Advanced Teaching Methods for the Technology Classroom

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Chapter VIII

Technology Content, Process, and Standards

Introduction

If status of a school subject is at issue, then content, benchmarks, and standards cannot be underestimated. Of course, the question is what content and what (or whose) standards? Technology has suffered as a school subject in many ways because of the lack of consistent content and a defensible set of standards. What technology should a student in grade 2 know about and be able to use? What about grade 6, grade 8, grade 10, or grade 12, at graduation? What are the benchmarks for each grade level? We do not yet know. Should we have consistent technology content and standards for all students from K-12? Should all teachers abide by the content and standards? Should we have exams to monitor the students and teachers? Or should teachers have the freedom to teach what they want? If a student moves from one school to another, he or she will face a different curriculum with different goals. But the teachers will have the freedom and power to make professional judgments about what to teach. Who should make these judgments?

As indicated in the previous chapter, there is one, and only one, persuasive justification for the inclusion of technology studies in the schools. That justification is the content of technology. As recent as ten years ago, we were unable to speak of "the content" of technology in North American schools. The situation has changed and persuasive cases have been made to move technology studies from the margins of the schools to the center. Technology is now an extremely relevant subject in its own right, with a well-established curriculum and fund of instructional methods. In Chapter VII, we began with a comprehensive rationale for teaching technology in the schools. This chapter deals generally with content and standards, and specifically with the most recent projects to specify content and standards for technology studies.

Consistency in content and standards from school to school has always been a contentious issue. In no subject has this been more contentious than technology. To date, technology teachers in North America have enjoyed near total liberty in offering any curriculum they pleased. Currently, Canadian students who move from one province to another, or from school to school, are penalized for the lack of consistency from province to province. In the U.S., this has also been the case, with differences between states, districts, and schools. Technology studies differs from school to school in BC and students or teachers who relocate find little, if any, consistency and continuity. Even the names are inconsistent. There is no examination system to generate consistency and hold teachers accountable to standard sets of content. Nevertheless, this is changing through content standards for technology. Consistency, articulation, and accountability are the operative words in technology studies at this point.

Technology Content

There are fundamentally three sources of content: individuals, culture, and nature. Content derived from an individual will be developmental, physical, or psychological. Content derived from nature will tend to be biological or ecological and based on basic needs and survival. Content derived from culture will be institutional, sociological, or spiritual. The emphases of content derived from each source will range from practical to academic. Over the past century, technology teachers have derived content from all three sources. Currently, technology educators are focusing their efforts on content derived from culture, or more specifically, from a structure or discipline of technology. The source of content has always been contentious in technology studies, partially due to our activity-based practices and partially due to the changing state of technology. How can we establish stable content when technology is inherently dynamic? Should we focus on technological processes, which tend to be transferable? Should we focus on technological occupations and tasks, which tend to be accessible and current? Should we focus on technological concepts, which tend to be durable? There is not an airtight argument to be made for any of these social sources of content. Each has its benefits and problems. However, given the politics of the schools in this new century, where survival depends on establishing a subject as an academic discipline with coherent K-12+ content, technology educators must choose wisely. And the wisest choice at this time is disciplinary content, not the content of processes or occupations. If necessary, disciplinary content can be ordered to serve the content of processes or content of occupations. Either way, disciplinary content must take priority.

We derive content through a number of methods. The content of a discipline is derived from a *conceptual analysis* of facts, concepts, generalizations, and theories established over time. The content of occupations is derived from a *task analysis* of work and workers at specific points in time. The content of processes is derived from a *systems analysis* of processes and methods at specific points in time extended over time. To do a conceptual analysis, one has to make logical inferences from established principles and existing problems. To do a task analysis, one has to make procedural observations of tasks. To do a systems analysis, one has to make systematic observations of problems or processes. The point is that we can derive social content from disciplines, processes or problems and tasks. In most cases, a curriculum consists of combinations of disciplinary content, processes, and tasks. Of course, disciplines, problems, processes, and tasks change over time. Values and priorities also change. The materials, process and task-based content of industrial (arts) education and audio-visual education is not as relevant today as it was in the 1950s and 1960s. The trend is toward disciplinary content in the technology curriculum.

Technology Content and Standards

Currently, in many countries there are efforts to reform the K-12 curriculum for all subjects by forming a defensible set of standards to make content consistent from school to school. For example, the International Technology Education Association's (ITEA) (2000) *Standards for Technological Literacy: Content for the Study of Technology* project is making technology content consistent and forming a defensible set of academic standards for the study of technology. The International Society for Technology in Education (ISTE) (2000) established standards for the study of information technology and published *National Educational Technology Standards*

Table 1. Definitions of standards

Academic standards are basically statements that clearly define what a student should know and be able to do. There are:
Content standards: What students should know and be able to do.
Performance standards: How students demonstrate that they meet a standard.
Proficiency standards: How well the students must perform.

for Students. In England, the Department for Education Standards established technology content and standards and published *Design and Technology in the National Curriculum* in 1995. Education standards for all subjects can be found in Kendall and Marzano's (1997) *Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education*. There are basically three kinds of academic standards: Content, performance, and proficiency standards.

The ITEA's and ISTE's standards projects deal primarily with content and performance standards. Both projects were initiated in the mid 1990s amidst national and international incentives to make the study of technology consistent. The relationship between the two projects is set to subset. The ISTE's standards can be seen as a subset of the ITEA's standards. ISTE has dealt specifically with information technologies where the ITEA dealt generally with the entire scope of technology, including information technology. The ITEA's standards extend over five broad themes: Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and the Designed World. These standards are providing an effective blueprint for the creation of a scope and sequence of content for technology subject at the K-12 levels. The question we asked in Chapter VII, "what should all students know about and be able to do in technology?" is being resolved. We now

Table 2. ITEA's (2000) standards for technological literacy

The nature of technology	
1.	Students will develop an understanding of the characteristics and scope of technology.
2.	Students will develop an understanding of the core concepts of technology.
3.	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
Technology and society	
4.	Students will develop an understanding of the cultural, social, economic, and political effects of technology.
5.	Students will develop an understanding of the effects of technology on the environment.
6.	Students will develop an understanding of the role of society in the development and use of technology.
7.	Students will develop an understanding of the influence of technology on history.
Design	
8.	Students will develop an understanding of the attributes of design.
9.	Students will develop an understanding of engineering design.
10.	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Table 2. continued

Abilities for a technological world
11. Students will develop abilities to apply the design process.
12. Students will develop abilities to use and maintain technological products and systems.
13. Students will develop abilities to assess the impact of products and systems.
The designed world
14. Students will develop an understanding of and be able to select and use medical technologies.
15. Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
16. Students will develop an understanding of and be able to select and use energy and power technologies.
17. Students will develop an understanding of and be able to select and use information and communication technologies.
18. Students will develop an understanding of and be able to select and use transportation technologies.
19. Students will develop an understanding of and be able to select and use manufacturing technologies.
20. Students will develop an understanding of and be able to select and use construction technologies.

have a defensible set of technology standards; we are approaching a comprehensive scope and sequence of content for study.

