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FIVE GOOD REASONS FOR ENGINEERING DESIGN AS THE FOCUS FOR TECHNOLOGY EDUCATION

Robert C. Wicklein, DTE

In this paper, the author will seek to identify and explain the primary rationale for having the field of technology education direct its focus on engineering design. The basis of this proposal stems from a combination of observations made over a 25-year career as a teacher/teacher educator of industrial arts/technology education and a broad-based review of the critical literature in the field. It is hoped that educators within technology education will appreciate the value of this rationale and begin to reorganize their curricula to focus on engineering design.

In my 25+ years as an educator in this field, I have rarely discussed my profession with individuals who have an accurate understanding of our educational purpose.

I consider the publication of the Jackson's Mill Industrial Arts Curriculum Theory document (Snyder and Hales, 1981) as the starting point of the modern era of technology education. Of course there were other significant contributions that helped to set the stage for this document. William E. Warner's *A Curriculum to Reflect Technology* (1947), Delmar Olson's *Technology and Industrial Arts: A Derivation of Subject Matter from Technology with Implications for Industrial Arts Programs* (1957), Paul DeVore's *Technology: An Intellectual Discipline* (1964) and the development and implementation of the *Industrial Arts Curriculum Project* (IACP), the *American Industry Project*, and the *Maryland Plan* (1960s and 1970s) all created a progressive stimulus that paved the way for the field of technology education. However, it was the Jackson's Mill document that provided the needed systemic refocus of the curriculum formerly known as industrial arts. The 20+ contributors to Jackson's Mill redefined industrial arts as "comprehensive educational programs concerned with technology, its evolution, utilization, and significance; with industry, its organization, personnel, systems, techniques, resources, and products; and their societal impact." (Snyder and Hales, 1981, pp. 1-2).

Many other important events and milestones followed the Jackson's Mill document; in March of 1985, the American Industrial Arts Association changed to the International Technology Education Association. During the summer of 1987, Michael Neden and Max Lunquist, middle school teachers in Pittsburg, Kansas, redesigned and reconfigured their teaching laboratory to reflect modular learning experiences in technology education. Their model classroom started a nationwide redesign in both physical characteristics of the technology education laboratory and the curricular format in the delivery of technology content. Ernest Savage and Leonard Sterry (1990) directed and edited the development of *A Conceptual Framework for Technology Education,* which helped to clarify and extrapolate the applications of the technological methods identified in the Jackson's Mill document.

In more recent times (1995-2005), research and publications resulting from the Technology for All Americans Project has yielded seminal work in the documents *A Rationale and Structure for the Study of Technology* (1996), *Standards for Technological Literacy: Content for the Study of Technology* (2000/2002), and *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (2003). Each of these documents has helped to define and direct the efforts of educators and students as they engage in the study of technology leading to the goal of technological literacy.

In each of these significant efforts, technology education has moved forward and grown as a profession and field of study that reflects a clearer and more defined goal. But herein lies a critical problem; with all the efforts, documentation, and developmental work supporting the national need for a technologically literate citizenry, it seems that there has been little practical and comprehensive advancement of technology education in most public schools. By and large, technology education is still viewed as a non-essential instructional program. Why is this? There are numerous causes for this problem, but here are three probable reasons for this condition:

- Inadequate understanding by school administrators and counselors concerning technology education.

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- Inadequate understanding by the general populace concerning technology education.
- Lack of consensus of curriculum content for technology education.

These three rationales were identified and ranked highly (#2, #3, #4) by technology educators in recent research on the critical issues and problems facing the field of technology education (Wicklein, 2005). Each of these identified problems speaks directly to the issue of focus and direction for technology education. Why is there an inadequate understanding of the technology education curriculum by some of the primary decision makers in schools? Why do students and parents lack an understanding of technology education? Why is there disagreement among technology educators about the focus of the technology education curriculum? I would propose that these conditions exist throughout the United States because we have not adequately identified and demonstrated our mission in ways that can be clearly captured and understood.

