# AC 2008-2828: THE NATURE OF TECHNOLOGY EDUCATION IN THE U.S.

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# The Nature of Technology Education in the United States

## Preface

Although engineering education and technology education (TE) shared a pedagogical interest in the late 19th century, the two fields have rarely crossed paths since. With the ASEE's establishment of the new K-12 Engineering Division and the variety of new initiatives in K-12 education promoted by the engineering community, there are unprecedented opportunities for engineering educators and technology educators to work together on their common interests in grades K-12. But because, the two disciplines have operated in different domains, neither is very familiar with nature, purposes, and culture of the other—all-important understandings for effective collaboration.

With that in mind, this paper is an attempt to acquaint readers—mostly engineers and engineering educators—with Technology Education in the U.S. It opens with an introduction to historical events that shaped the philosophy and culture of the field. The middle section of this paper describes the current status of Technology Education in the U.S. The final section will address the most recent trends in technology education, including recent efforts to effectively incorporate engineering content and method into K-12 technology education practice. The underlying purpose of this paper is to enable engineering educators to better understand the values and ideals that led Technology Education to its current place in K-12 education, and to better understand why technology educators have sought to integrate more math, science, and engineering content and method into their discipline over the past two decades.

## Historical Antecedents of Technology Education

### Manual Training

In the late 19$^{th}$ century, the transition from an agrarian to an industrial culture precipitated the growth of cities, demand for increasingly skilled workers, and a raft of related social problems. The infrastructure of public education was developing along with the industrial and social structures, with each of these cultural facets influencing the others. American education, which had been primarily by and for the wealthy, was becoming an increasingly important means of educating new workers for the rapidly expanding industrial economy and for socializing masses of immigrants into the "American" way of life.

It was against this backdrop that engineering education and TE briefly found common ground in the late 18$^{th}$ century. The story begins at the Imperial Technical School of Moscow in where a new pedagogical system for the preparation of civil and mechanical engineers emerged. Previously, students at the Imperial School had learned by watching and imitating tradesmen, who worked on jobs contracted by and completed in the school[1a]. This, essentially, is how technical training was addressed in schools in the U.S.—a pedagogy adapted from the apprentice system. In need of a more efficient instructional method, Professor Ershov began to oversee the development of a new system of "instruction shops" in the 1860s. Under this system, each student in the class was provided a set of tools, which they used to construct an extensive series of graded technical exercises of increasing difficulty. Specifically, students learned joinery this way, producing models from drawings working 14 hours/week for a year… followed by courses in woodturning, blacksmithing, and locksmithing [1b, 2]. Upon Erschov's death in 1867, Victor Della-Vos became Director of the Imperial School, and continued to develop and promote the "Russian System. It was, Della-Vos, therefore, who was largely responsible for the "Russian System" exhibit at the 1876 Centennial Exhibition in Philadelphia.

The Russian System exhibits at the Centennial Exposition made an immediate and profound impression on Dr. John Runkle, President of the Massachusetts Institute of Technology (MIT). Runkle had been concerned with MIT students' lack of tool skills, which he said "always seemed to me a fault in the education, and yet I did not see the way to remedy it without building up manufacturing works in connection with the school" [1c]. In describing the Russian System exhibit he wrote, "In an instant, the problem I had been seeking to solve was clear to my mind; a plain distinction between a mechanic art and its application in some special trade became apparent" (Bennett, p. 320). Shortly after the Exhibition, Runkle convinced MIT's governing board to establish a new department and a group of "instruction shops" in which mechanical engineering students would receive instruction patterned on the Russian system.

Foreshadowing engineering's current interest in K-12 engineering education, Runkle wrote, "I believed that this discipline could be made a part of general education, just as we make the sciences available for the same end through laboratory instruction" [1d], which led MIT to provide leadership to the establishment to the *School of Mechanic Arts* for secondary students in Boston. In 1882, John Ordway, Vice President of MIT, wrote a letter to the secretary of the Public Education Association of Philadelphia, strongly encouraging them to expand the work of the *School of Mechanic Arts* to all of Boston's public schools [1e].

In the 1870s, Harvard graduate Calvin Woodward was professor of mathematics, and dean of the Polytechnic faculty at Washington University in St. Louis. Concerned that his math students were having difficulty grasping certain concepts, he began to teach an applied mechanics course in the early 1870s, in which students made wooden models to assist in visualizing the basic mechanical forms, so that "engineering students will be able here to acquire some dexterity in the use of tools, which, though slight, will be of great value to them in the subsequent work of their profession (i.e., this experience will make them better judges of workmanship)" [1f].

But it was the Russian System and Runkle's influence that propelled Woodward to establish, in 1879, the first *Manual Training School* in St. Louis. The previous year, Woodward had written, "To Russia belongs the honor of having solved the problem of tool instruction.... In their hands, manual tool instruction has become a science"[1g]. Woodward became the most ardent champion of manual training—the forerunner of TE—in the U.S. and by 1883, he was aggressively promoting the "general education" aspects of manual training; citing, for example: "better intellectual development; more wholesome moral education; sounder judgments of men and things, and of living issues; better choice of occupations; a higher degree of material success, individual and social" [1h]. Woodward's strong conviction that manual training was beneficial for all students was the "general education" philosophy strongly embraced by proponents of industrial arts (IA) in the 20$^{th}$ century, and by technology educators to this day.

Manual training thrived in the last two decades of the 20th century. There were other "border crossings" between engineering and manual training education elsewhere in the U.S. similar to MIT's establishment of the *School of Mechanic Arts*. But in the 20th century, postsecondary engineering educators very rarely crossed paths with secondary level IA / TE teachers. Coincidentally, it was in the Boston area again—at the end of the 20th century—where engineers re-entered the K-12 education sector in a grand way, promoting a new "Curriculum Framework for Science and Technology/Engineering" for the commonwealth of Massachusetts.

**Progressive Education and the Industrial Arts Era**

Seeking new ideas to transform their poorly performing schools, the Quincy, Massachusetts's school board hired Frances Parker in 1875. Parker replaced the traditional curriculum with teacher-developed group-oriented activities that emphasized relevance, self-direction, observation, and discovery. These activities were taught in workshop, garden, and laboratory settings. Parker believed manual activities such as these facilitated thinking, imagination, and good health [3]. His two major works, *Talks on Teaching*[4] and *Pedagogics*[5] inspired others, including John Dewey, and provided the foundation for what would later be known as "progressive education." These ideas, in turn, "provided the "pedagogical antecedent of the work that was later to find acceptance in the American schools as industrial arts"[3].

In 1894, Dewey and his wife Evelyn moved to the Chicago, and building on Parker's ideas, founded an experimental school at the University of Chicago. There, he experimented with his "psychology of occupations" that would later provide a theoretical rationale for the IA curriculum throughout the 20th century[3]. "Occupations" were a central component of Dewey's educational theory, wholly consistent with his philosophical ideals.

