# Pennsylvania Technology Education


## K-12 Program Rationale and Guide

TEAP

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## Introduction

The Technology Education K-12 Program Rationale and Guide for Pennsylvania was developed to provide a rationale and an educational model for technology education programs in the Commonwealth. It reflects both the *Pennsylvania Academic Standards for Science and Technology* and the national *Standards for Technological Literacy: Content for the Study of Technology*. This guide is intended to assist in the process of developing as well as improving a technology education curriculum. It emphasizes well-established principles of curriculum development and assessment and applies them specifically to technology as a content area. This guide provides a viable strategy for implementing Technology Education, K-12. The courses, course sequence and activities are offered as examples and recommended solutions. The challenge is to use this guide to apply the principles of good curriculum development to the field of technology education and to create the best possible experience for students. This will require even experienced teachers to reevaluate the curriculum presently in use. It is important to remember that delivering good curriculum in technology education is a process that requires continuing work; we never "arrive." If we share this journey with our students they may learn to emulate a teacher who practices lifelong learning.


"Integrating Mathematics and Science through Technology Education"

## Technological Literacy For All

We use technology to change and adapt to our surroundings. Countless marvels have been created using technology, although we have also learned that not all of the changes have a positive effect. Controlling technology requires that we use it carefully; understanding how to balance the positive and negative effects of the change we create. Early applications of technology addressed basic human needs. For example, using a spear to hunt for food and basic structures for shelter. During the past few centuries, changes created by humans using technology have accelerated quickly. Steam power removed the limitations of human or animal muscle and fueled the Industrial Revolution. We have learned to manipulate the atom in order to release tremendous energy. Controlling the electron has given us amazing abilities to manage and manipulate information, spawning a new age of communication. In the last half of this century the pace of change has been confusing. Are we in the atomic revolution, the electronics revolution, or the information revolution? The dizzying answer is "yes" to all these questions.

> Technological literacy involves the ability to understand, use, manage, and assess technology
> (Standards for Technological Literacy, 2000).

With an increasingly sophisticated understanding of genetics we are beginning to manipulate life itself. We are on the verge of incredible power to create change. But are we wise enough to control it? We must remember that with power comes responsibility. Thomas Jefferson believed that those who would seize the right to self-government had a responsibility to educate themselves. He did not believe that a few well-educated people should control the nation, but rather the entire population should be prepared to participate in the process of government. Such participation required a widely educated populace, Jefferson reasoned.

Certainly, a similar responsibility exists in regard to technology. We have a responsibility to help our society understand technology in a way that will allow us to use it wisely. Making decisions about technology is not the job of a few well-educated individuals; it falls to all of us. A basic level of technological literacy is a necessity for all citizens. Of course, high levels of technological ability will reside with the experts. Some of the students who study technology will discover a real aptitude; nurturing this aptitude is an important role of technology education. Technological literacy cannot be developed solely in a single curricular area. Consequently, while this guide focuses on the contribution of the technology education programs it is important to note that the experiences in technology education and other disciplines are, or should be, mutually reinforcing.

All citizens need a basic level of technological literacy, because one important benefit of living in the United States is that all of us have a voice in decision-making. Many decisions have technological implications. As such, technological literacy is important for all students, even those who will not go into technological careers. Because technology is such an important force in our economy, everyone can benefit by being familiar with it. At the individual level, technological literacy helps consumers better assess products and make informed buying decisions because it provides the ability to help make informed, unemotional, and balanced responses. The study of technology should involve interdisciplinary approaches.

Technological literacy clearly is a valuable trait for all students and must permeate the entire school curriculum; it cannot be developed solely in a single curricular area. This guide focuses on the contributions that technology education programs can make toward technological literacy. It is important to note that significant contributions from other disciplines are not only mutually reinforcing but also are required to achieve technological literacy.

## Technology Standards

Within the past decade, the educational community has undergone major changes in its view of curriculum, instruction, standards, and assessment. One significant shift is the move toward educational standards. The Pennsylvania Department of Education has prepared Academic Standards for Science and Technology that will apply to all students in kindergarten through twelfth grade. Nationally, the International Technology Education Association has completed standards specifically for technology education. Both the Pennsylvania and national documents are briefly described below.

**Pennsylvania Academic Standards for Science and Technology**

Following the direction of many national associations and other states, Pennsylvania is developing standards for all academic areas. Although many disciplines appear separately as their own set of standards, the fields of science and technology are combined. The science and technology standards contain nine different areas. The most significant ones for technology education are entitled "Technology," "Technological Devices," "Inquiry and Design," "Unifying Themes," and "Science, Technology, and Human Endeavors." These standards "describe what students should know and be able to do at four grade levels (fourth, seventh, tenth, and twelfth)" (Pennsylvania Department of Education, 2000). They reflect the increasing levels of complexity and sophistication that students are expected to achieve in science and technology as they progress through school. It is important for the technology education teacher to realize that these standards, unlike ITEA's Standards For Technological Literacy, are not voluntary. School districts are required to comply with them. Copies of the proposed standards may be downloaded from Pennsylvania Department of Education's web site: http://www.pde.psu.edu/standard/science.pdf

## 'KEY' Pennsylvania Standards Related To Technology - Grade 12

**3.1.12. Unifying Themes**

A. Apply concepts of systems, subsystems, feedback & control to solve complex technological problems

B. Describe concepts of models as a way to predict and understand science and technology

C. Evaluate change in nature, physical systems, and man-made systems

**3.2.12. Inquiry and Design**

A. Evaluate the nature of scientific and technological knowledge

B. Analyze and use the technological design process to solve problems

**3.6.12 Technology**

A. Analyze biotechnologies that relate to propagating, growing, maintaining, adapting, treating, and converting

B. Analyze knowledge of information technologies of processes encoding, transmitting, receiving, storing, retrieving, and decoding

C. Analyze physical technologies of structural design, analysis and engineering, personnel relations, financial affairs, structural production, marketing, research, and design to real world problems

