Editorial

Technology Education and History: Who's Driving?

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Standard 7 of *Standards for Technological Literacy* calls for understanding "the influence of technology on history" (ITEA, 2000 [hereafter *STL*], p. 79). Standard 7 and its *STL* narrative are a curious mix of myth and outdated historiography (the way history is conceptualized and written). Even more problematic, they imply a perspective that is inconsistent with the basic assumptions of technology education as expressed in Standard 6, which focuses on the "role of society in the development and use of technology" (*STL*, p. 73). Standard 6 focuses on humans' active role while Standard 7 avoids humans' active role in favor of how technology influenced history. Why are standards 6 and 7 so opposite in conception? What difference does it make? How could we redesign Standard 7 to reflect an active human role in history?

In this essay, I argue for historiographic approaches that emphasize how people designed and constructed technology, including technological education, in their own contexts in the past. From a historiographic perspective, such historical accounts of the challenges that our predecessors faced in their own contexts will be significantly different from accounts of the effects or "influence of technology on history" as stipulated in Standard 7.

Evaluating Standard 7

According to the narrative of Standard 7 in *STL*, "history has seen at least three great transformations that were driven by technology" (*STL*, p. 79). Standard 7 suggests that the focus should be on technology—some artifact, process, or force out there that has been a primary influence on history. Standard 7 further implies that people do not "drive" technological change, even though the design and abilities standards (8-13) are concerned with how people design and construct technology. This history is segmented into "at least three

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great transformations" or "revolutions" (agriculture; industrial age; "powerful computers and high-speed telecommunications networks," p. 79) as well as other periods such as the "Stone Age," "Bronze Age," "Iron Age," "Industrial Age," and "Information Age" (pp. 57; 86-87). Within these periods, the *STL* narrative locates a sequence of selected great men, events, and artifacts, and the "inventions and innovations...that produced the world as it is today" (pp. 79; 86-87).

The apparent point here is that history is a heroic account of the progress of technology. As a result, "children were not needed on the farm and could stay in school longer" during the Industrial Revolution (p. 87). Eventually, digital artifacts "led to an explosion of computers, calculators, and communication processes to quickly move information from place to place" (*STL*, p. 87). Historians of technology often criticize "heroic" historiography for its failure to recognize the challenges that people of the past faced in solving problems in their own contexts. This "heroic" view also reinforces a "presentist" ideology that implies that the past should be interpreted in terms of the present rather than in its historical context.

There are other problems inherent in this narrative—it portrays the Industrial Revolution as a celebration of America's leadership of technology in the world, starring Eli Whitney's interchangeable parts and Henry Ford's movable conveyor (p. 87). Yet, several decades of research have demonstrated the mythical status attributed to Eli Whitney, who did not invent the principles or practice of interchangeable manufacturing (Alder, 1997; Hounshell, 1984; Smith, 1977; Woodbury, 1959). More problematic is the assumption of American superiority implied in *STL*—an effort associated with an organization that promotes itself as "international."

In contrast, an approach to history that is consistent with Standard 6 would differ in two important ways from Standard 7 in that it would emphasize *historical context* and *humans' active role* in history. In referring to these two characteristics, I will use the terms "contextualist" and "constructivist" respectively. Students would learn how individuals and social groups developed and used arts, crafts, tools, systems, and technologies to solve problems in their own contexts (for more on constructivist approaches, see Bijker, Hughes & Pinch, 1987; Bijker & Pinch, 2002; Clayton, 2002). This approach to history would also be more consistent with the design and abilities standards (8-13). Moreover, grades 9-12 would be less oriented to memorizing dates and lists of great men, events, and inventions, or end products, impacts, or effects. Instead, they would focus on the real struggles that people experienced in designing, constructing, and using technology in their social and cultural contexts.

STL authors made a small attempt to support a constructivist, though not contextualist, approach in K-8 by including hands-on activities and combining multiple standards (*STL*, pp. 80-84). But the vignette selected to support Standard 7 (*STL*, p. 82) is an example of how teaching can distort history and contextual meaning. (The problem here is not so much the vignette itself as the authors' selection of it for this particular context.) In that vignette, Mr. S realizes that his students had never heard of the railroad telegraphers' Morse code as covered in the lesson on Westward expansion. As a result, Mr. S designs activities around the theme of communication, with each group of students focusing on different forms of technology in different time periods. Telegraphy is thus inserted into a timeline of "heroic progress" from drums to telegraphy to email, thus implying that today's technology is inherently superior.

