# INVENTION and INNOVATION
# Fourth Edition

## OVERVIEW

*Invention and Innovation* prepares students with opportunities to apply the design process in the invention or innovation of a new product, process, or system. In this course, students learn all about invention and innovation. They have opportunities to study the history of inventions and innovations, including their impacts on society. They learn about the core concepts of technology and about the various approaches to solving problems, including engineering design and experimentation. Students 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.

*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.

### OVERVIEW OF UNITS

| KSB | ACTIVITY | BIG IDEA |
|---|---|---|
| **First Five Days** | Day 1 (1 hour)<br>Protect the POD | Everyone has the ability to invent, innovate, and improve designs. |
| | Day 2 & 3 (2 hours)<br>Expectations and Orientation | The *I&I* course is designed to provide as many opportunities to apply the Engineering Design Process as possible. These next two days are designed to allow the students to discover the course's expectations and requirements. |
| | Day 4 (1 hour)<br>What do I Know | The purpose of this lesson is to assess where the students are in regard to their knowledge about Invention and Innovation. |
| | Day 5 (1 hour)<br>Safety | Students will Identify tools and equipment of the shop and give examples of equipment safety. |
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|---|---|---|
| **KSB 1**<br>15 Hours | **Activity 1:** Inventing 101<br>(3-5 hours) | Invention and innovation are creative ways to turn ideas into real things. |
| | **Activity 2:**<br>Engineering Design Process<br>(5-7 hours) | Inventions and innovations are the result of demands, values, and interests of individuals, industries, and societies. |
| | **Activity 3**:<br>What's Your Problem?<br>(5 hours) | All technologies have flaws; there is no perfect design. |
| | | |
| **KSB 2**<br>25 hours | **Activity 1:**<br>The Process in Action<br>(6 hours) | Technology involves many types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation. The engineering design process must take all of these things into account. |
| | **Activity 2**<br>Working With the Design Process<br>(7 hours) | The Engineering Design Process is a systematic problem-solving strategy, with criteria and constraints that are used to develop many possible solutions to a problem, so as to satisfy human needs and wants. This process is iterative, and is informed by many factors such as human values, resources, environmental concerns, and trade-offs in order to arrive at the best possible solution to the problem. |
| | **Activity 3**<br>The Engineering Design Process in Action<br>(12 hours) | Technology involves many types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation. The engineering design process must take all of these things into account. |
| | | |
| **KSB 3**<br>10 Hours | **Activity 1:**<br>Core Concepts of Technology<br>(5 hours) | Core concepts; including systems, resources, requirements, optimization and trade-offs, processes, and controls; serve as cornerstones for the study of technology. |
| | **Activity 2**<br>Real World Designing<br>(5 hours) | Designers and inventors must consider the core concepts of technology and other resources such as scientific knowledge during the process of designing. They must also adhere to the criteria and constraints of a design. |
| | | |
| **KSB 4**<br>11 Hours | **Activity 1:** Technology Around You!<br>(6 Hours) | Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems. |

| | | |
|---|---|---|
| | **Activity 2**: What is Design?<br>(4 Hours) | Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems. |
| | **Activity 3:** Communicating Your Design?<br>(2 Hours) | Communicating your design is important to the process of invention and innovation. As you brainstorm and collaborate, you create pictorial representations of your design. Accurate drawings and sketches can communicate your design ideas globally. |
| | **Activity 4:** Rube Goldberg Entertainment<br>(4-5 Hours) | Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems. |
| | | |
| **KSB 5**<br>6 Hours | **Activity 1:** A Clean Solution to a Messy Problem<br>(4 Hours) | While technology has allowed humans to prosper, negative impacts have also resulted. |
| | **Activity 2**: Getting from There to Here<br>(4 Hours) | Many of the inventions and innovations we enjoy today have taken centuries to develop into their modern form. |

# Invention and Innovation
*Introduction to I & I*

# FIRST 5 DAYS

## BIG IDEA

Knowledge of basic technology and engineering skills and classroom routines will be essential for student success in the KSBs and Activities of the Invention and Design Course.

## PURPOSE

First 5 Days allows the teacher to set the focus for the course. The expectations for how the class will run will be established. Students will have the opportunity to participate in a design challenge. They will also establish the format for the engineering design journal and student guide. Students will also gain knowledge of class safety procedures as well as take the course pre-test. The teacher will be able establish daily classroom routines for the students to follow during this time.

## MATERIALS NEEDED

The materials needed for the first 5 days are as follows:

| | |
|---|---|
| **DAY 1** | • Paper of various sizes, straws, tape, paperclips, index cards, and colored pencils |
| **DAY 2** | • Paper of various sizes, straws, tape, paperclips, index cards, and colored pencils (if students haven't finished their IPod cover)<br>• Intro PowerPoint, Sample Title Page, Sample Engineering Design Journal, 12-Step EDP worksheets |
| **DAY 3** | • Intro PowerPoint, Sample Title Page, Sample Engineering Design Journal. 12-Step EDP worksheets. |
| **DAY 4** | • Computers and student log ins to take the EbD Pretest |
| **DAY 5** | • Tools and equipment of the lab that the students will be using. |

## RESOURCES

Resources (digital/print) are listed by day

| | |
|---|---|
| **DAY 1** | File FFD.1.1.docx IPod Cover Challenge<br>File FFD.1.2.docx Introduction Letter<br>File FFD.1.3.docx Safety Policies and Procedures |
| **Day 2 and 3** | File FFD.3.2.docx Title page example<br>File FFD.3.3.docx EDP for EDJ |
| **DAY 4** | Computers and student log ins to take the EbD Pretest |

| **DAY 5** | File FFD.5.1.docx Machine Safety |
|---|---|

# DAY 1: Problem Solving Protect the POD

## BIG IDEA

Everyone has the ability to invent, innovate, and improve designs.

**Teacher's Note:**
*Big ideas should be made explicit to students by writing them on the board and/or reading them aloud. Additionally, they should be referred to often throughout the Learning Cycles and Preliminary and Primary Challenges.*

## PURPOSE OF THE LESSON

The purpose of this lesson is to engage students in the *Invention and Innovation* course from day one, while enhancing their technological literacy and their skill set to solve problems and engineer.

## LESSON DURATION:

45-60 minutes

## STANDARDS AND BENCHMARKS THAT ARE ADDRESSED

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **H** | Apply a design process to solve problems in and beyond the laboratory-classroom. |
| **I** | Specify criteria and constraints for a design. |
| **Q** | Develop and produce a product/system using a design process. |

## LEARNING OBJECTIVES

Students will design, invent, or innovate a cover for their iPod or electronic device with limited materials.

## KNOWLEDGE AND SKILL BUILDING (KSB)/LEARNING PROGRESSIONS

### ENGAGE

1. This is your first day with the students they are getting the rules and procedures in all of their classes. The teacher will welcome the students and then hand out a

piece of computer paper to each student and ask them to write down the following three words: Design, Invent, and Innovate

**Teacher's Note:**
*This activity is used to actively engage the students from day one while setting the atmosphere for the rest of the course. The teacher may want to offer some type of prize for the first group of students to solve the problem.*

### EXPLORE

1. Students have five minutes to break into groups of 2-3 and attempt to define each word.

**Teacher's Note:**
*Since the students may not have an EDJ they may take notes and write words down on any type of paper they may have. The intent is to get them thinking about what the words mean.*

### EXPLAIN

1. Teacher brings the students back to hear and guide explanations of the three words. (Five minutes.)

### ENGINEER

1. Students are introduced to the design challenge to design a cover to protect the iPod. (Twenty minutes this class).

**Teacher's Note:**
*About five minutes before the end of class have the students clean up their area and tell them where they should store their iPod covers. They may need 10 or 15 minutes next class to finish and present them.*

### ENRICH

1. Students create a more durable cover for their device out of more sturdy materials, depending on the availability of such materials.

### EVALUATE

1. Students discuss what they learned about Invention and Innovation

## RESOURCE MATERIALS

The following resource materials support this lesson

| Resource List | Filename |
|---|---|
| iPod Cover Challenge | File FFD.1.1.docx |
| Introduction Letter | File FFD.1.2.docx |
| Safety Policies and Procedures | File FFD.1.3.docx |

# DAYS 2 and 3
# Expectations and Orientation

## BIG IDEA

The *I&I* course is designed to provide as many opportunities to apply the Engineering Design Process as possible. These next two days are designed to allow the students to discover the course's expectations and requirements.

**Teacher's Note:**
*Big ideas should be made explicit to students by writing them on the board and/or reading them aloud. Additionally, they should be referred to often throughout the Learning Cycles and Preliminary and Primary Challenges.*

## PURPOSE OF THE LESSON

The purpose of this lesson is to take care of the housekeeping items a teacher needs to do in order to make the class run smoothly. It will allow the students to set up their EDJ's and see the Student Guides and other essential information about the class.

## LESSON DURATION:

90 minutes

## STANDARDS AND BENCHMARKS ADDRESSED

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |

## LEARNING OBJECTIVES

- Understand the rules and expectations for 7th grade technology education
- Be able to successfully create a title page for an Engineering design journal
- Successfully log on to the EbD pretest site
- Have an Engineering Design journal set up with the Engineering design process outline and steps
- Students will collaborate with others to effectively solve a problem.

# KNOWLEDGE AND SKILL BUILDING (KSB)/LEARNING PROGRESSIONS

## ENGAGE

1. As students enter the room, the teacher will welcome them and briefly complete the cover challenge, leading with the question "what do you think class expectations will be?" After a brief Q & A, the teacher will introduce the Welcome PowerPoint to the class and review student expectations, drawing similarities from the opening discussion. (Approximately 20 -25 minutes.)

**Teacher's Note:**

*This activity is used to actively engage the students from day one while setting the atmosphere for the rest of the course. Depending on how much time the teacher has, he or she may extend or shorten the IPod Cover activity. The teacher may also need to modify the Welcome PowerPoint depending on the type of classroom tools and equipment available.*

## EXPLORE

1. Upon completion of the PowerPoint, the will allow students to choose seats at their discretion. As students take their seats they should bring two EDP worksheets and one blank piece of computer paper with them.
2. The teacher will lead the students into making a name tag for each desk, table, or computer station. The teacher will have the students fold the paper in half, twice, making it into a tent or triangle shape, on which students can colorfully add their names and something of interest to them.