Why is there an inadequate understanding of the technology education curriculum by some of the primary decision makers in schools? Why do students and parents lack an understanding of technology education? Why is there disagreement among technology educators about the focus of the technology education curriculum? I would propose that these conditions exist throughout the United States because we have not adequately identified and demonstrated our mission in ways that can be clearly captured and understood.

The goal of effecting positive change in technological literacy is both admirable and worthy of the efforts of all people, especially the professional technology educator community. Technological literacy can be argued to be equal to reading, writing, mathematics, science, and historical literacy goals. The pervasiveness of technology literally affects every living creature in our society. Therefore, it is of critical importance that the educational system includes and supports the study of technology in the general curricula. This need is clear and obvious—or is it? On one hand it seems logical that technological literacy topics should be addressed and taught in our schools, but on the other hand this topic seems nebulous and vague for many people, especially those who are not "technologically literate." The efforts by school administrators to address this situation often yield ill-defined and inappropriate approaches to the study of technology, or more commonly, lack overall support of technology education instructional programs.

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The rich products of technology education often go unnoticed or unfulfilled in many school systems around the country. Why is this? I believe that at least one explanation for this lack of understanding is the deficiency within the technology education profession to formulate a clear and defined target for the curriculum that has both an understood goal (general populace can recognize a perceived purpose) and value (general populace perceives positive worth). The goals of technological literacy do not provide the level of importance that is required by most people to cognitively connect on a long-term basis to technology education, and they lack the specificity for the general populace to understand what technology education contributes regarding career purposes. Therefore, the perceived values of technology education programs are less than what they could be if they were able to capture and sustain the interest of students, parents, and school decision makers.

The question then arises, what could technology educators do to simultaneously meet the standards for technological literacy while at the same time providing a technology education curriculum that informs and motivates students, parents, and school decision makers with a clear and viable education program? I would propose that by organizing the technology education high school curriculum around the study of engineering design, we will be able to accomplish our goal of technological literacy and at the same time create a well-defined and respected framework of study that is understood and appreciated by all. The benefits of having engineering design as the academic focus for high school technology education are as follows:

- Engineering design is more understood and valued than technology education by the general populace.
- Engineering design elevates the field of technology education to higher academic and technological levels.
- Engineering design provides a solid framework to design and organize curriculum.
- Engineering design provides an ideal platform for integrating mathematics, science, and technology.
- Engineering provides a focused curriculum that can lead to multiple career pathways for students.

Engineering Design is More Understood and Valued Than Technology Education by the General Populace

"Inadequate understanding by the general populace concerning technology education," (Wicklein, 2005, p. 7) was identified as the #3 critical problem facing the field. This statement referred to the notion that, by and large, people simply do not know, nor do they understand what technology education's goals and purposes are. Discussions of technological literacy add little to help resolve the confusion about who we are and what we do in the educational arena. Many people assume incorrectly that technology education and technological literacy focuses strictly on computer skills. Therefore, we are constantly trying to educate parents, students, colleagues, and administrative staff about the role and goals of technology education. In my 25+ years as an educator in this field, I have rarely discussed my profession with individuals who have an accurate understanding of our educational purpose. This confusion about the overall purpose of technology education lends to a general malaise and lack of support, resulting in parents and students not taking the technology education programs seriously. Technology education is still viewed by many students as simply a "filler" course that has little value in their overall academic preparation.

The term engineering or engineering design, although not completely understood by the general populace, carries a clearer and more defined purpose and goal. Most people have at least heard of engineering as a career, and many people are aware of engineering designs that have been used in creating products. Of equal importance, engineering is viewed by most people as a valued career path; therefore, parents and students may be more inclined to participate in an instructional program that seeks to have a focus on this area of study. Engineering design can provide greater clarity and importance for the general populace as they examine technology education instruction in schools.