In an approach that is constructivist and contextualist, students would study how individuals and social groups designed, developed, and used telegraphy in its historical context. Each group could research an element of the time, from telegraphy and railroads to agriculture, national and local politics, Native Americans, and immigrant populations, to create a contextual picture of their interaction. The students might also contrast the pros and cons of technologies competing with Morse's system. Students would thus learn how different groups interacted and contributed to the design and construction of technology, including conflicts, challenges, and failures. As a result, technology education would go beyond outdated historiography, myths, and national chauvinism that distort our understanding of the development of technology.

Hidden Assumptions and Problems of the Ideology of "Effects"

A Platonic model seems to undergird *STL*—a model that portrays "the design process" as systematic, controlled, and harmonious, despite occasional failures, "bad effects," or a sporadic nod to multiple design paths. It is perhaps appropriate for the design and abilities standards (8-13) to minimize the role of conflicts and politics, but a history standard should recognize social complexity. In acknowledging the role of conflicts and politics in developing and using technology, I am certainly not suggesting that *STL* should promote conflict.

But our standards should reflect recent historical work that recognizes factors such as conflict, constraints, and contingency as well as teamwork. Designing and building technology is often a messy endeavor. Contingent aspects (chance, uncertain conditions, and accidents), conflicting human choices, and power relationships (politics) play a critical role in technological change. An awareness of contingency counterbalances deterministic interpretations. Yet Standard 7 and its narrative do not communicate this complexity. The fixed structures, rigid divisions, and canon of heroic inventors convey the sense that technology was a highly determined, linear, and predictable enterprise of successful inventors and artifacts.

Historiography can further clarify hidden assumptions in the standards. For comparative purposes, the research and writing of history can be considered internalist, externalist, or contextualist (e.g., Staudenmaier, 1985). Internalist accounts (now rare in *Technology and Culture*) focus primarily on the insides or internal workings of technology, with little reference to social context. Externalist views (e.g., from the standpoint of political or economic history) treat technology from an outside perspective, emphasizing its effects on society, with little interest in how it actually functioned or how people designed or constructed it. Contextualist views consider the development and use of technology in historical context. Standards 4, 5, and 7, which are articulated in terms of the effects or influence of technology, tend to promote an externalist view focused on the use of the completed artifact. As a result, students are likely to focus not on historical *development*, but on the finished artifact and its *end use*—a view similar to externalist views common in traditional history courses.

The artificial separation between development and end use of technology has concerned me since the early 1990s when I argued against the expression "impacts of technology on society" as the sole metaphor in technology education for representing relationships between society and technology (Pannabecker, 1991). Substituting "effects" or "influences" for "impacts" changes little. Contextualist, constructivist historical approaches to understanding relationships between society and technology are more consistent with the field's emphasis on teaching students to design, construct, and use technology. However, the dominant tone of standards 4, 5, and 7 is externalist, focused on "effects." Why does *STL* promote this view?

Technology Education, Engineering, and the Ideology of "Effects"

In the 1980s, changes in name and content from industrial arts to technology education contributed to a sense of ambiguity about the field's heritage. Some teacher educators, myself included, shifted away from a focus on teaching the history of practical education (e.g., Bennett, 1926, 1937; Barlow, 1967) to the history of technology such as told by DeVore (1980). We spent years retraining to include in our courses the history of technology and how technology relates to society, and we expanded the content of our lab courses. That shift towards a broader understanding of technology was invigorating, even as it apparently triggered a decline in the field's reflection on how people designed and constructed practical education. Meanwhile, members of the Society for the History of Technology (SHOT) produced a considerable body of research in *Technology and Culture*. Professional historians increasingly outnumbered engineers in SHOT, and historiography changed markedly since DeVore's *Technology* published in 1980.

In the 1990s, technology education strengthened ties with science and engineering and some of their professional groups became more involved in designing new standards for technology education. While they made positive contributions, they also introduced a new imbalance. For example, the engineering community has never been widely viewed as a leader in general education or in articulating historical methods.