**Teacher's Note:**

*The teacher may choose to set up the class procedures at his or her discretion. You may have another activity that will allow the students to share information.*

## EXPLAIN

1. To help learn students' names and create a positive atmosphere of trust and learning, students will go around the room and say their name and share an interest. This may be more for the teacher then the students as many will already know each other.

## ENGINEER

2. In the Engineering design journal, students to create a title page so that it can be easily identified. The title page should include "Technology Education Engineering Design Journal" or "EDJ," their name, and class period. Students' should have their EbD login/password information so they can access the test. Finally, if computers are available, students could get a picture of an example of technology that interests them and place it on the page to add some color. Students will glue this on the inside front page of the journal. They will also glue in the two Engineering byDesign worksheets.

3. As students begin preparing their EDJs, the teacher will distribute login information. The introductory PowerPoint, name tags, and login distribution typically requires most of one 45 minute class period. The teacher can come back the next class period and practice getting students to the site and have students login to avoid any problems the day of the test. If computers are not available, the teacher may

model what to do with the students via a PowerPoint and have them take notes to prepare for the pre-test day. Once students have practiced logging in they may continue on setting up their EDJs (title page and EDP worksheets). This may also be a good time to introduce the Student Guide as a resource that they will be using during the class.

**Teacher's Note:**
*If the teacher does not have the class time to devote to setting up the EDJs, they may assign it as a homework assignment*.

### ENRICH

1. Students will further organized their EDJs into various sections utilizing paperclips and color paper if they wish.

### EVALUATE

2. Teacher will visually observe the students logging on and developing their EDJs and name tags.

## RESOURCE MATERIALS

The following resource materials support this lesson

| Resource List | Filename |
|---|---|
| Title page example | File FFD.3.2.docx |
| EDP for the EDJ | File FFD.3.3.docx |

# DAY 4: What Do I Know About Technology?

## BIG IDEA

What do I already know about Invention & Innovation?

**Teacher's Note:**
*Big ideas should be made explicit to students by writing them on the board and/or reading them aloud. Additionally, they should be referred to often throughout the Learning Cycles and Preliminary and Primary Challenges.*

## PURPOSE OF THE LESSON

The purpose of this lesson is to assess where the students are in regard to their knowledge about Invention and Innovation.

## LESSON DURATION:

45 minutes

## STANDARDS AND BENCHMARKS ADDRESSED

N/A-Pretest

## LEARNING OBJECTIVES

Complete the *I&I* Pretest to the best of your ability.

## KNOWLEDGE AND SKILL BUILDING (KSB)/LEARNING PROGRESSIONS

### ENGAGE/EXPLORE/EXPLAIN/ENGINEER/ENRICH

Students will log on and take the EbD Pretest. The test takes between 35-55 minutes depending on the students. Some will need to finish the next class period depending on the length of the class.

**Teacher's Note:**
*Hopefully the students have had an opportunity to practice logging on and getting to the test. If they haven't, be prepared for some difficulty for some to get to the test. It is recommended to have a few copies of the students' login information. The most common problem occurs when students type a number incorrectly or in the wrong order, which prevents a successful login. It may take several minutes to get everyone logged on and started.*

**Teacher's Note:**

*Students sometimes have difficulty with the demographic questions so be prepared to help them through those initial steps. Also be sure you have activated all of the tests so that they can be accessed by the students.*

### EVALUATE

Teacher will look at the student scores to see where they fall so you can adjust instruction as needed.

## RESOURCE MATERIALS

The resources needed for this lesson is computers with internet access and student logins.

# DAY 5: Safety is Our Number One Priority

## BIG IDEA

Why is safety important in a work environment?

> **Teacher's Note:**
> *Big ideas should be made explicit to students by writing them on the board and/or reading them aloud. Additionally, they should be referred to often throughout the Learning Cycles and Preliminary and Primary Challenges.*

## PURPOSE OF THE LESSON

The purpose of this lesson is to provide students with the information necessary to operate the tools and machines in a safe manner. This lesson should be followed up with proper demonstrations of the machines and opportunities for the students to practice using the machines.

## STANDARDS AND BENCHMARKS ADDRESSED

***STL* 12, E** Select and safely use tools, products, and systems for Specific tasks

## LEARNING OBJECTIVES

Students will Identify tools and equipment of the shop and give examples of equipment safety.

## LESSON DURATION:

45 minutes/one class period

## KNOWLEDGE AND SKILL BUILDING (KSB)/LEARNING PROGRESSIONS

### ENGAGE:

The teacher will take students over to lab and introduce the various power tools in the room. Then ask students, "Why is safety a concern while working in lab A brief Q & A should follow. The teacher may choose to supply a sheet of graph paper for sketching.

> **Teacher's Note:**
> *This activity is used to allow the students the opportunity to learn about the machines they will be using and the safety expectations of the Lab.*

> **Teacher's Note:**
> *This activity can be easily substituted with the safety activities the teacher already has in place. Or the teacher may use this in conjunction with other safety requirements from your local school system.*

### EXPLORE:
The teacher will hand out the safety worksheet and ask the students to write four safety rules that apply directly to them while working on the various machines.

> **Teacher's Note:**
> *Depending on the type of lab you have and the machines you will be using with the student, you may need to adjust the worksheet to suit your individual needs.*

### EXPLAIN
Once students have completed the safety sheet, the teacher will address each machine, asking the students to share what they wrote down then explain further some of the safety precautions used while operating the machine. Depending on how a teacher will test students on the various equipment, they could take notes so they have some prior knowledge when it comes time for the demonstration, safety quiz, and operating opportunity on the equipment.

### ENGINEER (EXTEND/ELABORATE)
Students can break into groups of 2-3 pick a machine and develop a safety poster for the machine or a general shop safety poster to be displayed in the shop or hallway.

### ENRICH
Students can further research via the internet statistics on work place accidents in the United States. Or they may make up safety guidelines on a poster for the class to adhere to.

### EVALUATE
Teacher Observation, Safety worksheet, Safety Poster, Safety Quiz (to be administered at a later time. Depending on what the teacher has in the way of tools and equipment they can develop an appropriate safety quiz. A sample Safety worksheet is attached in the lesson files.

## RESOURCE MATERIALS
The following resource materials support this lesson

| **Resource List** | **Filename** |
|---|---|
| Safety Worksheet | File FFD.5.1.docx |

# Invention and Innovation
## KSB 1

# Snapshot

## ENDURING UNDERSTANDINGS

- Students will understand the difference between invention and innovation.
- Students will use creative ways to turn ideas into real things.
- Students will learn that Inventions and innovations are the result of demands, values, and interests of individuals, industries, and societies.
- Students will learn that all technologies have flaws; there is no perfect design.

## BIG IDEA

Invention and innovation are creative ways to turn ideas into real things.

**Teacher's Note**

*Big ideas should be made explicit to students by writing them on the board, reading them aloud, and/or posting them on worksheets associated with the lessons. For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words if they choose.*

## PURPOSE OF THE KSB

- To familiarize students with how people of all times and places have increased their capability by innovating and inventing.
- To familiarize students with important inventors, inventions, and their innovations.
- To create awareness that technologies, no matter how useful, have intended and unintended consequences that can pose ethical, economic, political, or cultural issues.

## INSTRUCTIONAL TIME

KSB 1 requires 3-4 weeks of instructional time based on one hour per day and depending on how many Enrichment activities that are being assigned. Each of the three Activities in KSB 1 in the *Invention and Innovation* course require the following number of hours to cover the content:

| REQUIRED KSB HOURS | ENRICHMENT HOURS | TOTAL KSB HOURS | TOTAL KSB WEEKS |
|---|---|---|---|
| 15 Hours | 9 Hours | 24 Hours | 5 Weeks Including Enrichment. |

## STANDARDS AND BENCHMARKS ADDRESSED

This KSB is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| **STL 1** | Understanding the characteristics and scope of technology |
| **STL 2** | Understanding the Core Concepts of Technology |
| **STL 3** | Understanding the relationships among technologies and connections with other fields of study |
| **STL 4** | Understanding the cultural, social, economic, and political effects of technology |
| **STL 5** | Understanding the effects of technology on the environment |
| **STL 6** | Understanding the role of society in the development and use of technology |
| **STL 7** | Understanding the influence of technology on history |
| **STL 8** | Understanding the attributes of design |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |
| | |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |

| | |
|---|---|
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:*** **Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **WHST 6-8** | |
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have |

| | |
|---|---|
| | been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences |

## KSB 1 OBJECTIVES:

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|
| | | |
| **Activity 1**: Inventing 101 (3-5 hours) | Invention and innovation are creative ways to turn ideas into real things. | 1. Explain that 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.<br>2. Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>3. Explain that technology is closely linked to creativity, which has resulted in innovation.<br>4. Define the terms invention and innovation.<br>5. Design and make a simple invention.<br>6. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>7. Work safely and accurately with a variety of tools, machines, and materials. |
| | | |

| | | |
|---|---|---|
| **Activity 2**<br>Engineering Design Process<br>(5-7 hours) | Inventions and innovations are the result of demands, values, and interests of individuals, industries, and societies. | 1. Explain that design is a creative planning process that leads to useful products and systems.<br>2. Explain that requirements for a design are made up of criteria and constraints.<br>3. Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>4. Explain that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.<br>5. Explain that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>6. Identify and describe the major steps in the engineering design process.<br>7. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>8. Work safely and accurately with a variety of tools, machines, and materials.<br>9. Actively participate in group discussions, ideation exercises, and debates. |
| | | |
| **Activity 3**:<br>What's Your Problem?<br>(5 hours) | All technologies have flaws; there is no perfect design. | 1. Explain that 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.<br>2. Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>3. Explain that the development and use of technology poses ethical questions.<br>4. Explain that economic, political, and cultural issues are influenced by the development and use of technology.<br>5. Explain that decisions to develop and use technologies often put environments and economic concerns in direct competition with one another.<br>6. Explain that there is no perfect design.<br>7. Define requirements of a design as criteria and constraints.<br>8. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task. |
| | | |
| **Total for this KSB = 15 Hours plus 9 hours Enrichment** | | |

## ASSESSMENT TOOLS

There are no KSB-level assessments the KSBs are assessed using:

- Selected Response Items
- Brief Constructed Response Item
- Performance Rubrics

Specific tools are incorporated into each lesson as Supporting Files.

