

Chapter 2, Unit 1

Systems and Optimization

Standards for Technological Literacy Standards Addressed in Unit 1

Unit 1 addresses the following STL standards:

- **Standard 2** Students will develop an understanding of the core concepts of technology.
- **Standard 14** Students will develop an understanding of and be able to select and use medical technologies.

Big Ideas

Concepts of Technology and Medical Technology

Student Assessment Criteria – Concepts of Technology

Achievement Level Sub-concept	Above Target 3	At Target 2	Below Target 1
Systems	Thoughtfully designs , prototypes, and tests a technological system that effectively accomplishes an outcome and includes input, process, output, and feedback components.	Designs , prototypes, and tests a technological system that accomplishes an outcome and includes input, process, output, and feedback components.	Designs , prototypes, and tests a technological system that includes input, process, output, and feedback components but may not accomplish the system's objectives .
Processes	Correctly, safely, and efficiently operates and maintains effective technological systems that process matter (separate, form, combine, and condition) and data (collect/detect, manipulate, and display).	Operates and maintains effective technological systems that process matter (separate, form, combine, and condition) and data (collect/detect, manipulate, and display).	Operates and maintains with minimal effectiveness , technological systems that process matter (separate, form, combine, and condition) and data (collect/detect, manipulate, and display).
Resources	Effectively, efficiently, and appropriately applies resources (materials, energy, personnel, information, capital, and property) to a task, with highly positive results .	Adequately applies resources (materials, energy, personnel, information, capital, and property) to a task, with positive results .	Ineffectively applies resources (materials, energy, personnel, information, capital, and property) to a task, with minimally positive results .
Impacts	Insightfully and critically assesses and makes thoughtful recommendations about the impacts of the systems and processes employed and the appropriate use of resources, with respect for individuals, society, and the environment. Probes the extent to which the objectives of a technological activity were attained, new challenges and opportunities were created, and new knowledge was generated.	Assesses and makes recommendations about the impacts of the systems and processes employed and the appropriate use of resources, with respect for individuals, society, and the environment. Questions the extent to which the objectives of a technological activity were attained, new challenges and opportunities were created, and new knowledge was generated.	Reviews the impacts of the systems and processes employed and the appropriate use of resources, with respect for individuals, society, and the environment. Asks few questions about the extent to which the objectives of a technological activity were attained, new challenges and opportunities were created, and new knowledge was generated.

Student Assessment Criteria – Medical Technology			
Achievement Level	Above Target	At Target	Below Target
Sub-concept	3	2	1
Prevention	Thoroughly compares the relationship between good health and the technology associated with factors such as exercise, nutrition, monitoring (check-ups), vaccines, genetic modifications, and heredity.	Compares the relationship between good health and the technology associated with factors such as exercise, nutrition, monitoring (check-ups), vaccines, genetic modifications, and heredity.	Marginally compares the relationship between good health and the technology associated with factors such as exercise, nutrition, monitoring (check-ups), vaccines, genetic modifications, and heredity.
Diagnosis	Clearly explains the technology used to diagnose health-related issues and thoughtfully speculates about how new technology could detect future problems before they become obvious.	Explains the technology used to diagnose health-related issues and speculates about how new technology could detect future problems before they become obvious.	Explains to a limited extent the technology used to diagnose health-related issues and lists a few ways about how new technology could detect future problems before they become obvious.
Treatment	Explains in detail and with documentation , how new technology has aided in treating medical problems, the impacts (positive and negative) those treatments have had, and areas where new technological developments and policy decisions could help to improve the quality of life globally.	Explains in some detail and with a little documented support , how new technology has aided in treating medical problems, the impacts (positive and negative) those treatments have had, and areas where new technological developments and policy decisions could help to improve the quality of life globally.	Explains, but with limited documentation , how new technology has aided in treating medical problems, the impacts (positive and negative) those treatments have had, and areas where new technological developments and policy decisions could help to improve the quality of life globally.
Rehabilitation	Effectively explains, with supporting documentation , how technology aids in a person's recovery from a treatment procedure or injury and how new technology might further enhance the recovery process.	Explains how technology aids in a person's recovery from a treatment procedure or injury and how new technology might further enhance the recovery process.	Explains, with minimal effectiveness , how technology aids in a person's recovery from a treatment procedure or injury and how new technology might further enhance the recovery process.

Student Learning Experiences

System Loops

Material Systems Dissection

Texas Traffic

Waste Management Systems

Stress Analysis

As a set of learning experiences, the following *STL* content standards and corresponding benchmarks are addressed: Standard 2, Benchmarks W, X, Y, Z, AA, BB, CC, DD, EE, and FF; Standard 14, Benchmarks K, L, and M. However, if you choose to use only a specific activity, please refer to Appendix B to determine exactly which standards and benchmarks are being addressed by that learning experience. See **Appendix B** for a complete listing of the *STL* content standards.

