ENGINEEERING BY DESIGN

A STANDARDS-BASED MODEL PROGRAM

ENGINEERING byDesign™

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION
CENTER TO ADVANCE THE TEACHING OF TECHNOLOGY & SCIENCE

ENGINEERING byDesign™

A Guide to a National Standards-Based Program Model

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ITEA CATTS.

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Chapter 1

Engineering byDesign™ - A Standards-Based Approach

> "Somewhere, something incredible is waiting to be known." Carl Sagan

In 2004, the International Technology Education Association's (ITEA) Center to Advance the Teaching of Technology and Science (CATTS) began development of the Engineering byDesign™ Program, of which the Foundations of Technology guide is one component. The Program is described in detail later in the Introduction section of this guide and has been written so that you, as the teacher, supervisor, principal, or teacher educator can implement or develop standards-based instruction. The reader will find that the entire Program is described so that a sense of the overall approach to developing technological literacy through the study of Technology, Innovation, Design, and Engineering (TIDE) in Grades K-12 can be seen.

More than anything else, the program has been developed through a process that is based on standards. Each course in the Program focuses on one organizing principle that was developed based on the content standards in Standards for Technological Literacy: Content for the Study of Technology (STL) (ITEA 2000/2002). As the reader and implementer, you will find that the approach is significantly different than the traditional "find the activities then develop the content" method. To be truly standards-based, the Program must be created around standards and benchmarks—not a series of activities. This guide is one of many to be produced that will do just that, so that the assessments that are introduced can be used appropriately by educators to inform instruction and improve student achievement.

It is the goal of this guide to provide educators with a model for implementing a standards-based program and course. Each section will be related to standards and will use the forms that can be found in the ITEA Technological Literacy Standards Series and the supporting Addenda Guides. This guide presents content and lessons in a cornerstone technology education model course for the high school. It is based on *Technology for All Americans: A Rationale and Structure for the Study of Technology (Rationale and Structure)* (ITEA, 1996) and *Standards for Technological Literacy: Content for the Study of Technology (Standards for Technological Literacy/STL)* (ITEA, 2000/2002). Further guidance is provided through *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)* (ITEA, 2003), *Realizing Excellence: Structuring Technology Program* (ITEA, 2005) and Planning *Learning: Developing Technology Curricula* (ITEA, 2005). Because these ITEA publications contain the fundamentals of technological literacy curriculum, teachers, supervisors, and teacher educators are encouraged to review them prior to using this guide.

Technology for All Americans: A Rationale and Structure for the Study of Technology

Technology for All Americans: A Rationale and Structure for the Study of Technology provides a vision for the study of technology. It addresses the power and promise of technology and the need for every American student to be technologically literate when he/she graduates from high school. Understanding the nature of technological advances and processes and participating in society's decisions on technological issues is of utmost concern. This publication outlines the knowledge, processes, and contexts for the study of technology.

Standards for Technological Literacy: Content for the Study of Technology

What is *Standards for Technological Literacy*?

ITEA and its Technology for All Americans Project published *Standards for Technological Literacy: Content for the Study of Technology (STL)* in April of 2000. *STL* defines, through K-12 content standards, what students should know and be able to do in order to be deemed technologically literate. However, it does not put forth a curriculum to achieve these outcomes. *STL* will help ensure that all students receive an effective education about technology by setting forth a consistent content for the study of technology.

Why is *STL* important?

- Technological literacy enables people to develop knowledge and abilities about human innovation in action.
- *STL* establishes requirements for technological literacy for all students from kindergarten through Grade 12.
- *STL* provides expectations of academic excellence for all students.
- Effective democracy depends on all citizens participating in the decision-making process; many decisions involve technological issues, so citizens need to be technologically literate.
- A technologically literate population can help our nation maintain and sustain economic progress.

Guiding Principles for *STL*

- The standards and benchmarks were created with the following guiding principles:
- They offer a common set of expectations for what students should learn about technology.
- They are developmentally appropriate for students.

- They provide a basis for developing meaningful, relevant, and articulated curricula at the local, state, and provincial levels.
- They promote content connections with other fields of study in Grades K-12.
- They encourage active and experiential learning.

Who is a technologically literate person?

A person who understands—with increasing sophistication—what technology is, how it is created, how it shapes society, and in turn, how technology is shaped by society, is technologically literate. A technologically literate person can hear a story about technology on television or read it in the newspaper and evaluate its information intelligently, put that information in context, and form an opinion based on it. A technologically literate person is comfortable with and objective about the use of technology—neither scared of it nor infatuated with it. Technological literacy is important to all students in order for them to understand why technology and its use is such an important force in our economy. Anyone can benefit by being familiar with it. All people, from corporate executives to teachers to farmers to homemakers, will be able to perform their jobs better if they are technologically literate. Technological literacy benefits students who will choose technological careers—future engineers, aspiring architects, and students from many other fields. Students have a head start on their future with an education in technology.

What is included in *STL*?

There are 20 content standards that specify what every student should know and be able to do in order to be technologically literate. The benchmarks that follow each of the broadly stated standards at each grade level articulate the knowledge and abilities that will enable students to meet the respective standard. A summary of the content standards and benchmarks is presented in Appendix A of this document. Teachers and supervisors are encouraged to obtain *STL* to review the benchmarks associated with each standard.

Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)

While *A Rationale and Structure for the Study of Technology* provides a vision and *Standards for Technological Literacy: Content for the Study of Technology* provides the content, neither was designed to address other important elements that are critical to a comprehensive program of technological studies. As a result, ITEA's Technology for All Americans Project published *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL). AETL* is currently available from ITEA and is designed to help schools implement new strategies and evaluate existing practices of assessing students for technological literacy, providing professional development for teachers and other professionals, and improving programs of teaching and learning.

Advancing Technological Literacy: ITEA Professional Series

The Advancing Technological Literacy: ITEA Professional Series is a set of publications developed by the International Technology Education Association (ITEA) based on *Standards for Technological Literacy* (ITEA, 2000/2002) and *Advancing Excellence in Technological Literacy* (ITEA, 2003). The publications in this series are designed to assist educators in developing contemporary, standards-based K-12 technology education programs. This exclusive series features:

- Direct alignment with technological literacy standards, benchmarks, and guidelines.
- Direct alignment with mathematics and science standards and benchmarks.
- Connections with other school subjects.
- Contemporary methods and student activities.
- Guidance for developing exemplary programs that foster technological literacy.
- Titles and resources in the series include:

Technological Literacy Standards Series

- *Standards for Technological Literacy: Content for the Study of Technology*
- *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards*
- *Technology for All Americans: A Rationale and Structure for the Study of Technology*

Addenda to Technological Literacy Standards Series

- *Realizing Excellence: Structuring Technology Programs*
- *Developing Professionals: Preparing Technology Teachers*
- *Planning Learning: Developing Technology Curricula*
- *Measuring Progress: A Guide to Assessing Students for Technological Literacy*

Engineering byDesign™: Standards-Based Program Series

Elementary School Resources

- *Technology Starters: A Standards-Based Guide*
- *Models for Introducing Technology: A Standards-Based Guide*

Middle School Resources

- *Teaching Technology: Middle School, Strategies for Standards-Based Instruction*
- *Exploring Technology: A Standards-Based Middle School Model Course Guide*
- *Invention and Innovation: A Standards-Based Middle School Model Course Guide*
- *Technological Systems: A Standards-Based Middle School Model Course Guide*

High School Resources

- *Teaching Technology: High School, Strategies for Standards-Based Instruction*
- *Foundations of Technology: A Standards-Based High School Model Course Guide*
- *Technological Issues: A Standards-Based High School Model Course Guide*
- *Impacts of Technology: A Standards-Based High School Model Course Guide*
- *Technological Design: A Standards-Based High School Model Course Guide*

- *Advanced Design Applications: A Standards-Based High School Model Course Guide (ProBase)*
- *Advanced Technological Applications: A Standards-Based High School Model Course Guide (ProBase)*
- *Engineering Design: A Standards-Based High School Model Course Guide (Capstone Course)*

Engineering byDesign™: Standards-Based Technological Study Units

Elementary School Resources

- Kids Inventing Technology Series (KITS)

Elementary/Middle School Resources (Grades 5-6)

- Invention, Innovation, and Inquiry (I_3) Lessons
- Invention: The Invention Crusade
- Innovation: Inches, Feet, and Hands
- Communication: Communicating School Spirit
- Manufacturing: The Fudgeville Crisis
- Transportation: Across the United States
- Construction: Beaming Support
- Power and Energy: The Whispers of Willing Wind
- Design: Toying with Technology
- Inquiry: The Ultimate School Bag
- Technological Systems: Creating Mechanical Toys

Secondary School Resources

- Humans Innovating Technology Series (HITS)

The Center to Advance the Teaching of Technology and Science: ITEA-CATTS

The International Technology Education Association's Center to Advance the Teaching of Technology and Science (ITEA-CATTS) was created to provide curriculum and professional development for technology teachers and other professionals interested in technological literacy. ITEA-CATTS initiatives are directed toward four important goals:

- Development of standards-based curricula
- Professional development through learning communities
- Research on teaching and learning
- Curriculum implementation and diffusion

The Center addresses these goals to fulfill its mission to serve as a central source for quality professional development support for the teaching and learning of technology and science.

The ITEA-CATTS Consortium was established as part of ITEA-CATTS to form professional leadership and alliances in order to effectively enhance teaching and learning about technology and science. Consortium members receive quality curriculum products and professional development based on the standards. The *Engineering byDesign™ Program* and this publication were conceptualized and developed through the ITEA-CATTS Consortium.

Chapter

2

Engineering byDesign™ - A Pathway Program for STEM and IT Clusters

The EbD™ Program was designed to maintain integrity through three delivery scenarios. First, the model was designed as a Pathway program, where schools may adopt the articulated sequence of courses in a STEM themed academy and/or an IT themed academy. Secondly, the program may be delivered by modularizing the components and adapting the design themes to support the STEM, IT, or other academy models. In this scenario, as in many career-themed academy models, some modification is required to ensure themes are aligned with the Cluster Knowledge and Skills.

The Engineering byDesign™ Program has been designed with current research on the development of smaller learning communities around career-themed academies as the guiding principle. While technology education courses are designed for all students, and not based on preparing students with technical skills, they are preparing students for the global workplace by ensuring that they are technologically literate.