Historically, the engineering profession has often been identified with business and active political influence in controlling technology—not a balanced perspective for interpreting how technology relates to society. Edwin T. Layton's (1986) *The Revolt of the Engineers* remains one of the best historical accounts of the tensions among engineers over social or public responsibility versus loyal service to business and employer. It is noteworthy that Layton's (1974) article on "Technology as Knowledge" is cited in *STL*, but his (1986) *The Revolt of the Engineers* is not. This prompts the question: how did engineering groups influence *STL*?

Greg Pearson's recent editorial in *JTE* (2004) provides some context. He recognized explicitly that "engineering has for years—decades, in fact—been engaged in a campaign for public recognition" (p. 67). He noted that the teaching profession is ranked by the public as higher in prestige than engineering, and that one of the reasons engineering is not well understood is its near absence in US K-12 classrooms (pp. 67-68). Pearson clarified engineering's influence on technology education, and its standards in particular, when he noted: "The NRC review group, chaired by Wulf [president, National Academy of Engineering] himself, proposed a number of substantive changes to the standards' content and organization, and the ITEA managers of the standards project, Bill Dugger and Pam Newberry, adopted nearly every one" (p. 72). The general adoption of these changes suggests that engineering perspectives probably played a greater role in designing the standards than did other professional groups except perhaps science-related groups.

How might the influence of engineering relate to the ideological emphasis on the "effects" of technology in *STL* standards 4, 5, and 7? By designing these standards around "effects," the development of technology can be separated conceptually from social values, thus reinforcing the evaluation of technology as "end result." The artifact can then be controlled and fixed by engineers. It might be government agencies that employ engineers to evaluate the technologies and recommend "fixes," but engineers remain in control of fixing, redesigning, or retrofitting the technology. This approach contrasts with an instructional model that integrates social conscience or responsibility within the design and construction process, and that sanctions the expression of critical reflection (such as "whistle-blowing") for both engineers and the public.

Instead, *STL*'s dominant tone is one of implied neutrality, but with the "engineer in control." Although ethics is mentioned a few times in the *STL* narrative of standards 8-13 (pp. 97, 98, 104, 111), it is clearly not central to the standards of design and development. This is subtle politics that isolates the discourse of social responsibility from the design and construction process, focusing social responsibility at the end use, or "effects" stage. Historians labor to uncover and understand these kinds of politics, the study of which should be included in teacher preparation and graduate programs in technology education. (For an extended discussion of the ideology of engineering, see Layton, 1986, pp. 53-78.)

The assumptions undergirding Standard 7 are now clearer. In the *STL* view, technology is conceived as an "end-use" artifact that has had "effects" on history. The student's view is essentially externalist, possibly with a hint of context implied by Standard 6. Students learn very little about the struggles, debates, conflicts, and challenges of the designers and makers of technology, nor its context, except as "effects" and placed within an artificial period such as "The Iron Age" (p. 86). By the end of grades 9-12, students will have absorbed a canon of selected successful inventors and technologies, placed in their proper "period."

Other interpretations of the "effects of technology" metaphor are possible. For example, some engineering groups have tried to respond to criticisms of their weak coverage of ethics. One of the most common approaches, as reflected in *STL*, examines the social effects or impacts of technology, but that approach remains ambiguous. Indeed, where does one study ethics, values, or "effects"? In contextualist historical case studies? As hypothetical case studies? In the design or implementation stages of engineering practice? Under whose management, and in whose interests?

Fortunately, Hill's (2004) collection of essays provides some guidance in modeling ethical thinking at various stages: design, development, and end use. The collection has at least two major limitations, however: the chapters are generally ahistorical and they lack richly documented narratives and analyses of actual practice, either in technology or technological education. In other words, the authors provide a multitude of rational ideas, models, hypothetical scenarios, and references, but few if any in-depth, contextualized narratives of the real struggles and challenges of human beings. Indeed, our field tells few stories and we lack a heritage of storytelling. Such stories of real-life people and experiences can provide both teachers and students with a richer context for discussing and debating ethics in regard to technology. But *STL* configures history not as critical, richly documented historical inquiry, but as simplistic, uncritical thinking—exactly the opposite climate required for teaching ethics.

Contextualizing the Heritage of Technology Education

Contextualizing the history of technology education is critical for teacher preparation and graduate programs. Otherwise, the field risks a continued decline in its capacity to think critically, research, and teach about the relationships between technology and society. I present the following three themes as examples of how the heritage of industrial arts and technology education intersects with the heritage of other forms of technological education such as engineering education.