**3.7.12 Technological Devices**

A. Apply advanced tools, materials, and techniques to answer complex questions

B. Evaluate appropriate instruments and apparatus to accurately measure material and processes

C. Evaluate computer operations and concepts as to their effectiveness to solve specific problems

D. Evaluate the effectiveness of computer software to solve specific problems

E. Assess the effectiveness of computer communication systems

**3.8.12 Science Technology and Human Endeavors**

A. Synthesize and evaluate the interactions and constraints of science and technology on society

B. Apply the use of ingenuity and technological resources to solve societal needs and improve quality of life

C. Evaluate the consequences and impacts of scientific and technological solutions

**Technology for All Americans (TFAA)**

Like many other national and international organizations in education, the International Technology Education Association (ITEA) has developed content standards. The basic premise behind the Technology for All Americans Project was to give a new vision for the study of technology at the national level. National Standards For Technological Literacy, released in 2000, defines both the knowledge base and processes for the study of technology. Along with the standards, the document "discusses the power and the promise of technology and need for technological literacy" (ITEA, 1996). These content standards are organized around five broad areas of study: The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World. The National Science Foundation and the National Aeronautics and Space Administration jointly funded this project. TFAA can be found at: http://www.iteawww.org

## Standards for Technological Literacy (ITEA)

**The Nature of Technology**

**Standard 1:** Students will develop an understanding of the characteristics and scope of technology.

**Standard 2:** Students will develop an understanding of the core concepts of technology.

**Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

**Technology and Society**

**Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology.

**Standard 5:** Students will develop an understanding of the effects of technology on the environment.

**Standard 6:** Students will develop an understanding of society's role in the development/use of technology.

**Standard 7:** Students will develop an understanding of the influence of technology on history.

**Design**

**Standard 8:** Students will develop an understanding of the attributes of design.

**Standard 9:** Students will develop an understanding of engineering design.

**Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

**Abilities of a Technological World**

**Standard 11:** Students will develop abilities to apply the design process.

**Standard 12:** Students will develop abilities to use and maintain technological products and systems.

**Standard 13:** Students will develop abilities to assess the impact of products and systems.

**The Designed World**

**Standard 14:** Students will develop an understanding of and be able to select and use medical technologies.

**Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

**Standard 16:** Students will develop an understanding of and be able to select/use energy-power technologies.

**Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies.

**Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies.

**Standard 19:** Students will develop an understanding of and be able to select/use manufacturing technologies.

**Standard 20:** Students will develop an understanding of and be able to select/use construction technologies.

## Curriculum Content Sequence - PA

*(Sample Recommended Model)*

| | | | | |
|---|---|---|---|---|
| *Elementary Gr. K-5* | ***Design and Technology Education (Integrated into the Elementary Curriculum)*** | | | |
| *Middle Level Gr. 6-8* | ***Exploring Technology Course*** | ***Applying Technology Course*** | ***Creating Technology Course*** | ***Required*** |
| *High School Foundations Gr. 9* | ***Technological Design and Systems*** | | | ***Required*** |
| *High School Electives Gr. 9-12* | ***Design and Problem-Solving Electives*** | | | ***Elective*** |
| | ***and/or*** | | | |
| *High School Capstone Gr. 11-12* | ***Innovation**** | | | |

****Required if no electives taken in grades 9-12***

## Sample Technology Education Program Framework K-12

The primary purpose of technology education is to provide technological literacy. Technological literacy is a basic citizenship skill that is required of all students. In Pennsylvania, the Academic Standards for Science and Technology will define the minimum level of technological literacy. The variety and level of these standards require a series of activities articulated throughout the K-12 schooling experience. To properly develop into a technologically literate individual, students should experience numerous and varied technological activities with real world contexts and should be exposed to the widest possible range of technological careers.

The TEAP K-12 Program Rationale and Guide course sequence is designed specifically to assist technology teachers address the *PA Academic Standards for Science and Technology* as well as to align with the national *Content Standards for Technological Literacy*. In kindergarten through fifth grade an introduction to technological literacy can be accomplished through activities integrated into the regular curriculum. The certified technology education teacher can meet with students or may serve as a "consultant/facilitator" or guide for the regular elementary teachers as they make technology education a part of the curriculum. TEAP recommends a design and technology approach to technology education at the elementary level. Three courses at the middle school level (*Exploring Technology, Creating Technology, and Applying Technology*) follow this elementary experience. At a minimum, the profession recommends that two high school technology courses are necessary to meet the requirements of the proposed

Pennsylvania Academic Standards for Science and Technology. A *Technological Design and Systems* course should occur in ninth or tenth grades. Following this course, students in grades nine through twelve can elect to take technology education courses that will further develop their technological literacy and help them make decisions about potential careers or future schooling. Each of these elective courses must use a design and problem solving methodology and be designed to address state and national standards. An alternative to offering a series of required electives is to require that all students take a capstone course called *Innovation* at the eleventh or twelfth grade level.

**Elementary School (grades K to 5)**

The TEAP Elementary Design and Technology Guide is available at http://www.teap-online.org/guide.html

Elementary Design and Technology is the application of knowledge, creativity, and resources to solve real world problems and extend human potential. An important foundation of technological content is delivered at this level. Design and technology at the K-5 level provides students the opportunity to become technologically aware of the society around them. The delivery of design and technology in grades 4-5 provides the basis for integrating learning across all disciplines while applying technological concepts. Design and technology education offers elementary educators a project-centered, student-centered, inquiry-driven pathway to deliver and reinforce other content areas (e.g. science, math, history and language).

**Middle School (grades 6 to 8)**

The TEAP Middle Level Guide is available at http://www.teap-online.org/guide.html At the middle level three technology courses are required to meet the proposed Pennsylvania standards. **Each of these locally planned comprehensive courses (as recommended below) should be a minimum of approximately 90 contact hours in length.** Additional time may be necessary to adequately provide the opportunity for all children to learn and do technology and meet the PA Science and Technology Standards.