The Engineering byDesign™ Program was conceived with the intent to help school districts provide a program that constructs learning from a very early age and culminates in a capstone experience that leads students to become the next generation of technologists, innovators, designers, and engineers and ultimately restore America's status as the leader in innovation. Additionally, school reform efforts at the high school and middle school levels have been working hard to create a vertically (based on standards) and horizontally (articulated sequencing of courses and experiences) integrated program that employs career themes to guide the content learned by students. EbD™ is both horizontally and vertically articulated, and leverages themes through authentic learning and collaborative themes so that students envision their future through their experiences.

It is the experience of the developer (ITEA-CATTS) that States and Districts are desperately searching for models that improve student achievement, that, when forming smaller learning communities and academies around career themes, help to improve student achievement and test scores. The EbD™ Program is a model that may be used by schools developing themes in the STEM and IT Clusters that are looking to increase all students' achievement in technology, science, mathematics, and English through authentic learning. The program is built on constructivist models and creates awareness and competence over time as it builds on learned knowledge and skills – aligning closely with the Cluster Knowledge & Skills in both the STEM and IT Clusters. Nationally eleven states are using the model. Each state modifies the program to their needs, but reduces the need for developing curriculum, professional development, and assessments from the ground up. States that have adopted the Program have found that it provides districts with a model for standards-based instruction as well as models for using learning communities among their teachers and supervisors (see Professional Development Plan.)

The Engineering byDesign™ Program has been developed through a series of carefully constructed processes that integrates the concepts of school reform and aligns with the goals of the NASDCTEc States' Career Clusters Initiative. In addition, as one of the only standards-based models available, the EbD™ Program is able to deliver content knowledge and skills for both the STEM and IT Clusters through themes that closely align with their identified Career Cluster Knowledge & Skills. A cross-reference of these Cluster Knowledge and Skills and the Standards for Technological Literacy (STL) will be found on the NASDCTEc Endorsement website http://www.teachstem.net

Scenario:

As schools work through a planning process to determine what types of Academies will be offered to students, they begin to look at the strengths of the community and the school. School leadership teams identify between three and six themes built on the career-cluster model. Research shows that these themes should identify one academy for every 250-300 students in a school. The concept of the academy uses a team of teachers to present the content around the theme. So, if the career-themed academy is Arts and Media, then all of the teachers identified in that academy plan their content around the Arts and Media theme. While some schools identify the theme that is directly related to a career cluster name, many do not. Some common Academy themes include: Arts and Media, Business and Finance, Entrepreneurship, Theatre, Science and Technology, Social Science, Human Services, Engineering, and International Studies.

In each of these examples, technology education and the delivery of technological literacy is critical to the success of students in their future endeavors. The high school courses Impacts of Technology and Technological Issues are written in such a way that the framework for content can be centered on *any of the listed academy themes*. A course in Technological Issues can easily be focused (given the way the product is written) on International Studies, etc. This makes them a valuable part of the articulated sequence of courses that students take in their academy focus. These courses emulate the transferability necessary in a world where changing technology impacts our everyday life and creates issues for society.

SAMPLE STEM Pathway - Programs of Study

STEM Cluster
Engineering & Technology Pathway

Elementary	Middle School	6th Grade	7th Grade	8th Grade
Integrated Lessons (KITS)*		Exploring Technology*	Invention & Innovation*	Technological Systems*

High School	9th Grade	10th Grade	11th Grade	12th Grade
	English I	English II	English III	English IV
	Algebra I or Geometry	Geometry or Algebra II	Algebra II, Pre-Calculus, or Trigonometry	Trigonometry or Calculus
	Physical Science or Biology I	Biology I or Chemistry I	Chemistry or Physics	AP Biology, AP Chemistry, or AP Physics
	Geography/State History	World History	American History	Economics/Government
	Required Courses/Electives PE, Health, Art, Foreign Language, or Computer Technology	*Required Courses/Electives* PE, Health, Art, Foreign Language, or Computer Technology	*Advanced Technology/Engineering Electives* Choose one: Advanced Design Applications* Advanced Technological Applications*	*Technology Capstone* Engineering Design*
	Career Electives Foundations of Technology * (Transition Course)	*Career Electives* Choose one: Technological Design* Technological Issues* Impacts of Technology *		

Post-Secondary	Technology Center	Community College	College/University
	❑ Automated Manufacturing Technology ❑ Drafting and CAD ❑ Electronics ❑ Industrial Maintenance ❑ Manufacturing Engineering Technology ❑ Precision Machining	❑ Design Engineering Technology ❑ Pre-Engineering ❑ Industrial Drafting ❑ Biology ❑ Chemistry ❑ Physics ❑ Mathematics	❑ Mechanical Engineering ❑ Civil Engineering ❑ Mathematics ❑ Biology ❑ Biochemistry ❑ Chemistry ❑ Physics ❑ Management Science and Systems Analysis

	Work-based Learning Options	Short-Term Training Options	
	Job-Shadowing: Internship/Mentorship: On-The-Job Training:	❑ Safety Training ❑ Visual Basic 6 ❑ Internet & Network Security	❑ Wireless Technology ❑ VB Net ❑ AutoCAD

STEM Cluster
Science & Mathematics Pathway

Elementary	Middle School	6th Grade	7th Grade	8th Grade
Integrated Lessons (KITS)*		Exploring Technology*	Invention & Innovation*	Technological Systems* Algebra I

High School	9th Grade	10th Grade	11th Grade	12th Grade
	English I	English II	English III	English IV
	Geometry	Algebra II	Pre-Calculus, or Trigonometry	Trigonometry or Calculus
	AP Biology	AP Chemistryl	AP Physics	Engineering Science
	Geography/State History	World History	American History	Economics/Government
	Required Courses/Electives PE, Health, Art, Foreign Language, or Computer Technology	*Required Courses/Electives* PE, Health, Art, Foreign Language, or Computer Technology	*Advanced Technology/Engineering Electives* Advanced Technological Applications*	*Technology Capstone* Engineering Design*
	Career Electives Foundations of Technology * (Transition Course)	*Career Electives* Advanced Design Applications*		

Post-Secondary	Technology Center	Community College	College/University
	❑ Automated Manufacturing Technology ❑ Drafting and CAD ❑ Electronics ❑ Industrial Maintenance ❑ Manufacturing Engineering Technology ❑ Precision Machining	❑ Design Engineering Technology ❑ Pre-Engineering ❑ Industrial Drafting ❑ Biology ❑ Chemistry ❑ Physics ❑ Mathematics	❑ Mechanical Engineering ❑ Civil Engineering ❑ Mathematics ❑ Biology ❑ Biochemistry ❑ Chemistry ❑ Physics ❑ Management Science and Systems Analysis

	Work-based Learning Options	Short-Term Training Options	
	Job-Shadowing: Internship/Mentorship: On-The-Job Training:	❑ Safety Training ❑ Visual Basic 6 ❑ Internet & Network Security	❑ Wireless Technology ❑ VB Net ❑ AutoCAD

SAMPLE IT Pathway - Programs of Study

IT Cluster
Information Support & Services

Elementary	Middle School	6th Grade	7th Grade	8th Grade
Integrated Lessons (KITS)*		Exploring Technology*	Invention & Innovation*	Technological Systems* Algebra I

High School	9th Grade	10th Grade	11th Grade	12th Grade
	English I	English II	English III	English IV
	Algebra I or Geometry	Geometry or Algebra II	Algebra II, Pre-Calculus, or Trigonometry	Trigonometry or Calculus
	Physical Science or Biology I	Biology I or Chemistry I	Chemistry or Physics	AP Biology, AP Chemistry, or AP Physics
	Geography/State History	World History	American History	Economics/Government
	Required Courses/Electives PE, Health, Art, Foreign Language, or Computer Technology	*Required Courses/Electives* PE, Health, Art, Foreign Language, or Computer Technology	*Advanced Technology/Engineering Electives* Choose one: Advanced Design Applications* Advanced Technological Applications*	*Technology Capstone* Engineering Design*
	Career Electives Foundations of Technology * (Transition Course)	*Career Electives* Choose one: Technological Design* Technological Issues* Impacts of Technology *		

Post-Secondary	Technology Center	Community College	College/University
	❑ Business and Computer Technology ❑ eCommerce and Web Services ❑ Information Services ❑ Network Services ❑ Cyber Security	❑ Computer Program and Computer Science ❑ Graphic Design and Visual Communications ❑ E-Commerce ❑ Computer Information Systems ❑ Information Technologies	❑ Management Information Systems ❑ Management Science & Computer Systems ❑ E Commerce ❑ Computer Science ❑ Information Science

Career Enhancement Options	Work-based Learning Options	Short-Term Training Options	
	Job Shadowing: Internship/Mentorship: On-The-Job Training:	❑ Advanced Networking ❑ Desktop Certifications ❑ Linux I ❑ Linux II ❑	❑ Windows XP ❑ Network + ❑ Internet Network and Security

IT Cluster
Network Systems

Elementary	Middle School	6th Grade	7th Grade	8th Grade
Integrated Lessons (KITS)*		Exploring Technology*	Invention & Innovation*	Technological Systems* Algebra I

High School	9th Grade	10th Grade	11th Grade	12th Grade
	English I	English II	English III	English IV
	Algebra I or Geometry	Geometry or Algebra II	Algebra II, Pre-Calculus, or Trigonometry	Trigonometry or Calculus
	Physical Science or Biology I	Biology I or Chemistry I	Chemistry or Physics	AP Biology, AP Chemistry, or AP Physics
	Geography/State History	World History	American History	Economics/Government
	Required Courses/Electives PE, Health, Art, Foreign Language, or Computer Technology	*Required Courses/Electives* PE, Health, Art, Foreign Language, or Computer Technology	*Advanced Technology/Engineering Electives* Choose one: Advanced Design Applications* Advanced Technological Applications*	*Technology Capstone* Engineering Design*
	Career Electives Foundations of Technology * (Transition Course)	*Career Electives* Choose one: Technological Design* Technological Issues* Impacts of Technology *		

Post-Secondary	Technology Center	Community College	College/University
	❑ Business and Computer Technology ❑ eCommerce and Web Services ❑ Information Services ❑ Network Services ❑ Cyber Security	❑ Computer Program and Computer Science ❑ Graphic Design and Visual Communications ❑ E-Commerce ❑ Computer Information Systems ❑ Information Technologies	❑ Management Information Systems ❑ Management Science & Computer Systems ❑ E Commerce ❑ Computer Science ❑ Information Science