Representing and Systematizing Technology

Technology education has a rich historical tradition, including mechanical, manual, and industrial arts. But its expanded scope of content, emphasis on design, and increased links to engineering contribute to a more complex heritage that we need to understand better. For example, the increased emphasis on design in engineering is relatively recent. Wunsch (2002), in his discussion of engineering standards EC 2000, stated that "engineering design, not a part of the curriculum until a generation ago, is now a prime focus of ABET" (Accreditation Board for Engineering and Technology).

Yet systematic design has a rich heritage and industrial arts and other practical arts have distinct traditions of representing and systematizing technology for instruction. In the United States, the introduction of systematizing instruction was typically attributed to the "Russian system" of tool instruction of the 1860s and 1870s (e.g., Bennett, 1937, pp. 13-52; Martin & Luetkemeyer, 1979, pp. 25-26; Kliebard, 1999, pp. 3-13). According to that view, the "Russian system" stood in stark contrast to disorganized, inefficient apprenticeship methods of instruction. As a result of its sudden adoption in the United States and much publicity, the "Russian system" took on a mythical status—not unlike Eli Whitney's "invention" of interchangeable manufacturing. In fact, the developers of the "Russian system" borrowed from other European efforts to represent and systematize practical knowledge in tools, texts, and pictorial representations.

Historians of technology have recently shown more interest in how people developed and used drawing systems, in part because those systems were a means of linking very different types of functions such as design, production, social control, and marketing. While some of the development of design systems occurred outside of schools (e.g., Brown, 2000; McGee, 1999; Pannabecker, 1998), educational institutions played a role in modifying and integrating drawing systems for design, production, and marketing (Pannabecker, 2002, 2004).

Beyond the technical sides of drawing and design, this recent research emphasizes the importance of historical contexts—how different groups and countries developed competing systems of drawing. In addition to representing and systematizing knowledge, drawing was also used to organize and control people through new social hierarchies. Its expanded use in industry and education correlated with growing tensions between workers and management, as well as the spread of political democracies and industrialization. By studying contextual history, technology teachers can develop their ability to understand social interaction, hierarchies, and politics as they relate to technology.

Integrating Math, Science, and Technology

Current efforts in technology education to integrate math, science, and technology also have an extensive heritage, although much of that heritage has either been neglected or ignored. For example, teachers who taught navigational practice in colonial America integrated complex knowledge and artifacts (Fee, 1938, p. 59), as do teachers who now teach geospatial technology systems (e.g., Reed & Ritz, 2004). Yet we have few well documented and contextualized stories of teachers and their struggles to integrate math, science, and technology.

Seeking and telling some of those stories became a challenge for me, which intensified after I started working through the archives of the School of Arts and Crafts of Châlons, France. That School was the first of eight similar schools that now produce the largest number of engineers in France and maintain partnerships with engineering schools in 23 countries. But as originally conceived under Napoleon Bonaparte, they were industrial schools for integrating theory and practice. The School of Châlons was one of the earliest schools to teach the metric system as well as the design and construction of precision instruments. In this regard, Alder (2002) illustrates a contextualist approach for understanding the implementation of the metric system and the practical use of precision instruments. In that story, two French astronomers struggled from 1792 to 1799 to determine the natural length of the meter by measuring the meridian from Dunkerque to Barcelona.

Those astronomers used the repeating circle, an instrument that minimized weight and optimized precision in navigation and surveying, which was developed by Charles Borda in the late eighteenth century. Yet few people know that by 1810, teachers and shop foremen were teaching high-school age students to understand, draw, and construct Borda repeating circles at the School of Châlons. Moreover, that School marketed those student-made instruments to engineers in northern France for the purpose of surveying and road and bridge construction (Pannabecker, 2002, 2003, 2004). In the 1820s, however, as the School's staff sought to integrate math, science, and technology, it encountered enormous resistance from the right-wing government that opposed the transfer of "advanced" knowledge to working class students. The School's experience highlights the challenges that teachers faced in integrating math, science, and technology in the broader social, cultural, and political context.

