Chapter 1 — Technology and Engineering Education

MISSOURI DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION
DIVISION OF CAREER EDUCATION

Chapter 1
Technology and Engineering Education

1 ─ Introduction

Technology has been going on since humans first formed a blade from a piece of flint, harnessed fire, or dragged a sharp stick across the ground to create a furrow for planting seeds, but today it exists to a degree unprecedented in history. Planes, trains, and automobiles carry people and cargo from place to place at high speeds. Telephones, televisions, and computer networks help people communicate with others across the street or around the world. Medical technologies, from Magnetic Resonance Imaging (MRI) to vaccines, help people to live longer, healthier lives. Furthermore, technology is evolving at an extraordinary rate, with new technologies being created and existing technologies being improved and extended.

Humans have been called the animals that make things (as well as design things), and at no time in history has that been as apparent as the present. The U.S. Patent Office reports that since its beginning in 1792, about 70% of all U.S. patents ever issued have been since 1935. More than a third of all patents have been issued in the past twenty years.

Today every human activity is dependent upon various tools, machines, and systems, from growing food and providing shelter to communication, healthcare, and entertainment. Some machines, like the tractor, speed up and make more efficient activities that humans have done for hundreds or thousands of years. Others, such as the airplane or the Internet, make possible things that humans have never been able to do before. This collection of devices, capabilities, and the knowledge that accompanies them is called technology (Dyrenfurth & Kozak, 1991).

We are a nation increasingly dependent on technology. Yet, in spite of this dependence, U.S. society is largely ignorant of the history and fundamental nature of the technology that sustains it. The result is a public that is disengaged from the decisions that are helping shape its technological future. In a country founded on democratic principles, this is a dangerous situation. In an August 2003 National Science Foundation funded report from the National Science Board (NSF), it is clearly stated:

Science and technology have been and will continue to be engines of US economic growth and national security. Excellence in discovery and innovation in science and engineering derive from an ample and well-educated workforce – skilled practitioners with two- and four-year degrees and beyond, researchers and educators with advanced degrees, and pre-college teachers of mathematics and science [and technology] (NSF, 2003, p. 1).

The U.S. Commission on National Security/21st Century (2001) also spelled out clearly the importance of technology:

The scale and nature of the ongoing revolution in science and technology, and what this implies for the quality of human capital in the 21st century, pose critical national security challenges for the United States. Second only to a weapon of mass destruction detonating in an American city, we can think of nothing more dangerous than a failure to manage properly science, technology, and education for the common good over the next quarter century (NSF, 2003, p. 1).

With the growing importance of technology to our society, it is vital that students receive an education that emphasizes technological literacy. (ITEA, 2000) This document, together with the national Standards for Technological Literacy: Content for the Study of Technology, present a vision of what students should know and be able to do in order to be technologically literate, and what school programs isolated from other academic and career subjects. The delivery of Technology and Engineering must share in this responsibility and be a contributing member of the school instructional team to enhance core academic knowledge and skills, especially mathematics and science.

2 — Definitions and Terms

Design: Technological Design, according to the Standards for Technological Literacy, Content for the Study of Technology (STL), is a distinctive process which has a number of defining characteristics. Design is a process which has a defined purpose with identifiable requirements (constraints) and follows a systematic approach allowing for iteration. The design process encourages human creativity utilizing intuition, feelings, and impressions leading to the designer's "best possible solution."

Engineering: Engineering is the art of applying scientific and mathematical principles, experience, judgment, and common sense to make things that benefit people. Engineering is the process of producing a technical product or system to meet a specific need. In other words, engineering is a process used for solving problems relevant to our lives.

Engineering Technology: Engineering technology is the profession in which knowledge of mathematics and natural sciences are used to create and enhance technologies that benefit humanity. Engineering technologists and technicians deal with application, manufacturing, implementation, engineering operation, sales, and production as opposed to the conceptual design and research functions performed by many engineers.

Missouri Career Paths: These clusters of occupations that require different levels of education and training. People working in a career path share interests, abilities, and talents. Career Paths help students identify a career focus without being locked into a specific occupation. With career paths, students are able to begin preparing for a career, but still have the flexibility needed in today's constantly shifting work world. Missouri has identified six Career Paths that are broad in nature. The Career Paths that Technology and Engineering pays close attention to are shown in bold font. The States' Career Clusters that match with the Missouri Career Paths follow each cluster (see Table 1).