Acceptable Evidence of Student Understanding

1. Document daily progress in a lab report or journal.
2. Define and apply terms related to systems in the correct context
3. Analyze a system and subsystems and identify the input, process, output, and feedback loops.
4. Create a functioning system that incorporates input, process, output, and feedback loops.
5. Safely dissect a material system, breaking it down into specific material categories.
6. Assess a system, forecast the future of the technology, and predict where the system could be improved.
7. Analyze data provided by a system and give feedback for re-design.
8. Present research on the development of a waste management system. Create a model to inform others of the research and a solution to the problem.
9. Collect pulse rate data and organize it.
10. Analyze results of data collection and make a hypothesis.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix D, Acceptable Evidence Glossary**, for definitions.)

Overview

A **system** is a means of achieving a desired result. It has input, process, output, and feedback. The system approach can also be considered a way of thinking. Whenever you are presented with a problem or a case study, simply break it down into smaller subsystems to simplify the approach. For example, an automobile has systems and subsystems: mechanical systems (gears and pulleys); electrical systems (battery, wiring, and now computers in new cars); and fluid systems. As the driver, you become the input part

of the system when you feed the car information in the form of pressure on gas and brake pedals. You manipulate a wheel mounted to a column that controls the direction of the vehicle.

The automobile converts the input to process, obeying the driver's signals and converting them into output. Does the vehicle "want" to engage its four-wheel drive? Will the brakes "choose" to function correctly when the driver "miscalculates" and has to slam them only ten feet from a tree or another vehicle?

If one of these systems fails, the driver certainly wants to have feedback. In a vehicle, the gauges and displays give one form of feedback—from the fuel gauge to the large warning lights that simply tell you that something is wrong with your engine. We do not think of these "feedbacks" consciously until a crisis arises, like looking down at the speedometer after passing a police vehicle.

Optimization can be defined as doing the most with the least. A crude but distinct example would be that of cutting a 2" by 2" square

out of a piece of paper. Would cutting it out of the center be the best solution? Or might it be a better solution to use the edges of the paper in a corner to eliminate two unnecessary cuts and have a large portion of the paper uninterrupted for future use?

Most design problems we face have no definitive answer. Most solutions are a series of compromises, which, in turn, allow the product to function well. An engineer or technician must assess all the parts of a problem and optimize each before the job is resolved. Webster's

Dictionary defines optimization as "The procedure or procedures used to make a system or design as effective or functional as possible, especially the mathematical techniques involved."

Teacher Preparation

The following general suggestions will help the teacher prepare for instruction in this unit. To begin, review the technological literacy standards and academic connections for this unit. You may want to meet with the math and science teachers in your school or school district to

obtain input for the content in this unit and additional resources for the class. Another suggestion is to contact local businesses or engineering experts to get another perspective on the unit content and activities. Locate the resources recommended at the end of each case study and review their content.

You may want to introduce this unit by pointing out recent technology-related issues and events cited in the national or local newspaper. Prepare questions that will engage students in a discussion of the potential impacts of these issues locally and globally.

Unit 1 Content Outline

- | | |
|--|--|
| <ul style="list-style-type: none"> I. Core concepts in technology <ul style="list-style-type: none"> A. Systems <ul style="list-style-type: none"> 1. Application of logic and creativity with compromises 2. Systems can be embedded within other systems 3. Stability of a system is related to its components 4. Feedback loop may be the most important step 5. Human systems <ul style="list-style-type: none"> a. Family b. Government 6. Interaction between human and technological systems B. Resources <ul style="list-style-type: none"> 1. Availability 2. Cost 3. Desirability 4. Waste 5. Requirements <ul style="list-style-type: none"> a. Criteria b. Constraints c. Effect on final design C. Optimization and trade-offs D. Processes/new technologies <ul style="list-style-type: none"> 1. New technologies create new processes 2. Can new processes create new technologies? | <ul style="list-style-type: none"> E. Controls <ul style="list-style-type: none"> 1. Quality control 2. Management F. Complex systems <ul style="list-style-type: none"> 1. Many layers of controls/feedback loops 2. Provide information II. Medical Technologies <ul style="list-style-type: none"> A. Prevention B. Rehabilitation C. Vaccines D. Pharmaceuticals E. Medical and surgical procedures F. Genetic engineering G. Telemedicine <ul style="list-style-type: none"> 1. Medicine 2. Telecommunications 3. Virtual presence 4. Computer engineering 5. Informatics 6. Artificial intelligence 7. Robotics 8. Materials science 9. Perceptual psychology H. Biochemistry I. Molecular biology <ul style="list-style-type: none"> 1. Manipulate the genetic materials |
|--|--|