Despite the considerable potential for historical research in the field, I remain puzzled by a paradox confirmed by my years of teaching lab and shop courses—many teachers in our field have well developed storytelling abilities, but we seem to have a sparse written account of our heritage. There are certainly exceptions, such as Tom Hull, editor of *Quarter Inch Drive*, now at issue 40 and counting. (See also his article related to the cover of *Technology and Culture*, Hull, 2003.) Tom and other teachers, graduate students, and teacher educators should be encouraged by the profession to help develop a written heritage of constructivist and contextualist history.

General Education

The place of technology education in general education should be a central issue for the field and understanding the heritage of our field is critical to navigating the politics of general education. In this regard, industrial arts and technology education have several claims that engineering does not have: (a) an historical though often ambiguous place in both K-12 and general education distributions; (b) a non-elitist outlook and reputation; and (c) a rich heritage of recognized figures in the history of education such as J.-J. Rousseau, Johann Pestalozzi, and John Dewey who made compelling arguments for the importance of hands-on skills in child development. The American Industrial Arts Association (AIAA) often emphasized the place of industrial arts in general education, in contrast with specialized, professional, occupational, or vocational courses.

General education has long sought to moderate powerful instrumentalist ideologies associated with the agenda of business, industry, and the military. If engineering groups start exercising too much influence on technology education, our field risks a greater association with engineering's vocational or professional orientation, its perceived loyalty to business, and its traditional political alliances. Indeed, the heritage of engineering is heavily marked by its loyalty to business, often "big business" (Layton, 1986), as well as military education and priorities. Historically, those associations have not lent credit to a role for engineering in the general education of children. Moreover, the illusion of neutrality in engineering design tends to obscure subtle politics, thus implying greater challenges in teaching human freedom, rights, and choice in design contexts (see, for example, Petrina, 2003, p. 73).

In contrast to engineers, teachers of industrial arts and technology education have been considered non-elitist, and important threads in our heritage have been countercultural. For example, movements such as "arts and crafts" and Sloyd, and figures in the history of education such as J.-J. Rousseau, have strongly marked our heritage as closer to the arts or cottage industry, if not in explicit conflict with industrial production and big business (e.g., Martin & Luetkemeyer, 1979, pp. 27-8). That non-elitist, countercultural side of our heritage positioned our field well in general education. Abandoning that heritage in favor of a stronger, uncritical ideology of engineering presents a weaker argument for our place in general education. Our teacher preparation and graduate programs need to provide students with the complex and sophisticated analytical tools for understanding relationships between technology and society in the past and the present and for negotiating our place in general education.

Conclusion

Without disciplined reflection on the past and associations with influential and diverse groups beyond science and engineering, the field of technology education will not be able to provide its teachers adequate tools for understanding relationships between technology and society in the past and present. Historical analysis can help develop a professional capacity for understanding the role of human choice and freedom in technology and education. Contextualizing our heritage can improve critical thinking if we teach stories of how people designed and constructed technology in their own contexts. We must avoid teaching a simplistic ideology of "effects" and a timeline of decontextualized artifacts and processes portrayed as a canon with a predictable, linear trajectory. Such teaching reinforces a deterministic view of history that makes it difficult to instill in students the importance of human choice and responsibility in design decisions. Teaching a contextualist heritage will increase the field's capacity for reflection and analysis, and for designing standards that are flexible and that stimulate interest in alternate choices. As a result of changing from an "American" (AIAA) to an "International" (ITEA) orientation, Americans need to make a radical reassessment of what it means to be a professional who looks beyond narrow American nationalism.

The following recommendations are directed to all members of the profession in hopes of reviving an interest in our heritage and our capacity to communicate it to future teachers.

1. Modify standards 4, 5, and 7 to be more consistent with the "constructivist" view of Standard 6 and to include contextualist analysis. Example of a revised Standard 7: "The different ways that people designed, constructed, and used technologies in their historical contexts."
2. Build the capacity of teacher educators, teachers, and student teachers to understand the complex dynamics of society and technology in historical contexts, and to make compelling arguments for technology education as part of general education. In order to do this, engage with diverse professional groups beyond science and engineering.
3. Promote storytelling and written accounts of our heritage that include contextualist, constructivist interpretations, that stimulate reflection on ethical decision-making, and that show how overlapping communities of practitioners (e.g., shop foremen, workers, engineers, scientists) contributed to the design, construction, and use of technology in historical contexts.

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