Table 1
States' Career Clusters & Missouri Career Paths Comparison

Missouri Career Paths	States' Career Clusters
Arts and Communication	Arts, A/V Technology & Communications; Architecture and Construction
Business, Management & Technology	Science, Technology, Engineering & Mathematics
Industrial & Engineering Technology	Science, Technology, Engineering & Mathematics; Transportation, Distribution & Logistics; Manufacturing; and Architecture & Construction
Natural Resources/Agriculture	Agriculture, Food & Natural Resources
Health Services	Health Science
Human Services	Human Services

Professional Teacher/Educator: In the broadest sense, a professional educator is a teacher that never stops learning nor wants to stop learning. The professional educator continues to look for ways to improve instruction, knowledge, and collegiality with other professional educators. Professional growth begins the first day of their career and never ends (The Master Teacher, vol. 25, no. 34). Ultimately, this process of growth has only one goal, to serve the needs of their students today, tomorrow, and in the future. To the professional educator, successfully serving students requires a clear understanding of their needs. When a student walks into a technology teacher's classroom/lab, the student does not leave their academic or emotional needs outside. They step into the lab as a whole person with all of their emotional and academic needs attached. The professional educator has a clear understanding of not only the content of their course or program but that of other academic programs in the school building and the school district. Professional educators will be familiar with the entire K-12 curriculum, which better positions them to plan for their own programs and meet the needs of the whole student. Educators will be prepared to address core content as well as their own content found in their technology program. In addition, collegially, "…when teachers begin to show a professional interest in and awareness of what colleagues are doing in their classrooms and schools, new staff relationships emerge." (The Master Teacher, vol. 21, no. 22) These new relationships will only help increase the capabilities of the professional educator who in turn helps students achieve academically.

States' Career Clusters: "A Career Cluster is a grouping of occupations and broad industries based on commonalities. Career clusters provide an organizing tool for schools, small learning communities, academies and magnet schools. Career clusters identify Pathways from secondary school to two- and four-year colleges, graduate school, and the workplace, so students can learn in school and what they can do in the future. This connection to future goals motivates students to work harder and enroll in more rigorous courses. Career clusters provide students with relevant contexts for learning" (National Association of State Directors of Career Technical Education Consortium, 2002). States' Career Clusters, as identified by the National Association of State Directors of Career Technical Education Consortium (http://www.careerclusters.org), are organized into sixteen groups. The career clusters Technology and Engineering is most concerned with are shown in bold type (see Table 2).

Table 2
States' 16 Career Clusters

Agriculture, Food, & Natural Resources	Health Science
Architecture & Construction	Human Services
Arts, A/V Technology & Communications	Information Technology
Business, Management & Administration	Law, Public Safety & Security
Education & Training	Manufacturing
Finance	Marketing, Sales & Service
Government & Public Administration	Science, Technology, Engineering & Mathematics
Hospitality & Tourism	Transportation, Distribution & Logistic

Technology: Broadly speaking, technology is how people modify the natural world to suit their own purposes. From the Greek word technē, meaning art or artifice or craft, technology literally means the act of making or crafting, but more generally it refers to the diverse collection of processes and knowledge that people use to extend human abilities and to satisfy human needs and wants through a process of design (ITEA, 2000, p. 2).

Technology and Engineering (TE): The school subject that teaches about the processes used to design, create, and maintain the human-made world through the integration of technical, mathematical, and scientific knowledge and skills. (Technological studies, design and innovation and pre-engineering are other terms used to describe this subject area).

Technological Literacy: The ability to use, manage, assess, and understand technology. A technologically literate person understands (in increasingly sophisticated ways that evolve over time) what technology is, how it is created, and how it shapes society, and in turn is shaped by society. He or she would be able to hear a story about technology on television or read it in the newspaper and evaluate the information in the story intelligently, put that information in context, and form an opinion based on that information. A technologically literate person would be comfortable with and objective about technology neither scared of it nor infatuated with it (ITEA, 2000, p. 9).

Technology is the modification of the natural environment in order to satisfy perceived human needs and wants (ITEA, 2000, p. 9). A great benefit when learning about technology is the opportunity one has to do technology (ITEA, 2000, p. 2). A very strong implication in this definition of technology is that technology must involve design. The process of design is central to the practice of engineering and a key element in Technology and Engineering. If one is good at design, it follows that one will have a tacit knowledge of materials, artifacts, and systems as they relate to each another (Technically Speaking, p.58). In learning to do design, students will master a set of abilities that will serve them well throughout their lives (ITEA, 2000, p. 2). However, design is often defined or viewed in various ways. It often means different things to different people. Therefore it is important to establish a common definition for design as it is addressed in this document. This will allow common ground and common understanding for the importance of design in education and more importantly, Technology and Engineering.

3 ─ Philosophy of Technology and Engineering

Our world will be very different 10 or 20 years from now. We have no choice about that. We do, however, have a choice whether we march into that world with our eyes open, deciding for ourselves how we want it to be, or whether we let it push us along, ignorant and helpless to understand where we're going or why. A technological literate society will make the difference (ITEA, 2000, p. 10). The achievement of a technologically literate society is a societal goal that is supported by K-12 Technology and Engineering programs.