# Activity 1: Inventing 101

## ENDURING UNDERSTANDINGS

- Students will understand the difference between Invention and Innovation.
- Students will use creative ways to turn ideas into real things

## BIG IDEA

Invention and innovation are creative ways to turn ideas into real things.

## PURPOSE

To familiarize students with how people of all times and places have increased their capability by innovating and inventing

## HIGHLIGHTS

**ENGAGE** Students identify the attributes or personal characteristics of successful inventors.

**EXPLORE** Students read one of the four vignettes from "Great Thinkers and Their Inventions" and identify the need or desire satisfied by the inventions.

**EXPLAIN** The teacher leads a discussion on how inventors and innovators design inventions and innovations.

**ENGINEER** Student teams choose a problem from a list and brainstorm ideas about designing an invention that can "fix" the problem. Teams choose their best idea, then design and develop it, and finally, present their solution to classmates.

**ENRICH** Students create a plan to fix a "problem" within the school.

**EVALUATE** The student's knowledge, skills, and attitudes are assessed using brief-constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LESSON DURATION: 4-5 Hours

## STANDARDS AND BENCHMARKS THAT ARE ADDRESSED

This KSB is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
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| ***STL 1*** | **Students will develop an understanding of the influence of the characteristics and scope of technology.** |
| **F** | New products and systems can be developed to solve problems or to help to do things that could not be done without the help of technology. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| **H** | Technology is closely linked to creativity, which has resulted in innovation. |
| **E** | Corporations can often create demand for a product by bringing it onto the market and advertising it. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, 2013)** | |
|---|---|
| **MS-ETS1-1 Engineering Design** | |
| | *Students who demonstrate understanding can:* |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |

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| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:*** **Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) |

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| | and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences |

## LEARNING OBJECTIVES

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|
| | | |
| **Activity 1**: Inventing 101 (3-5 hours) | Invention and innovation are creative ways to turn ideas into real things. | 1. Explain that 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.<br>2. Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>3. Explain that technology is closely linked to creativity, which has resulted in innovation.<br>4. Define the terms invention and innovation.<br>5. Design and make a simple invention.<br>6. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>7. Work safely and accurately with a variety of tools, machines, and materials. |

## RESOURCES

### Audiovisual Materials

Invention Emporium. (n.d.). Posters of Famous Inventors and Inventions. Retrieved from www.patentstuff.com/posters/posters-inventors.html.

Posters of Black Innovators. Pitsco. Identifier: W56237

Posters of Inventions That Changed the World. Pitsco. Identifier: W56248

### Print Materials

Ebert, C., & Ebert, E.S., II. (1998). *The inventive mind in science: Creative thinking activities.* Englewood, CO: Teachers Ideas Press. ISBN: 1-56308-387-6.

Egan, L. (1997). *Inventors and inventions.* New York, NY: Scholastic Professional Books. ISBN: 0-590-10388-1.

Flack, J. D., (1989). *Inventing, inventions and inventors: A teaching resource book.* Englewood, CO: Teachers Ideas Press. ISBN: 0-87287-747-7.

Osborn, A. (1953). *Applied imagination; Principles and procedures of creative problem-solving.* New York, New York: Charles Scribner's Sons. ISBN: 978-0023895203.

### Internet Sites

Bellis, M., (n.d.). About.com. Inventors. Creativity and Creative Thinking. Retrieved 2010 from http://inventors.about.com/od/lessonplans/a/creativity_2.htm.

Lemelson Center for the Study of Invention and Innovation. (n.d.). Invention at Play. Retrieved from www.inventionatplay.org.

Pitsco Explor-A-Pak: www.shop-pitsco.com/pitsco3/finditem.cfm?itemid=1287

# ASSESSMENT

There are no activity-level assessments. The KSBs are assessed using:

- Selected Response Items
- Brief Constructed Response Item
- Performance Rubrics

Specific tools are incorporated into each lesson as Supporting Files.

## KNOWLEDGE AND SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

### ENGAGE

1. Students, working in groups of 2 or 3, research and identify who they believe to be the three most famous inventors of all time, their inventions, and how the invention may have impacted the way people lived, worked, or produced things.
2. Students share their ideas of inventors and the related information.
3. The teacher asks students to identify the attributes or personal characteristics of the people cited that made them successful inventors.
4. Students share their ideas on the attributes or personal characteristics of inventors

**Teacher's Note:**
*Depending on the time you have you could make this a quick warm up activity and then move on to the next step. As you read through the lessons you may have to make some adjustments so that they may flow with your schedule more effectively.*

### EXPLORE

1. Students read one of the four vignettes from File 1.1.1: "Great Thinkers and Their Inventions."
2. The group identifies the need or desire satisfied by the invention.
3. Students identify materials used in the fabrication of the invention.
4. At the conclusion of the Exploration stage, students complete File 1.1.2: "Who Dunnit?

**Teacher's Note:**
*Here you may have the students research some other great inventors via the internet and answer the questions if computers are available.*

### EXPLAIN

1. The student groups present their ideas from the Exploration Activity to the class and respond to the questions.
2. The teacher explains that:
    a. People of all times and all places have increased their capability by innovating and inventing.
    b. The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.

c. Invention requires patience and creativity.
d. Technology is closely linked to creativity, which has resulted in innovation.
e. Invention is a process of turning ideas and imagination into devices and systems.
f. Innovation is the process of modifying an existing product or system to improve it.
g. Innovation often involves decreasing the overall capabilities of a product or system in order to increase its ability to perform a more narrow or specific task very efficiently. This process is called specialization of function.
h. 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.

3. Students, working individually or in groups of 2 or 3, will solve File: 1.1.3 "Invention and Innovation Crossword Puzzle."
4. Class reviews answers to the crossword puzzle.
5. Teacher-led discussion on design and brainstorming.
6. Teacher distributes File 1.1.4: "What is Brainstorming?" and discusses with class
7. Teacher distributes and discusses File 1.1.5: "SCAMMPERR" Method. Students practice brainstorming using File 1.1.6: "SCAMMPERR IT."
8. Class discusses how inventors and innovators use a design process to invent and innovate.
9. Class discusses the importance of contributing to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
10. The teacher provides instruction on working safely and accurately with tools, machines, and materials.
11. Students clarify their understanding of concepts by asking questions.

**Teacher's Note:**
*The activities in this part of the lesson may be spread out or even done for homework if need be. As you introduce these topics it may take some students longer to complete than others. The crossword puzzle can be used as a filler if need be.*

## ENGINEER

1. Students, working in groups of 3 or 4, practice design and create a new product that will solve a problem in the classroom. File 1.7: "Fix My Class Design Brief."
2. The teacher leads a discussion about problems in the classroom that need to be solved and writes the problems on the board. Examples could be that students often lose their pencils, or that pencils fall off the desks.
3. Students are reminded to use the brainstorming techniques learned previously in the lesson.
4. All students' ideas are written on the board.
5. From the list of problems, student groups select the problems that would be possible for them to solve.
6. Student groups select one problem to work on.
7. The teacher:
    a. Assigns a group leader.
    b. Obtains and reviews materials.
8. The student groups:
    a. Discuss the problem (take notes).
    b. Discuss ideas for solving the problem (make sketches).

c. Choose the best idea and build a prototype (working model).
d. Evaluate and test the prototype.
e. After the prototype is finished, name it—be creative.
f. Present the completed classroom innovation to the class

### ENRICH

1. Students create a plan to fix a problem within the school. Students create a survey, and then ask people in the school to take part in the survey to discover what problems exist in the school. Students should survey a variety of people (different ages and occupations) to get the most ideas. Students graph the results, and then analyze the results. Students can calculate the mean, median, mode, and range of their data. (File 1.8: What's it all mean?)
2. Students create a plan of action to present a plan to the principal to create a solution to the problem.

### EVALUATE

1. The students' knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LAB/CLASSROOM PREPARATION

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

Tools/Materials/Equipment

1. Straws
2. Tape
3. Paper Clips
4. Paper Cups
5. Paper Plates
6. Paper Fasteners
7. Construction Paper
8. Clothespins
9. String

## Classroom Safety and Conduct

Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students will use tools and equipment in a safe manner and assume responsibility for their safety as well as for the safety of others.

2. Students will demonstrate courtesy in regard to the ideas expressed by classmates and will show appreciation for the efforts of others.

| **Student Resource** | **Filename** |
|---|---|
| Great Thinkers and Their Inventions Vignettes (1 per team) | File 1.1.1.docx |
| Who Dunnit? (Either 1 per team or 1 per student) | File 1.1.2.docx |
| Invention and Innovation Crossword Puzzle (Either 1 per team or 1 per student) | File 1.1.3.docx |
| What is Brainstorming? | File 1.1.4.docx |
| SCAMMPERR Method | File 1.1.5.docx |
| SCAMMPERR It! | File 1.1.6.docx |
| Fix My Classroom Design Brief | File 1.1.7.docx |
| Survey Results | File 1.1.8.docx |

| **Teacher Resources** | |
|---|---|
| KEY: Crossword Puzzle Solution | File1.1.3k.docx |

# Activity 2: Time Will Tell!

## ENDURING UNDERSTANDINGS

- Students will understand the difference between invention and innovation.
- Students will learn that inventions and innovations are the result of demands, values, and interests of individuals, industries, and societies.

## BIG IDEA

Inventions and innovations are the result of demands, values, and interests of individuals, industries, and societies.

## PURPOSE

To familiarize students with important inventors, inventions, and their innovations.

## HIGHLIGHTS

**ENGAGE:** Students, working in a buzz group, identify what they believe is the most important invention or innovation of all time, share their selection of the topic and discuss their selection processes, including their second and third options.