> "By occupation, I mean a mode of activity on the part of the child which reproduces, or runs parallel to, some from of work carried on in social life. In the University Elementary School, these occupations are represented by shop-work with wood and tools; by cooking, sewing, and by 'textile work.' The fundamental point in the psychology of an occupation is that it maintains a balance between the intellectual and practical phases of experience."[6a]

It is impossible to examine the ideals underlying IA and TE without referencing Dewey. Much of what Dewey believed and wrote eloquently describes the "general education philosophy" that has driven the profession for more than a century. Nearly every student of education is aware Dewey promoted learning through experience—a radical departure from the dominant belief in education, dating to Aristotle, that "good" knowledge resulted from idle thought, and knowledge that grew from experience was a lesser variety of knowledge. In contrast to that notion, Dewey believed that knowledge and understanding result from "doing":

> " …there is no such thing as genuine knowledge and fruitful understanding except as the offspring of *doing*. The analysis and rearrangement of facts, which is indispensable to the growth of knowledge and power of explanation and right classification, cannot be attained purely mentally – just inside the head. Men have to *do* something to the things when they wish to find out something; they have to alter conditions. This is the lesson of the laboratory

> method, and the lesson which all education has to learn. The laboratory is a discovery of the conditions under which *labor* may become intellectually fruitful and not merely externally productive."[6b]

Dewey believed strongly that robust educational *experiences* could and should be created in school laboratories.

> "Where schools are equipped with laboratories, shops, and gardens, where dramatizations, plays, and games are freely used, opportunities exist for reproducing situations of life, and for acquiring and applying information and ideas in the carrying forward of progressive experiences. Ideas are not segregated; they do not form an isolated island. They animate and enrich the ordinary course of life. Information is vitalized by its function; by the place it occupies in direction of action"[6c].

The structured technical exercises at the core of the 19th century manual training movement were out of synch with the progressive movement championed by Dewey and others in the early 20th century. In the new industrial culture, activities drawn from industry that provided opportunities for problem-solving and connections to art, science, and other subjects were ideally suited to the progressive education philosophy.

Sensing these trends and opportunities, Charles Richards, head of the Manual Training Department of Teachers College Columbia, proposed "Industrial Art" as a new name for the profession[7] in a 1904 issue *Manual Training Magazine*, for which he served as Editor. In addition to the proposed name change, he encouraged the field look to industry as a source of content, rather than the technical exercises and "meaningless projects" that comprised the manual training curriculum. This idea of industry as the source of content would become the dominant paradigm of IA.

"Industrial arts" was a far better descriptor of the ideals of the field—a discipline grounded in the study of the industry *and* of the culture of the new industrial society, intended for the benefit all boys and girls in American education. The "arts" represented a growing interest in the creative design aspects of the curriculum, which dovetailed nicely with the arts and crafts movement in American education, as well as with the ideals of Dewey and other progressive educators in the early 20th century.

Conceived as a curriculum for all boys *and* girls, IA had much to offer. At the experimental school at Teachers College Columbia, Frederick Bonser and Lois Coffey Mossman developed an IA curriculum for the elementary grades, which captured the essence of the new movement. Their seminal text published in 1923, *Industrial Arts for Elementary Schools* offered an eloquent rationale and structure for their new IA curriculum, as well as a succinct definition for IA that would serve the profession well for the next six decades: "*Industrial Arts is a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes*."[8a]

Situating the curriculum in the elementary grades and in the context of "*the problems of life related to these changes"* left no mistake that this was a "general education" curriculum for all, not a pre-vocational skills-based curriculum. While they recognized that contemporary proponents of "industrial education" promoted "the vocational study of an industry"… whose "fundamental and controlling purpose is to develop efficient workers,"[8b] they sharply delineated their "industrial arts" curriculum, stating "Clearly, such [vocational industrial education] work has no place in the elementary school nor in the early years of the junior high school." In their introductory chapter of the text, they described the "General Education Purpose" of Industrial Arts this way:

> *"The general educational purpose*. The materials, processes, conditions of production, and the purchase and use of the products of the more important industries may be studied for the values which such study affords in one's everyday life, regardless of his occupation. Such a study of the industrial arts we describe as general. To realize its purposes we make no attempt to develop any considerable degree of skill in any of the several industries studied. Productive skill is not included in its purposes as it is in vocational education. The field includes numerous industries, not limiting itself to one industry as in vocational education.[8b]
>
> The purposes or outcomes of the general study are realized in the degree in which it helps one to become efficient in the selection, care, and use of the products of industry, and to become intelligent and humane in the regulation or control of industrial production. This study is from the point of view of the problems, opportunities, and obligations of the consumer and the citizen."[8c]

In addition, Bonser and Mossman outlined five "specific values and objectives for industrial arts," including the health, economic, aesthetic, social, and recreational purposes, as well as a number of "subordinate purposes:

> "There are such objectives as the development of manual dexterity; coordination of hand and eye; cultivation of a sense of form; developing a love of bodily labor; cultivating patience, persistence, neatness, and accuracy; and developing powers of observation. All of these, however, as far as they may be developed at all in the elementary school, will be developed as by-products of the work as it is properly directed toward the realization of the five foregoing prominent objectives."[8d]

This "general education" philosophy was the predominant foundation of IA in the 20th century, though it was never well understood by those *outside* the profession, nor was it sufficiently acculturated and universally promoted *within* the profession. The general education goals of IA were endangered from their very beginnings by the competing and growing demand for a skilled workforce in the U.S. That demand led to the vocational education movement at the turn of the century. Those business and industry interests led to the establishment of the "National Society for the Promotion of Industrial Education," which lobbied for federal resources to prepare technically trained workers for industry (Bennett, 1937). The end result was the passage of the Smith-Hughes Vocational Education Act of 1917, the first federal funding for education in the US; federal funding that continues to support secondary vocational education in the U.S. to this day.

Although IA was philosophically a general education curriculum for all, the use of industrial tools, equipment, and materials to achieve the goals of the curriculum allowed educational administrators and IA teachers alike to view the IA laboratories as “vocational shops” whenever it seemed advantageous to do so. Such “border crossings” occurred throughout the 20th century as a result of a complex matrix of factors, including local workforce needs, state level IA leadership, the quality of IA teacher education institutions, and so forth. One indicator of this phenomenon was the establishment of some state offices for IA education in departments of vocational education (e.g., Virginia and south along the east coast) while others established these offices alongside the “general education” subjects (e.g., Maryland and north along the east coast). In the mid 1960s, an IA contingent successfully lobbied for formal inclusion of IA, for the first time in the federal Vocational Education legislation to enable state and local IA administrators to draw resources for the support of local IA programs. Many who believed firmly in the general education philosophy of IA saw this as a “deal with the devil,” fearing it would forever obscure the general education ideals of the IA curriculum.