*Exploring Technology (Grade 6)*

Exploring Technology is an activity-based course that introduces students to technology by examining the basic systems of communication, manufacturing, construction, transportation and bio-related technologies. Students will study the evolution of technology, invention and innovation, impacts of technology, the systems approach, and various problem-solving methods.

*Applying Technology (Grade 7)*

Applying Technology is an activity-based course that focuses on the application of the tools, materials, and processes of physical, information, and biotechnology systems. Students will study the ways materials, energy, and information are processed to transmit information, build structures, make products, move passengers and freight, and alter & affect living organisms.

Student working on fabrication of Hovercraft directional unit. (Warwick School District)

*Creating Technology (Grade 8)*

Exploring and Applying Technology courses provides the foundation for Creating Technology. This component comprises designing and developing real-word solutions to technological problems and challenges. This could include project-centered and service-learning components. A sample of this activity-based course can be one in which students form an enterprise (company). Students participate in the organization and management of the enterprise; select and engineer a product; raise money; hire employees; engineer a production line; produce, advertise, and sell the product; and distribute profits. Students play the roles of a variety of different careers and solve real design, engineering, production, and economic problems.

The Benchmark Data Sheet (found in Appendix "C") provides a sample to assist local school districts in developing technology education curriculum that identifies the Pennsylvania State Standards being addressed, as well as the form(s) of assessment to be utilized.

**High School (Grades 9 to 12)**

Technology education at the high school level provides a foundation for understanding, using, assessing, and managing technology through a broad variety of real-world contexts designed to integrate academic learning in grades 9-12. In addition, there are various opportunities designed within the high school technology education offerings to fit the unique needs of a diverse student population. For students to achieve technological literacy as they complete their secondary education, it is essential that they successfully complete a minimum of two courses. One should be Technological Design and Systems, and the other should be one of the elective technological studies courses or a single Innovation Technology course. **Each of these locally planned comprehensive courses (as recommended below) should be a minimum of approximately 90 contact hours in length.** Additional time may be necessary to adequately provide the opportunity for all children to learn and do technology and meet the PA Science and Technology Standards.

Students present their solution to a design challenge.

Pennsylvania standards identify three areas: physical systems, information systems and biotechnological systems. These three categories are further divided in the National *Standards for Technological Literacy* under the heading “Designed World.” These include: construction technologies, manufacturing technologies, transportation technologies, energy and power technologies, medical technologies, agricultural and related biotechnologies, and information and communication.

*Technological Design and Systems (Grade 9/10 – Foundation for Early High School)*

The “Technological Design and Systems” course is the initial high school level course offering recommended for all students to address the (Grade 10 benchmarks) Pennsylvania Science and Technology Standards. This course provides a sound base in technological understanding that allows students to successfully progress and become technologically literate. The areas of information technology, physical technology, and biotechnology are integrated into a hands-on and minds-on problem-solving design course. Teamwork is also stressed in this course as students work cooperatively when solving the design problems. This and all courses are organized into 5 major categories:

**1. Nature of Technology**

**2. Technology and Society**

**3. Design**

**4. Abilities for a Technological World**

**5. The Designed World**

(Content for the Study of Technology)

*Design and Problem Solving Elective Courses (Grades 9-12)*

After students complete this initial course, the high school technology education sequence offers unique elective courses to meet individual needs within a diverse student population. It is recommended that all students with an interest in technology take one or more courses from these areas. This will allow all students to learn about careers in technology, develop more advanced problem solving skills, and increase their level of technological literacy.

The elective high school categories provide a foundation for students to develop a broad perspective of technology and ultimately will increase overall citizenship skills. The chart given below is a sampling of course titles that schools could offer for students in grades 9 through 12 after taking the “Technological Design and Systems” to further technological literacy. ( Note: The chart does not comprise an exhaustive choice of possible course offerings.)

*Innovation (Grade 11 or 12 – Capstone/Advanced Placement High School Course)*

The final course is entitled “**Innovation**.” This is a capstone course that all students should take during eleventh or twelfth grade in order to address the final level of the PA Science and Technology Standards. Innovation can be taught as a one-semester technology course. Whenever possible it is recommended that this course be taught as a one-year course which integrates tech-