**EXPLORE:** Students working in groups are assigned an advertisement to review and analyze.

**EXPLAIN:** Teams present their ad analysis, the teacher promotes discussion by prompting students with questions regarding aspects of society, economy, education, recreation, politics, safety, health, etc.).

**ENGINEER:** Students in groups will work together to complete Student Resource 2.4-Time Traveler Design Brief.

**ENRICH:** Groups brainstorm ideas of the evolved invention thirty years from now: function, appearance, purpose, attributes, etc. Criteria and limitations should be given, such as scale, size, etc. and should be reflected in the design drawing.

**EVALUATE:** The students' knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LESSON DURATION: 5 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This KSB is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
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| ***STL-6*** | *Technology and Society - Understanding of the role of society in the development and use of technology* |
| **D** | Throughout history, new technologies have resulted from the demands, values, and interests of individuals, industries, and societies. |
| **E** | The use of inventions and innovations has led to changes in society and the creation of new needs and wants. |
| **F** | Social and cultural priorities and values are reflected in technological devices. |
| **G** | Meeting societal expectations is the driving force behind the acceptance and the use of products and systems. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, 2013)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | *Students who demonstrate understanding can:* |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or |

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| | vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:*** **Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and |

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| | present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences |

## LEARNING OBJECTIVES

| | | |
|---|---|---|
| **Activity 2**<br>Engineering Design Process<br>(5-7 hours) | Inventions and innovations are the result of demands, values, and interests of individuals, industries, and societies. | 1. Explain that design is a creative planning process that leads to useful products and systems.<br>2. Explain that requirements for a design are made up of criteria and constraints.<br>3. Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>4. Explain that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.<br>5. Explain that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>6. Identify and describe the major steps in the engineering design process.<br>7. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>8. Work safely and accurately with a variety of tools, machines, and materials.<br>9. Actively participate in group discussions, ideation exercises, and debates. |

## RESOURCES

**Audiovisual Materials**

- Edison Tech DVD, http://shop.history.com/detail.php?p=68973, #3849-68973
- Famous Inventors and Inventions, DVD, Best Sellers America, ASIN: B000BMRX70

**Print Materials**

Flatow, I. (1993). *They all laughed. From light bulbs to lasers: The fascinating stories behind the great inventions that have changed our lives*. New York, NY: Harper Perennial. ISBN: 0060924152.

Harrison, I. (2004). *The book of invention*. Washington, DC. ISBN: 0792282965.

Karwatka, D. (n.d.). *Technology's past: America's industrial revolution and the people who delivered the goods; Technology's past: More heroes of invention and innovation*; and *History of technology* series. Available from Tech Directions: www.techdi¬rections.com.

**Internet Search Terms and Suggested Sites**

- About.com. Inventors. (n.d.). Famous inventions: A to Z. Retrieved from http://inventors.about.com/od/astartinventions/a/FamousInvention.htm
- About.com. Inventors. (n.d.). The inventions of Thomas Edison. Retrieved from http://inventors.about.com/library/inventors/bledison.htm
- About.com. Inventors. (n.d.). Timeline of inventions. Retrieved from http://inventors.about.com/od/timelines/tp/timeline.htm
- Factophile. (2005). Major technological inventions. Retrieved from www.factophile.com/show.content?action=browse&catid=100
- Library of Congress. (n.d.). Thomas Edison, electricity and America. Lesson Three: Merchandising and Advertising. Advertisement Gallery. Retrieved from http://www.loc.gov/teachers/classroommaterials/lessons/edison/gallery.html
- National Academy of Engineering. (2010). Greatest engineering achievements of the 20th century. Retrieved from www.greatachievements.org/


# ASSESSMENT

# KNOWLEDGE AND SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

## ENGAGE

1. Students, working in a buzz group, identify what they believe is the most important invention or innovation of all time (Student Resource 2.1 "Buzz Group/The Most Important Invention or Innovation of All Time"). A leader is chosen and the class is broken into small groups (i.e., three to four students) and given a topic to discuss for about 10 to 20 minutes. In the buzz group, the leader is responsible for directing the discussions and reporting to the class. In each buzz group, the group must reach a consensus on the topic being discussed.
2. Student groups share their topic selection and discuss their selection processes, including their second and third options.
3. The teacher asks the student groups to list, in order of importance, the criteria they used to make their selection. Student groups share their criteria lists.

**Teacher's Note:**
*Depending on the time you have you could make this a quick warm up activity and then move on to the next step. As you read through the lessons you may have to make some adjustments so that they may flow with your schedule more effectively.*

## EXPLORE:

1. The teacher cites the development of the electric lightbulb as one of the most important inventions of all time and notes that Edison was the most prolific inventor in American history, recording 1,093 patents that included key inventions, innovations, and minor improvements in a variety of fields. Additionally, Edison invented the industrial research laboratory, transforming what we think of as invention to encompass what we now call innovation-invention, research, development, and commercialization.

2. A teacher-led discussion continues on the demands, values, and interests of individuals, industries, and societies that lead to the development and acceptance of new inventions and innovations.
3. Students, working in groups of two, are assigned an advertisement to review and analyze. Groups work together to interpret the connotation of the ad (invention) in terms of demands, values, and interests of individuals, industries, and societies (Student Resource 2.2 "Profile of an Ad" ). Students prepare a brief presentation of their ad analysis.

**Teacher's Note:**
*The teacher may choose to let the students lead the discussion and just facilitate, this would focus the lesson being that much more student-centered.*

## EXPLAIN

1. As teams present their ad analysis, the teacher promotes discussion by prompting students with questions regarding aspects of society, economy, education, recreation, politics, safety, health, etc.).
2. Students answer questions like:
    a. What do you think society was like back then?
    b. Was the economy strong or struggling?
    c. Do the ads target educated people?
    d. What role did corporations and/or politics play in the development of new products and innovations?
    e. Do you think the inventors of the products in the ads thought about how the invention would help peoples' lives before they invented it? Explain your answer.
    f. What kinds of things should inventors think of before they invent something? Why?
3. The teacher explains that:
    a. Throughout history, new technologies have resulted from the demands, values, and interests of individuals, industries, and societies.
    b. Meeting societal expectations is a driving force behind the acceptance and use of products and systems.
    c. Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements.
4. Students complete Student Resource 2.3 Brief Constructed Response - "Life Without It."
5. A review of research techniques will be conducted:
    a. Selecting a topic
    b. Researching the topic
    c. Appropriate sources
    d. Note-taking
    e. Data collection
    f. Completing the project
    g. Preparing for an oral presentation

**Teacher's Note:**

*The activities in this part of the lesson may be spread out or even done for homework if need be. Instead of taking time for each student group to present you could have one group share with another group to reduce the time expenditure.*

### ENGINEER

1. Students, in groups of 4-5, will work together to complete Student Resource 2.4-Time Traveler Design Brief.
2. In this activity, student groups:
    a. Imagine themselves as time travelers whose mission is to travel back in time to research the history of a selected invention that played an important part in shaping history.
    b. Compile important dates on an annotated timeline.
    c. Note, in a journal, historical details about the invention along with the impacts on individuals and society as well as social and cultural values of the time period.
    d. Plan and deliver an oral presentation to the class.

### ENRICH

Student groups imagine they are traveling forward in time—30 years in the future. They are now the inventors, or actually, the innovators of the invention researched in the Extension activity. Groups brainstorm ideas of the evolved invention 30 years from now: function, appearance, purpose, attributes, etc. Criteria and limitations should be given, such as scale, size, etc. and should be reflected in the design drawing.

Options for this activity:

- Students design the innovation
- Students build a prototype of the innovation.

### EVALUATE

The students' knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LAB/CLASSROOM PREPERATION

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

### Tools/Materials/Equipment

- Computer w/Internet access
- Paper plates
- Paper cups
- Paper clips
- Paper fasteners
- Construction paper
- Straws

- Clothespins
- String
- Tape

**Classroom Safety and Conduct**
Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson

| **Student Files** | **Filename** |
|---|---|
| The Most Important Invention of All Time | File 1.2.1.docx |
| Profile of an Ad (8 pages) | File 1.2.2.docx |
| BCR - "Life Without It" | File 1.2.3.docx |
| The Time Traveler Design Brief | File 1.2.4.docx |

# Activity 3: What's Your Problem?

## ENDURING UNDERSTANDINGS

- Students will learn that all technologies have flaws; there is no perfect design.
- Students will learn that inventions and innovations are the result of demands, values, and interests of individuals, industries, and societies.

## BIG IDEA

Students will learn that all technologies have flaws; there is no perfect design.

## PURPOSE

To familiarize students with important inventors, inventions, and their innovations.

## HIGHLIGHTS

**ENGAGE:** Students discuss and report on a News Release Report concerning an Invention.

**EXPLORE:** Students discover the unintended effects of inventions and technology.

**EXPLAIN:** Students share the results of the activity and then discuss how this may relate to a real-world experience.

**ENGINEER:** Students design a "radioactive waste soil/rock separator."

**ENRICH:** Students research and gather information about three important technologies that have been "in the news" within the past five years.

**EVALUATE:** The students' knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LESSON DURATION: 5 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This KSB is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) (ITEA/ITEEA, 2000/2002/2007)** | |
|---|---|
| | |
| ***STL-1*** | ***Understanding the characteristics and scope of technology*** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| ***STL-4*** | **Understanding the cultural, social, economic, and political effects of technology** |
| **F** | The development and use of technology poses ethical questions. |
| **G** | Economic, political, and cultural issues are influenced by the development and use of technology. |
| ***STL-5*** | **Understanding the effects of technology on the environment** |
| **F** | Decisions to develop and use technologies often put environments and economic concerns in direct competition with one another |
| ***STL-8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |
| | |

| ***MATHEMATICS:* Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of |

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| | fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:*** **Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and |

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| | efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences |

## LEARNING OBJECTIVES

| | | |
|---|---|---|
| **Activity 3**: What's Your Problem? (5 hours) | All technologies have flaws; there is no perfect design. | 1. Explain that 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.<br>2. Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>3. Explain that the development and use of technology poses ethical questions.<br>4. Explain that economic, political, and cultural issues are influenced by the development and use of technology.<br>5. Explain that decisions to develop and use technologies often put environments and economic concerns in direct competition with one another.<br>6. Explain that there is no perfect design.<br>7. Define requirements of a design as criteria and constraints.<br>8. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task. |

## RESOURCES

### Print Materials


Bijker, W. E., Hughes, T. P., & Pinch, T. J. (Eds.). (1999). *The social construction of technological systems. New directions in the sociology and history of technology.* Cambridge, MA: The MIT Press.