Career Enhancement Options	Work-based Learning Options	Short-Term Training Options	
	Job-Shadowing: Internship/Mentorship: On-The-Job Training:	❑ Advanced Networking ❑ Desktop Certifications ❑ Linux I ❑ Linux II ❑	❑ Windows XP ❑ Network + ❑ Internet Network and Security

IT Cluster
Programming & Software Development

Elementary	Middle School	6th Grade	7th Grade	8th Grade
Integrated Lessons (KITS)*		Exploring Technology*	Invention & Innovation*	Technological Systems* Algebra I

High School	9th Grade	10th Grade	11th Grade	12th Grade
	English I	English II	English III	English IV
	Geometry	Algebra II	Pre-Calculus, or Trigonometry	Trigonometry or Calculus
	AP Biology	AP Chemistryl	AP Physics	Engineering Science
	Geography/State History	World History	American History	Economics/Government
	Required Courses/Electives PE, Health, Art, Foreign Language, or Computer Technology	*Required Courses/Electives* PE, Health, Art, Foreign Language, or Computer Technology	*Advanced Technology/Engineering Electives* Advanced Technological Applications*	*Technology Capstone* Engineering Design*
	Career Electives Foundations of Technology * (Transition Course)	*Career Electives* Advanced Design Applications*		

Post-Secondary	Technology Center	Community College	College/University
	❑ Business and Computer Technology ❑ E Commerce and Web Services ❑ Information Services ❑ Network Services ❑ Cyber Security	❑ Computer Program and Computer Science ❑ Graphic Design and Visual Communications ❑ E-Commerce ❑ Computer Information Systems ❑ Information Technologies	❑ Management Information Systems ❑ Management Science & Computer Systems ❑ E Commerce ❑ Computer Science ❑ Information Science

	Work based Learning Options	Short-Term Training Options	
	Job-Shadowing: Internship/Mentorship: On-The-Job Training:	❑ Advanced Networking ❑ Desktop Certifications ❑ Linux I ❑ Linux II ❑	❑ Windows XP ❑ Network + ❑ Internet Network and Security

IT Cluster
Interactive/Digital Media Pathway

Elementary	Middle School	6th Grade	7th Grade	8th Grade
Integrated Lessons (KITS)*		Exploring Technology*	Invention & Innovation*	Technological Systems*

High School	9th Grade	10th Grade	11th Grade	12th Grade
	English I	English II	English III	English IV
	Algebra I or Geometry	Geometry or Algebra II	Algebra II, Pre-Calculus, or Trigonometry	Trigonometry or Calculus
	Physical Science or Biology I	Biology I or Chemistry I	Chemistry or Physics	AP Biology, AP Chemistry, or AP Physics
	Geography/State History	World History	American History	Economics/Government
	Required Courses/Electives PE, Health, Art, Foreign Language, or Computer Technology	*Required Courses/Electives* PE, Health, Art, Foreign Language, or Computer Technology	*Advanced Technology/Engineering Electives* Choose one: Advanced Design Applications* Advanced Technological Applications*	*Technology Capstone* Engineering Design*
	Career Electives Foundations of Technology * (Transition Course)	*Career Electives* Choose one: Technological Design* Technological Issues* Impacts of Technology *		

Post-Secondary	Technology Center	Community College	College/University
	❑ Business and Computer Technology ❑ eCommerce and Web Services ❑ Information Services ❑ Network Services ❑ Cyber Security	❑ Computer Program and Computer Science ❑ Graphic Design and Visual Communications ❑ E-Commerce ❑ Computer Information Systems ❑ Information Technologies	❑ Management Information Systems ❑ Management Science & Computer Systems ❑ E Commerce ❑ Computer Science ❑ Information Science

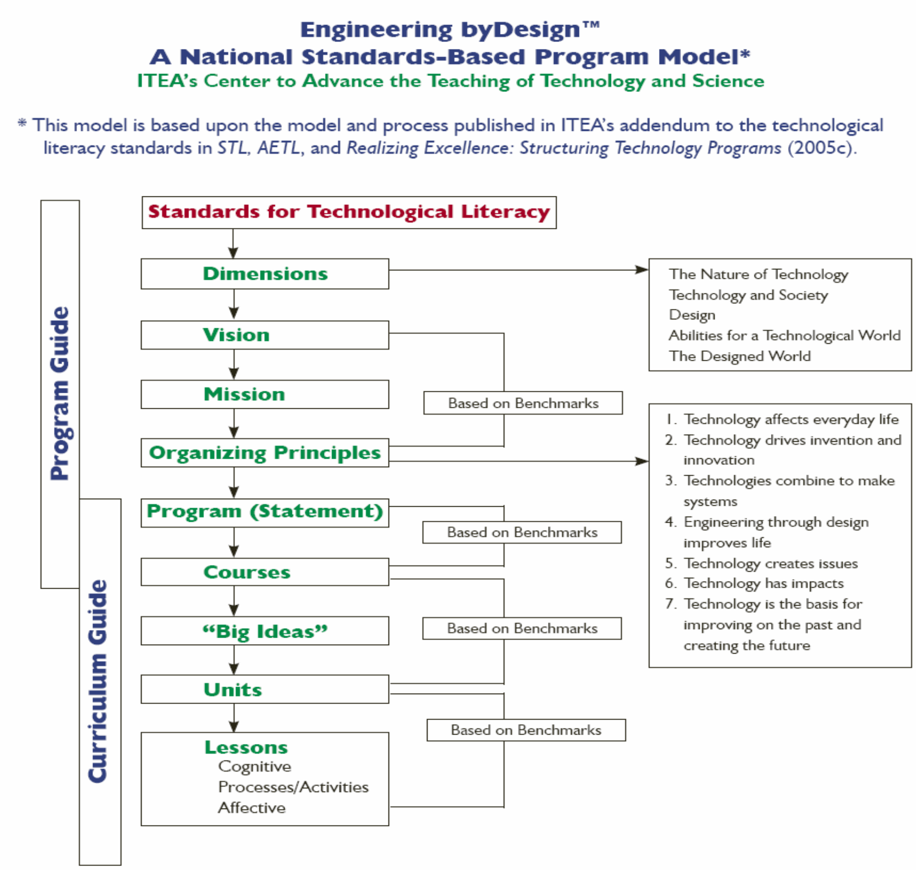
	Work based Learning Options	Short-Term Training Options	
	Job-Shadowing: Internship/Mentorship: On-The-Job Training:	❑ Advanced Networking ❑ Desktop Certifications ❑ Linux I ❑ Linux II ❑	❑ Windows XP ❑ Network + ❑ Internet Network and Security

Chapter 3

The Engineering byDesign™ Concept

Engineering byDesign™ is a National Model Program that was developed in collaboration and consultation with the ITEA-CATTS Consortium, Technology Education Advisory Council, ITEA Institutional Members, and the Mathematics, Science, and Engineering communities. The reader will see, as the structure of the program unfolds, that the intent is related to the development of technological literacy for students in Grades K-12 and delivered in the context of Technology, Innovation, Design, and Engineering (TIDE.)

States, districts, and schools may wish to use this chapter as the basis for the development of a new program in TIDE, or to use it just as it is written. Note that either way, the assessments that are used in the Program and in this course are designed specifically to measure achievement of the *STL* technological literacy standards and corresponding benchmarks.



The Vision - *Engineering byDesign™*

We live in a technological world. Living in the twenty-first century requires much more from every individual than a basic ability to read, write, and perform simple mathematics. Technology affects every aspect of our lives, from enabling citizens to perform routine tasks to requiring that they be able to make responsible, informed decisions that affect individuals, our society, and the environment. Citizens of today must have a basic understanding of how technology affects their world and how they exist both within and around technology.

Technological literacy is fundamentally important to all students. Technological processes have become so complex that the community and schools collaborate to provide a quality technology program that prepares students for a changing technological world that is progressively more dependent on an informed, technologically literate citizenry.

The Mission - *Engineering byDesign™*

The ITEA model technology program is committed to providing technological study in facilities that are safe and facilitate creativity, enabling all students to meet local, state, and national technological literacy standards. Technological study is required in sixth, seventh, and eighth grades. Students are prepared to engage in additional technological study in the high school years and beyond. Students will be prepared with knowledge and abilities to help them become informed, successful citizens who are able to make sense of the world in which they live. The technology program also enables students to take advantage of the technological resources in the local community.

Organizing Principles

The program consists of seven organizing principles. These principles are very large concepts that identify major content organizers for the program. As stated earlier, *Engineering byDesign*™ is to be taught in the context of Technology, Innovation, Design, and Engineering (TIDE). In order of importance, the seven identified organizing principles are listed below:

- Engineering through design improves life.
- Technology has and continues to affect everyday life.
- Technology drives invention and innovation and is a thinking and doing process.
- Technologies are combined to make technological systems.
- Technology creates issues that change the way people live and interact.
- Technology impacts society and must be assessed to determine if it is good or bad.
- Technology is the basis for improving on the past and creating the future.

Program Descriptions

The program statement on which the courses are developed is based on the identification of benchmarks for each organizing principle. (Note that the number of courses does not necessarily have to be the same as the number of organizing principles—there may be more than one organizing principle for each course.)

Engineering byDesign™: District/State Level Program Description

This program provides students with a foundation in the role of technology in everyday life, along with a broad range of technological skills that make them aware of technology around them. Students completing the program will become technologically literate by learning the concepts and role that engineering, design, invention, and innovation have in creating technology systems that help make life easier and better. Students learn that technology must be assessed to determine the positive and negative effects, and how these have shaped today's global society. The key component of the program is that students become knowledgeable about technology, and use hands-on lessons to apply and transfer this knowledge to common problems. The program consists of ten courses in Grades 6-12 that build on experiences provided in elementary school.

Engineering byDesign™: Student-Oriented Program Description for Registration Booklets

Students in this program use hands-on lessons to learn the concepts and roles of engineering, design, invention, and innovation in creating technology systems that help make life easier and better. They learn to apply and transfer this knowledge to common, everyday problems. Students learn how to assess technology, its impacts and resulting issues, and present the positive and negative consequences and how these have shaped today's global society. The program incorporates the applications of mathematics and science concepts and provides a strong background for students investigating careers in all career-focused academies.