## Relationship Of Pennsylvania And National Technology Education Standards With Possible Courses

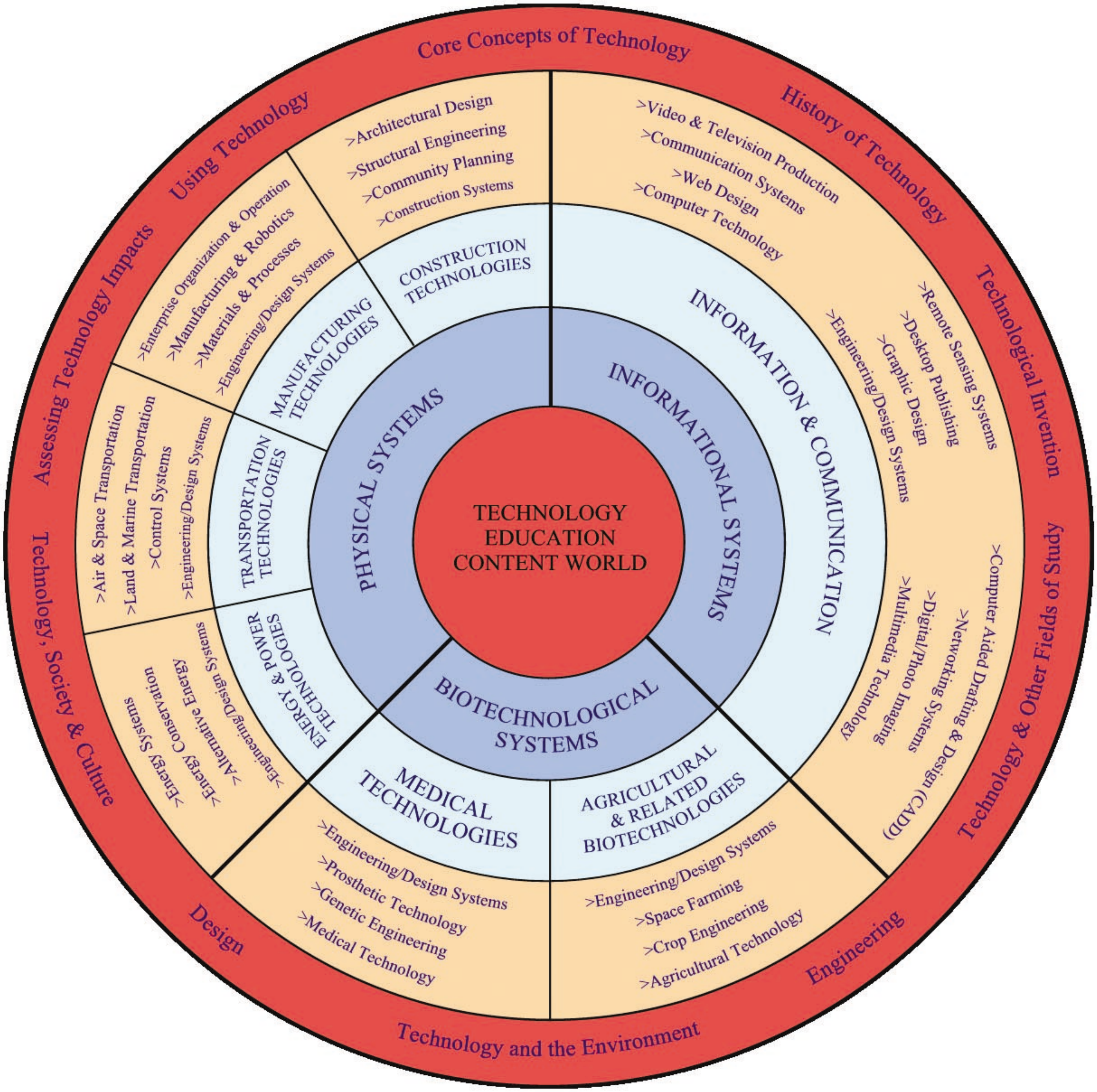



**Figure 1. Relationship of Pennsylvania and National Technology Education Standards with Possible Courses.**

- (Blue) Technology content organizers as defined by the Pennsylvania Science & Technology Standards.
- (Light blue) Technology content organizers as defined by the national Standards for Technological Literacy produced by the International Technology Education Association.
- (Tan) A sampling of elective courses in technology education at the high school level. This list is not intended to be interpreted as a comprehensive listing of all technology education courses offered at the high school level.
- (Red) Technological Topic Areas.

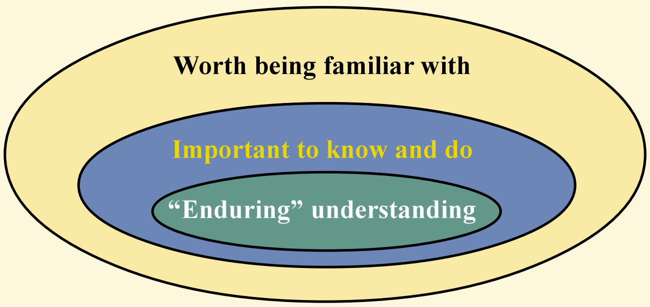
nology and science. This course allows students to use their technological and scientific expertise to seek out and solve technological, societal or environmental challenges in the school or community around them. It will be necessary for students in this course to work cooperatively since members of the class may have expertise in only one of the technological competence courses. This course provides the ability to meet the PA Science and Technology standards.

## Creating Technology Education Curriculum

What makes a good technology curriculum? What separates a technology program from an industrial arts program? Is it really worth making the change since technology changes so quickly? What do students really need to 'know and be able to do' in a technology education curriculum? How can standards be used to improve curriculum and instruction? What content is unique to technology education?

Asking these questions can help to begin the development of a standards-based curriculum. This program guide does not contain all the answers but does provide a starting point. The first step is to design a scope and sequence of courses that will meet national and state standards for technology education. This will require that standards be addressed through the courses selected and that goals and objectives are selected for each course. Then, each individual course can be developed. Established practice in curriculum development is to start at the end by identifying what results are required and working back toward individual lessons and activities. The book Understanding by Design by Grant Wiggins and Jay McTighe is an excellent synthesis of years of experience in developing curriculum, lessons, activities, assignments, and assessment methods. It will be used here as a guide for the development of technology education curriculum. Wiggins and McTighe espouse a "backward design process." They identify three stages in the backward design process:

1. **Identify desired results**
2. **Determine acceptable evidence**
3. **Plan learning experiences and instruction**




***Establishing Curriculum Priorities***

**Developing Curriculum and Instructional Activities**

How can the knowledge and processes of technology be synthesized into a meaningful technology education activity? Because there is so much to learn about technology, every activity should result in essential knowledge and skills. Each activity should develop important skills in research and development, application of scientific and technological principles, balance of constraints, and communication of results. At the same time there are important concepts involving transportation, environmental impacts, structures, and strength of materials that could be addressed.

National, state and local standards should guide the process of identifying what students should know, understand, and be able to do. Considering these standards will help prevent the curriculum from becoming narrow and unstructured. Studying national or state standards can, however, result in a feeling of being overwhelmed by the huge job of addressing all the standards. Wiggins and McTighe offer a practical guide to the process of establishing curriculum priorities. An explanation of the illustration about the three nested rings will provide some additional help.

*Identifying desired results.*

Too frequently curriculum is designed around everything that might be known about a particular field. The largest ring represents this approach. In a traditional "materials and prototyping lab," the entire focus naturally might be wood and the construction of wooden products. Inside the largest ring are knowledge and skills worth being familiar with; in-depth and complete knowledge is not required here. The "important to know and do" ring represents the knowledge and ability which is essential to mastery of the subject. Enduring understandings are the true core of the subject. As the title suggests, this is what students should understand and be able to do long after the course is completed. Unfortunately, the work of narrowing down standards to focus on enduring understandings is far more difficult than the work of simply identifying everything that is worth knowing about a subject.