There were a number of individuals and events that further defined IA in the 20th century. William Warner, professor of IA at Ohio State University, was among the most influential. In 1929, citing a need for an organization that might provide recognition and “dignity, honor, and prestige” for IA, Warner founded the IA honorary society, Epsilon Pi Tau. In the 1930s, he developed and promoted the “Laboratory of Industry” as the optimal facility for achieving the general education goals of the IA curriculum. In 1936, Warner and others made a series of presentations titled “IA as General Education” at the annual conference of the National Education Association (NEA). More than 500 NEA members attended the presentation and “interest was surprisingly high”[9]. Encouraged by the NEA’s response, Warner organized a meeting in 1939 for the purpose of establishing the American Industrial Arts Association (AIAA). Warner was elected President of the AIAA, which in 1939 was “allied” with the NEA, and awarded *affiliated* NEA status in 1941[9]. Warner is perhaps best remembered for his 1947 presentation of “The New Industrial Arts Curriculum” that he and six graduate students developed. The framework they proposed was organized around six “divisions” of industry: Management; Communications; Construction; Power; Transportation; and Manufacturing—five of which are reflected in the *Standards for Technological Literacy*[10]. The conceptual framework laid out in this paper and its widespread dissemination by Epsilon Pi Tau were important steps in the transition to Technology Education.

Delmar Olson, one of Warner’s doctoral advisees, took the profession a step closer to the “curriculum to reflect technology, with his 1957 doctoral thesis, *Technology and IA: Derivation of Subject Matter from Technology with Implications for IA*[11], later published by Prentice-Hall (Olson, 1963). Olson described a curriculum grounded in “technology” and reiterated the “general education” goals in the six “functions” he identified as the technical, occupational, consumer, recreation, cultural, and social functions of his new curriculum design.

Gordon Wilber’s *Industrial Arts in General Education*[12], first published in 1948, with continued publication through the 1980s, once again offered a robust and convincing rationale for the inclusion of IA in the school curriculum, for *all* students. This text was used to indoctrinate many thousands of IA teacher education students to the “general education philosophy” for decades.

The educational reforms that resulted from the launch of Sputnik resulted in a wave of major IA curriculum projects in the 1960s. Most prominent among these were the "Industrial Arts Curriculum Project" (IACP) at Ohio State University and "The Maryland Plan"[13]. The IACP utilized an advisory committee and task forces of subject-matter specialists selected from industrial design, engineering, psychology, organization, and management divisions, to identify the structure of a body of knowledge they called "industrial technology," which they published in 1966 in *A Rationale and Structure for Industrial Arts Subject Matter*[14]. Perhaps their most tangible outcome was the development and publication of two junior high curricula and accompanying textbooks of the same names—*World of Manufacturing* and *World of Construction*—which sought to convey knowledge of those two industries and their impacts upon society to junior high students in a laboratory setting.

Donald Maley, who headed the IA program at the University of Maryland from the 1950s through the 1980s, represented a very different philosophical approach to IA curriculum development. As Maley later assessed the landscape of the profession in the 1960s: "There was an overemphasis on the materialistic elements—projects, processes, and materials—with a very minor concern for the individual. Teaching processes were dominated by the teacher, and what was learned was limited largely to what the teacher knew or could demonstrate"[15]. Looking more like Dewey and other progressive educators of the turn of the century, Maley's "Maryland Plan" curriculum focused on students and method, rather than content, as was the focus of IACP and other curriculum models of the 1960s. Though the Maryland Plan was situated in the study of American industry, Maley was more concerned with the learning process and intellectual development of students, than with the structure of content, placing "emphasis in the psychological needs of the individual, as well as his resourcefulness, capability, and problem solving"[16a].

Maley's 7th grade IA course employed what he called the "anthropological approach" to study aspects of American industry and "certain basic elements common to all civilized mankind." Typically, students conducted an historical study of an industry, and built a historical model, such as a small wooden printing press. The model was accompanied by a written research report and a formal presentation to the class.

Maley's "Research and Experimentation" course engaged 9th grade students in self-directed research projects that involved them in materials science[16b]. Students conceptualized a scientific investigation (usually of materials) and were expected to contact experts in the field, using the telephone installed in the "R & E Lab." Students formally reported their progress in a weekly seminar, and presented their findings at the end of the course. Interestingly, a nearly identical course titled "Engineering Research" is *currently* being taught at our local Governor's School for Science and Technology," and perhaps in other schools focusing on STEM subjects across the U.S.

While others were refining the "curriculum to reflect technology" in the 1960s and 1970s, Paul DeVore was working at West Virginia University to characterize the study of technology as an "intellectual discipline" from which all would benefit[17]. DeVore brought to the profession the central idea that technology and culture are inextricably linked. DeVore's ideas are particularly apparent in Chapter 4, "Technology and Society" of *Standards for Technology Education*.

Regrettably, IA never achieved the ideals articulated by Richards in 1906, defined so eloquently by Bonser and Mossman in 1923, and repeatedly thereafter throughout the 20th century. Most outsiders—including education decision-makers at all levels and most parents jumped to erroneous conclusions about the purposes and ideals of IA.

The great failure of the IA era was its inability to convince education administrators, guidance counselors, and the public of the value of the "general education" goals and purposes of IA. Despite repeated efforts throughout the century to justify the curriculum as general education for all, outsiders rarely saw more than the instructional facilities (labs they called "shops") and the student-made projects (the byproduct of intellectual activity) and erroneously assumed the facilities and curriculum were designed for skill development, rather than for human development. Even more disconcerting, many teacher education programs failed to effectively acculturate IA *teachers* to the general education philosophy of the field. As a result, IA teachers often accepted the quasi-vocational or "pre-vocational" role, which their administrators and school divisions often promoted.

Nonetheless, IA mostly grew and prospered in the American schools throughout the century, and into the 1970s, but not generally in the way the profession had intended. For better or worse, IA was one of the few places in the school where nearly all students could be successful, creative, productive, and develop positive self-esteem. Though there are physicists, engineers, physicians, and attorneys who recall IA courses with fondness, IA became a tool for administrators and guidance counselors; a place where they knew academically challenged students would likely find a rare opportunity for success and greater self-esteem in the confines of the school day. So, despite all efforts in the post-World War II era to provide a "curriculum to reflect technology" for all students, the high school IA curriculum became a destination of convenience for many "general track" high school students.

**Current Status of Technology Education**

**The Rise of Technology Education**

In 1985, the AIAA formally changed its name to the International Technology Education Association (ITEA), signaling the change from IA to TE. Most state and local IA departments/programs quickly followed suit, though at the end of the century, nearly 1 program in 10 was still using IA to describe their program[18]. In the late 1980s, ITEA received funding to develop, publish, and promote a "framework" for TE throughout the profession. This effort resulted in the publication of *A Conceptual Framework for Technology Education*[19], which ITEA distributed widely in 1990. Perhaps its most significant contribution was the promotion of the "technological method" as replacement for the "project method."

