, the community, and teachers;
13. Have the opportunity to use scientific literature, media, and technology to broaden their knowledge beyond the scope of immediate inquiries;
14. Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching;
15. Have learning experiences in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts;
16. Be able to connect and integrate all pertinent aspects of science and science education;
17. Be able to integrate their knowledge of science content, curriculum, learning, teaching, and students;
18. Be able to tailor learning situations to the needs of individuals and groups;
19. Have a firm grounding in learning theory; understanding how learning occurs and is facilitated;
20. Have a broad repertoire of instructional strategies that engage students in multiple ways;
21. Have the ability to examine critically and select activities to use with their students to promote the understanding of science;
22. Develop an understanding of how students with different backgrounds, experiences, motivations, learning styles, abilities, and interests learn science;
23. Be able to collaborate with other teachers, teacher educators, teacher unions, scientists, administrators, policy makers, members of professional and scientific organizations, parents, and business people, with clear respect for the perspectives and expertise of each;
24. Be able to conduct research in their classrooms on science teaching and learning and be able to share their results with others;
25. Be able to articulate questions, pursue answers to those questions, interpret information gathered, propose applications, and fit the new learning into the larger picture of science teaching.

1996), based on the belief that these individuals are the opinion leaders in their respective departments.

Instrumentation

The *Technology Education's Role in the New National Science Standards Opinion Survey* was developed to measure the opinions of technology teacher educators as to whether or not technology teacher education programs should get involved in the pregraduation education of science teachers, and if so, the role that the programs should play. It consisted of three parts. The 25 statements in the first part (see Table 1) were taken directly from the National Science Standards (NAS, 1995) and were selected because of their relationship to the goals of technology education (International Technology Education Association [ITEA], 1996). Respondents were requested to circle either *yes* or *no* to indicate whether or not they felt preservice technology education courses should be used to assist in meeting the standard or goal expressed in the statement.

The second part of the questionnaire requested the respondents to rank the top three statements to which technology education can most contribute. The final part of the questionnaire solicited input, via open-ended questions, as to the specific role that technology teacher education should play in preparing new science teachers and whether or not a service or disservice would be done to technology teacher education programs by getting so involved.

Technology Teacher Educators' Views

The instrument and cover letter were mailed to the 324 subjects in late September 1999, and 80 usable instruments were returned, for a total return rate of 25.24% (80 out of 317). The return rate for members of the MVTTE Conference was 57.14% (36 of 63) compared to a return rate of only 17.05% (44 of 254) for department chairs. Of the 80 respondents, 45% (*n* = 36) were members of the MVTTE Conference, and 55% (*n* = 44) were chairs/heads/coordinators of departments with technology teacher education programs across the country.

The data from the first section were tabulated and analyzed using percentages of *yes* and *no* responses. Data from the second section (ranking of the top three statements) were tabulated with a value of 3 assigned to the statements ranked first. Statements ranked second were assigned a value of 2, and those statements ranked third were assigned a value of 1. All other statements, therefore, received a value of 0. The values were then totaled to arrive at the final ranking of statements.

Two questions comprised the final section of the questionnaire. The first one, an open-ended question, asked about the specific role technology teacher education should play in preparing new science teachers. The second question asked if the respondent thought we would be doing a service or disservice to technology teacher education by getting involved. These responses were tabulated and analyzed using percentages for either *service* or *disservice*.

Ninety percent or more of the respondents indicated that the following five science standards (statements) should be addressed through preservice technology education courses:

#4 Have the opportunity to engage in active learning that builds their knowledge, understanding, and ability (95% agreement, *n* = 76).

#1 Be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology, and other school subjects (93.75% agreement, *n* = 75).

#7 Have direct contact with phenomena, gather and interpret data using appropriate technology, and be involved in groups working on real, open-ended problems (93.75% agreement, *n* = 75).

#6 Use a variety of technological tools, such as computerized databases and specialized laboratory tools (91.25%, *n* = 73).

#20 Have a broad repertoire of instructional strategies that engage students in multiple ways (90% agreement, *n* = 72).

The following six standards (statements) received the <u>least</u> number of favorable (*yes*) responses:

#11 Develop a deep understanding of accepted scientific ideas and the manner in which they were formulated (45% agreement, *n* = 36).

#16 Be able to connect and integrate all pertinent aspects of science and science education (52.5% agreement, *n* = 42).

#24 Be able to conduct research in their classrooms on science teaching and learning and be able to share their results with others (55% agreement, *n* = 44).

#10 Be involved in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding (57.5% agreement, *n* = 46).

#3 Understand the nature of scientific inquiry, its central role in science, and how to use the skills and processes of scientific inquiry (62.5% agreement, *n* = 50).

#17 Be able to integrate their knowledge of science content, curriculum, learning, teaching, and students (63.75% agreement, *n* = 51).

The final part of the instrument consisted of two questions. The first question was, "Specifically, what role should technology teacher education play in preparing new science teachers?" Phrases or terms such as collaboration, real-life experience, hands-on experiences, and application appeared in a majority of the responses.