Engineering byDesign™

A K-12 Standards-Based National Model Program

K-2	1	Integrated concepts & lessons	
3-5	2	Integrated concepts & lessons	
6	MS-1	Exploring Technology	18 weeks
7	MS-2	Invention and Innovation	18 weeks
8	MS-3	Technological Systems	18 weeks
9	HS-1	Foundations of Technology	36 weeks
10-12	HS-2	Impacts of Technology	36 weeks
10-12	HS-3	Technological Issues	36 weeks
10-12	HS-4	Technological Design	36 weeks
11-12	HS-5	Advanced Design Applications/Probase*	36 weeks
11-12	HS-6	Advanced Technological Applications/Probase*	36 weeks
11-12	HS-7	Engineering Design (Highly Rigorous)	36 weeks

* Probase—developed through NSF grant at Illinois State University

Chapter 4

Course Descriptions

The following is course information and interrelationships to ensure that students in all grades, K- 12, have the opportunity to develop technological literacy.

Elementary School Descriptions

Elementary Integration	**Lessons Integrated in Curricula in Grades K-2**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades K-2
Overview	Introducing young children to the natural world is a significant part of the elementary curriculum. Grades K-2 provide a unique opportunity to introduce and refine the knowledge and skills for understanding the designed world that is equally important during the early years. Children are as fascinated with the world of technology as the natural world, maybe even more intrigued. The earliest interest in "how things work" and what makes their environment function are clearly present in the earliest stages of a child's development. Making sense of the "natural" and "designed world" is the essence of the earliest attempts to learn by children. For every venture into the designed world, there are limitations, requirements, and elements that guide the process. Designing is a challenging and rigorous process. To design something means to apply all available resources, including knowledge and skills about all subjects, to effect a scheme, solution, concept, or theory that offers a reasonable and effective resolution to a problem. In order to comprehend the attributes of design, students in Grades K-2 learn that: • Everyone can design solutions to a problem. • Designing is a creative process that turns ideas into actions.
Course Length	Integrated throughout the year
Connections	These concepts connect to the Grades 3-5 emphasis on the design process and requirements for design, providing the basis for the middle and high school studies of Technology, Innovation, Design, and Engineering (TIDE).

Elementary Integration	Lessons Integrated in Curricula in Grades 3-5
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 3-5
Course Overview	In Grades 3-5, students should learn that: • The design process is a purposeful method of planning practical solutions to problems and includes: creating ideas, putting ideas on paper, using words and sketches, building models, testing the design or idea, and evaluating the solution based on requirements. • Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design such as, but not limited to, size, cost, type of material, weight, color, etc. Children have experiences in design at the earliest stages of development. Ingenuity is a natural human trait. It needs to be nurtured, developed, and refined. To design solutions to specific problems is the application of ingenuity. Add to this ingenuity several resources, parameters for the design solution, and some guidance, and children begin to display an interest in and ability to understand the design process. To this end, they have the foundation for understanding technological development and innovation.
Course Length	Integrated throughout the year
Connections	These concepts connect to the middle school Program of Study, where students learn about technology, invention and innovation, and how the core concepts of technology are combined to create technology systems. This background provides the basis for more focused high school studies in Technology, Innovation, Design, and Engineering.

Middle School Course Descriptions

Exploring Technology

Name of Course	Exploring Technology
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	6th Grade students (no prerequisite)
Course Overview	In *Exploring Technology*, students develop an understanding of the progression and scope of technology through exploratory experiences. In group and individual activities, students experience ways in which technological knowledge and processes contribute to effective designs and solutions to technological problems. Students participate in design activities to understand how criteria, constraints, and processes affect designs. Brainstorming, visualizing, modeling, constructing, testing, and refining designs provide firsthand opportunities for students to understand the uses and impacts of innovations. Students develop skills in communicating design information and reporting results. This course is a cornerstone for a middle school technology education program.
Course Length	18 weeks
Connections	*Exploring Technology* builds on K-5 experiences and develops a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Likewise, students will be able to communicate their ideas verbally and visually, and document the development of their plans through visual representation, journals, and portfolios. Teaming, peer monitoring, and individual actions contribute to student achievements at this level. Similarly, *Exploring Technology* provides the foundation for future studies in the sequence. Students learn how technology, innovation, design, and engineering interrelate and are interdependent. This background provides the basis for more focused high school studies.

Invention and Innovation

Name of Course	Invention and Innovation
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	7th Grade students (no prerequisite)
Course Overview	*Invention and Innovation* provides students with opportunities to apply the design process in the invention or innovation of a new product, process, or system. In this course, students will learn all about invention and innovation. They will have opportunities to study the history of inventions and innovations, including their impacts on society. They will learn about the core concepts of technology, and about the various approaches to solving problems, including engineering design and experimentation. Students will apply their creativity in the invention and innovation of new products, processes, or systems. Finally, students learn about how various inventions and innovations impact their lives. Students participate in engineering-design activities to understand how criteria, constraints, and processes affect designs. Students are involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students also develop skills in researching for information, communicating design information, and reporting results.
Course Length	18 weeks recommended
Connections	*Invention and Innovation* builds on K-5 experiences as well as those in *Exploring Technology* and develops a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Likewise, students participate in engineering-design activities to understand how criteria, constraints, and processes affect designs. Students will be involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students will also develop skills in researching for information, communicating design information, and reporting results. *Invention and Innovation* provides the foundation for future studies in the sequence. Students learn how Technology, Innovation, Design, and Engineering interrelate and are interdependent.

Name of Course	Technological Systems
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	8th Grade students (no prerequisite)
Course Overview	This course is intended to teach students how technological systems work together to solve problems and capture opportunities. A system can be as small as two components working together (technical system/device level) or can contain millions of interacting devices (user system/network level). We often break down the macrosystems into less complicated microsystems in order to understand the entire system better. However, technology is becoming more integrated, and systems are becoming more and more dependent upon each other than ever before. Electronic systems are interacting with natural (i.e. biological) systems as humans use more and more monitoring devices for medical reasons. Electrical systems are interacting with mechanical and fluid-power systems as manufacturing establishments become more and more automated. This course will give students a general background on the different types of systems but will concentrate more on the connections between these systems.
Course Length	12-18 weeks recommended
Connections	*Technological Systems* builds on K-5 experiences as well as those in *Exploring Technology* and *Invention and Innovation* to develop a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Students participate in engineering-design activities to understand how criteria, constraints, and processes affect designs. Students are involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students also develop skills in researching for information, communicating design information, and reporting results. As the suggested capstone middle school course, *Technological Systems* provides the foundation for future studies in a Technology Education sequence. Students learn how Technology, Innovation, Design, and Engineering interrelate and are interdependent.

High School Descriptions

Foundations of Technology

Name of Course	Foundations of Technology
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 9-12
Purpose of Course	*Foundations of Technology* prepares students to understand and apply technological concepts and processes that are the cornerstone for the high school technology program. Group and individual activities engage students in creating ideas, developing innovations, and engineering practical solutions. Technology content, resources, and laboratory/classroom activities apply student applications of science, mathematics, and other school subjects in authentic situations.
Course Overview	This course will focus on the three dimensions of technological literacy: knowledge, ways of thinking and acting, and capabilities, with the goal of students developing the characteristics of technologically literate citizens. It will employ teaching/learning strategies that enable students to build their own understanding of new ideas. It is designed to engage students in exploring and deepening their understanding of "big ideas" regarding technology and makes use of a variety of assessment instruments to reveal the extent of understanding. Students will develop an understanding of the influence of technology on history by exploring how people of all times and places have increased their capability by using their unique skills to innovate, improvise, and invent. They will gain an understanding of technology innovation and the fact that it often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields of study. Students will develop an understanding of engineering design, the formal process that transforms ideas into products or systems of the designed world. They will select and use manufacturing technologies and understand that modern manufacturing technologies produce quality goods at low prices, enhancing the quality of life for many people. Students will select and use construction technologies and recognize that cultural norms, environmental conditions, and the requirements of enterprises and institutions impact the design of structures. Opportunities will be provided that enable students to select and use energy and power technologies and to explore the processing and controlling of the energy resources that have been important in the development of contemporary technology. They will become familiar with information and communication technologies and their role in maintaining competitive economic growth. The course will conclude with the synthesizing of major ideas through an understanding of the core concepts of technology, with an emphasis on "systems thinking" and related principles.
Course Length	36 weeks recommended
Connections to: Engineering byDesign™ Program Sequence	The Foundations of Technology course is one component of the overall technology education program designed to prepare students for the technological world by preparing them to assume the roles of informed voters, productive workers, and wise consumers. The Foundations of Technology course will focus on the development of knowledge and skills regarding the following aspects of technology: 1) its evolution, 2) systems, 3) core concepts, 4) design, and 5) utilization. The Foundations of Technology course is an introductory high school level learning experience that builds on student understanding gained in elementary and middle school courses. It capitalizes on the maturing adolescent's ability to understand technological concepts and analyze issues regarding the application of technology. The course will prepare students for more specialized technology courses at the high school level such as Technological Issues, Impacts of Technology, and Engineering Design,

Technological Issues

Name of Course	Technological Issues
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	In *Technological Issues*, students learn that technology allows us to extend our ability to modify or change the natural world to meet our wants and needs. However, the resulting changes can be complicated and unpredictable. Solutions to a particular problem may cause other types of problems. Each potential technological solution creates certain issues, such as benefits, costs, risks, and limitations. Not all impacts of technology are predictable or show up right away. However, the key issues of a technology should be studied and debated prior to the technology being introduced or eliminated. Alternatives should be explored (scientific and mathematical dimensions should be integrated into the decision). Technological issues are not solely technical in nature. Attitudes towards technology can be influenced by social, cultural, economic, political, and ecological concerns. The decision to introduce or eliminate a technology will affect different people and vary depending on the timing. Issues can create some heated debates, which require that both sides of the debate acquire detailed information and ask the right questions. By studying technological issues, students learn that there may not be a solution that everyone agrees upon, nor will everyone benefit or receive the cost in the same way. The study of technological issues will not give students the correct answers but allows them to develop skills in asking critical questions, understanding alternative viewpoints and their origins, and gives them the confidence to be involved in deciding which technologies to develop, which to use, and how to use them.
Course Length	36 weeks recommended
Connections to Engineering byDesign™	*Technological Issues* contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values so that students can reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific needs. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school.

