The Journey Towards Technological Literacy for All in the United States — Are We There Yet?

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The Journey Towards Technological Literacy for All in the United States—Are We There Yet?

By Philip A. Reed

Emerging research will continually shape teaching and learning, and the changing nature of technology continually shapes the discipline.

Anyone who has traveled with small children or watched one of the National Lampoon Vacation movies understands both the humor and unrelenting nature of the question above. I pose this question not to be amusing but rather to have the reader pause and analyze technology education in the United States. We are at a point where all those interested in technological literacy must take a critical, unrelenting look at the profession’s history, research base, and contemporary practice. This article will discuss each of these areas to help us in our travels.

Historical Context

Reflect for a moment on the history of education in the United States, specifically the required subject areas of language arts/reading, mathematics, history/social science, and science. Each of these areas became a part of general education for very different reasons. Language arts and reading were initially taught by many churches in order for children to study the Bible. Mathematics and history were endorsed in a bill introduced by Thomas Jefferson in 1778 to respectively help students “manage their affairs” and “improve the citizens’ moral and civic virtues” (Urban & Wagoner, 1996, p.72). Science, however, was not accepted into the education mainstream until the strong endorsement of the National Education Association’s (NEA) Committee of Ten in 1893 (DeBoer, 1991).

How can technology education be recognized as a required subject for all students? The practice of studying technology within general education has a well-documented history dating back to the 1870s (Anderson, 1926). Recent research shows that the acceptance of Standards for Technological Literacy (STL) (ITEA, 2000/2002) within state educational frameworks has increased but also shows that technology education is only required in twelve states (Dugger, 2007). The likelihood of a Jeffersonian-style solution à la mathematics and social science is highly unlikely since education is primarily a state endeavor in the United States. Nevertheless, endorsement of STL by the National Academy...
of Engineering (NAE) and many recent publications by the NAE and the National Research Council (NRC) do emulate, on some levels, the support science received from The Committee of Ten.

The book *Technically Speaking: Why All Americans Need to Know More About Technology* (NAE & NRC, 2002), for example, is a well-articulated argument outlining five reasons for the study of technology. Benefits include improving decision making, increasing citizen participation, supporting a modern workforce, narrowing the digital divide, and enhancing social well-being. Each of these benefits is highlighted with examples and tied to the three dimensions of technological literacy (Figure 1). Additional publications from the NAE and NRC aid the research effort in technology education.

**Research Context**

Shortly after the release of *Standards for Technological Literacy: Content for the Study of Technology (STL)* (ITEA, 2000/2002), the NRC published *Investigating the Influence of Standards: A Framework for Research in Mathematics, Science, and Technology Education* (NRC, 2002). Figure 2 illustrates the NRC model, with student learning as the outcome. Steps in the model leading to student learning include contextual forces, channels of influence within the educational system, and teachers and teaching practice. A fourteen-year review of literature shows that all of these areas have received a considerable amount of attention, but the level of research support in each area varies widely (Reed, 2006).

The strong support for *STL* from the NAE and NRC highlight the influence of contextual forces. Additionally, the American Association for the Advancement of Science (AAAS) has held several conferences on the importance of technological literacy. Despite these efforts, there has been little follow-up research on these efforts. How have these efforts impacted student learning or technological literacy in the United States? Several studies conducted by ITEA do offer excellent data for framing the contextual forces behind technological literacy for all (See Dugger, 2007; ITEA 2002 & 2004.)

The channels of influence outlined by the NRC (2002) have received tremendous attention in the form of materials development and research. The International Technology Education Association has developed student assessment, professional development, and program standards (ITEA, 2003) as well as model curriculum materials for elementary through secondary education. Research in this area has been strengthened through the Council on Technology Teacher Education (CTTE) yearbook series. Recent yearbooks on standards-based teacher education, instructional methods, distance learning, and assessment help guide technology education at all levels (see www.ctteonline.org to learn more about the yearbook series).

The final pieces of the framework, teachers and teaching practice and student learning, are starting to receive more research attention in technology education. Researchers are investigating the impact technology education has on other subject areas (Culbertson, Daugherty, & Merrill, 2004; Dyer, Reed, & Berry, 2006), but we must move into the area of researching what specifically happens in the technology

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**Figure 1.** The three dimensions of technological literacy are interdependent. A technologically literate person has varying levels in each area that change over time with education and experience (NAE & NRC, 2002, p. 15).

