For a History of Technology Education: Contexts, Systems, and Narratives

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In his paper on "Shaping the Future of a Profession," Waetjen (1992) challenged technology education to establish itself as an academic discipline. He emphasized four elements common to disciplines: domain, history, mode of inquiry, and instructive capability. In assessing these elements, Waetjen noted the lack of a history of technology education and also recommended the development of a framework for such a history.

This paper focuses on several historiographical issues that need to be considered in developing a framework for a history of technology education. Historiography is concerned with how we select and interpret historical data and how we conceptualize and write history. For example, Bennett (1926, 1937), one of the best known American historians of industrial education, usually focused on aspects associated with industrial education but rarely interpreted them in the broader social context.

Today, technology educators are expected to help students interpret technology in the context of society. Consequently, Bennett cannot be considered an adequate guide to the heritage of technology education. Furthermore, technology education claims a wider scope of content and more explicit reflection on solving problems than industrial education. Thus, a history of industrial education is not adequate for understanding the heritage of technology education.

This paper is divided into three main sections, the first of which is concerned with technology education and society. The second section addresses narrative and systems approaches to historical data and is followed by a third section that illustrates these different approaches through two examples.

Technology Education in Society

In addition to having a general historical background, historians of technology education need to become familiar with specialized bodies of historical literature such as the history of technology, social history, or history of educa-

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tion.[1] The issues central to this essay arise out of recent literature in the history of technology, especially as reflected in the work of members of the Society for the History of Technology (SHOT) in its journal *Technology and Culture*. Within SHOT, there has been much reflection on technology, its historical relationships to other aspects of society, and alternate approaches to writing history. But as recently as 1974, two authors still stressed the lack of a "conceptual framework" for the history of technology (Staudenmaier, 1985, p. 7).

In *Technology's Storytellers*, published jointly by SHOT and MIT Press, Staudenmaier (1985) analyzed the articles that had appeared in *Technology and Culture* from 1959 to 1980. Staudenmaier (1985) initially classified articles into three broad historiographical categories: internalist, externalist, and contextualist. Although there is considerable historiographical diversity among articles in these categories, the categories are pedagogically useful.

Definitions: Internalist, Externalist, and Contextualist

In internalist history, attention is focused primarily on the artifact rather than on how it relates to social context. For example, an internalist history of the bicycle or computer would focus primarily on the design and construction of bicycles and computers and perhaps some of the people and places directly associated with their development.

An externalist approach is almost the exact opposite of the internalist. Here the artifact is granted only marginal attention or treated more as an illustration. For example, the development of bicycles or computers might be included in a broader study of social or political history. While there might be some attention given to technical changes, the technological artifacts do not occupy a central position.

[1] The focus here on the history of technology education and the history of technology is not intended to diminish the importance of other specialized historical literature such as the history of education. Unfortunately space only permits several suggested readings that would contribute to a better understanding of the possibilities for historical research in technology education. For example, Cremin (1988), Tanner (1991), Tanner and Tanner (1990), Cuban (1984), and Kliebard (1992) represent contemporary approaches for a historical background in education. Goodson and Walker (1991), Short (1991), and Schubert (1986) include various approaches to curriculum inquiry and historiographical issues. Kantor and Tyack (1982), Kliebard (1987), and Wirth (1983) take a critical historical approach to education, industry, work, and economic issues. DeBoer's (1991) treatment of American science education (including STS programs and scientific literacy) and McCulloch, Jenkins, and Layton (1985) on the politics of school science and technology in England and Wales are especially pertinent. Goodson (1987) combines issues in curriculum history with an international perspective. See Jasanoff, Markle, Petersen, and Pinch (1994) for a comprehensive resource on science and technology studies published in cooperation with the Society for Social Studies of Science (4S); and Restivo (1991) for a broad overview of sociological perspectives.

A contextualist approach shows "the internal design of specific technologies as dynamically interacting with a complex of economic, political, and cultural factors" (Staudenmaier, 1985, p. 11). Current trends in the history of technology tend to favor contextualist history. Such approaches emphasize the particularities of the social and historical conditions in which different technologies have developed. In so doing, they have avoided the excessively deterministic implications of so many internalist histories.

Still, SHOT is not a monolithic group of historians. They may have, in Staudenmaier's terms, a "shared discourse," but the lines between internalist, contextualist, and sometimes externalist styles are not always sharply defined. Many people would agree that contextualist history at its best includes detailed accounts of technological systems. For example, Hughes (1983) has shown in considerable detail how electrical power systems developed differently in several different countries. Contextualist history builds on an earlier consciousness of technical differences as illustrated in internalist history but also reflects a concomitant awareness of how social factors influence design and development.