The "project method," virtually synonymous with the IA throughout the 20th century, engaged students in building projects from plans typically, but not always, provided by the teacher. In the mid-1980s, TE programs across the U.S. began experimenting with "design briefs"—rather than project plans—as the basis of their instructional activity. The "design brief," an idea imported from the United Kingdom, was typically a 1- or 2-page description of a design challenge that provided just enough structure to direct students to use the tools and materials of a TE laboratory to design, build, and test a technological solution to the problem posed in the brief. A subset of "problem-based learning" (PBL), this "technological method" (also commonly referred to as "technological design," "engineering design," "design & technology," or just design-based instruction") challenged students in ways that the project method generally did not. Design briefs typically provided students with opportunities for "research" (information gathering), higher level thinking, intellectual and aesthetic creativity, and often employed competition for purposes of interest and motivation. Moreover, technological design problems are typically challenging for the entire range of the academic spectrum, and can be situated in a wide range of contexts. This section of *Conceptual Framework* helped to establish technological design instructional activities as the "signature pedagogy" of TE. Importantly, *Conceptual Framework* also added "bio-related technologies" to the list of "content organizers" the field had recognized since the publication of *Curriculum to Reflect Technology*.

Among its many contributions, the *Technology for All Americans Project* (TfAAP) provided a platform for explaining a contemporary approach to Technology Education to those within and, more importantly, beyond the profession. Although the 1996publication, *TfAA: Rationale and Structure for the Study of Technology*[20] didn't fully deliver on its title, it was a handsome and effective public relations piece for facilitating the "technological literacy for all" conversation with educational administrators, parents, teachers, politicians, and others within and beyond the profession. This is where IA had fallen down in the past. Hence, *RSST* was an important publication, and set the table for the publication of *Standards for Technological Literacy: Content for the Study of Technology*, the most important in the many attempts to define the "curriculum to reflect technology" over the previous half-century.

Not surprisingly, *STL* is primarily a compilation of the ideas that emerged from the field in the latter half of the 20th century. "Medical technologies" and "agriculture" (in Standards 14 and 15 respectively) were added to the list of content organizers the field had previously championed. Here again, the real strength of *STL* was/is its potential as a communication tool beyond the profession. It offered a credible overview of the ideals that the profession had been striving to achieve for decades. Perhaps most importantly, it offered a goal the engineering education community could support. With the National Academy of Engineering's enthusiastic endorsement of the *STL* as "an essential core of technological knowledge and skills we might wish all K-12 students to acquire," engineering and technology education were once again on the same page after a 120-year hiatus.

**National Studies of Industrial Arts and Technology Education**

Two comprehensive, federally funded national studies of IA Education were conducted in the latter half of the 20th Century: Schmitt & Pelley's 1962 study[21] the Standards for IA Programs Project (SfIAPP) study[22]. The SfIAPP study intentionally used many of the survey items included in the Schmitt and Pelley (1966) instrument, so it would be possible to examine certain trends occurring between 1960 and 1980. In 1999, Sanders (2001) conducted a third national study[18]—this time of Technology Education Programs—that once again included a number of survey questions employed on the two previous national studies, in order to examine trends in the profession from 1960 through the end of the century. Sanders distributed his survey instrument to department heads of 1,486 randomly selected middle school and high school TE programs. Following are selected findings from Sanders' study that provide some evidence for recent trends and describe some general characteristics of Technology Education as practiced in recent years.

***Program Name and Philosophy: A Continued March to Different Drummers***

Though most changed their program name to "Technology Education" in 1985, this is still not a universally accepted moniker for the field. In 1999, about 6 out of 10 respondents (58.6%) called their programs "Technology Education;" while 20.2% preferred "Industrial Technology;" and 9.1% were still using "Industrial Arts" to describe their programs. Moreover, there continues to be a division in the field between those who hold a "general education philosophy (technological literacy for all) and those who see the field as vocational in nature (job preparation for some). Specifically, about 55% of respondents thought of their programs as "general education," while about 40% associated their programs with vocational education; these percentages were very close to those reported by the 1979 study.

***Faculty: Getting Older and Still Predominantly Male***

Technology education program faculty at the turn of the century were still overwhelmingly male (89.9%) and Caucasian (94.1%), but female faculty numbers had increased from about 1% in 1979 to about 10%. The average age of TE faculty has climbed rather dramatically in the post-World War II era. TE programs in 1999 were about 10 times more likely to have faculty in their 40s (47.8%) than in their 20s (4.8%). A surprisingly high percentage of faculty in 1999 (about 92%) held TE (or IA) teaching licenses (with bachelor's or master's degrees) which was very consistent with the 94% reported in the 1979 and 1963 studies respectively. That said, the age of the faculty indicate the majority of practicing teachers in 1999 held IA teaching licenses, rather than TE licenses, which helps to explain why many programs continue to look more like IA than TE.

***Technology Education Students: Somewhat Mirroring the Population***

Few girls had the opportunity to enroll in IA until the 1970s; changing school policies have resulted in nearly equal access with about 46 % of those enrolled at the middle school level in 1999 were female. About half (51.8%) of all students in secondary schools were reported to be enrolled in technology education courses. Overall, about a third of those enrollments were female students, up radically from the 2.1% reported in 1963. More than one in four (26.2%) of those enrolled were from minority populations, mirroring the percentage of minority persons in the U.S. in 1999. This was a significant increase from the 18% minority enrollments reported in 1979. "Special needs" students accounted for 22.9% of the TE enrollment, while "gifted and talented" were reported at 12.2%. In contrast, guidance counselors surveyed in 1979 reported only about 3.2% of IA students to be "above average" and only about .5% as "well above average."

***Purposes of Technology Education: The Goals They Are A-Changin'***

Respondents were provided with 16 different statements representing purposes of TE. Ten of these purpose statements had appeared in the Schmitt & Pelley Study (1963) and a dozen were included in the SfIAPP (1979) study. Four new purposes were paraphrased from the "Program Goals for Technology Education" presented in *A Conceptual Framework for Technology Education*[19] and added to the Sanders (2001) study. Table 1 shows a rank-order comparison of the purposes reported in the three different studies[18, 21, & 22].

While the development of tool skills was deemed the most important purpose of IA in both 1963 and 1979, problem-solving skills were reported to be the most important purpose of TE in 1999, while tool skills plummeted to the lower third of the rankings. The other top-five ranked purposes—make informed educational choices, understand the application of science and mathematics (which ranked *last* in both 1979 and 1963), and understand the nature and characteristics of technology—are consistent with recent literature in the profession. That said, another important goal in the literature—assessing the impacts of technology, ranked very low (13 of 16) in 1999. Consumer knowledge and the development of leisure time interests—arguably important components of general education, seem to be a casualty in the quest for "technological literacy for all.