Britton, E., De Long-Cotty, B., & Levenson, T. (2005). *Bringing technology education into k-6 classrooms.* Thousand Oaks, CA: Corwin Press.

Dorf, R. C. (2001). *Technology, humans, and society: Toward a sustainable world.* San Diego, CA: Academic Press.


### Terms and Suggested Sites

- The Lemelson Center for the Study of Invention and Innovation. (n.d.). Retrieved from http://invention.smithsonian.org/home/
- The Lemelson-MIT Program and LEAD International. (2003). Invention and innovation for sustainable development. Retrieved from http://web.mit.edu/invent/n-pressreleases/downloads/sustainable.pdf
- PBS Teachers. (n.d.) Innovation and invention: Activity ideas. Retrieved from www.pbs.org/teachers/thismonth/innovation/index1.html

## ASSESSMENTS

**Should there be text here?**

## KNOWLEDGE AND SKILL BUILDING (KSB)/LEARNING PROGRESSIONS

### ENGAGE

1. Students are divided into five or six "Invention Detection Teams."
2. Each team receives a News Release Report (Student Resource 3.1 "News Release Report") (one side of the card reports a past event; the other side reports a current event).
3. The team leader reads the "past" news release to the group and for 5-10 minutes:
    a. Discusses the events and occurrences of the first news release (What does it appear life was like, in terms of society, economy, politics, culture, etc.)
    b. Discusses why this invention was important or not
4. The team leader reads the "current" news release to the group and for 5-10 minutes:
    a. Discusses the events and occurrences of the second news release (What does it appear life was like, in terms of society, economy, politics, culture, etc.)
    b. Discusses issues and effects that resulted from the original invention/innovation
    c. Do you think the people responsible knew what consequences could/would occur?
    d. What could have been done differently?
5. Teams share their information with the class

**Teacher's Note:**
*When dividing into the detective teams the teacher may want to adjust the number depending on class size or student ability.*

### EXPLORE

1. The teacher gathers pictures of various technologies from magazines, Internet, library books, etc., of things such as mobile phones, wind turbines, Styrofoam containers, plastic bags, batteries, oil rigs, household items, medical products, nuclear waste containers, etc.
2. A discussion occurs on how the technologies are useful and advantageous to civilization. Ultimately, the discussion is guided towards identifying potential negative effects of the technologies as well, some apparent, some not so apparent.
3. The class names other technologies, and a volunteer lists them on the board. As each is listed, students note the positive and negative effects of each. Students are prompted to identify a single technology that appears to be perfect.
4. Class concludes no technology is flawless-there is no perfect design.
5. Students complete Assessment Instrument (BCR) - "Explain this phrase - There is no perfect design."
6. Students work in teams to complete Student Resource 3.2 - "Radioactive Extraction Activity."

**Teacher's Note:**

*The students could also generate a list of failed technologies or technologies that have had unintended consequences.*

### EXPLAIN

1. Students share the results of the activity and then discuss how this may relate to a real-world experience.
2. Teacher discusses: As new technologies emerge, the impacts of those technologies create new concerns for humankind. Most often, issues with a technology do not surface until after the technology has been developed.
3. Technologies (however good they may be) sometimes result in by-products or have consequences that are harmful to humans, animals, the environment, etc., which in turn promote controversy in terms of ethics, society, environment, economy, political issues, and/or culture.
4. For example, green energy sources, such as wind power plants and nuclear power plants, have relatively little impact on the environment compared to fossil fuel power plants. However, wind power plants create noise pollution, are highly visible, and incite wildlife fatalities. Nuclear power plants generate electricity in an environmentally friendly manner but generate dangerous waste that cannot be safely disposed of. Teacher Resource 3.1 - Understanding the Effects of Technology
5. The teacher cites additional examples important in our lives:
    a. Plastics, while used profusely in everyday lives, emit hazardous waste as a by-product when burned or remain in landfills for a thousand years.
    b. Making automobiles or refrigerators results in hazardous wastes from acids used to clean steel and from cyanides used to harden steel.
    c. Medical products, like needles and blood samples, are biohazard in nature and can cause incurable diseases if disposed of insecurely.
    d. Nuclear waste can cause different types of harmful diseases and destructive problems for humans and the environment.
    e. Industrial waste is generated from chemicals that are used to produce different types of goods.
    f. Universal wastes, such as batteries, cell phones, and lightbulbs, when not disposed of properly can cause serious problems in the environment.

**Teacher's Note:**
*The activities in this part of the lesson may be spread out or even done for homework if need be.*

### ENGINEER

1. Students, working in groups of 4 or 5, design a "radioactive waste soil/rock separator." Student Resource 3.3 - Radwaste Device Design Brief.
2. The teacher reviews the Engineering Design Rubric to guide students in the design of the assignment.
3. Assign a group leader to facilitate:
    a. Obtaining and reviewing materials.
    b. Discussion of the problem
    c. Discussion ideas for solving the problem
    d. Choosing the best idea and building a prototype
    e. Evaluating and testing your prototype, refine as needed.

4. After the prototype is finished, naming it—be creative.
5. Presenting the completed device to the class.

### ENRICH

Students, working in groups of six, research and gather information about three important technologies that have been "in the news" within the past five years. The technologies should have a history of controversial issues in terms of societal, cultural, political, or economical. Students will choose one and then prepare a debate about the issues. Some students will be pros, and some will be cons. The debate will be presented to the class.

### EVALUATE

The student's knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LAB/CLASSROOM PREPARATION

The classroom should provide a flexible, resource-rich, learning environment that includes areas for lecture and demonstrations, small group meetings, design processes, research activities, production and fabrication, product/prototype testing and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- Computer w/Internet access
- Radioactive Extraction - Activity
- 2 brown paper lunch bags
- 5 rocks or large gravel, Styrofoam balls, etc., painted green to look like radiation, placed inside one of the paper bags
- 4 four-inch pieces of string
- 4 drinking straws
- 2 skewers
- 4 paper clips
- 4 rubber bands
- 5 Post-It notes
- push pins
- 1 pencil
- 1-foot length of scotch tape
- stopwatch
- Radwaste Device - Design Brief
- sand (20-25 ounces)
- Small dried beans or pebbles (25-30), (spray painted green - optional)
- Balsa wood
- Paper cups
- Paper clips

- Tape
- Balsa cutters
- 8" x 10" piece of screen or mesh, or something that will sift the sand and pebbles
- Cardstock
- Hot glue guns, glue
- Scissors
- Rulers
- Stopwatch
- Scale

**Classroom Safety and Conduct**
Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson

| **Student Files** | **Filename** |
|---|---|
| News Release Reports | File 1.3.1.docx |
| There are four News Release Reports. You will need one News Release Report per group; groups may have the same report as another group, depending on the number of students in the class. Cut each News Release Report in half and paste back to back, so that a past event is on the first side and the current event is on the other side. | |
| Radioactive Extraction – Activity | File 1.3.2.docx |
| Radwaste Device Design Brief | File 1.3.3.docx |

**Teacher Files**

| | |
|---|---|
| Understanding the Effects of Technology | File 1.3.4.docx |

# Invention and Innovation
## KSB 2 – Engineering Design Process

# SNAPSHOT

## ENDURING UNDERSTANDINGS

- The students will gain an understanding of the relationships among technologies and connections with other fields of study.
- Students will understand the attributes of design.
- An understanding of the engineering design process will be gained.
- The students will gain an understanding of and abilities to select and use information and communication technologies.
- Students will gain an understanding of and abilities to select and use manufacturing technologies.

## BIG IDEA

Invention and innovation are driven by human needs and wants, and are influenced by the core concepts of technology: systems, resources, requirements, optimization and trade-offs, processes, and controls. These concepts are the cornerstone for creative design.

**Teacher's Note**

*Big ideas should be made explicit to students by writing them on the board, reading them aloud, and/or posting them on worksheets associated with the lessons. For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose*

## PURPOSE OF THE KSB

- To familiarize students with a basic understanding of the Engineering Design Process.
- To ensure that students can list and describe process components.
- To use the design process to develop solutions to technological problems.
- To introduce students to technology systems.
- To develop a basic understanding of how a product goes from an idea to the store shelf.

## INSTRUCTIONAL TIME

KSB 2 requires 25 hours of instructional time. Each of the three lessons in the KSB 2 require the following number of hours to cover the content:

| REQUIRED UNIT HOURS | ENRICHMENT HOURS | TOTAL UNIT HOURS | TOTAL UNIT WEEKS |
|---|---|---|---|
| 20 Hours | 5 Hours | 25 Hours | 5 Weeks |

## STANDARDS AND BENCHMARKS ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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. |
| **H** | Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |
| | |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical |

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| | events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## KSB Objectives

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|

| | | |
|---|---|---|
| **Activity 1:** The Process in Action (6 hours) | Technology involves many types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation. The engineering design process must take all of these things into account. | • Explain that design is a creative planning process that leads to useful products and systems.<br>• Explain why there is no perfect design.<br>• Explain that requirements for a design are made up of criteria and constraints.<br>• Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>• Explain that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.<br>• Explain that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>• Identify and describe the major steps in the engineering design process.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>• Work safely and accurately with a variety of tools, machines, and materials.<br>• Actively participate in group discussions, ideation exercises, and debates. |
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|---|---|---|
| **Activity 2**<br>Working With the Design Process<br>(7 hours) | The Engineering Design Process is a systematic problem-solving strategy, with criteria and constraints that are used to develop many possible solutions to a problem, so as to satisfy human needs and wants. This process is iterative, and is informed by many factors such as human values, resources, environmental concerns, and trade-offs in order to arrive at the best possible solution to the problem. | • Explain that design is a creative planning process that leads to useful products and systems.<br>• Explain that requirements for a design are made up of criteria and constraints.<br>• Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>• Explain that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.<br>• Explain that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>• Identify and describe the major steps in the engineering design process.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>• Work safely and accurately with a variety of tools, machines, and materials.<br>• Actively participate in group discussions, ideation exercises, and debates. |

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| **Activity 3**<br>The Engineering Design Process in Action<br>(12 hours) | Technology involves many types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation. The engineering design process must take all of these things into account. | • Explain that design is a creative planning process that leads to useful products and systems.<br>• Explain why there is no perfect design.<br>• Explain that requirements for a design are made up of criteria and constraints.<br>• Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>• Explain that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.<br>• Explain that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>• Identify and describe the major steps in the engineering design process.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>• Work safely and accurately with a variety of tools, machines, and materials.<br>• Actively participate in group discussions, ideation exercises, and debates. |
| | | |
| **Total for This KSB = 20 Hours plus 5 hours Enrichment** | | |

## ASSESSMENT TOOLS

Activities are assessed using:

- Selected Response Items
- Brief Constructed Response Item
- Performance Rubrics

Specific tools are incorporated into each lesson as Supporting Files.