The second question asked the respondents, "Will we be doing a service or disservice to technology education programs by getting involved?" Seventy-two percent of the MVTTE members (*n* = 26) believed that we will be doing a service, along with 70.4% (*n* = 31) of the department chairs/heads/coordinators, for a total of 71.25% (*n* = 57) of all the respondents. Also, 12.5% of the total respondents (*n* = 10) believed that we will be doing a disservice, and 16.25% (*n* = 13) had no opinion.

What Does It Mean?

The data collected from the respondents indicate substantial support (71.25% of those surveyed) for technology teacher educators to become involved in the preparation of new science teachers to meet the mandate of learning to teach in an applied, constructivist manner. Their views are that technology teacher education should be utilized in the preservice education of science teachers to give them instruction and/or experience in the following:

- Providing for active learning (Statement 4).
- Making conceptual connections across disciplines (Statement 1).
- Group problem solving using a variety of
- The use of a variety of technological tools (Statement 6).
- Multiple teaching strategies (Statement 20).

These views are consistent with the widely held belief that technology education can and should be the course in the curriculum, at any level, where students are provided with opportunities to apply knowledge from various disciplines to solve problems (Lux, 1998). The *Technology for All Americans Project* (ITEA, 1996) included a discussion about how technology education can help develop a "richer sense of the relationships between technology and other school subjects . . . such as science and mathematics" (p. 40). Welty (1996) also described the roles that technology education can play in curricula at any level. He noted that the study of technology can be used to:

- teach concepts that are unique to technology;
- create contexts that make other aspects of the curriculum more meaningful to young people; and
- engage students in thought processes that promote the development of higher-order thinking skills. (p. 5)

Support is also implied for the Science-Technology-Society (STS) multidisciplinary curriculum initiative that "has become increasingly visible on college and university campuses during the past 20 years" (Gilliom, Helgeson, & Zuga, 1991, p. 233). As colleges and universities move toward implementing the STS multidisciplinary curriculum, the inclusion of one or more courses dealing with technology into the curriculum of science education majors will be commonplace.

The National Science Board (1983) emphasized that "the study of technological systems should be used as a basis for providing integrated and holistic learning" (p. 84). As far back as 1938, Dewey stated that "it is a sound educational principle that students should be introduced to scientific subject matter and be initiated into its facts and laws through acquaintance with everyday social applications" (p. 98). Johnson (1990) believed that "technology education can contribute to improving science and mathematics education" (p. 1), and that teachers who can "use technology as a curriculum integrator can add a sense of reality generally missing from current schooling" (p. 44).

Learning to teach in an applied, constructivist manner, therefore, should not be restricted to prospective science teachers. All teachers, regardless of discipline, should be prepared to assist students in applying knowledge and using technology to solve problems. The National Science Board wrote in 1983 that "technology topics need to be integrated into the present curriculum. This includes science and mathematics classes, industrial arts, social studies and the language arts, and art and music" (p. 75). A required technology education course in the teacher education curriculum would provide all preservice teachers, regardless of discipline, with the necessary skills and abilities to implement application and problem-solving activities for their students. As the Montgomery County Public Schools (1995) reported, "this combined 'know-how' and the 'ability to do' in carrying out technological work transforms technological understandings, communication skills, language arts skills, social and societal understandings, mathematical concepts, and scientific knowledge into reality" (p. 5).

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References

American Association for the Advancement of Science. (1990). *Science for all Americans.* New York: Oxford University Press.

American Association for the Advancement of Science. (1995). *Project 2061: Science literacy for a changing future…A decade of reform*. Washington, DC: Author.

Bredderman, T. (1987). A technology strand in elementary science: Is it defensible. *Bulletin of Science, Technology and Society*, 7(1/2), 218-224.

Dewey, J. (1938). *Experience and education.* New York: Macmillan.

Fraenkel, J. R., & Wallen, N. E. (1996). *How to design and evaluate research in education* (3rd ed.). New York: McGraw-Hill.

Gilliom, M. E., Helgeson, S. L., & Zuga, K. F. (1991). This issue: Science-technology-society/challenges. *Theory Into Practice*, 30(4), 232-233.

International Technology Education Association. (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Reston, VA: Author.

Johnson, J. R. (1990). The urgent need for broad-based technology education. *TIES*, 3(1), 1-2, 44-45.

Lux, D. G. (1998). *Technology and our schools*. Paper presented at the annual Epsilon Pi Tau, Gamma Tau chapter initiation, Clemson, SC.

Montgomery County Public Schools. (1995). *Technology education: A program for the 21st century.* Rockville, MD: Author.

National Academy of Science. (1995). *National science education standards.* Washington, DC: Author.

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform*. Washington, DC: U.S. Department of Education.

National Science Board, Commission on Precollege Education in Mathematics, Science and Technology. (1983). *Educating Americans for the 21st century*. Washington, DC: The National Science Foundation.

Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick, NJ. Rutgers University Press.

Welty, K. (1996, October) . *Collaboration of science and technology education.* Paper presented at the meeting of the Finnish Society for Science and Mathematics Education, Oulu, Finland.