Missouri's Technology and Engineering profession affirms that its programs should teach about technology and use technology in a way that serves as a vehicle to build understanding, skills, and attitudes that can be applied to society in general, i.e., technological literacy, regardless of students' career aspirations. Furthermore because all people are affected by technology, and technology has an increasing presence in our lives, students from kindergarten to twelfth grade should be involved with learning about and learning to use technology. Learning should extend not only to enhancing human capability but to using technology to design the build environment (sometimes referred to as engineering design). It is therefore recommended that a K-12 technology literacy program be in place in the state of Missouri to insure high school graduates are technologically literate.

Technology and Impacts on Daily Life as a Force Has Affected Most Aspects of Our Lives Business and industry have been required to grapple with technology engendered issues such as design/engineering, productivity, technological capability and global competitiveness. Workers have been challenged to retrain and develop currently marketable skills—in cognitive, affective and psychomotor domains—in order to maintain their ability to support themselves and contribute to our free-enterprise economy. And with technology's advances, Americans find these skills to be constantly changing.

Legislators have also been pressed to understand technology and its effects as they work to frame policies for the public good. With the rampant escalation of both the amount and complexity of technology, it is increasingly difficult for people to exercise appropriate citizenship functions, particularly given the curtain of confusion raised by technology and its media offspring.

Consequently, citizens have often found themselves bewildered by increasingly complex consumer decisions. Frequently they face decisions involving trade-offs between immediate gains and negative consequences, e.g. the effects of toxic wastes. Similarly, recreational environments and activities have increasing technological components, as do personal and societal learning activities.

Technology's pervasive influence has permeated even our homes. Our lifestyle is timed, microwaved, accelerated, recorded, computerized and confounded. A greater proportion of people are working, families are resorting to schedules to program their contact, and others are unemployed due to technological advances. Outside knowledge is pouring into the home via cable television and other media. Not infrequently the tensions from external aspects of life, many of which are technologically induced, do come home in the form of stress.

Even in social service arenas such as the health sciences, technological capabilities have caused us to ponder when enough is enough. We ask, for example, to what end do we operate life support systems in situations currently deemed hopeless?

Technology and Social Context

Contemporary and future society is clearly different from what America experienced during its first industrial revolution. To be sure, some elements of the industrial revolution remain, but many more have changed. Technology as a force has affected most aspects of our life, and thus technology seems to be the single most distinctive characteristic that sets today and the future apart from our past.

Evidence of this is seen in the literature. For example, there are frequent references to the post-industrial society, from the demise/reduction of smoke stack industries and to the information society. Furthermore, we have seen tangible evidence of such shifts in our automotive, steel, petroleum and electronics industries.

Technology and Industry

But what is technology? Simply stated, it is human kind's use of tools, machines, materials, processes, energy, and knowledge (mathematical, scientific and technical) to satisfy its wants and needs. As such, it is not the search for an explanation of why things work - that is science.

Technology is knowing "how" to design, construct or build something with tools, machines, material processes and energy - and then it necessarily involves being able to do. Knowledge alone is not sufficient. Rather, technology is a combination of knowledge, skills and attitude that is always more powerful than any single component. It takes all of the preceding. Leave off one and the process is incomplete. Operating a machine is not technology in of itself.

Industry is one of human kind's basic institutions. As such, it parallels that of government, religion, and education. It is that institution that supplies our civilization with goods and services to fill our wants and needs. It does so by using technology. The technology used by industry is typically referred to as industrial technology.

Implications for Education

Given the pervasive nature of technology, the Technology and Engineering profession raises the question: "Where do people develop the understanding, skills and attitudes to deal with forces such as technology?" Clearly our society uses formal schooling as a principal method to this end—at least for youth, and in increasing numbers, for adults. It follows then that one must ask, "What are the schools doing to help youth and adults address technology's challenges?" What systematic efforts are in place to develop technologically appropriate understanding, skills, and attitudes in elementary, secondary, post-secondary, adult and continuing education?

A technological program with a well developed standards-based scope and sequence is certainly the place to begin. Technology teachers have a bright future in the state of Missouri.

Technology and Engineering's Relationship to Career and General Education

Given these contexts, it is clear that Technology and Engineering (TE) must be an essential component of both general education, and career education (formally referred to as vocational education). Only in this way can Technology and Engineering serve as:

- the component of general education that develops generalizable understandings, capabilities, values and attitudes related to technology in all youth.
- a reinforcement of core academic knowledge and skills through practical application in technology related activities.
- a component of specialized education that contributes to meaningful occupational choice and/or preparation in a technological society.