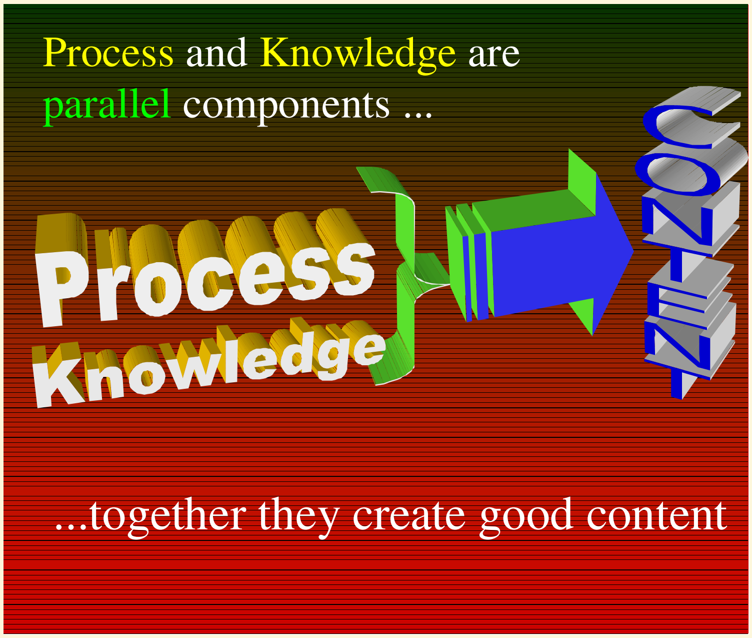
*Determining acceptable evidence.*

A range of assessment techniques should be used to collect evidence that students have the knowledge and ability identified in the first stage. Assessment techniques should be matched with the level of understanding required. Wiggins and McTighe explain that traditional quiz or test questions can work well to assess the shallow but broad knowledge appropriate to the "worth being familiar with" category. "Enduring understanding" might be better assessed using a performance task or project.

*Planning learning experiences and instruction (including the thought behind appropriate assessments)***.**

Lessons, projects, resources, and other essentials to the learning experience can only be identified after a clear definition of how the learning will be assessed is established. In turn, the assessments can only be identified after learning goals are clearly identified. Wiggins and McTighe identify a series of five questions that guide the process of planning learning experiences:

a. Which enabling knowledge (facts, concepts, and principles) and skills (processes) will students need to perform effectively and achieve the desired results?
b. What activities will equip students with the needed knowledge and skills?
c. What will need to be taught and coached, and how should it best be taught in light of learning goals?
d. What materials and resources are best suited to accomplish these goals?
e. Is the overall design coherent and effective?




**Content: Knowledge and Process Combined in an Activity-Oriented Lab Experience**

It is important for technology educators to have a proper understanding of both knowledge and process as they relate to a technological activity. The content of a discipline refers to the information and skills that are to be learned and developed by students.

The Technology for All Americans Project identified content standards for technological literacy. Content standards "specify what all students should know and be able to do in technology and represent the knowledge and processes essential to technology that should be taught and learned in school" (ITEA, 1998, p. 18). According to ITEA, the essential knowledge includes the following broad categories: the nature and history of technology, technological concepts, and principles and linkages. Essential processes include the following operations on technological systems: designing and developing, determining and controlling the behavior of, utilizing, assessing the impacts and consequences of. As discussed earlier, one process students should repeatedly be involved in is the application of the technological method to solve technological problems.

Technology is the process humans use to innovate. The only way to truly understand technology is to be actively involved in it. Therefore, the study of technology should involve activities that represent the wide range of actions involved in innovation. This process engages both the minds and the hands of the learner. Activities should engage learners in technological processes and use and build upon technological knowledge. While activities are an essential ingredient in studying technology, they should never be the driving forces behind the curriculum. Activities must be designed to deliver technological knowledge in a way that engages students in the process of technology. An important problem with some technology education learning activities is that the activity was allowed to determine what technological knowledge and process would apply; this is the reverse of how curriculum should be created. When activities are allowed to dictate knowledge and process an incoherent curriculum is the inevitable result.

**Abilities for a Technological World**

Applying the design process, using and maintaining technological products and systems, and assessing the impacts of products and systems are the essential abilities every learner needs to be successful in our technological world. Each learning experience in the study of technology should involve these abilities.

**Components of a Good Technology Education Activity**

What makes an activity a technology education activity? Technology education is a unique area of study in every student's educational experience and therefore the aspects that are found in a technology activity are somewhat different from that found in other academic areas. In 2000, researcher Dan Engstrom, identified ten items that were rated as essential for a technology activity. These items were consistent with the Standards for Technological Literacy and Pennsylvania Science and Technology Standards. Each of these ten ranked items are more fully described below.

> **Abilities for a Technological world**
>
> Students will:
>
> - Apply the design process,
> - Use and maintain technological products and systems, and
> - Assess the impacts of products and systems.

1. Safely use tools and machines. Safety is a real concern whenever working with any type of tool or material. Students must realize that if tools are not used with care and respect, serious injury or illness can result. Additionally, some materials or by-products of processing are poisonous and can cause illnesses that may not appear for years. Learners need instruction on the proper use of tools and machines, and they should demonstration their understanding.
2. Consider various solutions. Students should realize that it is important to design various potential solutions when solving a technological problem. By brainstorming, students are able to generate a variety of potential solutions to solve the problem. This strategy stimulates student thinking. Many times the final solution is the result of combining several ideas into one. Harmin (1994) indicates that this technique allows students to "think open-mindedly about a topic and generate a written [or sketched] list of possibilities without worrying whether any possibility is reasonable" (p. 167). Henak (1988) corroborates this statement and adds brainstorming is appropriate for problem solving activities and allows students to think freely and express their ideas.
3. Test and evaluate the solution. Technology has planned and unplanned, expected and unexpected, and delayed and immediate consequences. By testing and evaluating the final product, students should be able to determine what some of these potential consequences are and possibly improve their product. Hill (1998) stated that testing was "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" (p. 34). Testing and evaluating is important to determine if the initial problem has actually been solved according to the standards established.
4. Design a solution to the problem. The problem to be solved is sometimes given as part of a design brief statement. It gives the students enough detail and information to get them started investigating the problem. It also identifies what the solution must do and what limitations are put on the solution (Ritz & Deal, 1993; Engstrom, 1999). When designing a solution, students move away from simply building predetermined projects to understanding and applying design principles such as ergonomics, sketching, aesthetics, the problem solving process, and collaboration to create solutions to technological challenges. Design is a turnkey component of the national technology standards.