Technological Design

Name of Course	Technological Design
Standards Addressed	**See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A**
Intended Audience	**Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education**
Course Overview	**In Engineering Design, engineering scope, content, and professional practices are presented through practical applications. Students in engineering teams apply technology, science, and mathematics concepts and skills to solve engineering design problems and innovate designs. Students research, develop, test, and analyze engineering designs using criteria such as design effectiveness, public safety, human factors, and ethics. This course is the capstone experience for students who are interested in Technology, Innovation, Design, and Engineering.**
Course Length	**36 weeks recommended**
Connections to the Engineering byDesign™ Program	***Technological Design* contributes to the development of each high school student's capacity to understand how technology's development, control, and use is based on design constraints, and human wants and needs. The structure of the course challenges students to use technological design processes so that they can think, plan, design and create solutions to engineering and technological problems. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Students address the complexities of technology that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific purposes. Students are able to assess and understand the behavior and operation of basic technological systems in different contexts. Students extend and transfer their knowledge of systems to new and emerging applications by the time they graduate from high school.**

Impacts of Technology

Name of Course	Impacts of Technology
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	Students in *Impacts of Technology* learn that technology is a neutral topic that can have good or bad impacts on society. Technology assessment is a structured evaluation of the application of technology in an effort to avoid inappropriate or unwanted effects. Applying design and student imagination without considering the possible effects of new products or processes can lead to technological disasters, superfund sites, and unsafe products that could have been avoided in the initial design stages. Whether a new product, system, or process has an overall positive, neutral, or negative impact depends on the proper understanding of technology assessment. This aspect of *Impacts of Technology* gives students a head start on the road to technological literacy by focusing primarily on technology assessment and the impact on *technology design*.
Course Length	36 weeks recommended
Connections to Engineering byDesign™	The thrust of the *Impacts of Technology* course contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values that enable students to reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Through high school technology education experiences, students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific needs. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school.

Advanced Design Applications *(ProBase)*

Name of Course	Advanced Design Applications
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology highly* recommended Advanced Technology Education
Course Overview	In *Advanced Design Applications* consists of four units including Manufacturing, Energy and Power, Construction and Transportation. The Manufacturing unit examines the advances that maintain manufacturing efficiency, how human consumption affects manufacturing, how manufacturing affects the standard of living of various peoples, and how processing and changing raw materials can produce more desirable products. The Construction unit examines a number of the factors influencing the design and construction of permanent and semi-permanent structures, the practices related to construction maintenance, alteration, and renovation, and the functions of the primary systems installed in those structures. The Energy & Power unit explores the relationship between energy and power technologies and all other technologies, and how modern energy and power systems impact cultures, societies, and the environment. It also offers an examination of how energy and power systems can be made more efficient and how they may be utilized in problem solving. The Transportation unit examines the complex networks of interconnected subsystems that each transportation system comprises and the roles of these components in the overall functional process of the system. It also analyzes of the improvements and the impacts of transportation technologies on the environment, society, and culture.
Course Length	36 weeks recommended
Connections to the Engineering byDesign™ Program	The *Advanced Design Applications* course has been designed as an advanced study for students engaged in themed academies and general technology studies that lead to the capacity to understand how technology's development, control, and use is based on design constraints, and human wants and needs. The structure of the course challenges students to use design processes so that they can think, plan, design and create solutions to engineering and technological problems. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Students address the complexities of technology that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific purposes. Students are able to assess and understand the behavior and operation of basic technological systems in different contexts. Students extend and transfer their knowledge of systems to new and emerging applications by the time they graduate from high school.

Advanced Technological Applications *(ProBase)*

Name of Course	**Advanced Technological Applications**
Standards Addressed	**See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A**
Intended Audience	**Grades 10-12:** ***Foundations of Technology highly*** **recommended** **Advanced Technology Education**
Course Overview	**In the** ***Advanced Technological Applications*** **course, students study about four components of the Designed World, including Information Technology, Agriculture and Bio-related Technologies, Medical, and Entertainment/Recreation. The Agriculture and Biotechnologies unit explores how agricultural technologies provide increased crop yields and allow adaptation to changing and harsh environments, enabling the growth of plants and animals for various uses. It also offers an analysis of the various uses of biotechnology and the ethical considerations of those uses. The Entertainment and Recreation unit provides a study of technological entertainment and recreation systems, with an examination of the differences between these technologies, of how their use enhances human leisure-time performance, and of the social, cultural, and environmental implications of their usage. The Information Technologies unit examines how technology facilitates the gathering, manipulation, storage, and transmission of data, and how this data can be used to create useful products. It also provides students with opportunities for developing communications systems that can solve technological problems. The Medical Technologies Unit provides an analysis of how medical technologies are used to increase the quality and length of human life, and how increased use of technology carries potential consequences, which require public debate. Students will also examine tools and devices used to repair and replace organs, prevent disease, and rehabilitate the human body**
Course Length	**36 weeks recommended**
Connections to the Engineering byDesign™ Program	**The** ***Advanced Technological Applications*** **course has been designed as an advanced study for students engaged in themed academies and general technology studies that lead to the capacity to understand how technology's development, control, and use is based on design constraints, and human wants and needs. The structure of the course challenges students to use design processes so that they can think, plan, design and create solutions to engineering and technological problems. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Students address the complexities of technology that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific purposes. Students are able to assess and understand the behavior and operation of basic technological systems in different contexts. Students extend and transfer their knowledge of systems to new and emerging applications by the time they graduate from high school.**

Engineering
Design
(Capstone)

Name of Course	Engineering Design
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	In *Engineering Design*, engineering scope, content, and professional practices are presented through practical applications. Students in engineering teams apply technology, science, and mathematics concepts and skills to solve engineering design problems and innovate designs. Students research, develop, test, and analyze engineering designs using criteria such as design effectiveness, public safety, human factors, and ethics. This course is the capstone experience for students who are interested in Technology, Innovation, Design, and Engineering.
Course Length	36 weeks recommended
Connections to: Foundations of Technology	*Engineering Design* contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values so that students can reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Through high school technology education experiences, students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific purposes. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school. As the capstone experience for the **Engineering byDesign™ Program**, *Engineering Design* provides students with the knowledge and skills to delve deeper into engineering at the post-secondary level.

Chapter

5

Using The *Engineering byDesign*™ Course Guides

Each Model Course Guide provides standards-based content, activities, and resources for teaching a cornerstone technology course at either the middle or high school level. The information contained in the guide will assist teachers in preparing to implement *STL*. In addition, it can be used by state, provincial, and local curriculum developers as a model for creating new standards-based programs and curriculum.

The **Introduction** section addresses the Engineering byDesign™ Program and how it was conceived to be standards-based. States, school districts, and schools will find that this chapter is a model for designing a program that teaches technological literacy that is truly standards-based. Each model uses the processes and forms that are prescribed in the ITEA Addenda Guides, *Planning Learning: Developing Technology Curricula*, and *Realizing Excellence: Structuring Technology Programs*.

The **Overview** features an introduction to *Foundations of Technology*, course information, and goals and objectives. The use of a pre- and post-assessment is discussed, as well as examples of assessment items. A course content outline is provided, with the units of instruction for this course.

Units 1-8 provide the units of instruction in detail for use by the classroom teacher. Each unit presents standards-based content for students in the Foundations of Technology course. The unit framework consists of an overview, standards/benchmarks, the BIG Idea for the unit, assessment tools, lessons, and learning activities that include teacher preparation, unit content, suggested learning activities, assessment, and resources.

The **Appendices** contain descriptions of resources, materials, and references that teachers may obtain as they develop curriculum and instructional materials. Teachers, curriculum developers, and other interested readers are encouraged to review the guide in its entirety. The content across the chapters and instructional units collectively contributes to quality instruction that addresses the standards.

Chapter

6

Professional Development

The International Technology Education Association's Center to Advance the Teaching of Technology & Science (CATTS) is the professional development and curriculum development arm for the Association. CATTS was established by ITEA because of its deep commitment to improve student achievement in technology, science, and mathematics at all grade levels and to strengthen, broaden, and deepen the disciplinary and pedagogical knowledge of teachers.

The Center's mission is to provide teachers with support for professional development that will help ensure the education of technologically literate students. This guide is a professional development plan that in itself is based on national standards, including Advancing Excellence in Technological Literacy (ITEA, 2003) and the National Staff Development Council's Standards for Staff Development (NSDC, 2001).

Teacher competence and confidence are essential for the development and improvement of curricula that help students achieve higher levels of understanding in technology, science and mathematics. Professional development is intended to provide teachers with thorough exposure to appropriate content and pedagogical knowledge; knowledge and skills necessary to implement standards-based materials; and the follow-up support obtained through professional learning communities that is needed to improve classroom instruction.

Features of the ITEA-CATTS EbD™ Professional Development Plan

A quality professional development plan includes:

1. the creation of a professional learning community among teachers, post-secondary institutions and supervisors;
2. employ the "train-the-trainers" concept possible to leverage the expertise of highly qualified teachers;
3. help participants gain the skills necessary to better share their experiences with colleagues;
4. deliver in-service through eTIDEonline.net, enabling teachers to participate in synchronous and asynchronous professional development;

5. connect with colleges or universities for credit opportunities;

6. implement the Engineering ByDesign™ standards-based national model to develop technological literacy in students K-12;

7. create demonstration sites that implement the Engineering ByDesign™ model through the Engineering ByDesign™ Network of Schools (EbD);

8. implement and interpret student assessment tools to enhance the teacher effectiveness in the classroom.

Characteristics of Effective Professional Development and the ITEA-CATTS EbD™ Professional Development Plan

Characteristics of quality professional development include:

1. start with standards

2. improve student learning

3. enhance teacher content and pedagogical knowledge;

4. align with other reform initiatives;

5. promote collegiality and collaborative exchange;

6. are ongoing, career-embedded, and sustained,

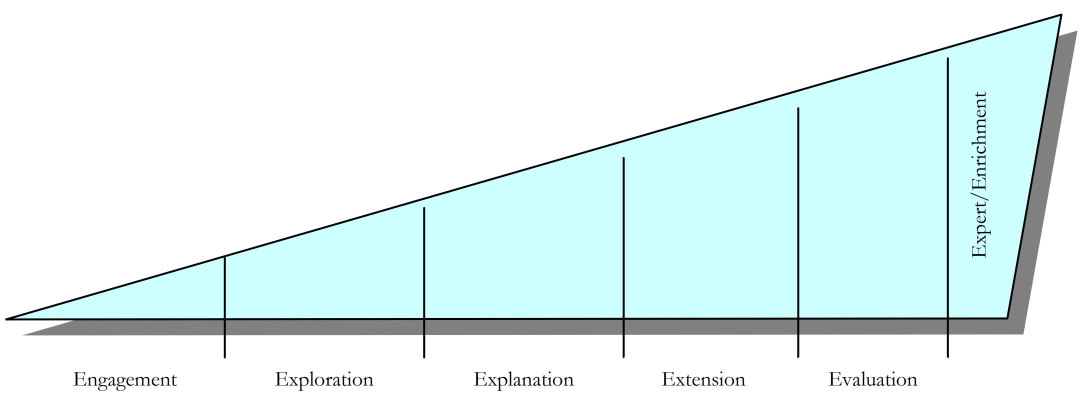
7. include accountability measures.