Analysis: Contextualist History in Technology Education

In view of the importance that technology education places on understanding technology in society, contextualist history might appear to be the most appropriate approach. Yet there are potential problems as can be learned from historians of technology. For instance, while SHOT has drifted towards a predominance of contextualist approaches, this drift seems to be linked to the most recent generation of historians of technology, many of whom were trained as historians, not as technologists. These historians have benefited from many of the fine and extensive internalist histories of technology.

This issue will not go away easily. In fact, it was considered so important by SHOT that the T&C [*Technology and Culture*] Editor Search Committee (1994) recently required applicants to react to comments made by Leo Marx (1991) that were critical of the contextualist trend. Marx recognized the strengths and limitations of both sides of the issue. His argument was provocative and needs to be taken seriously by technology educators as well. "Yet its [contextualist viewpoint] triumph, oddly enough, makes the rationale for this specialty [history of technology] even more dubious than that put forward by the internalists" (Marx, 1991, p. 395).

In contrast to historians of technology, technology educators do not do history as their primary occupation. The history of industrial arts was primarily internalist and was never as extensive in scope or depth as the history of technology. But while technology education is extremely broad in scope, the central interest of technology educators is education *in* and *about* technology, that is,

how people teach, learn, and otherwise transmit technological knowledge and how people can learn to (re)construct technological artifacts and culture.

While it may be philosophically sound to do contextualist history of technology education, practically it is difficult because of the time required to assimilate the social context, technology, and educational practice of a given time period. Initially, technology educators might start by writing in-depth articles that focus on specific aspects of the heritage of technology education, but at the same time, include sufficient background material to emphasize *relationships* between education, technology, and society. This represents a kind of middle ground, that is, internalist studies but presented in context.

Narratives and Systems

The second historiographical issue in this paper concerns narrative versus systems interpretations. This issue was addressed through a debate format in three articles in *Technology and Culture* on the strengths and weaknesses of narrative versus systems theory as organizing methods in historical writing (Buchanan, 1991; Law, 1991; Scranton, 1991).

Distinctions: Narrative and Systems Approaches

At one end of the spectrum, the historian collects evidence and then writes an individualist, yet coherent, narrative account as response to the research questions. At the other end of the spectrum, social science models or frameworks are used to organize and interpret historical evidence.

Narrative history places considerable value on collecting all the available evidence related to the particular questions posed for the study, and then subjecting the evidence to an evaluation of its relative importance or influence. At the same time, the historian searches for a coherent network of relationships among the pieces of evidence in order to provide a satisfactory set of answers to the research questions. Through this critical analysis of evidence, the historian then writes a narrative that becomes a secondary account of the subject. Admittedly, there exist certain biases in the posing of the questions, the evaluation of evidence, and the construction of a coherent network and secondary text. Narrative historians would claim, however, that to adopt an explicit theoretical model to explain or organize historical evidence constitutes even more of a bias.

Social science models used for historical analysis are usually contemporary in design, for example, as illustrated in *The Social Construction of Technology* (Bijker, Hughes, & Pinch, 1987) and thus lend an anachronistic element to the account. Similarly, econometric approaches to history generally use contemporary economic theory and quantitative analysis, not the theories prevalent at the time of the historical topic under study. But Law's position as a social scientist-

historian to this issue is relatively simple. "It is that narrative history and social science theory are driven by different kinds of concerns and interests" (1991, p. 377). He further points out that narrative historians and social scientists have much to learn from each other because of their different approaches.

Analysis: Systems and Narrative in Technology Education

The reason that this debate is so important for the history of technology education is that technology educators (including industrial arts educators) have traditionally been trained in educational methods heavily influenced by social science methods. In addition, the notion of "systems" has become increasingly influential in curriculum and methods design. Thus, one might think that technology educators' background in social science models, engineering models, and quantitative methods would lead them towards the use of such models in historical writing.

It is paradoxical then that the historical approach most common in the field seems to be narrative as illustrated by Bennett (1926, 1937). For the most part, subsequent historical writing has usually followed Bennett's approach as if there were no other approach. This situation can be explained largely by the scarcity of historical inquiry and conservatism in research methods in technology education.

