At some point, someone is going to ask you “what is technology studies?” Or what is technology education? Is it engineering education? Is this different than educational technology? Or from career and technology studies? And design and technology? In fact, Mark Sanders hosted a session at the International Technology Education Association’s annual meeting in 2005 to address this issue. The scenario was this: You are in an elevator and someone asks “what do you do?” You reply, “I’m a technology teacher.” They respond with the query, “what is a technology teacher?” How will you answer? What language will you choose to define your profession? Technology and design are themselves difficult to define. How will you define design or technology for your students? Define them in cognitive terms, such as problem-solving ability, and you exclude their socio-cultural dimensions. Define them in technical terms and you exclude their ecological dimensions.

Perhaps some of the most important challenges for teachers is defining their subjects. For example, the International Technology Education Association and the International Society for Technology in Education are currently trying to define the differences between educational technology and technology education. But they are overlooking the similarities, as I pointed out in an essay titled “The Educational Technology is Technology Education Manifesto” (Petrina, 2003a). In some very fundamental ways, teaching is a matter of definitions.
Technology refers to “the systematic, purposeful manipulation of the material world. It has four components: materials, technique, power, and tools or machines. Thus technology is the process of applying power by some technique through some medium of some tool or machine to alter some material in a useful way. These components are necessary and sufficient to describe any technology at any time, but they are static; they do not address technological change” (Roland, 1992, p. 83). Technology can also be defined as “the means and processes through which we as a society produce the substance of our existence. Specifically, technology consists of five items” (Bernard, 1985):

- **Tools** (hammer, presses, typewriters)
- **Energy forms** (steam, electricity)
- **Materials** (plastics, metals, fiber optics)
- **Techniques** (weaving, annealing metals)
- **Organization of work** (assembly line, craft production, batch processing) (p. 8)

*Figure 1. Economic sectors in technology*
Technology, as product and service, or as activity and as knowledge, pervades every economic sector. Think comprehensively when you think of labor and technology (Figure 1).

As explained in Chapter VIII, the way we define technology determines the scope of the technology studies curriculum. Narrowly define technology and the scope of the curriculum will be limited. Broadly define technology and the scope will be expansive. Philosophers of technology have been interested in the definitions of technology at least since the ancient Aboriginal, African, Chinese, Greek, and Egyptian philosophers began to make sense of their worlds. Currently, technology is divided into eight branches (Bunge, 1999) (Figure 2).

Technology studies refers to subjects that at one time or another were collected under technical education (i.e., design, educational technology, engineering, industrial education, information technology, technical education, technology education, or

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**Figure 2. General branches of technology (Adapted from Bunge, 1999)**

![Diagram of General branches of technology](image)
vocational education). This interpretation of technology studies, as a collective of disciplines, is represented in the *Journal of Technology Studies* and *Technology Studies*. Technology studies has recently come to refer to an even wider range of subjects. In Alberta for example, “Career and Technology Studies” includes subjects that range from agriculture to design and digital design, enterprise and innovation, fashion, information processing and marketing to tourism and wildlife management. This collection includes twenty-two subjects and is probably the most comprehensive interpretation of technology studies.

Technology studies also refers to the anthropology, economics, history, philosophy, politics, psychology, and sociology of cybertculture, technology, and technoscience (Petrina, 1998, 2003b). Work in this interdiscipline continues a tradition of both celebratory and critical studies. Over the past two decades, technology studies has challenged traditional understandings of technology, and has been working to undermine problematic technological practices in Australia, Britain, Europe and North America. For example, technology studies informs empirical questions of interrelations between science, technology and capitalism, or between human agency and social process in the design of new technologies. Research in technology studies deals with issues such as cybertculture, design, and the media, or technological threats to freedom, labor or privacy. Questions of how participation in technology is mediated by class, disability, gender, race, and sexuality are of prime importance.