The breadth of these standards is quite comprehensive and inclusive, encompassing nearly all facets of technology. This is one aspect of technological pluralism at work. These standards name the scope of what is to be studied and place parameters around the disciplinary content of technology. ISTE's standards focus specifically on information technology and primarily on the use of technology. Quite often in the education, we hear naive assertions that "technology is merely a tool." A tool is certainly a technology, but technology is not merely a tool to be used for tasks. As indicated in the previous chapter, technology is a subject to be studied. We need to be very careful of overemphasizing the "use" of technologies as this may come

Table 3. ISTE's (2000) technology foundation standards

Basic operations and concepts
• Students demonstrate a sound understanding of the nature and operation of technology systems.
• Students are proficient in the use of technology.

Table 3. continued

Social, ethical, and human issues

- Students understand the ethical, cultural, and societal issues related to technology.
- Students practice responsible use of technology systems, information, and software.
- Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.

Technology productivity tools

- Students use technology tools to enhance learning, increase productivity, and promote creativity.
- Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.

Technology communications tools

- Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
- Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

Technology research tools

- Students use technology to locate, evaluate, and collect information from a variety of sources.
- Students use technology tools to process data and report results.
- Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

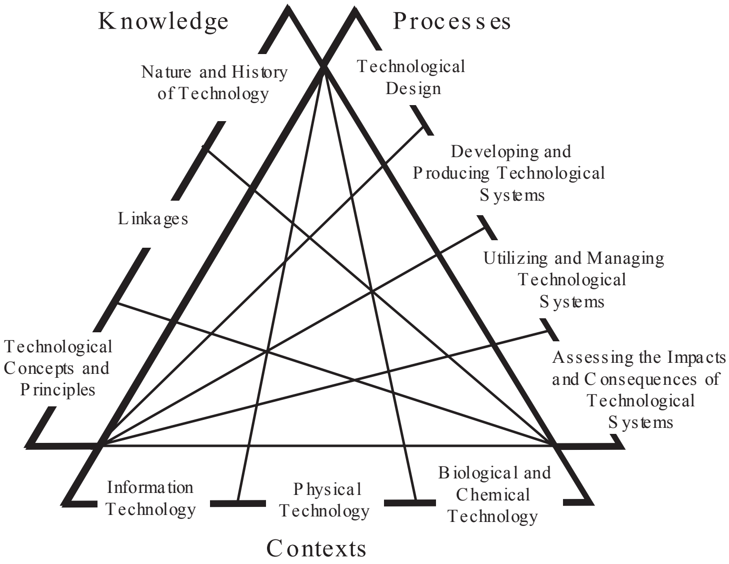
Technology problem-solving and decision-making tools

- Students use technology resources for solving problems and making informed decisions.
- Students employ technology in the development of strategies for solving problems in the real world.

at the expense of actually studying the technologies we use. We cannot justify an entire curriculum on the use of technology. Granted, the Standards for Technological Literacy covers a fairly comprehensive range of technologies that include the information technologies.

Rhe ITEA's and ISTE's standards are arranged according to similar content organizers (Table 4). Although this is by coincidence rather than by design, the organizers

Figure 1. ITEA's Organizers for technology standards (Adapted from ITEA, 1996, p. 17



for each set of standards complement and validate each other. But again, the ITEA's organizers are more comprehensive than ISTE's.

The ITEA's standards are derived from a discipline of technology arranged by contexts, knowledge, and processes (Figure 1). The base of the discipline is grounded on the forms that technology takes or the general sub-disciplines with which we

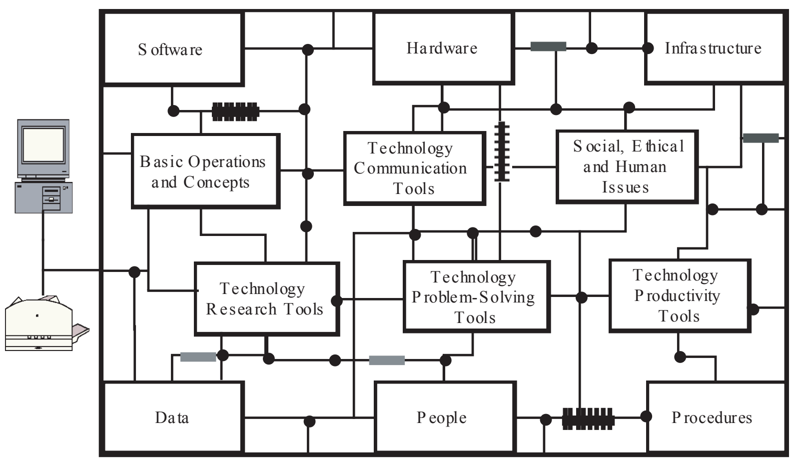
Table 4. ITEA's and ISTE's content organizers

• **ITEA organizers**	**ISTE organizers**:
• Technological concepts and principles.	• Basic operations and concepts.
• Technological design. • Developing and producing technological systems • Utilizing and managing technological systems. sion	• Technology communications tools. • Technology productivity tools. • Technology problem-solving and deci- making tools.
• Linkages. • Nature and history of technology. • Assessing the impacts and consequences of technological systems.	• Technology research tools. • Social, ethical, and human issues.

associate technology: Information technology, Physical technology, and Biological and Chemical technology. This is a departure from traditional sub-disciplinary organizers such as communications, production, and transportation. In another section, this tendency toward more general organizers is explained. These organizers are broad enough to accommodate a wide range of technological knowledge (concepts, history, linkages, and principles) and processes (assessment, design, development, management, production, and utilization). At another level, biological, physical, information and physical technologies are sub-divided into the technologies that most technology educators recognize: agricultural and related biotechnologies, energy and power technologies, information and communication technologies, medical technologies, construction technologies, manufacturing technologies and transportation technologies. Agricultural technologies, biotechnologies and medical technologies bring school subjects such as agricultural education and health occupations education into the fold of technology studies. At the lower levels of schooling, all of these technologies are included in the single subject of technology or integrated across the curriculum. At the upper levels, the entire spectrum is handled in one course, in some cases, and across several subjects, in most cases.