Given the scarcity of historical research in technology education, both critical narrative and social science approaches are needed, but their differences affect the formulation of research questions and the representation of history. For example, well-known "systems" such as the "input, process, output, feedback" model and the "content cluster" model are weak in explanatory power in both technical and historical contexts. For historical research, the models found in Bijker, Hughes, and Pinch (1987) are more integrative in terms of context and serve at the same time to undercut the credibility of simple, linear models such as the "input, process, output, feedback" model. Nevertheless, all models risk presenting a distorted view if historical evidence is "force fit" into them.

Two Examples: Narrative and Systems Approaches

This section illustrates a narrative and a systems approach to the history of technology education through a new look at two major educational artifacts. The first artifact is Denis Diderot's massive *Encyclopédie*, published from 1751-1772, distributed widely in Europe, and introduced into the United States by Thomas Jefferson. The second artifact is the Russian system of tool instruction developed at the Moscow Imperial Technical School in the late 1860s and adopted shortly thereafter in some schools in the United States. Both are relatively well known and have generated secondary critical literature. Diderot's work sought to disseminate technological knowledge by representing the me

chanical arts systematically in texts and illustrations; the Russian system sought to integrate systematic representation of the mechanical arts with practical instruction.

Historiographical Background

When Bennett (1937) discussed the Russian system of tool instruction, he focused on the instructional system. Bennett acknowledged the role of some people in the development of the Russian system (e.g., Della Vos) and in its transfer to the United States (e.g., Runkle), but he did not examine the Russian social context to understand why such a system was developed in Russia. Nor did he examine the American social context in detail to understand why it was transferred to America.

Bennett's approach was primarily internalist in conception, though he did attempt to connect the Russian system to something else, noting that "the theoretical instruction [of the Russian system] is said to have resembled that given at the *Ecole Centrale des Arts et Manufactures* in Paris" (1937, p. 15). But he did not say who said this nor did he elaborate on further connections. Nor do we know from his chapter precisely how the Russian system differed from other systems of technological education at the time. In all fairness to Bennett, it was neither his main purpose nor did he have space to account for the influence of similar programs or precursors. Although he recognized the existence of earlier attempts to analyze the mechanical arts, he suggested that "there seems to be no available evidence that any adequate analysis of the mechanic arts was made until 1868 when the Russian system of workshop instruction was devised by Della Vos and his associates for use in the Imperial Technical School at Moscow" (Bennett, 1937, p. 14). It seems difficult to justify this claim since there had already been many analyses of various arts and crafts prior to the Russian system. But Bennett probably meant the first analysis of the mechanical arts specifically for use in schools.

On the other hand, Marcus and Segal (1989), in a recent general history of technology in America that is contextualist in orientation, referred to the Russian system of tool instruction as an educational example in engineering education (p. 170). But they included few details and did not mention it in their discussion of the growth of industrial education (pp. 241-243). Some historians of American education have described briefly the influence of the Russian system in American education, though without considering the Russian context of its own development (e.g., Cremin, 1961, pp. 25-29; 361; Cremin, 1988, pp. 223-224; Kliebard, 1987, pp. 130-131).

How then would a contextualist account treat the Russian system? Schurter (1982) made a substantial contribution to understanding the original context, development, and introduction of the Russian system into the United

States. Unfortunately, Schurter's dissertation is not well known, but it represents a major step in providing context for a well-known educational endeavor in the heritage of technology education. One might consider it internalist "in context."

Several years after Schurter's work, I attempted to interpret the development of the Russian system in the context of Russian history, economics, and society and found that the Russian system occurred at about the same time as the emancipation of serfs, increased importation of skilled foreign workers, and a relatively high growth rate of the economy in certain sectors (e.g., iron, steel, railroads) (Pannabecker, 1986). Neither Russia nor the United States had a history of influential guild systems. Other similarities between the two countries can be identified, such as the emancipation of slaves and a high economic growth rate in America. While my essay broadened the frame of reference, it was really an attempt to understand why Russia and America might both have been so receptive to such a teaching system. It did not develop a clearer understanding of the educational differences in style between the Russian system and other influential educational endeavors and thus must be considered more externalist than contextualist. Unfortunately, it was somewhat deterministic in conception (a perspective which I have since critiqued, Pannabecker, 1991). It is unclear whether anyone has shown how the design of the Russian system and other related systems developed interactively in social context.