Most consider technology studies (TS) to be a necessary check on science studies, hence the TS in STS (science & technology studies). This interdiscipline came neither from physical science nor from engineering, but was a hybrid constructed out of the humanities and social sciences. The major tenet of Technology Studies is that technological practices, such as ICT and cybertculture, can be studied and not merely promoted as one might find in many educational institutions, IT professions, engineering, computer science, or other scientific disciplines.

Technology studies, then, refers to the spectrum of formal ways that we learn about, through and for technology—from disciplinary to interdisciplinary approaches, from applications to implications. The operative theme of technology studies is technological pluralism—the study of (but not the celebration of) all technologies and orientations to technology (alienation, instrumentalism, technoenthusiasm, technophilia, technophobia, luddism, technocriticism, etc.). This range or this spectrum is what makes this field so interesting and important. In technology studies, technology is taken as a serous subject of study. Technology is central to technology studies. Technology is incidental to a large range of other disciplines, as well. Rather than the primary subject of interest, technology is infused into the practices of disciplines. And, since technology is ubiquitous, meaning it is everywhere, we also learn about and through technology by immersion and interacting with it on a daily basis. Our movements and minds are shaped by technology, through media, mass media, rules, cybertculture, or infrastructure. We learn about, through and for technology whether we want to or not (Figure 3).
Figure 3. Formal and informal ways of learning technology

Figure 4. Engineering

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Engineering is a discipline and professional practice that deals with the design of dynamic and static devices, materials, and structures (Figure 4). It consists of chemical, civil, electrical, genetic, and mechanical subdisciplines as well as others more specific to practice such as acoustics, aeronautics, and synthetics. Except for the few prep schools that focus on engineering, the presence of engineering as a school subject has been limited in North America. In the early 1970s, the Engineering Concepts Curriculum Project was initiated as way providing students in the U.S. a basic understanding of engineering and a form of technological literacy (Chapter VII). Since the 1970s, there was a rapid growth of industrial technology programs in post-secondary colleges and many of these programs were transformed into engineering technology programs during the 1990s. Engineering technology is an applied practice established in response to the theoretical emphases of engineering in the universities. Many proponents of engineering technology claim that this ought to be the main discipline of technology studies.

Industrial technology refers to the industrial sectors of the larger field of technology and to a subject. For example, the industrial technology sector serves economic functions that differ from the domestic or health sectors. Most limit the industrial technology sector to goods and services within construction and manufacturing. Industrial technology also refers to the postsecondary field of study that was organized in the 1960s as a complement to engineering, as a field to prepare people who knew the techniques of production as well as the practices of management. The field was positioned at the point that intersects engineering, the trades and management. Hence, it is often described as a field with an ideal balance of practice and theory. The same has been said of engineering technology, a more recent field that is linked to industrial technology. While there may be a balance of practice and theory,
Industrial technology and engineering technology are well out of balance in their overemphasis on applications and neglect of implications (Figure 5).

Manual training (MT) was introduced into North American schools during the late 1800s, and consisted of handicraft with wood and board drafting for boys, and domestic science or cooking and sewing for girls (Figure 6). MT was a convergence of British Arts and Crafts, the Russian Tool System of instruction, Swedish Sloyd approach to woodwork, and mechanical engineering. The goal was to prepare students for an increasingly industrialized world, or what amounted to a form of industrial literacy and machine grammar (Stevens, 1995). MT was an integral component of general education, as opposed to vocational in intent, and introduced working class skills and technologies into the public schools. MT was vulnerable to vocationalization and partially yielded to technical education and differentiation of curriculum or tracking and streaming.