5. Integrate information from other academic studies. In the “real-world,” mathematics, science, language arts, social sciences, technology, and other content areas are not segmented; rather, they are fluid. As students learn information from other subjects, they should be able to connect that learning to content in the field of technology. There continues to be an increasing gap between the world of schooling and the world of work from the early schooling years into the college experience. Frost and Pierson (1998) found that “Many students walk through a series of core curriculum courses without perceiving their interrelatedness. Students have little motivation to connect what they learn elsewhere, and students graduate with little sense of how to identify problems – much less solve them” (p. 38). At the secondary schooling level, many authors have indicated the need to link technology education to the other schooling subjects. Technology education provides opportunities to develop “contextual relationships with other fields of study such as science, mathematics, social studies, language arts, the humanities, and society and the environment” (ITEA, 1996, p. 38).
6. Build a solution to the problem. Solving a technological problem involves making a new product, service, or system. In order for students to create solutions, they must be actively involved in using tools and machines to form materials into viable products. This may involve using a variety of tools and machines while using different materials and processes. Unlike science, which is concerned with inquiry and the understanding of natural occurrences, technology involves innovation and the construction of products, services, and/or systems. The design/problem solving approach utilizes a design brief to deliver an activity since “students at any age or ability level can create [emphasis added] solutions to technological problems through a design process” (Engstrom, 1999).
7. Receive formative and summative feedback from the teacher. Students and teachers need to know the skills and knowledge that have been achieved as well as the level of competency. During an activity and at its completion, students should review their work habits and processes to determine how they could be improved. Feedback involves having students examine their work habits and progress, determine if the final result matches the desired result, and test and evaluate the solution. Levande (1999) indicated that this type of feedback highlights the strengths and weaknesses of the solution and provides information about meeting the standard benchmarks in the activity. Reading the student’s log, having an interview with the student, or conducting teacher observations are examples of formative assessment. Summative assessment occurs at the completion of the activity and is especially important as students begin to self-assess it and their work.
8. Make sketches and drawings of potential solutions. This type of skill is important for students to learn as they become more involved in the many facets of technology, such as engineering and design. As ideas are thought of, students document them by creating sketches. This technique used to document ideas can be done in conjunction with brainstorming and as part of a student’s portfolio or journal. Sketching and drawing is a form of a language that allows individuals to document, visualize, refine, and communicate their ideas without using words (Hutchinson & Karsnitz, 1994). Although not everyone will be able to create artistic renderings by sketching, all people can learn to sketch and thereby communicate their ideas at some level.
9. Utilize a design or problem-solving model. This is one of the foundational aspects of technology education. Although other academic subjects advocate problem solving, they usually refer to it in different contexts than technology education. Mathematical problem solving involves solving the computational aspect of a real-world problem that has students investigate questions, tasks, and situations according to the suggestions a teacher gives. It also differs from scientific problem solving, sometimes called scientific inquiry, where methods of inquiry, observation of natural phenomenon, the scientific method, and a focus on knowing are paramount. In Technology Education, problem solving involves having the students create a solution to a technologically-related problem. By allowing students to apply problem-solving techniques to real problems, they are able to see application for the content that is being learned. Emphasis on

designing solutions to problems in the real world, applying problem-solving strategies, and a focus on "doing" characterize technological problem solving. Problem solving is characterized by students considering various solutions, designing a solution to the problem, and utilizing a design or problem-solving model.

10. Assess the impacts and consequences of technology. "Students should view technology as neither intrinsically good nor evil, but realize that trade-offs must be made when considering whether and how to apply technology" (McCade & Weymer, 1996, p. 42). Impact consideration accounts for how the solution may impact the world in which we live. This aspect of the activity should be considered as the problem begins. Students need to be engaged in "an act of appraising the value of a technological innovation or invention as to its worth to society as well as incorporating the social, economic, and environmental impacts that it may have" (Ritz & Swail, 1994, p. 53). Many of the impacts of technology, whether positive or negative, may not be seen for years to come. Students should realize the importance of assessing risk, and if necessary, take appropriate steps to control the potential for loss.

**Creating Design Briefs**

Students at any age or ability level can create solutions to technological problems through a design process. As they move through this process some tasks they will undertake include identifying, investigating, brainstorming, prototyping, making, testing, evaluating, and presenting a practical design solution. Students continue through this design process until the developed solution meets the problem criteria. The student may revert to a previous task several times to gather more information or to undertake another proposed solution. Throughout this process, students are challenged to seek solutions to problems that have a relationship to the world around them. The solution is usually not apparent at the beginning of the design process to either the teacher or student. According to Raizen, Sellwood, Todd & Vickers (1995) "The goal [of design briefs] is for students to invent and use their knowledge to design technological solutions, not to copy pre-designed ones from books or instruction sheets" (p. 105). The key is that students can observe the world in which they live, recognize technological problems, design and construct appropriate solutions, and evaluate those solutions. When writing effective design briefs, five important components should be included.