Narrative Approach

This narrative approach is intended to illustrate briefly the complexity of connections between the Russian system and earlier attempts to systematize and disseminate technological knowledge, in this case, Diderot's *Encyclopédie*. In so doing, I enlarge the context for understanding the Russian system but attempt to avoid a systems approach. I then suggest avenues of research that would expand our knowledge of the heritage of technology education.

According to Schurter (1982), Ershov, the original designer of the Russian system, had studied in western Europe and took courses from Morin at the *Conservatoire National des Arts et Métiers* (CNAM) in Paris (pp. 95-98; 136). Diderot's work on the *Encyclopédie* was centered at Paris in the 1750s and 1760s and would have been well known at CNAM (founded in 1794) when Ershov studied there in the nineteenth century. Of course, other earlier systematic descriptions of some of the arts and crafts would also have been available. But Diderot's work was particularly important because of its scope and extremely wide dissemination. For example, Durfee (1893) considered the French to be a leader in precision tools for making clocks and watches and referred on several occasions to Diderot's *Encyclopédie* as documentary evidence

of advanced machine tool design (e.g., milling machine [p. 1236]; lathe slide rest [p. 1241]).

Catherine II of Russia (1729-1796) was so interested in the ideas of the French Enlightenment that she invited Diderot to visit her in Russia. He complied in 1773, despite his general adversity to long trips. Diderot was a friend of Ivan Betskoi, educational advisor to Catherine II and director of the Moscow Foundling Home which would eventually evolve into the Moscow Trade School and then the Moscow Imperial Technical School. During his visit to Russia, Diderot was made an honorary curator of the institution (Schurter, 1982, pp. 45-57). Prior to his visit, when Diderot was in debt, Catherine had purchased his library in Paris on condition that it remain in his dwellings for his personal use until she asked for it (Crocker, 1966, p. 344). The point here is that Diderot's work, his systematic representations of the arts and crafts, and Enlightenment ideas were well known in Russia. Ershov was following a tradition of systematized knowledge, social ideas, and technological education that can be easily traced to the French Enlightenment.

At the same time, there were numerous attempts to systematize actual production, that is, to transform the arts and crafts into manufacturing systems. For example, when Adam Smith published his now famous economic treatise *The Wealth of Nations* in 1776, he referred to the systematic manufacture of pins, as had been illustrated in Diderot's *Encyclopédie* and Chambers' *Cyclopaedia* (Smith, 1937, pp. 3-5 and editor's note no. 6).

Somewhat later, Thomas Jefferson promoted the dissemination of Diderot's work and also encouraged the American government to pursue uniformity in the manufacture of arms as pioneered by two Frenchmen--Gribeauval in the 1760s and Blanc in the 1780s. Jefferson wrote of Blanc's ideas to John Jay in 1785 and discussed with Blanc in 1788 the possibility of moving his operations to the United States (Durfee, 1893, 1893-94; Hounshell, 1984, pp. 25-26). Eventually, some of these ideas could be found in the work of Eli Whitney (Hounshell, 1984, pp. 25-26). In America in the 1820s, Thomas Blanchard made gunstock-making machinery for producing uniform stocks and included an acknowledgment of Diderot's *Encyclopédie* as one of the sources for his ideas of turning objects through the use of cams (Durfee, 1893, p. 1243; Smith, 1977, p. 125).

The particular emphasis that the American government placed on uniformity or interchangeability in parts in the nineteenth century led to what has come to be known as the "American system of manufacturing." Still, Hounshell mentioned the case of an armsmaking plant at Tula in Russia that, according to Richard Prosser, was carrying out mechanized arms production using English machinery in the 1820s. Prosser called this the "Russian plan" (Hounshell, 1984, p. 24).

The preceding narrative illustrates some of the connections that existed among people, places, and systematic approaches to the diffusion of technology prior to the Russian system of tool instruction. To avoid confusion, it is important to note that three different types of technology-related systems are included: (a) industrial production systems; (b) representational systems of technology in books (texts and drawings); and (c) instructional systems, in this case, the Russian system of tool instruction. Nevertheless, the historiographical approach is narrative; it describes connections, without organizing the data according to a system.

Systems Approach

How then might one approach some of the historical evidence from a systems approach? Probably the most comprehensive single source for identifying possible systems approaches can be found in Bijker, Hughes, and Pinch (1987) and its 24-page bibliography. This work also discusses the limitations of different approaches.

The Russian system as described and illustrated by Bennett (1937) has some similarities with the representations of the mechanical arts in Diderot's *Encyclopédie*. In each case, an attempt was made to reduce practice into small elements and then to represent these elements as part of a system for instruction or another form of disseminating knowledge. A systems approach might help to distinguish between these two systems and to show how technological knowledge was viewed in different contexts.