Industrial arts (IA) or industrial education (IE) is a school subject that deals “experientially with technology—its evolution, utilization and significance; with industry—its organization, materials, processes and products; and with the benefits and problems resulting from the technological and industrial nature of society” (Figure 7). IA was introduced into the schools during the 1910s, following three decades of manual training and technical education which were introduced into the schools during the 1880s and 1890s (see Chapter VII). IA expanded MT from handicraft with wood and board drafting to include production with industrial machinery during the 1920s. IE was an expansion of IA in the 1960s. From the 1960s through the 1990s, IE and IA were commonly recognized by material and process-based workshops: automotive mechanics, drafting, electronics, graphics, metalworking, power mechanics, plastics and woodworking. Technical production was emphasized in IE and IA and the cultural intent of these subjects was reduced to little more than check and balance sheets. However, there was a fundamental cultural intent in this
subject from its inception in the 1920s. The subject’s most articulate advocate in
the 1920s and 1930s, defined IA as “the study of sources of materials, methods of
changing materials, factory organization, inventions, employer and labor coopera-
tion, distribution of products, and regulative measures to secure justice alike to
producers and consumers” (Bonser, 1930, p. 2).

Technology education (TE) is a school subject concerning knowledge in design-
ing, creating, using, maintaining, regulating, and recycling technologies (products,
processes and services) (Petrina, 1998). In 1991, Donald Maley defined the subject
as: “That phase of general education that deals with the study of technology, its;
evolution, utilization and significance; and with the technologies associated with the
many diverse elements of construction, manufacturing, communications, energy, and
their economic, political, social and environmental impacts” (p. 1). Similarly, TE was
defined in the Carl D. Perkins Vocational and Applied Technology Education Act
of 1990 as “an applied discipline designed to promote technological literacy which
provides knowledge and understanding of the impacts of technology including its
organizations, techniques, tools and skills to solve practical problems and extend
human capabilities in such areas as construction, manufacturing, communication,
transportation, power and energy” (Public Law 101-392, Title V, Part C, Section
521, p. 39). As indicated, the subject is identifiable by its organization of subjects in biotechnology, communications, energy and power, production (construction and manufacturing), and transportation (Figure 8). Most recently, within the ITEA’s Standards for Technological Literacy, information, physical, biological and chemical
technologies were used for organizers (Figure 9). TE deals with animation, computer aided design, information and communication technology and digital video, and there is little reason to differentiate between technology education and what has been called educational technology.

Audio-visual education (AV) began as a response to the proliferation of visual resources created for education during the late 1800s and early 1900s, and the introduction of motion pictures and radio into education during the 1920s. Educators were initially interested in the production of AV aids for teachers and AV effects on students (Figure 10). However, high schools began to develop infrastructure and studios for AV programming, production recording and repair. Through the 1950s and innovations with teaching machines, computers, and systems theory, AV morphed into technology education and educational technology (Petrina, 2003).

Educational technology (ET) has a wide range of connotations and generally refers to any use of technology for teaching and learning (e.g., books, computers, projectors, etc.) (Petrina, 2003) (Figure 11). ET basically derives from Audio-Visual Education, where artifacts such as AV materials, projectors, and teaching machines constituted the discipline. In universities, educational technology continues this tradition of instructional design and the current focus is on Web-based instruction and the efficient use of technologies for learning. ET has lost its currency, hence in countries such as Canada, England, and the U.S., ET is referred to as information technology, information and communication(s) technology (ICT), or technology education (see Chapter VIII, Figure 2). Some teachers have moved from a neglect of design tools and implications to an integration of design and information. ET deals with a variety of design tools and hence the new trend in switching the combination of words from ET to TE. These blurred boundaries are evident in schools where content and practices in ET and TE are indistinguishable (Petrina, 2003). The pioneering work of Seymour Papert and the MIT Media Lab had much to do with the blurring.