***Table 1: Purposes of Technology Education***

| Purposes of Technology Education | **Mean** | **1999 Rank** | **1979 Rank[2]** | **1963 Rank[1]** |
|---|---|---|---|---|
| Develop problem-solving skills [1,2] | 8.94 | 1 | 5 | 5 |
| Use technology (knowledge, resources, and processes) to solve problems and satisfy needs and wants [3] | 8.57 | 2 | NA | NA |
| Make informed educational and occupational choices [2] | 8.28 | 3 | 7 | NA |
| Understand the application of science and mathematics [1,2] | 7.97 | 4 | 12 | 10 |
| Develop an understanding of the nature and characteristics of technology [2] | 7.85 | 5 | 11 | NA |
| Provide technical knowledge and skill [1,2] | 7.75 | 6 | 2 | 4 |
| Recognize that problems and opportunities relate to and often can be addressed by technology [3] | 7.63 | 7 | NA | NA |
| Discover and develop creative talent [1,2] | 7.46 | 8 | 3 | 2 |
| Identify, select, and use resources to create technology [3] | 7.34 | 9 | NA | NA |
| Provide pre-vocational experiences [1,2] | 7.22 | 10 | 9 | 6 |
| Develop skill in using tools and machines [1,2] | 7.14 | 11 | 1 | 1 |
| Develop consumer knowledge and appreciation [1,2] | 6.68 | 12 | 8 | 9 |
| Evaluate the positive and negative consequences of technological ventures [3] | 6.64 | 13 | NA | NA |
| Understand technical culture [1,2] | 6.61 | 14 | 6 | 7 |
| Develop worthy leisure time interests [1,2] | 5.73 | 15 | 4 | 3 |

| | | | | |
|---|---|---|---|---|
| Provide vocational training [1,2] | 5.55 | 16 | 10 | 8 |

[1] From the Schmitt & Pelley study; [2] From the SfIAPP study; [3] Paraphrased from *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990)

***Instructional Methods***

Consistent with the changing nature of the purposes reported, more than half of the programs (56.9%) reported their instruction "engages students in problem-solving" and a third of the programs surveyed (32.7%) indicated that 80-100% of their instruction involved problem-solving activities. Respondents described about one fourth (22.8%) of the instruction as "lecture/demonstration (i.e., not hands-on activity)" which is consistent with the "hands on" instructional method/philosophy promoted since the inception of the field.

By the end of the century, century, digital activities had become very common, with about 9 of 10 TE programs reporting the use of computer-based instructional activities. On average, about 40% of instruction "used a computer as a tool to complete an activity or project, solve a problem, etc. and more than 6 programs in 10 reported Internet access in the TE laboratory.

Conventional labs with equipment for processing wood, metal, and plastic materials were regularly being converted into "modular Technology Education[1]" labs. While only 16.4% of respondents selected described their labs as fully "modular" about half of the respondents (48.5%) indicated their programs had at least some vendor-created modular work stations," and nearly three quarters (72.5%) were utilizing some "teacher-created modular work stations" in their facilities. Given the first modular labs didn't appear until the late 1980s, this was a relatively fast rate of transition, particularly at the middle school level, where modular labs became very popular.

The "most used" teaching approach reported by Sanders[18] was a fairly even split among the modular approach (35.4%, divided between "vendor-created" and "teacher-created"), the project approach (27.9%, "projects from plans provided by instructors"), and a design-based instruction (36.7%, "students design and build solutions to problems posed by instructors"). Design-based instruction was introduced at the same time as modular labs as a method to replace the more traditional "project method" that had dominated the IA era. So in the span of a decade, about a third of the programs had shifted from projects built from plans, to solutions designed and built by students in response to design problems posed by instructors. The shift from the project method to this "problem-based learning" (design) approach, is arguably the most decided difference between the IA and TE paradigms.

***Content***

Respondents were asked to indicate the percentage of instruction given to each of the four categories identified in *A Conceptual Framework*[19] and one additional category labeled "other." "Production"(34.3%), "Communication"(30.2%), and "Transportation" (19.7%) were common, while the fourth category, "Biotechnology" (2.93%) was not. Only 3 of the 1,756 courses listed by respondents in Part 2 of the instrument included "bio-related" or "biotechnology" among the courses they listed. Today, biotechnology is perhaps the fastest growing content area in the field.

## General Structure of Technology Education in the U.S.

Technology Education is, for the most part, an "elective" subject in grades 6-12, though in many local school divisions, all or nearly all students are required to take 6, 9, or 18 week middle school Technology Education course. Middle school TE courses typically introduce students to a wide range to technologies, under course titles such as "Introduction to Technology," "Inventions and Innovations," or "Technological Systems." Many of the "general laboratories" popular in the 20th century have been replaced by "modular laboratories." These typically consist of 6-15 modules, each of which provides students working in pairs with an activity representing the different technological systems (e.g., information and communication, transportation, power, energy, manufacturing, construction, medical, agriculture, or biotechnologies).[2]

In all but a few states, Technology Education is an elective subject in the high school. In the few states that "require" TE, the curriculum and or the actual requirement is often compromised because of the critical shortage of TE teachers nationwide. In practice, it would be difficult to find a high school *anywhere* in which *all* students in the school division were truly required to enroll in a Technology Education course as a condition of graduation.

Since the late 1800s, elementary programs have experimented with manual training/IA/TE instructional activities (see, for example, Battle's 1899 doctoral dissertation[23]). Moreover, elementary textbooks have been a commodity since the early 1920s [8, 24, 25, 26, & 27]. Elementary programs have continued to experiment with technology education activities, usually through state or federally funded project work. Historically, those experiments have generally been very highly regarded by those closest to the action: teachers, students, parents, and school administrators. But in the absence of a state requirement, these successes have never been sustained well beyond funding period. The "Technology Education Council for Children," a division of the ITEA has provided leadership for elementary school TE in the US and is the primary force behind *Technology and Children*, an ITEA serial publication that focuses solely on elementary school TE. A small, but dedicated group of teacher educators, state supervisors, and elementary teachers have kept elementary school Technology Education alive through pre-service teacher education courses, in-service workshops with elementary teachers, and funded curriculum projects. Consistent with the trend to incorporate more engineering content and method into Technology Education, the office of Technology Education in the Virginia Department of Education established its annual "Children's Engineering Convention" a decade ago.

## Technology Teacher Education in the U.S.

There are currently about 70 technology teacher education programs in the US, half as many as Householder reported just 15 years ago[28]. Nearly all of these programs operate four-year undergraduate baccalaureate degree programs leading to Technology Education licensure. A relatively small, but increasing percentage of Technology Education teachers are prepared through fifth year, masters/licensure, and alternative licensure models described below. Technology teacher education programs are found in all types of four-year post secondary institutions and are housed in a wide range of administrative units, including colleges, schools, or departments of education, arts and sciences, applied science and technology, technological studies, engineering, and human resources.

Technology teacher education in the US consists of three components: general education, pedagogy/professional education, and technical coursework. The general education component is a core of courses that most colleges/universities require of all students, regardless of the field they choose to pursue. These courses are typically arts and sciences courses in English, mathematics, social science, natural sciences, and the humanities. These general education courses are decided upon by university communities and are taught, for the most part, by faculty in the arts, sciences, and humanities.

The pedagogy/professional education component of the technology teacher education curriculum generally includes courses in educational foundations (e.g., the historical, philosophical, and social foundations of education), educational psychology, curriculum development, and instructional methods.