Chapter 7

The *Engineering byDesign*™ Network

The *EbD*™ Network links schools that believe that the ingenuity of children is untapped, unrealized potential that when properly motivated, will lead to the next generation of technologists, innovators, designers, and engineers.

The *Engineering byDesign™ (EbD™) Network* is the organizer for creating a group of committed professionals dedicated to implementing standards-based instruction resulting in technologically literate students. In the fall of 2005, approximately 50 sites will be selected nationally from states in the ITEA-CATTS Consortium. Teachers and principals at these sites will agree to a multi-faceted approach to professional development to improve the student achievement in technology, science and mathematics. The conceptual framework for the Network is based on a model that uses differentiated strategies to achieve an awareness level that is highly expert.



The 5E+ *EbD*™ Network Model builds on an increasingly more complex activities over time that create a community of learners who work together to enhance and refine strategies that ultimately improve student achievement in technology, science and mathematics.

The Guiding Principles of the *EbD*™ Network

1. **All students can learn,**

2. **Diversity enhances the creativity of teams and individuals,**

3. **Collaborative teams work to solve technological problems achieve better solutions and more reliable results,**

4. **Increasing student achievement is dependent upon providing students with opportunities that are standards-based, problem-based, and presented in an authentic environment,**

5. **Authentic learning will increase student achievement in mathematics, science, and English.**

The Goals of the *EbD*™ *Network*

1. **Provide a standards-based K-12 program that ensures that all students are technologically literate,**

2. **Provide opportunities for all students without regard to gender or ethnic origin,**

3. **Provide clear standards and expectations for increasing student achievement in technology, science, and mathematics**

4. **Provide leadership and support that will result in continuous improvement and innovation in the program.**

5. **Restore America's status as the leader in innovation**

6. **Provide a program that constructs learning from a very early age and culminates in a capstone experience that leads students to become the next generation of technologists, innovators, designers, and engineers.**

Standards & Outcomes

The ITEA process for improving student achievement through the development and sustained use of communities of learners, uses strategic outcomes to shape the Plan. Note that the ITEA-CATTS plan addresses three levels of implementation as described in AETL and the NSDC Staff Development Standards.

Levels of Implementation

1. **State Level**
2. **District Level**
3. **School Level**

AETL Professional Development Standards

Standard PD-1:	Professional development will provide teachers with knowledge, abilities, and understanding consistent with *Standards for Technological Literacy: Content for the Student of Technology* (*STL*).
Standard PD-2:	Professional development will provide teachers with educational perspectives on students as learners of technology.
Standard PD-3:	Professional development will prepare teachers to design and evaluate technology curricula and programs.
Standard PD-4:	Professional development will prepare teachers to use instructional strategies that enhance technology teaching, student learning, and student assessment.
Standard PD-5:	Professional development will prepare teachers to design and manage learning environments that promote technological literacy.
Standard PD-6:	Professional development will prepare teachers to be responsible for their own continued growth.
Standard PD-7:	Professional development providers will plan, implement, and evaluate the pre-service and in-service education of teachers.

NSDC Context Standards: *Staff development that improves the learning of all students:*

Standard Context-1	Organizes adults into learning communities whose goals are aligned with those of the school and district. (Learning Communities)
Standard Context-2	Requires skillful school and district leaders who guide continuous instructional improvement. (Leadership)
Standard Context-3	Requires resources to support adult learning and collaboration. (Resources)

NSDC Process Standards: *Staff development that improves the learning of all students:*

Standard Process-1	Uses disaggregated student data to determine adult learning priorities, monitor progress, and help sustain continuous improvement. (Data-Driven)
Standard Process-2	Uses multiple sources of information to guide improvement and demonstrate its impact. (Evaluation)
Standard Process-3	Prepares educators to apply research to decision making. (Research-Based)
Standard Process-4	Uses learning strategies appropriate to the intended goal. (Design)
Standard Process-5	Applies knowledge about human learning and change. (Learning)
Standard Process-6	Provides educators with the knowledge and skills to collaborate. (Collaboration)

NSDC Content Standards: *Staff development that improves the learning of all students:*

Standard Content-1	Prepares educators to understand and appreciate all students, create safe, orderly and supportive learning environments, and hold high expectations for their academic achievement. (Equity)
Standard Content-2	Deepens educators' content knowledge, provides them with research-based instructional strategies to assist students in meeting rigorous academic standards, and prepares them to use various types of classroom assessments appropriately. (Quality Teaching)
Standard Content-3	Provides educators with knowledge and skills to involve families and other stakeholders appropriately. (Family Involvement)

AETL Program Standards

Standard P-1:	Technology program development will be consistent with Standards for Technological Literacy: Content for the Study of Technology (STL).
Standard P-2:	Technology program implementation will facilitate technological literacy for all students.
Standard P-3:	Technology program evaluation will ensure and facilitate technological literacy for all students.
Standard P-4:	Technology program learning environments will facilitate technological literacy for all students.
Standard P-5:	Technology program management will be provided by designated personnel at the school, school district, and state/provincial/regional levels.

AETL Student Assessment Standards

Standard A-1:	Assessment of student learning will be consistent with Standards for Technological Literacy: Content for the Study of Technology (STL).
Standard A-2:	Assessment of student learning will be explicitly matched to the intended purpose.
Standard A-3:	Assessment of student learning will be systematic and derived from research-based assessment principles.
Standard A-4:	Assessment of student learning will reflect practical contexts consistent with the nature of technology.
Standard A-5:	Assessment of student learning will incorporate data collection for accountability, professional development, and program enhancement.

The 5E Approach to Professional Development

Phase 1 – Engagement

Phase 1-Engagement: This phase is the first step in a series of experiences that are designed to engage the audiences at each level. The first Phase includes an introduction to the Engineering ByDesign Program, the EbD Network of Schools, data to support the program, and information about standards-based instruction. Student assessment and Program evaluation are also discussed. The format is designed to be an interactive presentation that may be used as a marketing tool, as well as way to engage administrators and key decision-makers.

Big Idea:	The ITEA-CATTS Engineering ByDesign™ standards-based model provide a consistent organizer for assessing student attainment of the Standards for Technological Literacy and technological literacy

Essential Questions

- What are the *STL*?
- What is *AETL*?
- What is *Engineering byDesign*™?
- Why do we need consistency?
- Why do we need student assessments?
- What is problem-based instruction?
- What is the *Engineering byDesign™ Network*?
- What is the 5E Lesson-planning model?

Length: 1-2 hours. This phase is offered as sessions at state/local/national conferences, including the ITEA Annual Conference.

Audience: Potential implementers, including teachers, principals, district and state supervisors

Phase 2 - Exploration

Phase 2 -Exploration: This workshop is based on "Understanding By Design" philosophies and the content in the Engineering ByDesign™ courses, Exploring Technology and Engineering Design. The "Enduring Understanding" is the main idea that all participants should gain from the instruction. The "Essential Questions" further define the Big Ideas. In this instructional design, questions regarding the organization, the process, and the ByDesign philosophy are addressed clearly and often. This workshop is designed for participants whom have heard of the Engineering ByDesign™ standards-based model and are interested in more information. They will be ready to plan the implementation of the EbD™ model by the end of this workshop and they will be informed to the degree that they can speak knowledgably about it to decision makers with regard to the two model courses, Exploring Technology and Engineering Design.

Big Idea:	Understand how Engineering ByDesign™ uses constructivism and problem-based learning to augment technological literacy and increase student achievement.

Essential Questions

- What is Constructivism?
- What are the STL?
- What is the 5E Lesson-planning model?
- What is problem-based instruction?
- Why do we need broad-based assessment?

Length: 3-4 hours for each course. This phase is offered as the pre-conference workshop at the ITEA annual conference.

Audience: Potential implementers, including teachers, principals, district and state supervisors

Phase 3 - Explanation

Phase 3 -Explanation: This workshop is a combination of synchronous (face to face) and asynchronous (electronic/online) professional development. Participants are enrolled in the eTIDEonline courses that are being implemented as part of the Engineering ByDesign™ Network of Schools. The semester course uses online learning and regional meetings to develop and sustain learning communities dedicated to the consistent implementation of the courses.

Big Idea: Provide knowledge, abilities, and understanding consistent with STL and Engineering ByDesign™

Essential Questions:

- What are the management strategies for a successful *Engineering ByDesign*™ classroom?
- What are the technical skills that are specific *Engineering ByDesign*™?
- How do the units and lessons engage students to learn the knowledge and skills in *STL*?
- How are assessments used in *Engineering ByDesign*™ curriculum?
- What are the best practices in facilitating problem-based learning?
- What are some strategies for funding, marketing, promoting and recruiting?

Length: 3-4 hours for each course. This phase is offered as the pre-conference workshop at the ITEA annual conference.
Audience: Potential implementers, including teachers, principals, district and state supervisors

Phase 4 - Extension

Phase 4 -Extension: This workshop is a combination of synchronous (face to face) and asynchronous (electronic/online) professional development. Participants are enrolled in the eTIDEonline courses that are being implemented as part of the Engineering ByDesign™ Network of Schools. The semester course uses online learning and regional meetings to develop and sustain learning communities dedicated to the consistent implementation of the courses.

Big Idea: Provide knowledge, abilities, and understanding consistent with STL and Engineering ByDesign™

Essential Questions

- How do technology teachers develop a plan for continuous professional growth?
- What is the role and function of a strong educational leader?
- What techniques can be used to assure that instructional strategies are aligned with intended goals?
- How can opportunity provided for collaboration and problem solving among colleagues enhance instruction?
- What are the best practices in facilitating problem-based learning?
- What are some strategies for funding, marketing, promoting and recruiting?

Length: 3-4 hours for each course. This phase is offered as the pre-conference workshop at the ITEA annual conference.
Audience: Potential implementers, including teachers, principals, district and state supervisors

Phase 5 - Evaluation

Phase 5 -Evaluation: This workshop is a combination of synchronous (face to face) and asynchronous (electronic/online) professional development. Participants are enrolled in the eTIDEonline courses that enable them to develop resources and inter-rater reliability.