For example, in order to analyze technological knowledge as represented in Diderot's *Encyclopédie*, I adapted Collins'(1987) model for analyzing knowledge (Pannabecker, 1992). Collins illustrated this model in *The Social Construction of Technology*, applying it to the various types of knowledge he found in the process of designing a particular kind of laser. He identified four basic categories of technological knowledge: (a) facts and rules; (b) heuristics; (c) perceptual and manipulative skills; and (d) cultural skills. He also explained how various types of knowledge can shift across categories or boundaries over time. Collins' model can be considered representative of a social science approach, though as Law (1991) has noted, there is considerable diversity among such models.

I selected two known contributors to Diderot's *Encyclopédie* and their respective contributions on printing. Brullé wrote the article on letterpress printing and Goussier designed the accompanying plates and wrote their descriptions. Through this systems approach, I was able to distinguish their styles of describing printing technology and the extent to which they adhered to or deviated from Diderot's explicit system. Little detailed research of this type has been done to date, except for a few cases (e.g., Proust, 1967; 1972). Most his-

torians have not been interested in the distinctions of how people tried to analyze the mechanical arts.

If one applied this same systems approach to the Russian system of tool instruction, it would then be possible to compare the Russian system and Diderot's system, thus going beyond some of the superficial similarities in the pictorial illustrations of the two systems. Then, by comparing these two systems and posing research questions about relationships with other systems, one could begin to appreciate the richness of a central aspect of technology education, that is, how technological knowledge has been conceptualized, packaged, and disseminated.

For example, what were the relationships between the "Russian plan" of mechanized production at Tula in the 1820s, the extensive machine building in the Moscow Imperial Technical School in the 1840s (Schurter, 1982, p. 91), and the development of the Russian system of tool instruction in the 1860s? What kind of curriculum and instruction was Ershov exposed to during his studies at CNAM in Paris and in what ways did the program at CNAM influence Ershov's design of the Russian system? What relationships existed among people involved in the American system of manufacturing in the nineteenth century, instructors in American technical schools, and those who promoted the Russian system in America? These types of questions would be excellent subjects for historical research and could contribute much to our understanding of the conceptualization, representation, and dissemination of technological education in the past.

Bennett's (1937) approach to the Russian system was narrative history, but not really "critical narrative" history. He did not present enough data to make his far-reaching claims about the Russian system's precocity as a systematic approach in education. An analysis of various systems of representing the mechanical arts could complement narrative history and contribute to a revision or confirmation of the dominant position that the Russian system has gained through Bennett's work and subsequent derivative literature.

Conclusion

The two major issues discussed here, the importance of context and choice of narrative or social science approaches, have been central in the development of the history of technology and need to be considered in historical work in technology education. Contextualist history may be an appropriate goal, consistent with the philosophy of technology education, but it may be more practical to begin writing focused, internalist history "in context." Either critical narrative or social science systems approaches can be appropriate depending upon the nature of the research questions.

Beyond these methodological concerns, however, lie a host of other issues or themes not discussed in this paper. For example, the heritage of technology education could include such themes as international relationships, the transfer of technological knowledge, expert systems and automation, and issues of gender, race and religion. Contemporary research and curriculum development in technology education continue to be framed in narrow perspectives that ignore how and why technological education has developed differently in different contexts. There is very little research on how differences in gender, race, and religion have influenced forms of technological education.

Theoretical and conceptual issues affect our views of the past and inform our approaches to understanding the present. For example, our studies of contemporary curricula are usually internalist. Studies of successful educational endeavors in one institution or locality are often narrowly conceived and then recommended for all contexts, as if context did not matter. Was the Russian system of tool instruction transplanted intact from Moscow to St. Louis? We might learn important lessons from trying to understand what aspects of the Russian system did not fit other contexts. In general, historical studies of technology education programs will be more useful than the rhetoric of success and promotion that follows in the paths of narrowly conceived accounts of contemporary curricular change.

This paper began with a reference to Waetjen's (1992) articulation of a goal--that technology education establish itself as an academic discipline. Among his recommendations to further that goal was that the field produce historical writing about technology education. I do not know whether developing a history will have an important influence on technology education's disciplinary status. But regardless of disciplinary status, technology education does need a better understanding of the heritage that has so influenced its contemporary domain, modes of inquiry, and instructive capability.

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