ISTE's standards and organizers are derived from a practical field that merges educational technology with information and communication technology (Figure 2). This is both an advantage and a disadvantage. The advantage is that ISTE's standards can be easily integrated across the curriculum with little or no need for a separate subject of information technology. Of course this can be a disadvantage if we take the position that technology is a subject to be studied in its own right, and not merely integrated (Chapter VII). The disadvantage of combining educational

Figure 2. ISTE's organizers for technology foundation standards



with information technology is that there is not a coherent discipline from which to derive content. The result is that the curriculum of information technology cannot be derived from ISTE's standards or organizers. In Chapter I, the discipline of information technology was described as an outgrowth of computer engineering and science. As we proceed through this chapter, keep in mind the fact that information and communication technology (ICT) is a sub-discipline of the discipline of technology. The two sets of standards should not be interpreted as being in competition with each other. ISTE's standards are a subset of the ITEA's standards for technology studies.

Technology Content, Standards, and Benchmarks

The technology content standards are backed up by benchmarks and performance standards. Basically, content standards derive from well-articulated disciplines and fields. Benchmarks and performance standards derive from content standards, and proficiency standards from these performance standards. Ultimately, classroom activities, assessment, lessons, and projects are derived from these different types of standards. This is the rational procedure to follow. The reverse direction, where a structure of content originates from activities and projects, cannot lead to consistent practices in a subject. The challenge is to subscribe to the technology discipline and standards while developing locally based activities and projects to meet the standards. The challenge is to adopt a consistent structure of content and standards and then proceed toward local innovation. Standards have to be translatable for practice. Teachers must be able to express the standards in their practices at all levels.

Consistency, articulation, and accountability are the operative terms at this point in time. Consistency is a necessary step towards accountability. If technology teachers are consistent in the content they teach from school to school then technology studies can be accountable to its constituents. Articulation is dependent on consistency and accountability. It is somewhat easier to establish consistency than an articulation of content and knowledge over the K-12 system. What should a grade 6 student know about technology that a grade 5 student does not know? The task of articulation is extremely challenging but essential to subjects. I encourage all technology teachers to survey the ITEA's (2000) Standards for Technological Literacy: Content for the Study of Technology and ISTE's (2000) National Educational Technology Standards for Students. Kendall and Marzano's (1997) Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education is also invaluable in helping you pay close attention to the articulation of content from level to level.

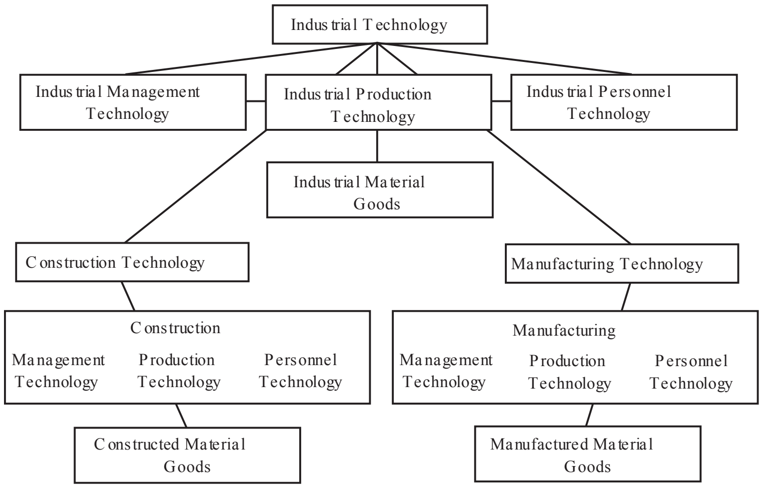
The Disciplines of Technology

The new content and standards of technology are derived from various disciplines of technology. There is a range of disciplines of technology just as there are different disciplines of science. One way of illustrating this is in engineering. The discipline of engineering consists of chemical, civil, electrical, genetic, and mechanical engineering. There are various sub-disciplines such as acoustics, aeronautics, avionics, ballistics, bionics, electronics, dynamics, hydraulics, mechanics, pneumatics, optics, robotics, statics, and synthetics. Each sub-discipline is a discipline in its own right. We can say that all the engineering disciplines collectively form the discipline of engineering. Design has its own disciplines (architectural, interior, etc.), as does communication or production. Ought the disciplines of technology include only technical fields, or does technology extend to social fields as well? Some scholars limit disciplines of technology to technical fields and isolate technology from other fields of study. Others expand technology to include political, psychological, and social fields. This is why it is more accurate to speak of disciplines rather than a discipline. Disciplines depend on what is included and excluded.

Charles Richards epitomized proto-theorists of the technology disciplines and initiated a progressive outlook on content that continues today. In 1904, in his now famous essay, "A New Name," he introduced the term "industrial art" to designate an integration of art and industry and to replace an outmoded practice of "manual training." The discipline of industrial arts education (IA) was to be derived from "nothing short of the elements of the industries fundamental to modern civilization," or as he said in Art in Industry, from the graphic, mechanical and textile arts. After expanding on Richards' and Dewey's work, F. Gordon Bonser, Lois Mossman, and James Russell at Columbia University defined the discipline of IA for the elementary schools during the 1910s and early 1920s (Foster, 1995a, 1995b). The IA discipline was organized by food, clothing, and shelter with the intent being "industrial insight, intelligence, and appreciation" (i.e., technological literacy). The trend towards disciplinary content was a direct reaction to prevailing emphases in the high schools on drafting, metals and woods, and the process of deriving content by task analysis. The trend, identified in the 1930s, was toward deriving content from the major industries (communication, power, production, and transportation) (Herschbach, 1984; Lewis, 1995).

When William E. Warner introduced A Curriculum to Reflect Technology in 1947, he named technology as the proper subject for industrial arts, rather than industry. Warner and his students envisioned a study of technology, rather than industries such as drafting, electricity, graphics, mechanics, metals, and woods. Industrial arts was, in theory, focused on conditions, materials, tools, processes, and products of these industries. In practice, it was merely a conglomeration of narrow procedures and projects derived from task analysis. For Warner, the most forward-looking way to organize industrial arts was through a study of five broad technological orga-

Figure 3. Industrial technology discipline (IACP)



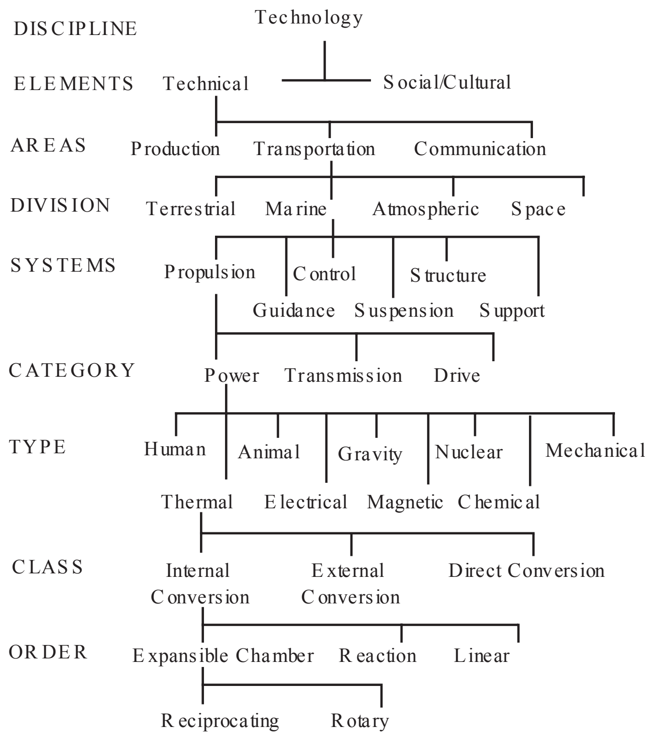
nizers, derived from a socioeconomic analysis: communication, construction and manufacturing, power, and transportation. The naming of these sub-disciplines of technology was a major breakthrough for technology studies.