The third component is comprised of a wide range of technical courses that provide the technical knowledge and skills needed to be an effective Technology Education teacher. Historically, these courses were taught by IA teacher educators, though currently, these courses are more commonly taught by highly technical faculty working in a non-teaching degree program such as "Industrial Technology," or less frequently, Engineering Technology.

**Recent Trends in Technology Education**

**Engineering Content and Method in Technology Education**

Engineering content and method have been a part of technology since the late 18$^{th}$ century. As noted earlier, MIT's President, John Runkle was promoting the "Russian System" instructional method in the 1870s at the same time Calvin Woodward was experimenting with that same method in the St. Louis School of Manual Training. In that era, the technologies, methods, purposes, and philosophies were sufficiently similar to facilitate, in some cases, co-mingling of university programs and departments. As a case in point, the manual training teacher education program at Ohio State University began as a part of the engineering program in the late 19$^{th}$ century, and was housed there until the early 20$^{th}$ century. Technology Education majors at OSU, Virginia Tech and some other universities have been required to take engineering courses during their undergraduate teacher education programs. Currently, Technology Education majors at Colorado State University earn a bachelor of science degree in Engineering Sciences, and supplement that degree with Technology Education courses and student teaching in order to earn TE teaching licensure. In many states, engineering graduates may be licensed to teach TE with surprisingly little coursework beyond their baccalaureate degree in engineering.

That said, the purposes of engineering, a postsecondary vocational program for the preparation of engineers, and TE, a general education program situated primarily in grades 6-12, have situated these fields in very different domains. The cultures of the two disciplines are very different, which has encouraged separation rather than collaboration. While engineering education became increasingly reliant upon mathematics and science in the 20th century, IA educators were focusing on craft and industrial processes. Thus, their "methods of doing" became increasingly divergent.

In the late 1980s, both fields began to pay more attention to technological / engineering design. Since the late 1980s, technology educators have promoted technological design as the "signature pedagogy" in the field, replacing the "project method" that dominated 20th century IA programs. Since the mid-1990s, Engineering has increasingly employed design as a pedagogical tool to generate interest and motivation in first-year students, and to facilitate the application of mathematics, science, and engineering principles taught throughout the engineering curriculum.

If "design is the essence of engineering," as is often claimed, one might logically consider this an area of common ground. There are certainly differences between the design approaches of the two fields, but those differences are more pronounced when comparing technological design of a 12 year old TE student with engineering design of a senior engineering major. The frame of reference with which the senior engineering student approaches a design problem is influenced largely by the sophisticated mathematics, science, and engineering principles that a 12-year old has yet to encounter. The differences are much more subtle when comparing the design approaches of a high-school senior enrolled in a well-designed/well-taught technology education course with the design approach of a first-year engineering student.

Technology educators began thinking about these issues in the late 1980s. In the early 1990s, technology educators began to direct a number of substantive curriculum / instructional materials development projects that sought to integrate mathematics and science with "technological design" problems [29, 30, 31, & 32]. These were, essentially, age- or developmentally-appropriate "engineering" problems for elementary schools [32, 33, & 34]; middle schools [35, 36, 37, 38 & 39]; and high school [39, 40, & 41]. Table 1 identifies these and other instructional materials that were explicitly developed as integrated technology, science, and mathematics instructional materials (employing technological design problems as the core pedagogy) or as engineering materials/curriculum (employing engineering design problems as the core pedagogy). When implemented within a curriculum accessible to all students in the school (as opposed to an extra-curricular competitions, typically accessible to less than 1% of the school body) engineering design instruction almost always occurs in a TE facility, taught by a TE teacher, simply because: 1) there is no such thing as a K-12 teaching license in "engineering education;" 2) science courses accessible to all students are unable to devote sufficient time to the conduct of engineering instructional activities during class time; and 3) TE programs are generally the only programs in public education that have the facilities and the expertise to facilitate engineering design instruction.

**Table 1. Integrated T/S/M and Engineering Curricula & Instructional Modules**

| Name | Developer/Publisher | Level | Notes |
|---|---|---|---|
| *Children Designing and Engineering* | Hutchinson, et al., TCNJ | Elementary | 8 EDAs |
| *City Technology: Stuff that Works* | Benenson, CCNY | Elementary | 5 Textbooks |
| *Engineering by Design: Integrated Concepts & Lessons* | ITEA | Elementary | Miscellaneous |

| | | | |
|---|---|---|---|
| *Engineering is Elementary* | NCTL | Elementary | 9 Units |
| | | | |
| *Design and Discovery* | Intel | Grades 6-9 | 6 Units |
| *Engineering & Design Applications* | LaPorte & Sanders, Glencoe/McGraw-Hill (2007) | MS | 9 EDAs[1] |
| *Engineering by Design: Exploring Technology; Invention & Innovation; Technological Systems* | ITEA | MS | 3 Courses |
| *Exploring, Designing, & Engineering* | TCNJ, Designed World Learning, LLC | MS | 6 Units |
| *Integrated Math, Science, & Technology* | IMaST Project | MS | Course |
| *Project Lead the Way: Gateway to Technology* | PLTW | MS | $80K Lab +Training & Lic. |
| *TechKnow Project* | Peterson, et al., Centre Pointe Learning | MS | 5 EDAs (correlated w/TSA Comps) Texts |
| *Technology, Science, Mathematics Connection Activities* | LaPorte and Sanders, Glencoe/McGraw-Hill (1996) | MS | 6 EDAs[1] |
| | | | |
| *Engineering by Design: Foundations of Technology* through *Engineering Design* | ITEA | HS | 6 Courses |
| *Engineering the Future* | NCTL | HS | Course, 5 EDAs |
| *Infinity Project* | Institute for Engineering Educators / Texas Instruments | HS | Course, 350 EDAs, Text, Tech Kit |
| *Materials Science & Technology Project* | Northwestern University | HS | Chemistry, Physics, Engineering Course |
| *Project Lead the Way: Pathway to Engineering* | PLTW | HS | 8 courses, $120K Lab + Training & Lic. |
| *TechKnow Project* | Peterson, et al., Centre Pointe Learning | HS | 5EDAs (correlated w/TSA Comps) Texts |

The National Academy of Engineering's enthusiastic endorsement of the *Standards for Technological Literacy* (*STL*) validated the notion that engineering content and method are to be found in TE. While President of the NAE, William Wulf offered this in the Foreword he wrote to the *STL*: "The International Technology Education Association has successfully distilled an essential core of technological knowledge and skills we might wish all K-12 students to acquire."

**State Curriculum Efforts**

Many engineers know about the "Massachusetts Curriculum Framework for Science and Technology/Engineering." What's unique about that effort is that it mandates "high stakes testing" of state standards in "technology/engineering" for the first time. But nearly all states prepare "curriculum guides" for their teachers, and engineers might be surprised to learn that most states have been seeking facilitate “age-appropriate engineering content” in TE courses and curriculum materials for two decades.