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How has the system responded to the introduction of nationally developed standards? What are the consequences for student learning?

Channels of Influence Within the Education System

**Curriculum**
- State, district policy decisions
- Instructional materials development
- Text, materials selection

**Teacher Development**
- Initial preparation
- Certification
- Professional development

**Assessment and Accountability**
- Accountability systems
- Classroom assessment
- State, district assessment
- College entrance, placement practices

**Teachers and Teaching Practice in classroom and school contexts**

Among teachers who have been exposed to nationally developed standards—
- How have they received and interpreted those standards?
- What actions have they taken in response?
- What, if anything, about their classroom practice has changed?
- Who has been affected and how?

**Student Learning**

Among students who have been exposed to standards-based practice—
- How have student learning and achievement changed?
- Who has been affected and how?

**Within the education system and in its context—**
- How are nationally developed standards being received and interpreted?
- What actions have been taken in response?
- What has changed as a result?
- What components of the system have been affected and how?

Figure 2. A framework for investigating the influence of nationally developed standards for mathematics, science, and technology education (NRC, 2002, p. 90).

classroom. More importantly, we need to investigate what students and adults learn through the study of technology.

Mathematics and science have investigated these areas for years. The National Council of Teachers of Mathematics (NCTM, 1992) and the National Science Teachers Association (NSTA, 1994) have each published handbooks of research in their respective fields. These comprehensive volumes cover the history of research in each field as well as philosophy, knowledge acquisition, curriculum, assessment, classroom climate, cultural diversity, and many other key areas. Many areas can be connected to technology education (e.g., contextual learning, problem solving, and instructional technology) but such an endeavor is needed in technology education in order to understand what students learn by studying technology.

The mathematics and science communities are now using this research in the development of learning progressions. Learning progressions are "descriptions of the successively more sophisticated ways of thinking about topics that can follow one another as children learn about and investigate topics over a broad span of time (e.g., 6 to 8 years)" (NRC, 2007, p. 219). The idea is to take content standards as well as research on teaching and learning to develop articulated steps in the instructional and assessment processes. For
example, **STL** 9 states that, “Students will develop an understanding of engineering design” (ITEA, 2000/2002, p. 99). Several benchmarks (e.g., A [Grades K–2] and C [Grades 3–5]) involve defining a problem. A learning progression in this area would outline the steps, in increasing complexity, that students would use in defining a problem. The idea behind learning progressions is to reduce repetitive content between grade levels. Learning progressions should be written in a way to reflect that knowledge and practice change over time. Additionally, no one learning progression is right or wrong. Writers starting with the same research and same standards are expected to develop different progressions. This point is important in order that a variety of instructional strategies and methods may be utilized.

How is this different from contemporary research-based practice in technology education? Another parallel to the history of science education can help clarify this question. In 1968 Robert Mills Gagne published a curriculum titled **Science—A Process Approach: Purposes, Accomplishments, Expectations** that has been used for curricula and text development since that time. The approach was to analyze the processes used by scientists, break them down, and use them to teach students (known as task analysis). The result has been almost 40 years of instructional materials that are not always coherent and do not factor in the key mental models involved in learning ever-increasing scientific content and skills (NRC, 2007). In technology education, Harold Halfin’s 1973 dissertation, *Technology: A Process Approach*, analyzed the writings of ten key technologists (e.g., the Wright Brothers, Goodyear, Edison, Fuller, Frank Lloyd Wright, among others) to identify the processes of renowned technologists. He identified and outlined seventeen processes:

- Defining the problem or opportunity operationally
- Observing
- Analyzing
- Visualizing
- Computing (applying mathematical principles)
- Communicating
- Predicting
- Questioning and hypothesizing
- Interpreting data
- Constructing models and prototypes
- Experimenting
- Testing
- Designing
- Modeling
- Creating
- Managing

A study has not been conducted to determine what impact, if any, Halfin’s research has had on technology education. As you look at the seventeen processes, however, you will surely recognize that they are intertwined throughout **STL**, textbooks, instructional materials, and contemporary instructional practice. Incorporating these processes and the use of the project method has been useful for engaging the whole student and piquing his or her interest in the study of technology. It is time, however, not to just look at the experts but to research what is occurring to novices as they learn about technology.