A second major breakthrough came a decade later with Delmar Olson's graduate thesis (as Warner's student) titled Technology and Industrial Arts (1957) and his subsequent book, Industrial Arts and Technology (1963). More than anyone prior to this time and for the following decade, Olson provided an entire K-12+ curriculum and justification for the study of technology. With his book, Olson popularized and elaborated on Warner's work and the discipline of technology. The sub-disciplines of technology were: construction, electricity and electronics (energy), industrial organization and management, industrial production, power and transportation, research and development, and services. Communication was embedded in services and distributed across the sub-disciplines. This discipline of technology was oriented toward industrial technology.

Following the steps of Warner and Olson, in 1966 Edward Towers, Donald Lux, and Willis Ray published A Rationale and Structure for Industrial Arts Subject Matter, or what they called the Industrial Arts Curriculum Project (IACP). The IACP limited the technology discipline to industrial technology, based on a socioeconomic analysis of classification systems. Industrial technology was divided into construction and manufacturing, which in turn sub-divided into management, personnel and production. These sub-divisions sub-divided and so on (Figure 3).

The IACP provided a logical basis for the selection of content in an industrial technology curriculum. Activities and projects were developed for the attainment of content and understanding of the discipline. The IACP was routinely used in about

Figure 4. Technology discipline (DeVore, 1964)



2,700-3,000 junior high schools in the U.S. by the late 1970s (Lux, 1979). Industrial technology, nevertheless, proved to be too limited. For example, communication and transportation were subordinate to construction and manufacturing.

DeVore remedied this problem, but created another, in 1964 with his Technology: An Intellectual Discipline, which was somewhat of a revisiting of Warner's 1947 curriculum. For DeVore, the discipline of technology divided into production, transportation, and communication. The production area sub-divided into divisions of manufacturing and construction; manufacturing into the categories of fabrication and processing; fabrication into five types and so on. This provided teachers with a basis for valid content selection (Figure 4).

Activities and projects were formed with the attainment of content and an understanding of the discipline of technology, or more specifically, the sub-disciplines of communications, production, and transportation. Creating confusion, he suggested that power and energy were distributed across these three industries. Nonetheless, the primary goal was to develop an understanding of content rather than the development of skills in one or another process or occupational area. The message was this: Use a conceptual analysis of a technology discipline rather than task analysis of industrial work to derive content.

The 1960s were an extremely active time for the disciplines of technology (Cochran, 1970; Householder, 1979). Notable initiatives included The Alberta Plan, specifically Man, Science, Technology, which identified the sub-disciplines of technology to be computer, electronic, graphic communication, mechanical, power transmission technologies. In 1966, this was among the first technology disciplines to include computer technologies as a sub-discipline (Ziel, 1971). Today, the technology discipline for content and standards in the schools is expansive and sweeping, inclusive of most except military technologies.

Task Analysis

Task analysis quickly rooted in industrial arts and audio-visual education during the 1910s and 1920s. At that time, task analysis was called "trade and job analysis." Trade and job analysis was a technique for taking an inventory of skills and procedures necessary to complete tasks. The inventory was taken for either instruction or for documenting the efficiency of workers. This process was based on the techniques developed in the early 1880s by Frederick W. Taylor, who argued that there was "one best way" to performing any individual task. For instance, there was one best way of shoveling coal, one best way of soldering seams, one best way to type, and one best way of ironing clothes. Taylor called his techniques "scientific management." Scientific management required a documentation of the movements and procedures of workers, typically with a stopwatch and often with a movie camera. He called these time and motion studies. The scientific manager reviewed the documentation and recommended to managers how the procedures of workers could be reduced to a one best procedure, supposedly to increase efficiency. A required number of shovels or key strokes per minute were now expected of workers, who would be re-trained to work according to the one best procedures prescribed by the scientific manager. Managers, such as Henry Ford, loved the process. Workers and labor unions despised scientific management. The monitoring software used in workplaces today is a remnant of scientific management, or Taylorism.

Taylorism proved to be an inspiration to educators who figured that the one best way of doing job tasks must be the model for teaching industrial procedures and skills. In 1919, Charles Allen published The Instructor, the Man, and the Job, effectively a manual for translating the practices of scientific management into instructional planning, or trade and job analysis. Selvidge's How to Teach a Trade reinforced this in 1923. Through the 1930s, educators such as Frykland and Selvidge managed to orient the entire curriculum of industrial arts curriculum toward trade and job analysis. Eventually in the 1960s, trade and job analysis was reduced to task analysis, still with us today. Generally, task analyses involved an analysis of the following aspects:

- **Duties and tasks:** Performance of specific tasks and duties. Information is collected includes frequency, duration, effort, skill, complexity, equipment, and standards.
- **Environment:** Related to the physical requirements to perform a job. The work environment may include unpleasant conditions such as offensive odors and temperature extremes. There may also be definite risks such as noxious fumes, radioactive substances, or hostile and aggressive people.
- **Technologies:** Some duties and tasks are performed using specific technologies. This may include protective clothing or safety equipment.
- **Relationships:** Relationships with internal or external people during the task.
- **Requirements:** Abilities, dispositions, knowledge, and skills required to perform the job. Basically the minimum requirements for adequate performance.

Trade and job analysis is designed to identify the work requirements of specific jobs by providing a detailed overview of the tasks that must be performed by workers in a given job. Task analysis, a step in the process of job analysis, is conducted to identify the details of specified tasks, including the required dispositions, knowledge, and skills required for successful task performance. There are basically four kinds of task analysis (Lankard-Brown, 1998):

1. Worker-oriented task analyses focus on general human behaviors required of workers in given jobs.
2. Job-oriented task analyses focus on the techniques in performing job tasks.
3. Cognitive task analyses focus on the cognitive components associated with task performance.
4. Emotional task analysis focuses on the emotional elements associated with task performance.