Big Idea:	Provide knowledge, abilities, and understanding consistent with *STL* and *Engineering ByDesign*™

Essential Questions

- What are the management strategies for a successful Engineering ByDesign™ classroom?
- What are the technical skills that are specific Engineering ByDesign™?
- How do the units and lessons engage students to learn the knowledge and skills in STL?
- How are assessments used in Engineering ByDesign™ curriculum?
- What are the best practices in facilitating problem-based learning?
- What are some strategies for funding, marketing, promoting and recruiting?

Length	4 - days
Audience	Planned Implementers including teachers, principals, district and state supervisors
Facilities Required	A functional classroom environment with supporting resources, materials and equipment.

Phase 6 – Expert/Enrichment

Phase 6 – Expert/Enrichment: This experience is a combination of synchronous (face to face) and asynchronous (electronic/online) professional development. Participants are enrolled in the eTIDEonline

Big Idea: **Provide knowledge, abilities, and understanding consistent with STL and Engineering ByDesign™**

Essential Questions

- How does involvement in professional organizations contribute to professional growth?
- What are the attributes of effective instructional modeling?
- How does efficient data collection impact instructional delivery?
- How are assessments results used to guide instructional planning?
- What is the relationship between UbyD and school reform?

Length	On-going
Audience	Planned Implementers including teachers, principals, district and state supervisors
Facilities Required	A functional classroom environment with supporting resources, materials and equipment.

Chapter

8

Assessments

The *Engineering byDesign™* (*EbD™)* Program is driven for success by a series of student assessments and Program evaluations that strive to enhance the ability of teachers to be skilled at helping students improve their achievement in technology, mathematics and science. Each of the implementation programs for the FY2006 and FY2007 are complete with student pre- and post-assessments that assist the teacher to develop adequate lessons to ensure students are technologically literate at the end of the Program. Each course has specific knowledge an skills that contribute to the end goal of technologically literate students. Therefore, as students progress through the program, it is inherent for teachers to be adequately trained to identify student exemplars from which to base student progress towards the achievement of benchmarks.

Currently, student assessments are being validated to ensure reliability that students are in fact achieving the *STL* standards, as well as that students in the *EbD™* Program are achieving higher in mathematics and science. This validation phase will be complete by June, 2007 in order that students will be able to complete the assessments at the end of the EbD™ Network initial year (May, 2007.)

In addition to the student assessments, the *EbD™ Program* will be working with member institutions to evaluate program performance, and the ability for the professional development that is being used (5E Planning Process) is working and proving to have a positive result on the expertise of teachers.

Responsibility Matrix for *STL* Standards and Benchmarks

Appendix A
Program Responsibility Matrix – Technology/Science/Mathematics

4 = Benchmark must be covered in detail; lessons and assessments cover this content
3 = Benchmark is covered, but topics and lessons do not center on them
2 = Topics and lessons refer to previous knowledge and integrate content covered
1 = Topics and lessons refer to previous knowledge

		172	232	217	186	172	256	176	186	197
		K-2	3-5	Exploring Technology	Invention & Innovation	Systems	Foundations	Impacts	Issues	Engineering Design
The Nature of Technology										
STL-1	**Understanding the characteristics and scope of technology**	**8**	**12**	**11**	**16**	**9**	**8**	**11**	**10**	**11**
A	The natural world and human-made world are different.	4								
B	All people use tools and techniques to help them do things.	4								
C	Things that are found in nature differ from things that are human-made in how they are produced and used.		4							
D	Tools, materials, and skills are used to make things and carry out tasks.		4							
E	Creative thinking and economic and cultural influences shape technological development.		4							
F	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.			4	4	4				
G	The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.			2	4	2				
H	Technology is closely linked to creativity, which has resulted in innovation.			3	4					
I	Corporations can often create demand for a product by bringing it onto the market and advertising it.			2	4	3				
J	The nature and development of technological knowledge and processes are functions of the setting.						2	3		4
K	The rate of technological development and diffusion is increasing rapidly.						2	4	3	
L	Inventions and innovations are the results of specific, goal-directed research.						2	2	3	4
M	Most development of technologies these days is driven by the profit motive and the market.						2	2	4	3
STL-2	**Understanding the core concepts of technology**	**20**	**28**	**13**	**29**	**35**	**21**	**14**	**20**	**23**
A	Some systems are found in nature, and some are made by humans.	4								
B	Systems have parts or components that work together to accomplish a goal.	4								
C	Tools are simple objects that help humans complete tasks.	4								
D	Different materials are used in making things.	4								
E	People plan in order to get things done.	4								
F	A subsystem is a system that operates as a part of another system.		4							
G	When parts of a system are missing, it may not work as planned.		4							
H	Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.		4							
I	Tools are used to design, make, use, and assess technology.		4							
J	Materials have many different properties.		4							
K	Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.		4							
L	Requirements are the limits to designing or making a product or system.		4							
M	Technological systems include input, processes, output, and, at times, feedback.			4	4	4				

Appendix A
Program Responsibility Matrix – Technology/Science/Mathematics

	4 = Benchmark must be covered in detail; lessons and assessments cover this content 3 = Benchmark is covered, but topics and lessons do not center on them 2 = Topics and lessons refer to previous knowledge and integrate content covered 1 = Topics and lessons refer to previous knowledge	172 K-2	232 3-5	217 Exploring Technology	186 Invention & Innovation	172 Systems	256 Foundations	176 Impacts	186 Issues	197 Engineering Design
N	Systems thinking involves considering how every part relates to others.				3	4				
O	An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.					4				
P	Technological systems can be connected to one another.			2	3	4				
Q	Malfunctions of any part of a system may affect the function and quality of the system.				4	4				
R	Requirements are the parameters placed on the development of a product or system.				4	4				
S	Trade-off is a decision process recognizing the need for careful compromises among competing factors.				4					
T	Different technologies involve different sets of processes.			2	4	3				
U	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.			2	3	4				
V	Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change.			3		4				
W	Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.									4
X	Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.						4		3	
Y	The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.						3		3	
Z	Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.						3	3	3	2
AA	Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.						3		3	4
BB	Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.							2	2	4
CC	New technologies create new processes.						4	2		
DD	Quality control is a planned process to ensure that a product, service, or system meets established criteria.							4		4
EE	Management is the process of planning, organizing, and controlling work.						4		3	2
FF	Complex systems have many layers of controls and feedback loops to provide information.							3	3	3
STL-3	**Understanding the relationships among technologies and connections with other fields of study**	**4**	**8**	**6**	**9**	**9**	**16**	**6**	**7**	**10**
A	The study of technology uses many of the same ideas and skills as other subjects.	4								
B	Technologies are often combined.		4							
C	Various relationships exist between technology and other fields of study.		4							
D	Technological systems often interact with one another.			3	2	2				
E	A product, system, or environment developed for one setting may be applied to another setting.				4	3				
F	Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.			3	3	4				
G	Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.						4			4
H	Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.						4	3		3
I	Technological ideas are sometimes protected through the process of patenting.						4		3	3
J	Technological progress promotes the advancement of science and mathematics.						4	3	4	
Technology and Society										
STL-4	**Understanding the cultural, social, economic and political effects of technology**	**4**	**8**	**14**	**14**	**3**	**0**	**15**	**11**	**8**
A	The use of tools and machines can be helpful or harmful.	4								
B	When using technology, results can be good or bad.		4							
C	The use of technology can have unintended consequences.		4							
D	The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use.			4	3	3				
E	Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.			4	3					
F	The development and use of technology poses ethical issues.			3	4					
G	Economic, political, and cultural issues are influenced by the development and use of technology.			3	4					
H	Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.							4		
I	Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.							4	3	3
J	Ethical considerations are important in the development, selection, and use of technologies.							3	4	3
K	The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.							4	4	2

STL-5	**Understanding the effects of technology on the environment**	**4**	**8**	**8**	**4**	**9**	**4**	**21**	**19**	**11**
A	Some materials can be reused and/or recycled.	4								
B	Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.		4							
C	The use of technology affects the environment in good and bad ways.		4							
D	The management of waste produced by technological systems is an important societal issue.			4		3				
E	Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.				1	4				
F	Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.			4	3	2				
G	Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.							4	3	2
H	When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.							3	4	
I	With the aid of technology, various aspects of the environment can be monitored to provide information for decision making.							3	4	
J	The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.							4		3
K	Humans devise technologies to reduce the negative consequences of other technologies.						4	3	4	3
L	Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.							4	4	3
STL-6	**Understanding the role of society in the development and use of technology**	**4**	**8**	**13**	**15**	**2**	**5**	**3**	**11**	**9**
A	Products are made to meet individual needs and wants.	4								
B	Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.		4							
C	Individual, family, community, and economic concerns may expand or limit the development of technologies.		4							
D	Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.			4	3					
E	The use of inventions and innovations has led to changes in society and the creation of new needs and wants.			3	4					
F	Social and cultural priorities and values are reflected in technological devices.			3	4	2				
G	Meeting societal expectations is the driving force behind the acceptance and use of products and systems.			3	4					
H	Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.						2		3	3
I	The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.							3	4	3
J	A number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.						3		4	3
STL-7	**Understanding the influence of technology on history**	**4**	**4**	**6**	**14**	**4**	**27**	**20**	**15**	**4**
A	The way people live and work has changed throughout history because of technology.	4								
B	People have made tools to provide food, to make clothing, and to protect themselves.		4							
C	Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements.			3	4					
D	The specialization of function has been at the heart of many technological improvements.			3	4					
E	The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.				2	4				
F	In the past, an invention or innovation was not usually developed with the knowledge of science.				4					
G	Most technological development has been evolutionary, the result of a series of refinements to a basic invention.						4			2
H	The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.							4	3	1
I	Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.							4	3	1
J	Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.						4		2	
K	The Iron Age was defined by the use of iron and steel as the primary materials for tools.						4		3	
L	The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society.						4	3		
M	The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology.						4	3		
N	The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.						4	3		
O	The Information Age places emphasis on the processing and exchange of information.						3	3	4	

Design

STL-8	**Understanding the attributes of design**	**8**	**8**	**9**	**12**	**0**	**13**	**2**	**8**	**15**
A	Everyone can design solutions to a problem.	4								
B	Design is a creative process.	4								
C	The design process is a purposeful method of planning practical solutions to problems.		4							
D	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.		4							
E	Design is a creative planning process that leads to useful products and systems.			3	4					
F	There is no perfect design.			3	4					
G	Requirements for a design are made up of criteria and constraints.			3	4					
H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.						4	2	2	4
I	Design problems are seldom presented in a clearly defined form.						3		3	3
J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.						3			4
K	Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.						3		3	4