1. Identify a realistic technological problem. Design brief problems range from selling a product to inventing a child safety proofing mechanism. The more realistic the problem the greater its relevancy to students. Problems presented from a local business, industry, or school are realistic and practical and, therefore, should be sought. This component of the design brief specifies what needs to be accomplished without providing precise answers. It may be general in nature or provide a step-by-step set of procedures for the students to follow.
2. Make sure the design brief has a purpose. A common question asked by students in school today is "Why do I need to know this?" In many subject areas the content is determined to be essential if it is going to be on the upcoming test and requires a significant amount of memorization. Upon reading the design brief, students should be able to identify what needs to be accomplished and why it is important. Although a solution will not be immediately seen, the rationale behind creating a solution should be understood.
3. Include specific contexts. A design brief should contain a context from which students can begin to solve the technological problem. A good context describes to the student the nature of the problem in a real-world environment. The context can be tailored to a local need or interest to which the students can relate. Example contexts include the community, a business, home, recreation, government, or school. Stating the intended context for the solution reinforces the context and begins to focus the students toward developing solution ideas.
4. Design briefs should be open-ended and have the ability to create a variety of solutions. An open-ended design brief enables the students to explore a variety of solutions without having to worry if they have found the "correct" one. As each design brief has numerous solutions, students will be uncertain as to what solution is best. Brainstorming can be used to develop a variety of solutions to the same problem. Students may wish to sketch as many solutions as they

conceive and then have other students or the teacher examine these sketches. Many times the best answer is not found the first time that sketches are made. This component of a design brief is what separates it from a science experiment or traditional activity where every student will obtain the same results if a specific procedure is correctly followed. Developing a variety of solutions stimulates creative thinking. These types of problems challenge students to look outside of their realm of knowledge and ability, conduct research, investigate a unique problem, create a practical solution, and test its effectiveness.

Students must understand that all technological problems have certain design requirements, limitations, and expectations that are given as parameters in the design brief. Professional designers such as architects and product designers must develop unique solutions given numerous parameters. Parameters do not necessarily make a design brief less open-ended, rather, the more parameters, the more challenging the design brief becomes. As students become more familiar and skilled at solving design briefs, additional parameters can be given.

5. Expected results should be clearly identified. Results may range from a basic sketch, to a sophisticated electronic product, to a manufacturing assembly line. Specific details for solution requirements can be further refined during a class discussion and consensus building time. For example, the students may determine when the final model is to be evaluated, what differentiates a good solution from an excellent one, and what the model should and should not be able to do.


"Problem solving through technological studies"

# APPENDIX A: DEFINITION OF TERMS

Assessment – Assessment is the "act of determining the extent to which the curricular goals are being and have been achieved" (ASCD, Wiggins & McTighe, p. 4).

Curriculum – "Curriculum refers to a specific blueprint for learning that is derived from content and performance standards" (ASCD, Wiggins & McTighe, p. 4).

Design and Technology – "The essence of Design and Technology Education in schools lies in empowering students to engage in the creative human process of bringing about positive change or exercising responsible control over the environment. This process is systematic and involves the application of knowledge in a variety of disciplines" (Design and Technology Section, 1996, p. 1, 2)

Educational Technology – This term is used synonymously with instructional technology. It refers to the use of "technological developments, such as computers, audio-visual equipment, and mass media to aid in teaching all subjects [italics added]" (Technology for All Americans Project, 1996, p. 29).

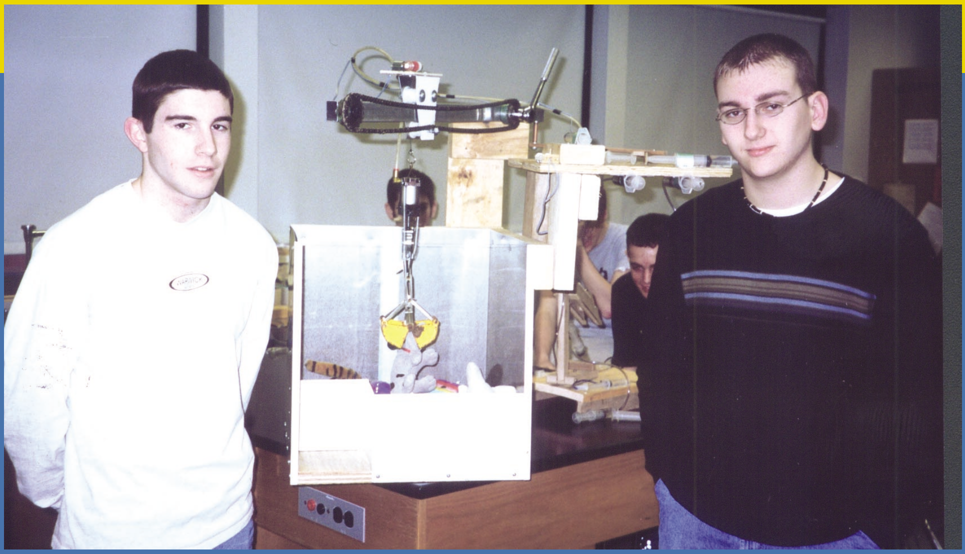
Engineering – Designing under constraints (National Science Foundation)

Instruction – Instruction deals with the techniques and procedures used to deliver the curriculum while appropriately matching the planned assessments.

Technological Literacy – In the broadest sense, "technological literacy is the ability to use, manage, understand, and assess technology" (Technology for All Americans Project, 1996, p. 6).

Technology – "Human innovation in action" (Technology for All Americans Project). "A body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants" (Savage & Sterry, 1990, p. 7).

Technology Education - "(technological studies) Technology education involves designing, making, developing, producing, using, managing, and assessing technological systems and products" (International Technology Education Association, 1998, p. 17).



Design engineering students demonstrating their final product that incorporates mechanical advantage, hydraulics, and gears to pick up an object.

**Technology Education Association of Pennsylvania (TEAP):**
**http://www.teap-online.org**

**Pennsylvania Science & Technology Standards (PDE): http://www.pde.psu.edu/standard/science.pdf**

**International Technology Education Association & Technology Standards (ITEA):**
**http://www.iteawww.org/TAA/TAA.html**

**Association of Supervision and Curriculum Development (ASCD):**
**http://www.ascd.org/readingroom/books/wiggins98toc.html**

**NASA Spacelinks:**
**http://spacelink.nasa.gov/.index.html**

**ITEA Rationale and Structure Document:**
**http://www.iteawww.org/TAA/R&S.htm**

**National Technology Student Association Curriculum Resource Guides (K-12):**
**http://www.tsaweb.org**

"Teamwork is essential when creating technological solutions."