Information technology or information and communication(s) technology (ICT) spans most economic sectors. Given the intensive automation that is currently taking place in industrial technology and service, ICT is currently the fastest growing economic
sector. As a field of study, information technology is a sub-discipline of computer science, business management and engineering technology and a school subject. In the schools during the late 1970s and 1980s, courses called computer science or computer studies continued the practices of educational technologists, whose focus was on programming and applications. While a general literacy was advocated, little was done on the issues of implications. The courses were renamed information technology in the early to mid 1990s. In BC for example, the computer courses were renamed in 1996 when computer studies had little currency. Like computer science and studies, information technology reflects preoccupations with applications and in business education is information technology management. Currently, the term (not the practices) “information technology” is losing its currency, as most researchers argue that the new digital technologies extend well beyond information and communication. They engage a wide range of actions and are not merely conveyances of information with technology. New media is becoming the new term of choice. In the universities, cultural studies of information technology and of cyberculture are part of a larger practice of technology studies (Figure 12).

Digital media design can be defined as simply design of, and with, new media (Figure 13). New media reflects the convergence of communication, media, and information:

- Technologies (camera, computer, copier, fax, messaging, phone, printer, audio and video player, etc., convergences)
- Modalities (image, print, sound, etc. convergences)
- Practices (art, communication, design, fashion, film, marketing, media, medicine, programming, technology, etc., convergences)
• Corporate formations (cable and internet providers, music, newspaper, radio, and television convergences)

Digital design refers to a branch of electrical engineering that deals with the design of digital hardware. However, the accessibility and applicability of software accompanying the convergences noted have resulted in a new knowledge worker and a new field of discourse, practice, and study. Like industrial design, new media occupies a necessary space between art and computer engineering and science.

New media focuses on the design of animated and interactive content for the internet, TV, CD, DVD, and other media environments. New media create experiences...
environments with time-sensitive data. New media involve the design of interactive, malleable, and motion and sound oriented messages, and expand to bidirectional communication in which content responds, adapts, and changes in response to users, hosts, or circumstances. Motion allows content and form to utilize an added dimension of time to transform the capacity of still images while sound provides additional sensory capacities. New media or digital media design signifies the new digital curriculum in the schools, such as animation, Web design, and video, and has more currency than IT or ICT in education.

Design can be simply defined as “a structure adapted to a particular purpose” (Figure 12) (Perkins, 1986a, p. 2). But this definition fails to capture design as a process, as knowledge or as a field of study. Design is both a mode or model of technological practice, and a discipline or field of study. Design is a source of philosophical and
practical knowledge regarding problems of aesthetics, ergonomics, health, function, structural integrity, and sustainability. It provides guidelines for successful construction or deconstruction, as well as criteria for discerning intent and quality, or the “workable” and “non-workable,” in technology. Design organizes knowledge embedded in cultural tools such as engineering tables, drawings and models, heuristic strategies, efficiency calculations, reliability, recyclability, and safety ratings, and user surveys attuned to physical or sexual differences.

Of course, a unified notion of design does not exist, and as a rule, the more concrete the idea for an artifact, image or process, the more direct design knowledge becomes. Perhaps the Bauhaus came closest to connecting architectural, engineering, fashion, graphic, interior, product and urban design within a single fund of knowledge and style. Today, engineering design is generally a source of structural and material knowledge, while disciplines like architectural and product design are sources of aesthetic and ergonomic knowledge. Biotechnical and therapeutic design are sources of knowledge concerning agri- or aquaculture, health and medicine. Philosophies like appropriate or intermediate technology, user-centered design, integrated and participatory design, concurrent engineering, and product life cycle represent tangible visions for transforming the immediate ground of technological design.

Design in the schools is typically claimed by two subjects: art and technology. For the most part, neither of these subjects does justice to the practice and theory of design. Art deals with the elements and principles of design, most often with an emphasis on graphic or visual arts. Rarely are these principles applied to the production of functional artifacts. Technology, on the other hand, traditionally dealt with
the production of artifacts but placed little emphasis on design. Artifacts were not so much designed as built and duplicated.