STL-9	Understanding engineering design	8	12	10	11	2	13	0	2	16
A	The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.	4								
B	Expressing ideas to others verbally and through sketches and models is an important part of the design process.	4								
C	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.		4							
D	When designing an object, it is important to be creative and consider all ideas.		4							
E	Models are used to communicate and test design ideas and processes.		4							
F	Design involves a set of steps, which can be performed in different sequences and repeated as needed.			4	4					
G	Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.			4	3	2				
H	Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.			2	4					
I	Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.						4			4
J	Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.						3			4
K	A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.						3			4
L	The process of engineering design takes into account a number of factors.						3		2	4

STL-10	Understanding the role of troubleshooting, R&D, etc. in problem-solving	8	12	9	10	6	12	0	15	9
A	Asking questions and making observations helps a person to figure out how things work.	4								
B	All products and systems are subject to failure. Many products and systems, however, can be fixed.	4								
C	Troubleshooting is a way of finding out why something does not work so that it can be fixed.		4							
D	Invention and innovation are creative ways to turn ideas into real things.		4							
E	The process of experimentation, which is common in science, can also be used to solve technological problems.		4							
F	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.			3	2	4				
G	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.			3	4	2				
H	Some technological problems are best solved through experimentation.			3	4					
I	Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.						4		4	3
J	Technological problems must be researched before they can be solved.						2		3	2
K	Not all problems are technological, and not every problem can be solved using technology.						3		4	2
L	Many technological problems require a multidisciplinary approach.						3		4	2

Abilities for a Technological World

STL-11	Abilities to apply the design process	12	16	15	20	2	24	2	6	19
A	Brainstorm people's needs and wants and pick some problems that can be solved through the design process.	4								
B	Build or construct an object using the design process.	4								
C	Investigate how things are made and how they can be improved.	4								
D	Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem.		4							
E	The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.		4							
F	Test and evaluate the solutions for the design problem.		4							
G	Improve the design solutions.		4							
H	Apply a design process to solve problems in and beyond the laboratory-classroom.			3	4					
I	Specify criteria and constraints for the design.			3	4					
J	Make two-dimensional and three-dimensional representations of the designed solution.			3	4					
K	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.			3	4					
L	Make a product or system and document the solution.			3	4	2				
M	Identify the design problem to solve and decide whether or not to address it.						4	2	3	4
N	Identify criteria and constraints and determine how these will affect the design process.						4		3	3
O	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.						4			3
P	Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.						4			3
Q	Develop and produce a product or system using a design process.						4			3
R	Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.						4			3

STL-12	Abilities to use and maintain technological products and systems	12	16	8	9	13	13	7	1	15
A	Discover how things work.	4								
B	Use hand tools correctly and safely and be able to name them correctly.	4								
C	Recognize and use everyday symbols.	4								
D	Follow step-by-step directions to assemble a product.		4							
E	Select and safely use tools, products, and systems for specific tasks.		4							
F	Use computers to access and organize information.		4							
G	Use common symbols, such as numbers and words, to communicate key ideas.		4							
H	Use information provided in manuals, protocols, or by experienced people to see and understand how things work.			4	3	3				
I	Use tools, materials, and machines safely to diagnose, adjust, and repair systems.				3	4				
J	Use computers and calculators in various applications.			4	3	2				
K	Operate and maintain systems in order to achieve a given purpose.					4				
L	Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.						3	4	1	3
M	Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.						3			3
N	Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.									3
O	Operate systems so that they function in the way they were designed.						3			3
P	Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.						4	3		3

STL-13	Abilities to assess the impact of products and systems	8	12	9	6	16	3	15	10	9
A	Collect information about everyday products and systems by asking questions.	4								
B	Determine if the human use of a product or system creates positive or negative results.	4								
C	Compare, contrast, and classify collected information in order to identify patterns.		4							
D	Investigate and assess the influence of a specific technology on the individual, family, community, and environment.		4							
E	Examine the trade-offs of using a product or system and decide when it could be used.		4							
F	Design and use instruments to gather data.			3		4				
G	Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology.				3	4				
H	Identify trends and monitor potential consequences of technological development.			3		4				
I	Interpret and evaluate the accuracy of the information obtained and determine if it is useful.			3	3	4				
J	Collect information and evaluate its quality.						3	3	4	3
K	Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.							4	3	2
L	Use assessment techniques, such as trend analysis and experimentation, to make decisions about the future development of technology.							4		2
M	Design forecasting techniques to evaluate the results of altering natural systems.							4	3	2

The Designed World

STL-14	Understanding of and abilities to select and use medical technologies	12	12	13	4	8	4	9	8	0
A	Vaccinations protect people from getting certain diseases.	4								
B	Medicine helps people who are sick to get better.	4								
C	There are many products designed specifically to help people take care of themselves.	4								
D	Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing.		4							
E	Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility.		4							
F	Many tools and devices have been designed to help provide clues about health and to provide a safe environment.		4							
G	Advances and innovations in medical technologies are used to improve health care.			3	4					
H	Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety.			4						
I	The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines is produced.			3		4				
J	Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups.			3		4				
K	Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.						4	3		
L	Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.							3	4	
M	The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures.							3	4	

STL-15	**Understanding of and abilities to select and use agricultural and biotechnologies**	**8**	**12**	**16**	**0**	**4**	**4**	**4**	**14**	**3**
A	The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources.	4								
B	There are many different tools necessary to control and make up the parts of an ecosystem.	4								
C	Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals.		4							
D	Most agricultural waste can be recycled.		4							
E	Many processes used in agriculture require different procedures, products, or systems.		4							
F	Technological advances in agriculture directly affect the time and number of people required to produce food for a large population.			4						
G	A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.					4				
H	Biotechnology applies the principles of biology to create commercial products or processes.			4						
I	Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment.			4						
J	The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.			4						
K	Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products.								3	
L	Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.						4		3	
M	Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.							4	4	
N	The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna.								4	3
STL-16	**Understanding of and abilities to select and use energy and power technologies**	**8**	**8**	**14**	**2**	**8**	**20**	**6**	**3**	**6**
A	Energy comes in many forms.	4								
B	Energy should not be wasted.	4								
C	Energy comes in different forms.		4							
D	Tools, machines, products, and systems use energy in order to do work.		4							
E	Energy is the capacity to do work.			4						
F	Energy can be used to do work, using many processes.			2		4				
G	Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.			4						
H	Power systems are used to drive and provide propulsion to other technological products and systems.				2	4				
I	Much of the energy used in our environment is not used efficiently.			4						
J	Energy cannot be created nor destroyed; however, it can be converted from one form to another.						4			
K	Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.						4			
L	It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings.						4	4		
M	Energy resources can be renewable or nonrenewable.						4	2	3	3
N	Power systems must have a source of energy, a process, and loads.						4			3
STL-17	**Understanding of and abilities to select and use information and communication technologies**	**12**	**16**	**13**	**4**	**11**	**23**	**6**	**4**	**7**
A	Information is data that has been organized.	4								
B	Technology enables people to communicate by sending and receiving information over a distance.	4								
C	People use symbols when they communicate by technology.	4								
D	The processing of information through the use of technology can be used to help humans make decisions and solve problems.		4							
E	Information can be acquired and sent through a variety of technological sources, including print and electronic media.		4							
F	Communication technology is the transfer of messages among people and/or machines over distances through the use of technology.		4							
G	Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations.		4							
H	Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.			3		4				
I	Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.			3		4				
J	The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.			4						
K	The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas.			3	4	3				
L	Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.						4			2
M	Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.						4			
N	Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.						3	3	4	
O	Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.						4			
P	There are many ways to communicate information, such as graphic and electronic means.						4	3		2
Q	Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.						4			3

STL-18	**Understanding of and abilities to select and use transportation technologies**	**12**	**8**	**4**	**3**	**15**	**8**	**12**	**8**	**3**
A	A transportation system has many parts that work together to help people travel.	4								
B	Vehicles move people or goods from one place to another in water, air or space, and on land.	4								
C	Transportation vehicles need to be cared for to prolong their use.	4								
D	The use of transportation allows people and goods to be moved from place to place.		4							
E	A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working.		4							
F	Transporting people and goods involves a combination of individuals and vehicles.			4		3				
G	Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.					4				
H	Governmental regulations often influence the design and operation of transportation systems.				3	4				
I	Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.					4				
J	Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.						4	3		
K	Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.						4	3	2	
L	Transportation services and methods have led to a population that is regularly on the move.							2	4	
M	The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques.							4	2	3
STL-19	**Understanding of and abilities to select and use manufacturing technologies**	**8**	**12**	**16**	**4**	**4**	**18**	**19**	**6**	**11**
A	Manufacturing systems produce products in quantity.	4								
B	Manufactured products are designed.	4								
C	Processing systems convert natural materials into products.		4							
D	Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products.		4							
E	Manufacturing enterprises exist because of a consumption of goods.		4							
F	Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning.			4						
G	Manufactured goods may be classified as durable and non-durable.			4						
H	The manufacturing process includes the designing, development, making, and servicing of products and systems.					4				
I	Chemical technologies are used to modify or alter chemical substances.			4						
J	Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining.			4						
K	Marketing a product involves informing the public about it as well as assisting in selling and distributing it.				4					
L	Servicing keeps products in good operating condition.							4		
M	Materials have different qualities and may be classified as natural, synthetic, or mixed.						4	3		4
N	Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.						4	2	2	2
O	Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.						4		2	
P	The interchangeability of parts increases the effectiveness of manufacturing processes.						2	4		3
Q	Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products.							4		
R	Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it.						4	2	2	2
STL-20	**Understanding of and abilities to select and use construction technologies**	**8**	**12**	**10**	**0**	**12**	**20**	**4**	**8**	**8**
A	People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools.	4								
B	The type of structure determines how the parts are put together.	4								
C	Modern communities are usually planned according to guidelines.		4							
D	Structures need to be maintained.		4							
E	Many systems are used in buildings.		4							
F	The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.			4						
G	Structures rest on a foundation.			3		4				
H	Some structures are temporary, while others are permanent.			3		4				
I	Buildings generally contain a variety of subsystems.					4				
J	Infrastructure is the underlying base or basic framework of a system.						4	2		2
K	Structures are constructed using a variety of processes and procedures.						4		3	
L	The design of structures includes a number of requirements.						4		3	3
M	Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.						4	2		3
N	Structures can include prefabricated materials.						4		2	