**A Sample TEMPLATE Of The Form Below Is Provided In Appendix 'D'**

Pennsylvania School District Sample Benchmark Data Sheet **- *(~Courtesy of Lower Merion School District~)*** Curriculum Project

**Standard Category: Technology Education**

**Academic Standard: Explain information technologies of encoding, transmitting, receiving, storing, retrieving & decoding. (3.6.7.B)**

**Course Number and Title: Applying Technology**

**Benchmark: Demonstrate the effectiveness of image generating technique to communicate a story (3.6.7.B1)**

## Content:

**Video Production:**

- Learn about the field of Video Technology and understand such topics as framing a shot and adding special effects
- Identify different types of shots & angles: close-up, medium, long shots
- Learn the phases of making a video: pre-production, production/postproduction
- Understand the various kinds of lenses of a video camera
- Identify the four types of camera movement
- Review the major controls of a camcorder
- Examine lighting techniques to enhance the quality of a shot
- Learn about voice-over and recording sound
- Understand the term "raw footage"
- Use video recorder to practice learned techniques & review editing equipment
- Edit a video; modify the movie window
- Add transition effects to a video
- Insert titles and voice-overs with video editing software
- Storyboard a video presentation

## Assessment(s):

- Pre-test – 'Advanced Thought Organizer'
- Formative assessment via electronic journal entries (T/F, MC, Fill-in, open-ended)
- Anecdotal Record Keeping (Teacher input into electronic journal via participation assessment and ongoing evaluation)
- Build and test solutions to specific design challenges related to the context areas of physical, information, and bio-related technologies
- Summative Assessment (Post-test)
- Peer assessment
- Self Assessment

## Instructional Strategies:

- Use the computer to view a series of multimedia presentations to provide an overview of physical, informational, and bio-technology systems, their technical concepts, and their social, economic, and environmental impacts.
- Students will be given a context-based problem to solve and will review the method of preparing their design charts for the task.
- Will use computer simulation to design and evaluate physical, information and bio-related technology system according to the stated problem context and design challenge previously given.
- Interpret graphical and numeric data to evaluate their design choices regarding physical, information, and bio-technology systems.
- Discuss and apply appropriate techniques, processes, and materials typically used in physical, information, and biotechnology systems.
- Apply the technological problem solving process to their designed solutions (Understand, Gather, Select, Implement, Test/Evaluate, Communicate) through physical, information, and bio-related technology systems.
- Apply the universal systems model of input-process-output-feedback, using the appropriate resources of technology (tools/machines, materials, information, people, capital energy, and time)

## Adaptations and Extensions:

-Utilize and implement the Pennsylvania and National Technology Student Association (TSA) curricular challenge for the physical, information and bio-related technology systems being studied in this technological area.

-Each instructional area (module) has an audible remediation component available for all students or for those that the instructor feels would benefit from having the text of the multimedia presentations read to them. The multimedia presentations also have hypertext links associated with new or difficult terms that provide additional explanation and vocabulary resource availability.

-Each activity includes an enhancement activity at the end to allow students who finish early to work on a physical science-related problem-solving software program.

-Each activity can also be setup with a link to an Internet site that is related to the modules technology topic, i.e. CNN.COM site.

## Multicultural/Interdisciplinary Connections:

- Interdisciplinary Connections : Universal core technology themes cover the social/cultural, economic, and environmental impacts of each technology that are inherit in each of the modules. This provides for a common foundation of understanding that reinforces the content and the rationale of the context-based problems across a variety of disciplines.
- Multicultural Connections: The teachers shall ensure that technology milestones and current event reports shall highlight or include the contributions of African-Americans and other minority groups.

## Resources:

- PA-TSA Curricular Resource Guide
- The video production software, student workstation manuals, Internet access, Time Almanac CD (for current event report), Compton's Home Encyclopedia CD (for use in the Technology Timeline activity), along with appropriate Internet sites for these research-based design activities.
- Timeline activity, a careers exploration activity, hands-on components for the construction of the students' hands-on activities in #'s 3-6. Each area also includes "The Incredible Machine," a physical and informational technology/science-based software problem-solving program which can be used as an enhancement activity.

*(~Courtesy of Lower Merion School District~)*

**Standard Category: Technology Education**

**Academic Standard:**

**Course Number and Title: Technology Education – 'Title Here'**

**Benchmark:**

| **Content:** | **Assessment(s):**<br>- |
|---|---|

**Instructional Strategies:**

**Adaptations and Extensions:**

**Multicultural/Interdisciplinary Connections:**

**Resources:**

**Course:** Applying Technology
**Standards Benchmark Level:** Grade 7

| | ***Pennsylvania Science & Technology Standards Addressed*** | | | | | |
|---|---|---|---|---|---|---|
| ***Course Activities*** | **3.1 a,b,c,d,e** | **3.2 a,b,c,d** | **3.6 a,b,c** | **3.7 a,b,c,d,e** | **3.8 a,b,c** | **Others** |
| **$CO_2$ Race Car** | **3.1.7 a b,c,d** | **3.2.7 a,b c,d** | **3.6.7 c** | **3.7.7 a,b,c,d** | **3.8.7 b** | |
| **Design a Business Card** | **3.1.7 b,d** | | **3.6.7 b** | **3.7.7 c,d,e** | | |
| **Program an Automated Guided Vehicle** | **3.1.7 d** | | **3.6.7 b** | | | **3.4.7 c** |
| **Design and Construct a Balsa or Toothpick Structure (e.g. Bridge or Tower)** | **3.1.7 d** | **3.2.7 d** | **3.6.7 c** | **3.7.7 a** | **3.8.7 a** | |
| **Technological Impacts Report** | | | | **3.7.7 c,d,e** | **3.8.7 a,b,c** | |
| **Manufacturing Enterprise** | | **3.2.7 d** | **3.6.7 c** | **3.7.7 a** | **3.8.7 a** | |

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