# Activity 1: The Process in Action

## ENDURING UNDERSTANDINGS

- Students will learn the core concepts of technology.
- Students will use the design process as a creative tool.

## BIG IDEA

Technology involves many types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation. The engineering design process must take all of these things into account.

## PURPOSE

Students will be provided with a foundation in the Engineering Design Process by watching professionals at work, then applying the design process in a design challenge.

## HIGHLIGHTS

### ENGAGE

The teacher asks students to identify items they see in the classroom/laboratory that were and were not designed by engineers.

### EXPLORE

Students watch the video: Harley Davidson Birth of the V-Rod and discuss the engineering design process used.

### EXPLAIN

The teacher reviews the steps in the engineering design process.

### eNGINEER

Students use the design process to design and develop a rubber band-powered vehicle given specific criteria and constraints. The design process may be memorialized by using the EbD Engineering Design Journal or another instrument that journals the student progress

### ENRICH

Students analyze the engineering resources (core technologies) employed in the solution in terms of common components, basic system design, safety, simple controls, and system performance evaluation.

### EVALUATE

The students' knowledge, skills, and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs.

## LESSON DURATION: 6 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| ***STL 8*** | **Understanding the Attributes of Design** |
| E | Design is a creative planning process that leads to useful products and systems. |
| F | There is no perfect design. |
| G | Requirements for a design are made up of criteria and constraints. |
| | |
| ***STL 9*** | **Understanding engineering design** |
| F | Design involves a set of steps, which can be performed in different sequences and repeated as needed. |
| 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. |
| H | Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use |

| | |
|---|---|
| | rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:*** **Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |

## LEARNING OBJECTIVES

| ACTIVTY | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 1:** The Process in Action (6 hours) | Technology involves many types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation. The engineering design process must take all of these things into account. | • Explain that design is a creative planning process that leads to useful products and systems.<br>• Explain why there is no perfect design.<br>• Explain that requirements for a design are made up of criteria and constraints<br>• Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>• Explain that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.<br>• Explain that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>• Identify and describe the major steps in the engineering design process.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>• Work safely and accurately with a variety of tools, machines, and materials.<br>• Actively participate in group discussions, ideation exercises, and debates. |

## RESOURCES

**Audiovisual Materials**

Harley Davidson Birth of the V-Rod. Available from the Discovery Channel

**Print Materials**

ITEA-HITS (Humans Innovating Technology Series) Volume #1, includes *What is Engineering Design*, PH1-1, www.iteaconnect.org/F6.html

ITEA-HITS (Humans Innovating Technology Series) Volume #2, includes "*What is Design*," PH1-2, www.iteaconnect.org/F6.html

Ertas, A., Jones, J. C., *The engineering design process*, John Wiley and Sons, NewYork, 1996.

Lumsdaine, E., Lumsdaine, M., Shelnutt, J. W., *Creative problem solving and engineering design*, McGraw-Hill, Inc., New York, 1999.

Sanders, M. S., McCormick, E. J., *Human factors in engineering and design*, McGraw-Hill, Inc., New York, 1993. Dym, C. L., Little, P., *Engineering design: A project-based introduction*, John Wiley, New York, 1999.

Hyman, B., *Fundamentals of engineering design*, Prentice Hall, New Jersey, 1998.

**Internet Sites**

1. www.mos.org/eie/engineering_design.php
2. www.nasa.gov/audience/foreducators/.../Eng_Design_5-12.html

# ASSESSMENT

# KNOWLEDGE AND SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

## ENGAGE

1. Students, working in groups of 2 or 3, are asked to list items they see in the classroom/laboratory that were designed by engineers.
2. Students share their lists.
3. The teacher asks students to identify items they see in the classroom/laboratory that were not designed by engineers. *The expected student response is "humans."*
4. The teacher shares that engineering, the systematic application of mathematical, scientific, and technical principles, produces tangible end products that meet our needs and desires.
5. The teacher shares that anyone can engineer, and that humans were engineering solutions to problems long before the field of Engineering was established, but that in order to be recognized as an "Engineer," a person must undergo a collegiate course of study.

**Teacher's Note**:
*Depending on the time you have you could make this a quick warm up activity and then move on to the next step. As you read through the lessons you may have to make some adjustments so that they may flow with your schedule more effectively.*

## EXPLORE

1. Students watch the video: Harley Davidson - Birth of the V-Rod and complete the "V- Rod" worksheet. The teacher leads a discussion about where and how the Design Process was used by Harley Davidson engineers.

**Teacher's Note:**
*Here you may want to have students execute a "Think-Pair-Share" and then report out to the entire class.*

## EXPLAIN

1. Review the steps of the Design Process, with particular attention to when and how the steps may be applied in different sequences. **(See Teacher Resource 2.3 - Design Process.ppt)**
2. Explain that:
    a. Design is a creative planning process that leads to useful products and systems.

b. There is no perfect design.
c. Requirements for a design are made up of criteria and constraints.
d. Design involves a set of steps that can be performed in different sequences and repeated when needed.
e. Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.
f. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.
g. The teacher will review the steps in the engineering design process:
h. Defining the Problem
i. Brainstorming a solution
j. Generating Ideas
k. Identifying Criteria
l. Exploring Possibilities
m. Selecting and Approach
n. Making a Model or Prototype
o. Testing and Evaluating the Design
p. Refining the Design

3. Lead a discussion on why it is important to contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
4. Students will clarify their understanding of concepts by asking questions.

**Teacher's Note:**
*The activities in this part of the lesson may be spread out or even assigned for homework if need be. As you introduce these topics it may take some students longer to complete than others.*

### ENGINEER

1. Students use the design process to design and develop a rubber band-powered vehicle given specific criteria and constraints. (See Student Resource 2.2)

2. Teams of 2-3 students will design and produce a vehicle that is designed either for speed or for distance. A record of the design and production activities will be kept in the Engineering Design Journal (EDJ).

### ENRICH

Students analyze the engineering resources (core technologies) employed in their solution in terms of common components, basic system design, safety, simple controls, and system performance evaluation (teacher led discussion).

**Teacher's Note:**
*This enrichment activity will require that students research the terms: core technologies, common components, etc.*

### EVALUATE

The students' knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## TEACHER PLANNING AND RESOURCE MATERIALS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- LCD Projector
- 12 Utility Knives w/additional blades
- 12 Hobby Knives (exacto type w/blades)
- 12 Hot melt glue gun (1/4 - 5/16)
- 6 packs of 100 hot melt glue sticks
- Box jumbo soda straws
- 6 wooden dowel rods (1/4")
- Box of 50 poker chips
- 50 used CD rom discs
- 5 medium sized cardboard boxes
- 6 sheets of 1/4" foam core board
- 12 rolls of masking tape (1")
- 1 roll of twine
- 6 stopwatches
- 12 pairs of scissors
- 1 box of 1/4" x 3" rubber bands

**Classroom Safety and Conduct**

Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson:

| **Student Files** | **Filename** |
|---|---|
| Harley Davidson Birth of the V Rod Worksheet | File 2.1.1.docx |
| The Design Process | Presentation 2.1.2.pptx |
| Rubber Band Vehicle Design Challenge | File 2.1.3.docx |

# Activity 2: Working With The Design Process

## ENDURING UNDERSTANDINGS

- Students will be able to search for information on the Internet.
- Students should gain knowledge on how to use word processing and presentation software.
- They should also know how to use basic hand tools safely to create prototypes.

## BIG IDEA

The Engineering Design Process is a systematic problem solving strategy, with criteria and constraints that is used to develop many possible solutions to a problem, so as to satisfy human needs and wants. This process is iterative, and is informed by many factors such as human values, resources, environmental concerns and trade-offs in order to arrive at the best possible solution to the problem.

## PURPOSE

The purpose of this lesson is for students to learn that using the Design Process as a systematic problem-solving strategy results in the best possible solution to a technological problem.

## HIGHLIGHTS

### ENGAGE

Students investigate a problem in their classroom. Each day, they find a new layer of dust on computers and other equipment. In small groups, they identify the possible source of the problem and brainstorm possible solutions, agree on a final solution, and present solutions to the class.

### EXPLORE

The teacher leads a discussion about air quality, and the potential hazards to humans. The teacher assigns group topics that relate to air quality, for example, coal miners who developed black lung disease, workers who have developed asbestosis over the years, reasons for asbestos removal in schools and public buildings, or other environmental pollutants such as auto emissions or side-stream cigarette smoke. Students explore a chosen topic online and return to the discussion to share information with the class.

### EXPLAIN

Students present their findings informally to their peers. The teacher stresses the need for people to be not only environmentally aware, but to make ethical choices regarding technology.

### ENGINEER

Students use the design process to develop solutions to the "Biotoxin Mitigation" Design Challenge (see File 2.2).

### ENRICH
Via classroom discussion, the students brainstorm and share possible ways to prevent pollutants or hazardous substances from entering the building in the future.