To help with this venture, we have a rich history of research to draw upon that spans back to at least 1892 (Reed, 2000). Additionally, new research is being outlined and conducted to investigate technology teaching and learning. The National Center for Engineering and Technology Education (NCETE) has developed a framework to aid in this endeavor. The research program consists of three main themes, each with several subthemes:

- **How and What Students Learn in Technology Education**
  - *Subthemes*: Learning and Cognition, Engineering Processes, Creativity, Perceptions, Diversity, and Learning Styles
- **How to Best Prepare Technology Teachers**
  - *Subthemes*: Teacher Education and Professional Development, Curriculum and Instruction, Diversity, and Change
- **Assessment and Evaluation**
  - *Subthemes*: Student Assessment, Teacher Assessment

The NCETE framework, like the NRC (2002) framework, also comes with multiple research questions in each area. To review the entire NCETE research framework, visit [www.ncete.org/flash/research.php](http://www.ncete.org/flash/research.php).

A discussion about technology education research would not be complete without mentioning the strong support of the National Science Foundation (NSF) over the past fifteen years. NSF helped fund the Technology for All Americans Project (TFAAP), Engineering by Design”, the I² Project (Invention, Innovation, and Inquiry), Project Probase, and other materials-development activities. NSF supports many projects such as the NCETE, not just materials development. In fact, Householder (2003) identified 141 NSF projects relating to technology education. Visit [www.nsf.gov/awards/about.jsp](http://www.nsf.gov/awards/about.jsp) to review recent awards by NSF.
Contemporary Practice

A great deal of NSF's education funding in recent years has been earmarked for science, technology, engineering, and mathematics (STEM) initiatives. STEM is one of the 16 Career Clusters and has received an enormous amount of attention because of the importance of STEM fields to the national economy and global competition. The Career Clusters were developed through years of research and deserve our attention because they will increasingly impact our profession in the coming years. All of the Clusters and their 81 Pathways involve varying degrees of technological literacy. States are beginning to use the Clusters and Pathways as they shape curriculum, assessments, articulation agreements, and other materials. Visit the States' Career Clusters website, www.careerclusters.org/, to learn more.

Assessment and international comparisons are inevitable as more and more attention is focused on the study of technology. The NAE and NRC publication Tech Tally: Approaches to Assessing Technological Literacy (2006) reviews historical and contemporary trends and makes recommendations on paper-and-pencil and portfolio assessments. Figure 3 is a matrix developed by the Committee on Assessing Technological Literacy, the author of Tech Tally. This framework was developed to help educators at all levels create sound assessments of technological literacy. The three dimensions of technological literacy outlined in Technically Speaking are represented across the top of the matrix. Four content areas are listed along the left side. The content areas are based on STL, with two distinctions: first, the “understanding” and “doing” of design is merged together as one row on the matrix (Design) and secondly, the designed world as represented by seven standards in STL is combined into the row titled “Products and Systems.”

The Committee on Assessing Technological Literacy also considered the work of the National Assessment Governing Board (NAGP) during the creation of the assessment framework. The NAGP has overseen the National Assessment of Educational Progress (NAEP) since 1969 (also known as the Nation's Report Card). The matrix presented in Tech Tally is consistent with the NAEP's science and mathematics frameworks. These interdisciplinary connections are crucial for developing sound assessments because of the many sets of standards that contain technology content.

Petrina & Guo (2007) provide an excellent overview on the status of large-scale assessments of technological literacy. In their review they discuss the two most common forms of assessment. Large standardized assessments have the benefits of higher reliability and validity, but more localized assessments offer the benefits of customization, performance assessment, and narratives. They conclude their review by calling for a third assessment that would incorporate the best of both present forms of assessment.

![Figure 3. A conceptual framework for developing technological literacy assessments (NAE & NRC, 2006, p. 53).](Image)
*Tech Tally* offers twelve compelling recommendations to improve the assessment of technological literacy. Figure 4 lists the recommendations by population, type of action, and actor(s). Many of the actors are large public entities because the Committee on Assessing Technological Literacy realizes that technological literacy is a public good just like traditional literacy, science literacy, civics, and numeracy. The committee recommends, however, that individuals at all levels need to get involved in these activities. To borrow a phrase from the environmental movement, can you find ways to think globally and act locally when it comes to technological literacy assessment?