Virginia is a case in point. In the late 1980s, the Virginia Department of Education (VDOE) introduced three new middle school courses: *Introduction to Technology* (Grade 6), *Inventions and Innovations* (Grade 7), and *Technological Systems* (Grade 8). To facilitate the implementation of these new courses, they promoted the transition from traditional “general labs” to “modular” TE middle school labs across the state. Modular labs, which have been popular TE learning environments across the U.S. since the late 1980s, include a range of “instructional modules” that engineers might consider “age-appropriate engineering instruction.” For example, the popular “Synergistics” modular lab, offers middle school boys and girls the opportunity to engage in hands-on learning, using modules with the following titles: *Alternative Energy, Applied Physics, Bioengineering, Biotechnology, CAD, CNC Lathe, CNC Manufacturing, CNC Mill, Computer Graphics Animation, Digital Design, Digital Transportation, Digital Video, Electricity, Electronics, Energy, Power, & Mechanics, Engineering Bridges, Engineering Towers, Engines, Flight Technology, Graphic Communications, Materials Science, Package Design, Plastics and Polymers, Practical Skills, Research & Design, Robots, Rocket Science, Rocketry and Space, Simple Machines, Video Production,* and *Webmaster.*

Along similar lines, in 1992, the VDOE published two new engineering curriculum guides: *Introduction to Engineering* and *Advanced Engineering.* These courses were labeled “pre-engineering” courses and targeted students in grades 11 and 12, aspiring to pursue postsecondary engineering degrees. College preparatory mathematics and science courses were encouraged as pre-requisites. That year, the VDOE also published three high school curriculum guides under the “Design and Technology” heading: *Technology Assessment*, *Technology Foundations*, *Technology Transfer*. These broadly construed curricula were a radical departure from the past; their goal was to begin to facilitate what the field would later call “technological literacy for all.” Virginia’s current TE course titles seemingly reflect a wide range of content and method engineers might consider “age-appropriate engineering instruction”:

- Pre-Engineering course cluster: *Introduction to Engineering*, *Advanced Engineering*, *Project Lead The Way*
- Technical Design/Geospatial Systems course cluster: *Technical Drawing and Design*, *Engineering Drawing and Design*, *Geospatial Technology*, *Architectural Drawing and Design*
- Applied Physics course cluster: *Principles of Technology I, Principles of Technology II*
- Biotechnology course cluster: *Bio-Engineering*, *Biotechnology Foundations*
- Communication Technology course cluster: *Graphic Communication Systems*, *Communication Systems*, *Digital Visualization*, *Imaging Technology*, *Media and Video Technology*, *Information Technology Fundamentals*
- Computer Control & Automation course cluster: *Computer Control and Automation*, *Electronics Systems I*, *Electronics Systems II*, *Electronics Systems III*

- Production Technology course cluster: *Materials and Processes Technology*, *Production Systems*, *Manufacturing Systems*, *Advanced Manufacturing Systems, Construction Technology*
- Energy & Power Technology course cluster: *Energy and Power*, *Power and Transportation*[42]

As is the case in nearly all states, Virginia also offers TE Teachers an array of professional development experiences that engineers might consider "age-appropriate engineering instruction" in nature. For example, the following professional development experiences were offered in conjunction with the 2004 Virginia Technology Education Association summer conference:

- 1-week Courses: Principles of Technology (an applied physics course); Geospatial Technology; Children's Engineering
- Full Day Workshops: Information Technology; Biotechnology; Digital Visualization
- 3-hour Workshops: 3D Studio Max; Architectural Desktop; Pro Desktop (Pro-Engineer); Information Technology; Digital Video Editing; Web Page Development; Computer Security Issues; Photoshop; TV Studio Production; Engineering Design Challenges; High Performance Manufacturing; Material Science for Technology Educators; Innovative Student Design Challenges; Math Used in Engineering Bridge and Glider Design Briefs; High School TSA Competitions; Middle School TSA Competitions; Solidworks; Introduction to Geospatial Technologies; Introduction to Autodesk Inventor; Creative Methods for Teaching Electronics; Nanotechnology; Flexible Modular TE; Design Portfolio; CAD/CAM Basics-MasterCAM; Rapid Prototyping
- Industry Tours: Philip Morris USA; Dominion Virginia Power; DuPont-Spruance Fibers Division; WVTR Channel 6; Hanover Printing-Richmond Times Dispatch; Virginia Biotechnology Research Park; Allied Concrete Products; Port of Richmond; International Paper-Corrugated Container Division; City of Richmond-Flood Wall; Wyeth Pharmaceutical

In 1997, the VDOE began sponsoring a "Children's Engineering Convention," which annually showcases elementary TE/engineering instructional activities and provides professional development for elementary teachers and administrators. It is part of a statewide effort to introduce TE/engineering activities into elementary school practice.

Virginia is just one example. Nearly all states have been similarly re-inventing their TE curriculum and offering TE teachers similar professional development experiences over the past two decades. This is not to say all middle and high school TE programs are offering "age-appropriate engineering instruction." Unfortunately, change in public K-12 education in the U.S. is a long, slow process, and there are in fact many programs under the TE umbrella that look more like the IA programs of the mid-20th century than like programs facilitating 21st century "technological literacy." The Virginia "case illustration" above is an attempt to counter the notion that TE curriculum and goals have no relationship to engineering. On the contrary, the goal of incorporating more (age-appropriate) engineering content and method has been influencing TE curriculum and instruction rather noticeably over the past two decades.

## National Curriculum Efforts

*Project Lead the Way*, the "pre-engineering" curriculum that is best-known to engineers, was co-founded by Dick Blais, whose TE course caught the attention of the Richard Liebich, the father of one of Blais' TE students [44]. Founded in 1996, PLTW indicates their courses are now offered in 2,300 schools. That's a remarkable growth curve over the past decade, attributable, I think, to their highly effective business practices and partnerships, packaged curriculum, and their two-week training workshop, during which teachers are run through the actual course they will be teaching.

What is less-well known is that an estimated 85% of all who teach the PLTW curriculum are TE teachers. Given the estimated 30,000 TE teachers in the U.S., perhaps as many as 1 TE teacher in 10 is teaching a PLTW course (though corroborative data are very difficult to obtain). If those teaching the PLTW curriculum are effective, it is likely the result of the instruction they received in their TE (baccalaureate) programs coupled with their years of TE teaching experience that *preceded* the two-week summer training they received from PLTW. The point is, those teaching PLTW are TE teachers teaching a PLTW course, not a "PLTW teacher" as is often the perception. While PLTW's university partnerships were initially with engineering programs, over the pasts few years, they have recently partnered with a half-dozen or so Technology Teacher Education (TTE) programs, a number which will certainly increase in the years ahead.