Rather than isolating one type of task analysis from the other, high-tech workplaces are demanding that single-focused task analyses give way to combinations that reflect the greater breadth and depth of skills required for high-tech jobs.

Worker-oriented task analysis typically involves observations of job tasks performed by workers, interviews with workers, review of tasks by supervisors and surveys to determine the value of tasks and the knowledge and skill requirements. A job-oriented task analysis is a systematic process for collecting information about the highly specific and distinct tasks required for particular jobs. Job-related task analyses rely on workers and supervisors who can explicitly state the step-by-step sequences of tasks and procedures. Cognitive task analysis attempts to determine the thought processes workers follow to perform the tasks and identify the knowledge necessary to perform the tasks at various levels (e.g., novice or expert). It is a process used to gather information on behavior in problem-solving situations that highlights the constructive nature of everyday knowledge and social constraints on problem-solving. Cognitive task analysis relies on the techniques of observation and interview.

Basically, task analysis involves the process of breaking complex behaviors (chain of simple behaviors that follow one another or occur simultaneously) down into their component parts. A comprehensive task analysis involves the use of task inventories, interviews, and observations. Simplified task analyses are based on observation and reflective practice.

Task analysis has witnessed a revival with the new information technologies. The complexities of software applications and related peripheral interfaces have required that instructors pay close attention to the performance of tasks. In response to the heavy reliance on task analysis, critics have pointed out that the information technology curriculum has become top heavy with procedural knowledge and utilitarianism. Given that applications and peripherals change so rapidly, technology teachers are challenged to teach content that is current. The rapid changes of content (derived from task analysis) in the new technologies have led some educators to promote the teaching of transferable processes over content.

In technology studies, task analysis plays an important role as both a technique to derive content for C&I and a teaching method. Task analysis is essential to teachers for organizing procedural knowledge, whether if is cognitive or sensorimotor oriented.

It is also a teaching method to engage your students in procedural knowledge and career education. Teachers who prioritize the role of task analyses tend to prioritize

Table 5. Task analysis (simplified)

1.	Identify a task to be analyzed.
2.	If possible, isolate the task from other tasks.
3.	Identify the goal of the task.
4.	Identify any special technologies necessary for task completion.
5.	Identify any special safety considerations.
6.	Focus on the essential elements (essences) of the task.
7.	List detailed sensorimotor steps of the sequence of the task from start to finish.
8.	List detailed cognitive steps of the sequence of the task from start to finish.
9.	List detailed emotional steps of the sequence of the task from start to finish.
10.	Condense detailed steps into a clear, concise, manageable procedure.
11.	Perform the task by following the new procedure and revise as necessary.

Table 6. Task analysis example how to scan

1.	Launch scanner application (double click on icon at bottom of screen).
2.	The software should locate the scanner (if it is powered up and connected).
3.	In new pop-up window, click on "Preview" (assuming you have already positioned the image to be scanned on the scanner bed upper left corner) (Tip: it is best to leave settings at their defaults).
4.	After preview, crop to-be-scanned image by pulling dotted-line window around desired image.
5.	Click on "Scan."
6.	In new pop-up window, name image file (e.g., image1.jpg or image1.gif).
7.	Save file in "Student Temp Files" folder or on hard drive. (You can copy to your own floppy or zip disk after you are finished).
8.	Click on save (the file is now written and exported to the destination folder as a JPEG or GIF file).
9.	Start over at step #3 if scanning a second image.

competencies and capability over content and instrumentalism over critical empowerment. In other words, doing tasks does not automatically lead to knowing about technology and making sense of the effects that we feel. Performing technical tasks may be a necessary condition for literacy about technology but it is not a sufficient condition in itself for this literacy.

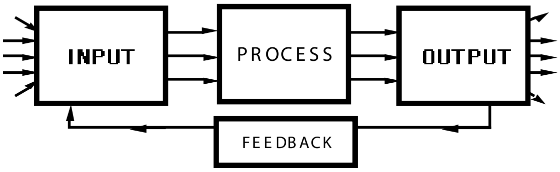
To edit image, it is recommended that you use Graphic Converter (for basic editing) or Corel Photo Paint or Adobe Photoshop (for advanced editing)

Processes as Content

The conceptual analysis of the discipline of technology and the task analysis of the activities of technology represent two alternative techniques for deriving the content of technology studies. Rather than one or the other, some technology educators suggested that there could be a middle path, where the processes of technology would be the content of technology studies (Hutchinson & Hutchinson, 1991). They integrated conceptual analysis with task analysis to derive content.

Technology processes have been part and parcel of the trend toward disciplinary content, most notably in Olson's Industrial Arts and Technology and the American Industry project of the 1960s. In American Industry, common processes were identified at the core of all industries. These included energy and materials procurement and processing, communicating, producing and transporting, financing and property acquisition, research, planning and maintaining industrial relations, marketing and management. Units such as Operating an Enterprise focused on process such as ideation, invention, prototyping, and marketing, organizing a business, planning for

Figure 5. Cybernetic system



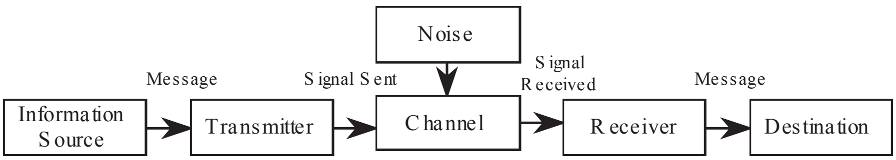
production, surveying market needs, inspecting products, selling and accounting. American Industry recognized the ways that public interests and private property conflicted, and the give and take among competition, resources, and the government of economies.

Drawing from these processes and the trends toward disciplinary content, technology educators in the U.S. set a course to establish processes as content for the curriculum of technology studies. The Jackson Mills Curriculum Theory of 1981 was an initial step to integrate technological processes and the discipline of technology. Similar to DeVore's discipline, Jackson Mills reduced technology to a series of "universal" systems that included communication, production, and transportation systems of technology. This shifted the emphasis from the processes of American Industry to processes of systems. Students were to develop a sense of how systems were designed and operated, laying the groundwork for a curriculum based entirely on systems logic and processes. In cybernetic grammar, activities and projects were developed to give students an understanding of technological systems of inputs, processes, outputs, and feedback loops. The processes of design and technology were reduced to a simple cybernetic system (Figure 5).

Communication systems demanded a different treatment to capture human-to-human, as well as machine-to-human and machine-to-machine communications. Here, students were to grasp not only the cybernetic system model, but also communication systems as captured in Shannon and Weaver's classic model (Figure 6). The emphasis was placed on the systems and processes of technology rather than the products.