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Target Population</th>
<th>Type of Action</th>
<th>Actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>K-12 students</td>
<td>Integrate items into existing national assessments.</td>
<td>National Assessment Governing Board (NAGB)</td>
</tr>
<tr>
<td>2</td>
<td>K-12 students</td>
<td>Integrate items into existing international assessments.</td>
<td>U.S. Department of Education (DoEd), National Science Foundation (NSF)</td>
</tr>
<tr>
<td>3</td>
<td>K-12 students</td>
<td>Fund sample-based studies and pilot tests.</td>
<td>NSF</td>
</tr>
<tr>
<td>4</td>
<td>K-12 teachers</td>
<td>Integrate items into existing assessments for teacher qualifications.</td>
<td>States, DoEd</td>
</tr>
<tr>
<td>5</td>
<td>K-12 teachers</td>
<td>Fund development and pilot testing of sample-based assessments.</td>
<td>DoEd, NSF, States</td>
</tr>
<tr>
<td>6</td>
<td>Out-of-school adults</td>
<td>Encourage or fund the integration of items into existing assessments.</td>
<td>International Technology Education Association (ITEA), DoEd, National Institutes of Health (NIH), NSF</td>
</tr>
<tr>
<td>7</td>
<td>K-12 students</td>
<td>Fund a synthesis study on learning processes.</td>
<td>NSF, DoEd</td>
</tr>
<tr>
<td>8</td>
<td>K-12 students</td>
<td>Support capacity-building efforts in learning research.</td>
<td>NSF, DoEd</td>
</tr>
<tr>
<td>9</td>
<td>K-12 teachers</td>
<td>Support capacity-building efforts in learning research.</td>
<td>NSF</td>
</tr>
<tr>
<td>10</td>
<td>K-12 students</td>
<td>Convene a major national meeting to explore innovative assessment methods.</td>
<td>National Institute of Standards and Technology</td>
</tr>
<tr>
<td>11</td>
<td>K-12 students</td>
<td>Develop frameworks for assessments in the three populations.</td>
<td>NAGB, NSF, DoEd</td>
</tr>
<tr>
<td>12</td>
<td>K-12 students</td>
<td>Broaden the definitions of technology and technological literacy.</td>
<td>DoEd state education departments, private educational testing companies, and education-related accreditation organizations</td>
</tr>
</tbody>
</table>

Figure 4. Recommendations for improving the assessment of technological literacy for K-12 students, K-12 teachers, and out-of-school adults (NAE & NRC, 2006, p. 194).
A common point of discussion in the literature involves another question: Is the curriculum too crowded to have all students study technology? *Technically Speaking* concluded that dedicated courses were unlikely on a large scale because of the tight curriculum and number of teachers that would be required (NRC, 2002). Dedicated courses have been the model for secondary technology education, and it is too early to determine if the projection in *Technically Speaking* is accurate. However, there are two points to consider when reflecting on this issue.

First, consider the proliferation of technology as an integrated subject within the elementary school over the past decade. ITEA’s Technology Education for Children Council (TECC) offers a dynamic conference program and journal, *Technology and Children*. In Virginia, the Children’s Engineering Convention (CEC), which is focused on elementary education, is now larger than the annual Virginia Technology Education Association (VTEA) conference. To learn more about the CEC, visit www.vtea.org/ESTE/convention/.

A second idea posed by Lewis & Zuga (2005) has interesting implications for the study of technology at all levels. Their approach advocates studying the knowledge of technology through language. We all know that technology has a language of its own, but Lewis & Zuga (2005) make a convincing argument that the study of language and the study of technology have a symbiotic relationship. It is easy to see the merit behind this idea considering how the industrial revolution completely shaped modern English, and now modern technologies (e.g., email, text messaging) are reshaping our language yet again.

**Discussion**

The intent of this article is to take a look in the rearview mirror and check our GPS navigation system to determine if technology education is getting close to the destination of technological literacy for all in the United States. The answer is a very optimistic “no” for several reasons. Just as Petrina & Guo (2007) concluded that we will never find the Holy Grail when it comes to assessment (e.g., one assessment), we can never have technological literacy for all by virtue of the educational enterprise and the field itself. In other words, emerging research will continually shape teaching and learning, and the changing nature of technology continually shapes the discipline.

A second meaning implied in the goal of technological literacy for all is that of a required course of study for all students. Hopefully the history, research, and practices outlined in this article will facilitate professional dialogue and, more importantly, action towards this end. After all, the weather is looking better all the time for this trip.

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