Because of these dimensions and TE's approach, it has an essential role in helping build the base that leads to successful transition plans such as Tech-Prep and/or 2+2 or 2+2+2 programs. Professional leaders need to be alert to opportunities that further the program's contributions to Missouri's youth as enabled by the Carl D. Perkins Vocational and Applied Technology Education Act.

4 — Content of Technology and Engineering

Just as technology spans across all aspects of human activity, Technology and Engineering draws its content from the entire range of technological endeavors, not just industry. Content is also selected by identifying the competencies individuals need to effectively use the products of a technological society.

Given the preceding philosophy and foundation, it is clear that the educational program known as Technology and Engineering derives its content, i.e. the subject matter it teaches, from technology, and not just industry. Technology and Engineering is therefore considered to be a body of knowledge or a discipline.

Industrial technology is a *subset* of technology and many of its aspects can be generalized to technology. To clarify:

- Technology consists of all human productive endeavors including agriculture, bio- and medical technologies and engineering technologies.
- Industrial technology is the technology that is used by industry. As such, industrial technology coexists with agricultural and other technologies.
- Industrial technology consists of three technology system clusters: Materials & Processing, Energy & Power, and Communication.
- Industrial Technology and Engineering focuses on learning the technologies of industry.
- Technology and Engineering education focuses on all of the technologies used by human kind.

5 — Mission and Goals of Technology and Engineering

Since industry and technology are distinctive characteristics of American culture, and since one of the key purposes of education is to transmit the culture to future generations, it follows that it is necessary for the schools to provide youth with an insight into, an understanding of, and selected capabilities with the technological nature of this society. Industry and technology spring from the human ability to reason, solve problems, create/design/engineer, construct, and use materials, tools, machines and processes imaginatively. Because these abilities are an integral part of our technological culture they should be developed in all students—regardless of their gender, background, educational goals or occupational aspirations.

The overarching mission of Technology and Engineering as a school program is to develop the human potential of all students for responsible work, citizenship and leisure roles in a technological society.

To accomplish this, programs must address each of its four primary missions, namely to:

- Develop each person's ability to comprehend and apply the concepts of technological systems through the design/engineering process which includes the integration and application of mathematical and scientific knowledge.
- Develop each person's values and attitudes related to the appropriate use of technology—its tools, machines, materials, processes, and products.
- Develop each person's ability to use materials, technological processes and hardware to achieve constructive work skills and enhance occupational opportunity.
- Develop an awareness of career options and the required technical and academic education for technologically related career clusters and career paths.

Technology and Engineering addresses these four primary missions by purposefully working toward an important set of goals. Simply put, this means that every student participating in any Technology and Engineering program should experience a systematically designed program of instruction and activity that accomplishes each of the 14 goals presented in Figure 1-1.

Technology and Engineering also operates within the context established by the *Standards for Technological Literacy*: Content for the Study of Technology (STL) and the *Missouri Show-Me Standards*. Technology and Engineering is particularly capable of addressing the Show-Me Process Standards. By articulating carefully to such goals, Technology and Engineering instructors can enhance the perceived value of their programs and they can increase the program's contribution to youth.

Figure 1-1
Missouri Technology and Engineering Program Goals

Every Student participating in technology and engineering education will experience a systematically designed and delivered program of instruction and activity that addresses two broad goals:

- Understand and experience technology's creation, application, and control.
- Understand and develop ways of thinking about technology that consistently respect the environment, promote human well-being, and benefit society.

Consistent with these two goals, technology and engineering education programs in Missouri enable students to:

1. Understand why and how people design, engineer, and innovate to meet human needs and wants.
2. Apply ways of thinking and doing essential to designing and problem solving, developing, making, managing, and assessing technological systems in various contexts.
3. Safely use, manage, and evaluate technological systems and engineering processes.
4. Relate technology and engineering with science, mathematics, and other subjects to understand systems in different contexts and to engineer solutions to practical problems.
5. Communicate technology content and processes, individually as well as in teams.
6. Understand the historical and future significance of engineered designs and impacts of technological solutions.
7. Develop basic skills in the safe use of tools, machines and processes used by industry and other technologies.
8. Foster creativity in using technology for desirable purposes by encouraging students to create, from materials and with technological processes and hardware, new and different forms which have greater or alternative value.
9. Facilitate the discovery of individual talents, aptitudes, interests and potentials related to technology through laboratory activity.
10. Encourage cooperative attitudes, constructive work habits and other traits that will help secure and maintain employment.
11. Develop pride in work done well.
12. Develop consumer skills related to the appropriate production, consumption and maintenance of technological goods and services.
13. Develop an awareness of and appreciation for career paths and opportunities in technology and engineering, and prepare for entrance into advanced secondary and post-secondary career and technical programs by promoting the development of a basic foundation of occupational skills and interests.
14. Develop leadership skills through the Technology Student Association activities.

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