This general shift toward a process-based curriculum came in 1989 with the Conceptual Framework for Technology Education. The Conceptual Framework adopted

Figure 6. Model of communication (Adapted from, Shannon and Weaver, 1949)



the systems approach as a given and designated problem-solving processes as the basis for content. The shift was from system processes to human and intellectual processes; from questions concerning what technologists produce to those concerning what they do and think as they design and produce. Problem-solving was simplified as a six step process: (1) define the problem, (2) reform the problem, (3) isolate solution, (4) implement plan, (5) restructure plan, and (6) synthesize solution. This process, or what was called the "technological method" in the Conceptual Framework, was supposedly adaptable to any form of technological content (Savage & Sterry, 1990). This shift echoed the emphases on design in the British technology curriculum. In fact, many educators argued that the proper referent for technology studies was design. Coinciding with the rise of information technology, processes as content allowed teachers to shift their preoccupations with specific software packages to the processes underlying the applications.

The turn towards systems and processes inspired teachers to focus on what was transferable despite the technology or software. In CAD, for instance, rather than concentrating on the commands of AutoCAD and associated skills, teachers began

Table 7. Intellectual processes of technologists (Wicklein & Rojewski, 1999)

1.	**Analyzing:** The process of identifying, isolating, taking apart, breakdown down, or performing similar actions for the purpose of setting forth or clarifying the basic components of a phenomenon, problem, opportunity, object, system, or point of view.
2.	**Communicating:** The process of conveying information (or ideas) from one source (sender) to another (receiver) through a media using various modes. (The modes may be oral, written, picture, symbols, or any combination of these.)
3.	**Computing:** The process of selecting and applying mathematical symbols, operations, and processes to describe, estimate, calculate, quantify, relate, and/or evaluate in the real or abstract numerical sense.
4.	**Contextualizing:** Understanding the social, cultural, organizational, etc. context for the task.
5.	Creating: The process of combining the basic components or ideas of phenomena, objects, events, systems, or points of view in a unique manner which will better satisfy a need, either for the individual or for the outside world.
6.	**Customer analysis:** The process of evaluating inputs of the receiver or technology.
7.	Defining problem(s): The process of stating or defining a problem which will enhance investigation leading to an optimal solution. It is transforming one state of affairs to another desired state.
8.	**Designing:** The process of conceiving, creating, investing, contriving, sketching, or planning by which some practical ends may be effected, or proposing a goal to meet the societal needs, desires, problems, or opportunities to do things better. Design is a cyclic or iterative process of continuous refinement or improvement.
9.	**Establishing need:** The process of determining the degree of need for the technological problem or solution.
10.	**Experimenting:** The process of determining the effects of something previously untried in order to test the validity of an hypothesis, to demonstrate a known (or unknown) truth, or to try out various factors relating to a particular phenomenon, problem, opportunity element, object, event, system, or point of view.

Table 7. continued

11.	**Innovating:** Taking existing "know-how" and being able to implement it in new situations.
12.	**Interpreting data:** The process of clarifying, evaluating, explaining, and translating to provide (or communicate) the meaning of particular data.
13.	**Managing:** The process of combining the basic components or ideas of phenomena, objects, events, systems, or points of view in a unique manner which will better satisfy a need, either for the individual or for the outside world.
14.	**Measuring:** The process of describing characteristics (by the use of numbers) of a phenomenon, problem, opportunity, element, object, event, system, or point of view in terms which are transferable. Measurements are made by direct or indirect means, are on relative or absolute scales, and are continuous or discontinuous.
15.	**Modeling:** The process of producing or reducing an act or condition to a generalized construct which may be presented graphically in the form of a sketch, diagram, or equation; presented physically in the form of a scale model or prototype; or described in the form of a written generalization.
16.	**Modeling and prototyping:** The process of forming, making, building, fabricating, creating, or combining parts to produce a scale model or prototype.
17.	**Monitoring data:** The process of collecting and recording data and time conditions related to problem occurrence.
18.	**Observing:** The process of interacting with the environment through one or more of the senses (seeing, hearing, touching, smelling, tasting). The senses are utilized to determine the characteristics of a phenomenon, problem, opportunity, element, object, event, system, or point of view. The observer's experiences, values, and associations may influence the results.
19.	**Predicting:** The process of prophesying or foretelling something in advance, anticipating the future on the basis of special knowledge.
20.	**Questioning and speculating:** The process of asking, interrogating, challenging, or seeking answers related to a phenomenon, problem, opportunity, element, object, event, system, or point of view.
21.	**Researching:** The process of becoming familiar with the background information necessary to investigate the problem. Knowing what type of information to look for and where to locate it.
22.	**Searching for solutions:** The process of examining multiple options when attempting to resolve technological problems.
23.	**Technology reviewing:** The process of evaluating the performance of a solution at an appropriate time in the future.
24.	**Testing:** The process of determining the workability of a model, component, system, product, or point of view in a real or simulated environment to obtain information for clarifying or modifying design specifications.
25.	**Transferring and transforming:** The process of transferring knowledge and skills across areas or fields to new situations.
26.	**Valuing:** The process of understanding the role of the technician's and other's values in deciding on courses of action.
27.	**Visualizing:** The process of perceiving a phenomenon, problem, opportunity, element, object, event, or system in the form of a mental image based on the experience of the perceiver. It includes an exercise of all the senses in establishing a valid mental analogy for the phenomena involved in a problem or opportunity.

to shift their efforts to processes of communication, visualization, representation, detailing, documentation, presentation, and modeling. In production, teachers moved from preoccupations with materials and machine-based skills to processes that cut across all material environments. The logic was that instead of the material environment dictating the material to be used, the nature of the problem to be solved ought to dictate. General lab facilities prevailed, where once a student grasped the process of cutting and shaping for instance, he or she could cut and shape virtually any material to the desired use. In addition to intellectual process of problem-solving, students would take away from the curriculum the general processes of production: bending, breaking, cutting, drilling, fitting, measuring, molding, shaping, etc. These processes turned on the more fundamental process of design.

Researchers note that the turn towards processes was generally defined by Harold Halfin in 1973. Halfin identified sixteen key intellectual processes used by designers and technologists. These processes include: operationally defining problems or opportunities; observing; analyzing; visualizing; computing; measuring; predicting; questioning and hypothesizing; interpreting data; constructing models; experimenting; testing; designing; modeling; creating; communicating; and managing. The challenge for technology teachers is one of creating activities to reinforce these processes. A process-based curriculum necessarily prioritizes process over content. Learning is not so much an issue of specific technical skills or content inasmuch as it is an issue of transferable processes. In the late 1990s, Halfin's 17 processes were expanded in the research of Wicklein and Rojewski (1999) to include a more comprehensive range of intellectual endeavors in technology (see Table 7).