Engineering Design Elevates the Field of Technology Education to Higher Academic and Technological Levels

"Inadequate understanding by school administrators and counselors concerning technology education," (Wicklein, 2005, p. 7) was identified as the #2 critical problem facing the field. In addition to the general populace's difficulty in understanding the roles and goals of technology education, significant decision makers inside of the schools lack knowledge about technology education. School administrators and guidance counselors suffer from the same confusion over who we are and what we do in the educational arena. The results of this confusion ultimately lead to inaccurate assumptions and a general lack of support overall. This is evidenced by many school principals' efforts to recast technology education programs into computer networking training centers (a growing trend in Georgia). School counselors who are integral in registering students for various classes in the high school, often view technology education classes as options for the non-college-bound students, thus eliminating the possibility for many other students to take these classes. The biased views that these decision makers have of the field of technology education continue to stifle potential growth and reduce our value.

By focusing the high school technology education curriculum on engineering and engineering design, school decision makers will be able to comprehend and value the purpose of these instructional programs. An engineering design focus for technology education will elevate the overall significance of this program in the school while simultaneously providing decision makers with a better understanding of the rationale and goals for this field of study. School administrators will be able to connect the academic focal point of engineering design with the technological applications often found in technology education classes. This connection can serve to both inform and motivate in-school personnel to view the contributions of technology education in a better light and allow it to develop to its fullest potential within the whole school curriculum.

Engineering Design Provides a Solid Framework to Design and Organize Curriculum

"Lack of consensus of curriculum content for technology education," (Wicklein, 2005, p. 8) was identified as the #4 critical problem facing the field. After 20+ years of experimenting, planning, and implementing curriculum designs for technology education, educators within the field are still struggling with identifying a clear and unique curriculum focus. General agreement has been reached in identifying technological literacy as the guiding principle for the study of technology; however, a principle by definition is an accepted rule of action, not a curriculum (International Technology Education Association, 2000/2002). Technology educators continue to seek a consensus of curriculum content that can steer their classes and programs along an appropriate path that supports and meets *Standards for Technological Literacy* (International Technology Education Association, 2000/2002) while at the same time creates an instructional model that attracts and motivates students from all academic levels.

Engineering or engineering design provides a platform to accomplish each of these goals. The instructional components needed for a high school technology education curriculum centered on engineering would include a series of focused courses and instructional activities that lead a student through the engineering-design process. Through systematic planning and coordination with administrative staff and academic faculty, technology educators could create a well-defined curriculum that provides a sound

academic grounding in engineering design while addressing *Standards for Technological Literacy* as well as local and state requirements. Curriculum planning done in this way will help to provide the needed consensus for the technology education profession as well as presenting an attractive option for many students. School administrators and counselors will have another strong academic option available for students.

Several high schools have already begun planning their curriculum around an engineering-design focus. Table 1 illustrates how a hypothetical high school curriculum plan could sequence its technology education program, leading to capstone experiences in engineering-design applications. Other instructional plans could address engineering design in different formats.

Table 1
Engineering-Focused Curriculum for High School

Technology Education	Mathematics	Science	Foreign Language
Engineering Concepts	Algebra I	Biology	Foreign Language I
Engineering Graphics (CAD)	Algebra II	Chemistry	Foreign Language II
Research & Design	Geometry or Trigonometry	Physics	
Engineering Applications	Trigonometry or Calculus		

Engineering Design Provides an Ideal Platform for Integrating Mathematics, Science, and Technology

Integrating or connecting subject matter from various school disciplines has been a rallying cry by many national, state, and local agencies. The U.S. Department of Education and the National Science Foundation have called for and funded multiple grants that integrate math, science, and technology. The *Technology Education Demonstration Projects* funded by the U.S. Department of Education (Wicklein, 1990) sought to build model integration sites where high school programs amalgamate components of their math, science, and technology education classes to enrich and strengthen student knowledge and application in each of these areas. The National Science Foundation (NSF) continuously calls for STEM integration in its education and integration grants. STEM refers to: S-Science, T-Technology, E-Engineering, and M-Mathematics. The NSF is serious in working to build these relations to improve our national academic preparation and to strengthen our nation.

An integral part of the engineering process is the connection and application of mathematics, science, and technology. To demonstrate this association, one needs to look no further than the process of engineering design. Engineering design requires the linkage of (1) narrative discussion/description, (2) graphical explanations, (3) analytical calculations, and (4) physical creation. In each of these design processes the connection of math, science, and technology is present.