### EVALUATE
The students' knowledge, skills, and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs, and classroom presentations.

## LESSON DURATION: 7 Hours

## STANDARDS AND BENCHMARKS ADDRESSED
This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| ***STL 8*** | **Understanding the Attributes of Design** |
| E | Design is a creative planning process that leads to useful products and systems. |
| F | There is no perfect design. |
| G | Requirements for a design are made up of criteria and constraints. |
| ***STL 9*** | **Understanding engineering design** |
| F | Design involves a set of steps, which can be performed in different sequences and repeated as needed. |
| 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. |
| H | Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the |

| | |
|---|---|
| | relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## Learning Objectives

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 2** Working With the Design Process (7 hours) | The Engineering Design Process is a systematic problem solving strategy, with criteria and constraints that is used to develop many possible solutions to a problem, so as to satisfy human needs and wants. This process is iterative, and is informed by many factors such as human values, resources, environmental concerns and trade-offs in order to arrive at the best possible solution to the problem. | • Explain that design is a creative planning process that leads to useful products and systems.<br>• Explain that requirements for a design are made up of criteria and constraints.<br>• Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>• Explain that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.<br>• Explain that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>• Identify and describe the major steps in the engineering design process.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>• Work safely and accurately with a variety of tools, machines, and materials.<br>• Actively participate in group discussions, ideation exercises, and debates. |

## RESOURCES

### Audiovisual Materials

1. Many video segments can be found on the Internet using suggested search terms.
2. www.discoveryeducation.com

**Print Materials**

ITEA-HITS (Humans Innovating Technology Series) Volume #1, includes *What is Engineering Design*, PH1-1, www.iteaconnect.org/F6.html

ITEA-HITS (Humans Innovating Technology Series) Volume #2, includes "*What is Design*," PH1-2, www.iteaconnect.org/F6.html

Ertas, A., Jones, J. C., *The engineering design process*, John Wiley and Sons, New York, 1996.

Lumsdaine, E., Lumsdaine, M., Shelnutt, J. W*., Creative problem solving and engineering design*, McGraw-Hill, Inc., New York, 1999.

Sanders, M. S., McCormick, E. J., *Human factors in engineering and design*, McGraw-Hill, Inc., New York, 1993. Dym, C. L., Little, P., *Engineering design: A project-based introduction*, John Wiley, New York, 1999.

Hyman, B., *Fundamentals of engineering design*, Prentice Hall, New Jersey, 1998.

# ASSESSMENT

# KNOWLEDGE AND SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

## ENGAGE

1. Ask the students to examine the cleanliness of the computers and equipment in their work area, and lead a discussion as to why the area might not be as clean as expected.
2. Students are asked to investigate this problem in their classroom:
    a. Each day, students find a new layer of dust on computers and other equipment.
    b. In small groups, they identify the problem and brainstorm possible solutions, agree on a final solution, and present their solutions to the class.
    c. Progress should be recorded in an Engineering Design Journal (EDJ). Through discussion, the teacher assesses the students' previous knowledge regarding the core concepts of technology, design process basics, knowledge of brainstorming, and their ability to produce a dimensioned orthographic sketch or drawing.
    d. Support student learning with review and reinforcement of these concepts as required.

**Teacher's Note:**

*Depending on the time you have you could make the students develop the solution as an out of class assignment. As you read through the lessons you may have to make some adjustments so that they may flow with your schedule more effectively.*

## EXPLORE

1. Lead a discussion about air quality, and the potential hazards to humans. Assign groups topics that relate to air quality, for example, coal miners who developed black lung disease, workers who have developed asbestosis over the years, reasons for asbestos removal in schools and public buildings, or other environmental pollutants such as auto emissions or side-stream cigarette smoke.

2. Students research and explore their topic and determine the potential or recognized impact on human health.

### EXPLAIN

1. Students present their findings to their peers via an informal presentation. The oral presentation can be enhanced through the use of various media such as slide presentations if time permits.

**Teacher's Note:**
*Presentations can be completed using various media outlets, depending on availability.*

### ENGINEER

1. Students use the design process to develop solutions to the "Biotoxin Mitigation" Design Challenge. (Student Resource 2.2). The teacher facilitates students in the laboratory experience.

### ENRICH

1. Via classroom discussion, the students brainstorm and share possible ways to prevent pollutants or hazardous substances from entering the building in the future.

**Teacher's Note:**
This enrichment can also be changed to allow the students to critique and improve the design of another group's solution.

### EVALUATE

1. The students' knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LAB/CLASSROOM PREPARATIONS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- LCD Projector
- Computer w/Internet access
- Small hand tools - scissors, rulers, squares, hobby knives
- Cans, cardboard boxes, fabric, cotton batting, various adhesives
- Assorted tape - masking, double-sided, duct
- Small - 6"-10"fan
- 12 rolls of masking tape
- 12 boxes of 50 pc. glue sticks
- 12 hote melt glue guns

- Assorted cans (aluminum or steel)
- Assorted plastic bottles
- Assorted wire scraps
- Assorted cloth scraps / burlap
- Package of tissue paper
- Assorted scrap paper
- 10 medium sized cardboard boxes
- 1 can of 3M 77 Spray adhesive

**Classroom Safety and Conduct**
Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson:

| **Student files** | **Filename** |
|---|---|
| Bio-toxin Mitigation Design Challenge | File 2.2.1.docx |

# Activity 3: The Design Process in Action

## ENDURING UNDERSTANDINGS

- Students will be able to search for information on the Internet.
- Students will gain understanding on the use of word processing and presentation software.

## BIG IDEA

Technology involves many types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation. The engineering design process must take all of these things into account.

## PURPOSE

This lesson provides support for students in understanding the engineering design process, with attention to 2D and 3D representation.

## HIGHLIGHTS

### ENGAGE

The teacher introduces the concept of orthographic and isometric drawing. The students are given various three-dimensional objects to sketch in orthographic form. The teacher observes, performs formative assessment, and provides feedback to the students.

### EXPLORE

The teacher introduces the students to parametric modeling software. Students explore and practice drawing basic 2D objects and extruding them into 3D models.

### EXPLAIN

The teacher demonstrates additional features of parametric modeling software. Students practice performing those operations, including but not limited to: filet, trim, chamfer, hole, extrude, and revolve.

### ENGINEER

Students will perform the "Crayon Conservation Challenge" wherein student teams will use the design process to develop a crayon recycling machine and process for a local elementary school.

### ENRICH

Students will develop a marketing plan to produce, sell, and distribute the Crayon Recycling machine to other teachers and schools within the district.

### EVALUATE

The students' knowledge, skills, and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs, and classroom presentations.

## LESSON DURATION: 12 Hours

## STANDARDS AND BENCHMARKS THAT ARE ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 3*** | **Design a product, system or environment for a specific setting** |
| E | Examine unrelated settings where their product, system, or environment may be applied. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| E | Design is a creative planning process that leads to useful products and systems. |
| F | There is no perfect design. |
| G | Requirements for a design are made up of criteria and constraints. |
| ***STL 9*** | **Understanding engineering design** |
| F | Design involves a set of steps, which can be performed in different sequences and repeated as needed. |
| 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. |
| H | Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| I | Specify criteria and constraints for a design. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, 2013)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |

| | |
|---|---|
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:*** **Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:*** **Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the |

| | |
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| | relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences |

## LEARNING OBJECTIVES

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|
| | | |

| | | |
|---|---|---|
| **Activity 3**<br>The Engineering Design Process in Action<br>(12 hours) | Technology involves many types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation.<br>The engineering design process must take all of these things into account. | • Explain that design is a creative planning process that leads to useful products and systems.<br>• Explain why there is no perfect design.<br>• Explain that requirements for a design are made up of criteria and constraints<br>• Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>• Explain that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.<br>• Explain that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>• Identify and describe the major steps in the engineering design process.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>• Work safely and accurately with a variety of tools, machines, and materials.<br>• Actively participate in group discussions, ideation exercises, and debates. |

## RESOURCES

### Audiovisual Materials

The Big Brain Theory www.discoveryeducation.com/thebigbraintheory

### Internet Sites

www.discoveryeducation.com

## ASSESSMENTS

## KNOWLEDGE AND SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

### ENGAGE:

Introduce the concept of orthographic and isometric drawing. The students are given various three dimensional objects to sketch in orthographic form. The teacher

observes, performs formative assessment, and provides feedback to the students. (Teacher Resource 3.1 - Orthographic Projection dwgs.ppt)

## EXPLORATION:

Introduce the students to parametric modeling software. Students explore and practice drawing basic 2D objects and extruding them into 3D models. Availability to professional software may be limited. The teacher should therefore refer to instructional materials provided by the software developer.

**Teacher's Note:**

*In the absence of high-end parametric design software, the teacher may choose to use open-source software available free of charge. An example of this is* ***Google SketchUp****®, which is currently available for download on the Internet. The professional version of this software may be available at no cost as well. The teacher should ask their local IT director for advice.*

## EXPLAIN

During this lesson, demonstrate additional features of parametric modeling software. Students practice performing those operations, including but not limited to: fillet, trim, chamfer, hole, extrude and revolve. Terminology for these operations may vary from product to product. The teacher should refer to the software tutorials that came with the product.

**Teacher's Note:**

*This may present the opportunity to have the students research the terms: fillet, trim, chamfer, etc., as a homework assignment. By doing this, it may allow for more class time using the technology as opposed to having to explain each term.*

## ENGINEER (EXTEND/ELABORATE)

Students will perform the "Crayon Conservation Challenge" (Student Resource 3.1) wherein student teams will use the design process to develop a crayon recycling machine and process for a local elementary school. The Engineering Design Journal should be used for documentation.

## ENRICH

Students will develop a marketing plan to produce, sell, and distribute the Crayon Recycling machine to other teachers and schools within the district.