Instead of expanding these intellectual processes, many design and technology educators merely focus on general technological processes. One trend is tending toward six general processes such as:

- Technology forecasting
- Creative problem-solving and design
- Research and experimentation or R&D
- Invention and innovation
- Enterprise and entrepreneurship
- Technology management
- Technology assessment

One problem of task analysis, system-based and process-based curriculum is that only certain essences tend to be identified as part of the task, system, or process. It became extremely difficult for technology educators to integrate ecological-natural, ethical-personal, existential-spiritual and socio-political content into activities and projects. Technical processes, rather than ecological, ethical, or political processes, systems and tasks dominated the curriculum. The shift back towards disciplinary content seems to resolve this dilemma by naming the ethical and political content to be studied at different levels. Another way of resolving this is to derive a curriculum from the imperatives of life in a technological world.

Universals of Technology?

Are there any universals of technology, that hold regardless of place or time? Are there universals that cut across all cultures? Anthropologists who study different cultures end up describing these cultures in an ethnocentric way. They project their own views of the world onto the cultures of interest. They see what they look for. So when they describe the cosmology of another culture, the anthropologists often group components of this cosmology into classifications that correspond to their own culture: economic, social, and technological systems for example. Similarly, it is easy to make historical assumptions that what holds now also held at all times in the past. In the anthropological instance we commit the fallacy of ethnocentrism and in the historical instance we commit a fallacy of presentism. There are differences as

Figure 7. Dimensions and content of technology

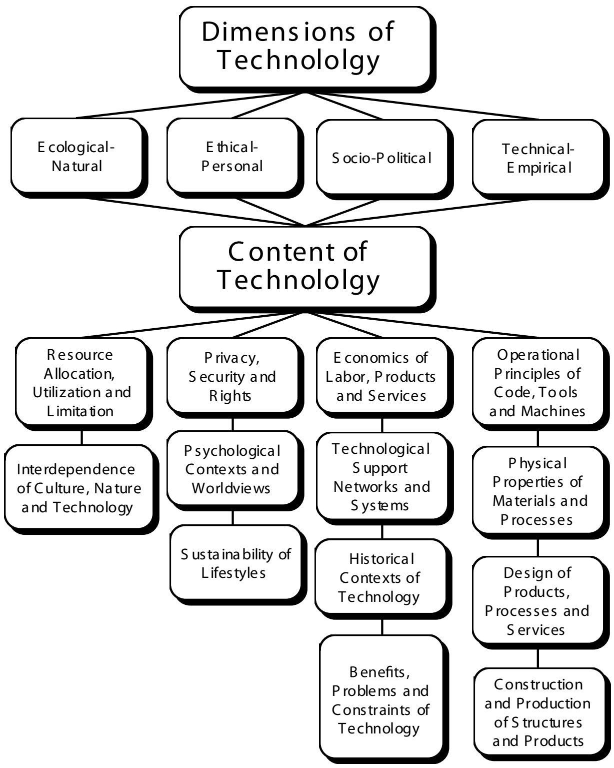


Table 8. Imperatives of technology content

Imperatives:

How can I do or make this? How was this made or done? What does this do, how does this work and how do I use it? How can I design this? How can this be fixed, maintained, or improved?

Key concepts:

Design	Design (architectural, biological, digital, engineering, graphic, interior, medical, product, urban); Principles and theory of aesthetics and function; Standards; Ideation, drawing, modeling and presentation; Animation; Experimentation and Testing; Order and planning; Cost estimate and comparison; Customization; User-centered design; Integrated and comprehensive anticipatory design; Visualization; Concurrent engineering; Product life cycle.
Materials, energy, information, process, and structure	Allocation, (re)manipulation, (re)utilization and limitation; Natural resources and synthetics; Generation and transformation of information and power; Physical, structural and aesthetic properties; Morphology; Waste reduction and removal; Media of expression; Dynamics and Statics; Material cause.
Tools and utensils, Instruments and machines	Use, efficiency and technique; Care and maintenance; Configuration and operational principles; Power and control; Quality control; Testing and Troubleshooting; Safety.
Human factors or ergonomics	Manual, mechanical and automated or cybernetic systems; Feedback; Affordance, constraint and mapping; Human-machine-artifact interface and symbiosis; Reverse engineering; prosthetics and Cyborgs; AI; Virtual reality.

Table 9.

Imperatives:

What and who was this for? Is this novel or necessary, and safe? What and whose resources were used to make this? What was the motive for making this?

Key concepts:

Subsistence, art, and utility	Survival; Luxury; Novelty; Fashion, style and taste; Minimalism; Subjectivism; Relativism; Expression and poetic license; Aesthetic and Utilitarian Judgment.
Consumerism	Consumer law and protection; Investigative media; Planned obsolescence; Marketing and hype; Human engineering; Manipulation of choice and need; Adulteration; Commodity.
Ecology	Perma-Culture; Industrial ecology; Conservation, development, scarcity, sustainability and waste; Accumulation; Pollution; Bioregionalism; Preservation and Restoration; Greenhouse effect; Green republic; Biodiversity; Biopiracy.
Consumption, convenience, capitalism, and commercialism	(Dis)information, product and labor markets; Price fixing and fluctuation; Enterprise and competition; Industrialism and urbanism; Cyberculture; Globalization.
Desire; cultural values, and identity	Symbolism; Semiotics, language and semantics; Static and Dynamic Quality.

Table 10. Creation of technology and conditions of labor

Imperatives:

Who made this? How was labor and work organized to make this? What were the conditions under which this was made?

Key concepts:

Artisanal knowledge, handicraft, and skill	Cognitive, emotional, and sensorimotor skill; Specialization; Standardization.
Occupations and conditions of labor	Division of labor; Sexual division of labor; Home, factory, office, sweatshop and open-air; Entrepreneurism; Batch and mass production; Interchangeable parts; Assembly line, mechanization and automation.
Organization of labor, technology, and work	Labor market; Job content and design; Skills and training; Economic sectors; Occupational health and safety; Discrimination and harassment; Power.
Management and unionism	Bureaucratic structure; Scientific management; Time, motion and fatigue; Total Quality; Participatory management; Labor relations.
Industry and labor	Distribution of work and income; Centralization; Productivity; Capital; Alienation; Exploitation and imperialism; Colonialism; Globalization.

Table 11.

Imperatives:

What was used before this? Who developed and who used this? What happened?