Focusing a high school technology education curriculum around engineering or engineering design will require greater efforts to integrate with mathematics and science. Technology teachers will be required to have a much deeper grasp of mathematics and science principles, and they will need to work with mathematics and science teachers within their schools to make sure that the engineering assignments are appropriate in level and evaluation. Again, the results of an engineering design-focused curriculum will strengthen the technology education program as well as provide a much improved overall school curriculum. Students, parents, teachers, and school administrators will all benefit from this type of collaborative arrangement.

Engineering Provides a Focused Curriculum That Can Lead to Multiple Career Pathways for Students

A paradox has existed within many technology education programs for a number of years: general education vs. career/vocational education philosophy of curriculum. Traditionally, we have declared that our field should be considered a general education program designed for participation of all students. However, in most realities, technology education has been housed and financially supported through vocational or career and technical (CTE) departments. This paradox has required many technology educators to shun or avoid professional connection with CTE associations while at the same time seeking financial support from the same agencies. This inconsistency has not been healthy for the technology education profession and has diluted our efforts to advance the cause of the field.

By centering a technology education curriculum on engineering or engineering design, a compromise is encouraged. A high school curriculum with an engineering-design focus would allow for both a general education and a career and technical education application. At the lower end of the

curriculum (see Table 1: Engineering Concepts, Engineering Graphics) the program would be inclusive and open for all students at any academic level (general education) and at the top end of the curriculum (see Table 1: Research & Design, Engineering Applications) the program would be more exclusive and open to students who have achieved appropriate academic prerequisites in technology, mathematics, and science courses (career and technical education). The result of this approach to curriculum planning would provide a balanced curriculum for all students, whatever their career path may be, as well as a highly refined curriculum for those interested in pursuing college majors in engineering, science, and/or architecture.

There is a need to prepare students to enter the engineering majors in college. Currently, engineering education has close to a 50% attrition rate for students. College students leave engineering majors for a variety of reasons, resulting in inadequate numbers of engineers entering the workforce and causing the U.S. to import vast numbers of non-citizens to meet the engineering demands. Georgia currently seeks 50% of the engineering workforce from out-of-state sources. With national security issues of paramount concern, the need to generate U.S. citizens to fill the engineering ranks has become more important. By establishing an engineering-design-focused curriculum at the high school level, the technology education field can provide both general technological literacy education and help to build the nation's engineering labor force, noble efforts on both fronts.

Summary

This paper seeks to establish a rationale for creating an engineering-design-focused curriculum for technology education. Explanation was provided to establish a need and to provide an explanation of why an engineering-design-focused curriculum would be an appropriate program development model. The ramifications of the proposed curriculum focus will have a significant impact on technology teacher education. University programs that prepare technology teachers will be required to change their programs to address the needs associated with engineering design. A primary need that must be addressed in technology teacher education programs will be the elevated mathematics and science requirements necessary to teach subjects such as engineering design and engineering applications. Most technology teachers will not be prepared to tackle the mathematics associated with the analytical components of engineering design. Serious reviews and changes of existing teacher education curriculum must be conducted if an engineering focus is to be attained and implemented at the high school level.

The benefits of an engineering-design-focused curriculum for technology education are huge. If done correctly, technology education will be viewed and understood in an entirely different light. Students and parents will see a curriculum that is organized and systematic, leading to valued career options. School administrators and counselors will have a curriculum that provides multiple options for students, both college-bound and non-college-bound. Engineering educators will receive a more prepared student who understands engineering design processes from the beginning of his/her college experience. Business and industry will have more U.S. citizens entering the engineering workforce. This is a viable future for technology education; are we willing to take the challenge?

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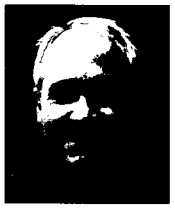

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This paper is intended to expand and explain the relevance of focusing on engineering design within the technology education field of study. Points of view of this document do not, therefore, necessarily support or advocate any particular product or curriculum design.