Design and technology is a school subject that emphasizes design in the study of technology (knowledge in designing, creating, using, maintaining, regulating, and recycling technologies—products, processes, and services). Design and technology (D&T) is most prevalent in Australia, England, Ireland and Wales and is found in a number of schools in the U.S. and Canada. D&T has its origins in the craft, design, and technology (CDT) programs initiated in England during the early 1970s to unify the workshop and lab-based technology subjects in the British schools. CDT was intended to amalgamate handicraft, or a concern with all aspects of artifact production, with design, or a concern with applied theory, and practical know-how (Chapter VII). D&T continues to emphasize design and creativity, but, like technology education and educational technology, minimizes the cultural and social implications of design and technology. CDT in England, beginning in the 1960s, aimed to change this isolation of design from technology. Today, design and technology in Australia, England, Ireland, and Scotland continues the tradition of CDT in the schools with an emphasis on the design of artifacts but not the design of sustainable lifestyles. Advocates of D&T note that all students ought to have an opportunity, as part of their general education, to design and make functional objects under the direction of a teacher. D&T is part of what it means to be a well-rounded person. There are few pretensions that D&T will have vocational pay-offs.

Vocational Education, which referred to career education, work education or work-force preparation, has generally been replaced by Career and Technical Education. For instance, the venerable America Vocational Association (AVA), established in 1926, changed its name to the Association for Career and Technical Educators (ACTE) in 2000. Career and Technical education typically refer to a range of subjects that extend from agricultural education to trades and industrial education (Figure 15). At the upper levels of high schools, many consider technology education to be part of career and technical education. “Career and technical education” is more appropriate than vocational education for a “post-industrial” era. Rather than an industrial model of vocational education, the new vocationalism positions technology studies as pre-engineering, pre-high tech trades, technical preparation, or “tech prep,” for technical careers (Colelli, 1995). In the tech prep model, technology courses in the secondary schools are aligned with the curriculum of colleges and institutes of technology courses to ease transitions. In the best case scenarios, tech prep courses are accepted for post-secondary credits and skills developed are transferable to the technical careers of interest.

Trades and industrial education (T&I) refers to a specific form of vocational education in the trades. Trades education is defined by a long tradition beginning with the English Guild system of the Middle Ages and extending to modern apprenticeship systems. For most of the twentieth century, trade unions enjoyed a large amount
of control over the education of apprentices, but that is changing under neo-liberal
governments. T&I educators typically position themselves on the side of trade
unions and see the high schools as pre-trades education. In this scenario, technical
careers and trades legitimate and validate technology studies. The trades confer
status for these teachers. Most economic forecasters predict a shortage in the trades
in North America over the next decade, but the numbers will never be adequate to
justify the existence of technology studies in the schools. For example, only 2.5%
of the students in BC secondary schools have any desire to make a transition into
an apprenticeship program after graduation, and only 1.3% actually enroll in an
apprenticeship program while in school.

With that much said, technology in education reminds one of the Philosopher’s El-
phant, a parable derived from the second century BC and spread through Islam by
Sufi theologian Muhammad al-Ghazzali in Theology Revived (Rhys Davids, 1911).
The parable was popularized in Islam by the Sufi Master Rumi and in the west by
John Godfrey Saxe. In the story, six people are challenged to describe an elephant
from a part of the elephant that they immediately perceive. Each one touches a part
of the elephant, the reality of what they perceive and ultimately conceive is distorted
by their interests. One from the group standing behind the elephant touches the tail
and describes a rope. The second touches the trunk and describes a snake. The third
touches the tusk and describes a spear. The fourth touches the leg and describes a tree. The fifth touches the side and describes a wall. The last person touches the ear
and describes a fan. Not one of the six could conceive of the elephant from their
narrow interests. Some who look at technology, in our case, see design, educational
technology, technology education, or trades. Others see applications for art or sci-
ence. Still others see information technology or communication. The disciplines
merely grope for a component of the larger picture. Technology Studies, on the other
hand, in its interdisciplinary nature and pluralism, provides for a collective of the
disciplines and the bigger conception or picture of technology.

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