Key concepts:

Technological change	Technological evolution and cumulative change; Invention, development, innovation, diffusion; Social construction of technology; Social and cultural selection; Technoscience.
Historical continuity and social change	Serialization; Anecdote; Human agency and intentionality; Contingencies; Technological determinism; Autonomous technology; Dialectical materialism.
Interaction of technology, culture, and nature	Biodiversity; Extinction of species; Green house effect; CFCs and ozone layer; Interdependence of science, technology and nature; Technological system; Research laboratories; R&D; Intellectual property rights; Copyright, trademark and patent systems; Actor-network theory; Complexity and chaos theory; Commodification; Reification.
Technology, class, gender, race, and sexuality	Harassment; Sexism; Racism; Environmental racism; Masculinity; Sexual division of labor; Emotional labor; Reproductive labor; Patriarchy; Oppression.
Military- industrial-academic complex	Networks; Collectives; Cyborgs; Patent system; Science, technology and the military; Political Ecologies; Complicity; Concentration of Power; Secrecy; Intelligence; Propaganda; Militia; Weapons systems; Procurement; Terrorism; Military-Industrial Complex; Imperialism; Empire.

Table 12. Making, using, and working technology

Imperatives:

Is there a better way of making, using and working? What are the options?

Key concepts:

Praxiology and mechanology	Economization of energy, time, materials, terrain and apparatus; Precision; Efficiency; Functionality; Durability; Speed; Skill; Ingenuity; Method; Working plans; Engineering Sciences (Statics and Dynamics).
Technophilosophy	Functionalism; Technocracy; Biomorphic and organic design; Bauhaus, Dymaxion (Buckminster Fuller) and Usonian (Frank Lloyd Wright); Utopianism; Science Fiction.
Forecasting and assessment	Input-output; Cost-benefit; Systems analysis; Trend extrapolation; Dynamic modeling; Hazard; Risk; Higher order consequence; Technological forecasting; Technology assessment; Disclosive analysis.
Appropriate or intermediate technology	Polytechnics and monotechnics; Anatechnology and catatechnology; Local knowledge; Decentralization; Technology transfer.
Cyberculture	Cybernetics; Networks; Collectives; Cyborgs; Cyberspace; Cyberpunk fiction; Virtual reality; Cyborg democracy.
Philosophies and theories of work and technology	Workplace democracy and profit sharing; Technology Bill of Rights; Technological "progress"; Neo-Luddism; Feminist technology; Democratic and autocratic technology; Civilizing, democratizing or humanizing technology; Constructive technology assessment; Distributive justice and wealth; Marxism; Frankfurt School; Hybridity; Human Rights.

well as commonalties across cultures and time. The challenge is to remain sensitive to both while refraining from asserting that dimensions or systems of technology are universal. The content or content organizers of any discipline or subject are not universal. They are contingent on a culture at particular points in time. In technology, there are no universal dimensions or systems. There are, however, dimensions and systems that gain a consensus at points in time (Figure 7).

This book asserts that at this point in time, the ecological-natural, ethical-personal, existential-spiritual, socio-political and technical-empirical dimensions of technology are the most effective to use in C&I. The alternative organization of content provided in the previous section was derived from these dimensions

Imperatives of Technology Content

In the disciplinary organizations of technology created in the 1960s, content was organized around economic sectors of technology (e.g., communication, produc-

Table 13. Change and technology

Imperatives:

What will help me to change how things are made and used, and who participates in technology? Who's in Charge?

Key concepts:

Critical regard and activism	How things work; Do-it-yourself; Access to information; Community Initiative; Act locally--think globally.
Grass roots and regulatory action	Science, Technology and Workplace Policy; Environmental and social policy; Investigative initiative and media.
Quality of Life	Human rights; Dignity of work.
Feminist and multicultural critiques	Access; Equity; Equal pay for equal work; Glass ceiling; Emotional labor; Cyberfeminism; Performativity; Postcolonialism; Gender studies; Globalization.
Cyborg agency	Monkey wrenching; Short circuiting; Culture Jamming; Machine ontology; Resistance.

Table 14. Lifestyle and technology

Imperatives:

Where do I begin with my lifestyle?

Key concepts:

Simplicity, modesty, and frugality	Sustainability.
Rights	"Natural" rights; Constitutional rights; Animal rights; Human rights; Disability rights; Gay and lesbian rights; Aboriginal rights; Environmental rights; Ontology; Majoritarian and Minoritarian rights; Limits; Privilege; Intellectual Property.
Vision	(Re)enchantment of nature and technology; Spirituality.
Artistic expression and political statement	Modernism; Realism; Dada and Futurist movement; Bauhaus; Performance.
Activism	Politics.
Ethical standards and moral strength	Prudence; Virtue; Whistle-blowing; Sensibility, Dignity and Compassion; Ethics and morality.

tion). In the most recent disciplinary organization in the standards project, content is organized around conceptual branches of technology (i.e., information, physical, biochemical) and technological processes (e.g., design, developing, utilizing and managing systems, assessing consequences). Alternatively, the content of technology can be organized around the imperatives of technology (i.e., cultural, ecological, ethical, practical, etc.). The structure that follows organizes content around imperatives in a general order from practical, cultural, economic, psychological and social imperatives to ethical imperatives (Petrina, 1998). This alternative organization of content in technology studies moves from the problem of how things work to the problems of how things work for some but not others and who's in charge?

The organization begins with what is often an innocent query of children and adults: How can I make this? The premise is that, eventually, through sustained questioning, practice, and study, students will develop more meaningful and complex understandings of technology, and toward the ends of the technology curriculum—critical technological sensibility and political action or literacy and capability. This outline derives content from four interdisciplines of technology studies (design, practice, studies, and criticism). In the elementary grades, the lower tiers of the organization of content would dominate and determine the curriculum. The middle years and high school curriculum would take on the middle and upper tiers of the outline. The outline goes well beyond the schools however, and continues through to adulthood, where we come to terms with the sociology and philosophy of technology and the active pursuit of ethical justice in technology.

Projection and Reflective Practice

This chapter and the last made the case that the content of technology studies is the primary justification for including the subject in the schools. This chapter began by acknowledging that there are three general sources of content: individuals, culture, and nature. Technology studies has drawn from all three of these sources but the trend is toward cultural sources, namely disciplinary content of technology. The trend is toward an inclusive discipline and technological pluralism. The ISTE's and ITEA's technology standards projects represent the latest attempt to develop consistent disciplinary content and standards for technology studies. A vast majority of technology educators feel that the standards projects are timely endeavors. In most cases during the last century, there was little consistency among schools and across provinces and states. Technology teachers had the liberty to teach whatever they wanted. There was little, if any, accountability. Content and standards derived from a coherent discipline are signs of maturity in technology studies. Without consistency and accountability, technology studies has little chance of becoming a subject required of all students, K-12. In this chapter, we also elaborated on conceptual analysis and task analysis, two methods used for deriving content. We addressed the challenges of processes as content models of curriculum, which represent attempts to merge conceptual and task analysis. In this chapter, the emphasis was on the question "what should be learned?" This next chapter focuses on the question "how should it be organized for teaching?" Both chapters provide an introduction to curriculum design and theory.

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