The International Technology Education Association describes *Engineering by Design*[40] as "the only standards-based national model for Grades K-12 that delivers technological literacy." EbD is a project of the ITEA's that offers instructional materials for grades K-12 that, according to the ITEA, were designed to facilitate technological literacy while also leading to STEM pathways. Some of these materials were developed by ITEA's Center to Advance the Teaching of Technology and Science (CATTS), while others were NSF-funded materials development projects that ITEA acquired and distributes under the Understanding by Design brand. In accordance with the CATTS model, state departments of education may pay an annual fee for membership in CATTS, which entitles them to distribute copies of all CATTS materials published during their membership year to all teachers in their state.

## Engineering and TE Collaborations

Two decades ago, the ideals of postsecondary engineering education and those of K-12 TE might have seemed worlds apart. But the changing goals of engineering education resulting from the "attributes" of the engineer identified in ABET Accreditation Criteria A-K[45] and *The Engineer of 2020*, coupled with the efforts across the U.S. to incorporate engineering content and method into TE, and recent K-12 initiatives of the engineering community have brought those paradigms closer together. As the two groups continue to work on K-12 education initiatives, the engineering community's consensus image of "good engineering education" in grades K-10 is not likely to be very different from the TE community's consensus image of "good TE."

Hacker[46] tried to capture this idea by comparing professional competencies required of engineers by ABET with the professional competencies required of TE teachers by the NCATE accreditation standards (Table1). He noted that while there is a focus on technical content preparation for engineers and on pedagogy for teachers, there is a high degree of alignment with respect to the other professional competencies. Both professional groups are well prepared in areas of professional practice, design and problem solving, team functioning, ethical and professional responsibility, communication skills, social and cultural impacts, and professional growth.

The most substantive difference—and it is substantive indeed—is the different preparation in mathematics and science the two groups receive. Engineers are well prepared to solve design problems requiring mathematics, science, and engineering topical knowledge, whereas TE teachers are well prepared to design instructional materials and environments.

**National Center for Engineering and Technology Education**

Established in 2005, the "National Center for Engineering and Technology Education" (NCETE)[47] brought together engineering and technology education faculty in nine universities to work together to "build capacity in technology education and to improve the understanding of the learning and teaching of high school students and teachers as they apply engineering design processes to technological problems." These efforts have facilitated new collaborations between the engineering education and TE communities as they work on issues of mutual concern.

With initial funding for five years, the Center supports 20 doctoral fellows who are engaged in many unique leadership development opportunities, and who assist the Center in the conduct of research to:

- define the current status of engineering design experiences in engineering and technology education in grades 9-12;
- define an NCETE model for professional development by examining the design and delivery of effective professional development with a focus on selected engineering design concepts for high school technology education; and
- identify guidelines for the development, implementation, and evaluation of engineering design in technology education.

The Center is increasing the number of doctoral-level professionals and research capability in the field, preparing future leaders for the profession, and developing a teacher professional development model for technology education that relates to the integration of engineering content and method in grades 9-12.

**2008 CTTE Yearbook: *Engineering and Technology Education***

The 2008 yearbook of the Council on Technology Teacher Education, *Engineering in Technology Education*[48] is further evidence of the trend to incorporate engineering content and method into TE. This book is an important effort, largely from the TE community, to give serious and thoughtful consideration to what it means to integrate engineering content and method into TE, how that process should or might unfold, and where that might lead us. The book is comprised of sections that address: the theoretical background for the dialogue; TE, engineering, and the curriculum; key connections, alliances, and resources, and future perspectives, challenges, and opportunities.

William Wulf's "Introduction" to the book begins "The theme of this book seems *just right to me*—there needs to be a dialog between engineering educators and technology educators! They share two profound responsibilities and have much to learn from each other."

**Discussion**

Engineering and TE have co-existed in the U.S. since the 1870s. While these two programs have found themselves, on occasion, administered within the same college or school, collaborations for the purposes of improving technological literacy in grades K-12 have been extremely rare. Engineers worked in universities, and technology teachers toiled, mostly, in the trenches of public secondary education. The emergence of the new K-12 Engineering Division of the ASEE signals an unprecedented opportunity for Engineering and TE to begin meaningful and productive collaborations in K-12 education.

The purpose of this paper is to offer a few insights into the history, culture, and contemporary activities and ambitions shared by Technology Education. It's important that engineers understand the historical commitment to "general education philosophy" underlying TE, because that's a different philosophy than that held by most engineering educators to this point in time. It's important to understand that the TE profession has continuously strived to evolve its curriculum to "reflect technology" and to facilitate "technological literacy" for more than half a century. It's important to understand that the integration of more mathematics, science, and engineering content and method have been important goals of TE for two decades. It's important to be aware that some of the most remarkable education in K-12 schools occurs in TE. That said, it is also the case that there are many "TE" teachers who are not living up to he ideals of the profession. Nevertheless, examination of the ideals of the TE profession should convince many engineers that those ideals are consistent with the ideals they might envision for K-12 teaching and learning.

There has been a tendency for both parties to focus on their differences. In working, for the first time, in the common venue of K-12 education, we will increasingly become aware of our similarities. The work of K-12 education may have looked deceptively simple to the engineering community. However, some engineering educators are discovering the challenges associated with research involving human subjects… especially when those human subjects are situated in public schools. Other engineering educators are beginning to better understand why change is a slow and difficult process in education, as they design, deliver, and evaluate professional development for K-12 educators. Still others are getting first-hand information of the challenges that teachers face on a daily basis. And, some engineering educators—particularly those working with PLTW—have even begun to experience the challenges of teacher education. This, I believe, is the arena where engineering education will have its greatest impact in the years ahead. There at least two factors that lead me to this conclusion. The first is the supply and demand of Technology Teachers. At a time when America is clamoring for "technological literacy for all," there remains a critical shortage of TE teachers, for decades. Specifically, By my estimation, there are currently about 3 times as many secondary level TE teaching positions opening up each year as there are licensed TE teachers to fill those openings. This is largely due to he fact there half as many technology teacher education (TTE) programs now as there were 15 years ago. Householder (1993) reported 139 TTE programs in 1992, and I count about 70 today. The solution to the TE teacher shortage areas is not likely to come solely from the TE community… particularly if the call for "technological literacy for all" increases demand for TE courses, as is likely in the decade ahead.

The other reason I believe engineering education will turn its attention to teacher education is because of the student recruitment and retention problem engineering faces. There is ample research that indicates many students leave engineering programs because they don't perceive engineering to be a "socially responsible," people-oriented profession. K-12 education is very high up on the "social responsibility scale! What other professions allow engineers to combine their technical knowledge and fascination with the design process with the satisfaction of changing young people's lives for the better. The truth is, the majority of Technology teacher education majors in universities that have engineering programs have historically transferred into the TTE program from the college of engineering. Engineering stands to retain a lot of very capable engineering students be getting into K-12 teacher education business… and at the same time benefit their engineering profession immensely in the long run, since it takes 10 years to move from novice to expert[49].

As engineering educators continue to move their work into the K-12 arena, engineering education and TE both stand to benefit from new collaborative efforts, as do students, schools, and society.

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