**Teacher's Note:**

*This enrichment can also be changed to allow the students to critique and improve the design of another group's solution.*

## EVALUATE

The students' knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LAB/CLASSROOM PREPARATION

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- LCD Projector
- Computer w/Internet access
- Scissors, rulers, glue, tape - standard classroom supplies
- 12 ceramic lamp bases
- 100' roll of 16-2 lamp cord
- 12 2-conductor plugs
- Package of 100 small aluminum pie pans
- 3 pieces of 2'x4'x1/4" plywood
- 1 foil backed insulation board(4'x8'x1/2")
- Misc. soda cans and bottles
- 50 20cc syringes (w/o needle)
- Roll of 3/4 electrical tape

**Classroom Safety and Conduct**

Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson:

| **Student Files** | **Filename** |
|---|---|
| Orthographic Projection Drawings | Presentation 2.3.1.docx |
| The Great Crayon Conversation Challenge | File 2.3.2.docx |

# Invention and Innovation
## KSB 3 – THE DESIGNED WORLD

# SNAPSHOT

## ENDURING UNDERSTANDINGS

- Students will learn the core concepts of technology.
- Students will learn that all technologies have pros and cons.
- Students will use the design process as a creative tool.
- Students will learn how the criteria and constraints effect how people design objects.

## BIG IDEA

Invention and innovation are driven by human needs and wants, and are influenced by the core concepts of technology: systems, resources, requirements, optimization and trade-offs, processes, and controls. These concepts are the cornerstone for creative design.

**Teacher's Note**

*Big ideas should be made explicit to students by writing them on the board, reading them aloud, and/or posting them on worksheets associated with the lessons. For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose*

## PURPOSE OF THE UNIT

- To familiarize students with the core concepts of technology and the relationship of those concepts to invention and innovation.
- To create awareness that all parts of a system are interdependent and that a malfunction of one part affects the function and quality of a system as a whole.
- To create awareness that technologies have intended and unintended consequences that can pose ethical, economic, political, or cultural issues.
- To familiarize students with the design process as a creative planning tool.
- To familiarize students with the impact of criteria and constraints on a design.
-

## INSTRUCTIONAL TIME

KSB 3 requires 17 hours of instructional time. Each of the 3 lessons in the KSB 3 require the following number of hours to cover the content:

| REQUIRED UNIT HOURS | ENRICHMENT HOURS | TOTAL UNIT HOURS | TOTAL UNIT WEEKS |
|---|---|---|---|
| 10 Hours | 3 Hours | 13 Hours | 3 Weeks |

## STANDARDS AND BENCHMARKS THAT ARE ADDRESSED

This unit is based on three sets of Standards:

1. Standards for Technological Literacy (STL)
2. Next Generation Science Standards (NGSS)
3. Common Core State Standards (CCSS)

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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. |
| **H** | Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |
| | |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP. 1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP. 2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double |

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|---|---|
| | number line diagrams, or equations |
| **7.NS. 1** | The Number System |
| **7.NS. 2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS. 3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. |

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|---|---|
| | e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## KSB OBJECTIVES

| ACTIVITY | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 1:** Core Concepts of Technology (5 hours) | Core concepts; including systems, resources, requirements, optimization and trade-offs, processes, and controls; serve as cornerstones for the study of technology. | • Explain that 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.<br>• Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>• Explain that technology is closely linked to creativity, which has resulted in innovation.<br>• Define the terms invention and innovation.<br>• Categorize a technology as being a physical, informational, or bio-technical technology.<br>• Evaluate an invention or innovation<br>• Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>• Work safely and accurately with a variety of tools, machines, and materials. |
| | | |

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|---|---|---|
| **Activity 2**<br>Real World Designing<br>(5 hours) | Designers and inventors must consider the core concepts of technology and other resources such as scientific knowledge during the process of designing. They must also adhere to the criteria and constraints of a design. | • Explain that 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.<br>• Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>• Explain that the development and use of technology poses ethical questions.<br>• Explain that economic, political, and cultural issues are influenced by the development and use of technology.<br>• Explain that design is a creative planning process that leads to useful products and systems.<br>• Explain that there is no perfect design.<br>• Define requirements of a design as criteria and constraints.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task. |
| | | |
| **Total for This KSB = 10 Hours plus 3 hours Enrichment** | | |
| | | |

## ASSESSMENT TOOLS

Activities in the unit are assessed using:

- Selected Response Items
- Brief Constructed Response Item
- Performance Rubrics

Specific tools are incorporated into each lesson as Supporting Files.

# Activity 1 Core Concepts of Technology

## ENDURING UNDERSTANDINGS

- Students will learn the core concepts of technology.
- Students will use the design process as a creative tool.

## BIG IDEA

Core concepts; including systems, resources, requirements, optimization and trade-offs, processes, and controls; serve as cornerstones for the study of technology.

## PURPOSE

To introduce students to the core concepts of technology, and how they are used to evaluate or develop technology products or systems.

## HIGHLIGHTS

### ENGAGE

Students identify significant inventions or innovations in our world today.

### EXPLORE

Students explore and identify "Core Concepts of Technology"

### EXPLAIN

Students present their findings informally to their peers. Discussion on "Core Concepts of Technology.

### eNGINEER

Students design solutions using "Core Concepts" to problem

### ENRICH

Student teams trade and redesign solutions from previous eNGINEER activity.

### EVALUATE

The students' knowledge, skills, and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs, and classroom presentations.

## LESSON DURATION: 5 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| **H** | Technology is closely linked to creativity, which has resulted in innovation. |
| ***STL 2*** | **Understanding the core concepts of technology.** |
| **G** | Malfunctions of any part of a system affect the function and quality of the system. |
| **R** | Requirements are the parameters placed on the development of a product or system. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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. |
| **H** | Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the |

| | |
|---|---|
| | relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## KSB OBJECTIVES

| ACTIVITY | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 1:** Core Concepts of Technology (5 hours) | Core concepts; including systems, resources, requirements, optimization and trade-offs, processes, and controls; serve as cornerstones for the study of technology. | • Explain that 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.<br>• Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>• Explain that technology is closely linked to creativity, which has resulted in innovation.<br>• Define the terms invention and innovation.<br>• Categorize a technology as being a physical, informational, or bio-technical technology.<br>• Evaluate an invention or innovation<br>• Explain that design involves a set of steps that can be performed in different sequences and repeated when needed.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.<br>• Work safely and accurately with a variety of tools, machines, and materials. |

# RESOURCES

### Audiovisual Materials

1. Posters of Inventions That Changed the World. Pitsco. Identifier: W56248
2. Center, L. (Director). (1999). Lewis Latimer: Renaissance Man, African American Inventor [Documentary]. United States: The Smithsonian, ITEEA

3. Center, L (Director). (2004). She's Got It! Women Inventors and Their Inspirations [Documentary]. US: Smithsonian

**Print Materials**

1. Ebert, C., & Ebert, E.S., II. (1998). The Inventive Mind in Science: Creative Thinking Activities. Englewood, CO: Teachers Ideas Press. ISBN: 1-56308-387-6
2. Egan, L. (1997). Inventors and Inventions. New York, NY: Scholastic Professional Books. ISBN: 0-590-10388-1
3. Flack, J.D., (1989). Inventing, Inventions and Inventors: A Teaching Resource Book. Englewood, CO: Teachers Ideas Press. ISBN: 0-87287-747-7
4. Hutchinson, J., & Karsnitz, J. (19971994). Design and problem solving in technology . New York : GLENCOE/MCGRAW-HILL. (Original work published 1993)
5. Hutchinson, P., & Sellwood, P. (1996). Design and problem solving . Cincinnati, OH: Thomson Learning Tools.
6. Karsnitz, J. R., Brien, S., & Hutchinson, J. P. (2009). Engineering design: an introduction. Clifton Park, NY: Delmar Cengage Learning.
7. Smithsonian (Dc) 2007. The innovative path: creating the washington metropolitan bicycle trail network. Retrieved from http://invention.smithsonian.org/downloads/bikemap.pdf February 20, 2011
8. Smithsonian (Dc) 2007. Reinventing the wheel: continuing evolution of the bicycle. Retrieved from http://invention.smithsonian.org/downloads/bicycleguidebw.pdf February 20, 2011

**Internet Sites**

1. Bellis, M., (n.d.). About.com. Inventors. Creativity and Creative Thinking. Retrieved February 19, 2011 from http://inventors.about.com/od/lessonplans/a/creativity_2.htm.
2. Lemelson Center for the Study of Invention and Innovation. (n.d.). Invention at Play. Retrieved February 19, 2011 from www.inventionatplay.org.

# KNOWLEDGE & SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

## ENGAGE

1. Students, working in groups of 2 or 3, and using Student Resource 1.1 "Invention Inventory," students identify significant inventions or innovations in today's world.
2. Students share and compare their ideas about inventions or innovations.
3. Class views the video Inventions That Changed Our Lives.
4. The teacher asks students to explain the significance of the inventions or innovations they have chosen.
5. Referring to the student work, the teacher leads a discussion about which are inventions and which are innovations, and what category of technology they fall under.

**Teacher's Note:**

*Depending on the time you have you could make this a quick warm up activity and then move on to the next step. As you read through the lessons you may have to make some adjustments so that they may flow with your schedule more effectively.*

## EXPLORE

1. The teacher introduces the "Core Concepts of Technology" guide sheet, (Student Resource 1.2) and briefly explain each of the core concepts.
2. Students, still working in groups, select one or two inventions and try to identify how two or more of the core concepts might have been used in the development of the inventions, using the "Core Concepts Worksheet." (Student Resource 1.3)

**Teacher's Note:**

*Here you may assign 1 or 2 core concepts to a group, and allow them to become an "expert" on them. They can then teach those concepts to the class.*

## EXPLAIN

1. The student groups present their ideas from the Exploration Activity to the class and respond to the questions.
2. The teacher briefly reviews concepts from Unit 1:
    a. The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.
    b. Invention requires patience and creativity.
    c. Technology is closely linked to creativity, which has resulted in innovation.
    d. Invention is a process of turning ideas and imagination into devices and systems.
    e. Innovation is the process of modifying an existing product or system to improve it.
    f. Design involves a set of steps that can be performed in different sequences and repeated as needed.
    g. 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.
3. The teacher selects one or more of the inventions or innovations, and leads a class discussion about how the core concepts of technology can be used to develop or evaluate technology products or systems.

## ENGINEER (EXTEND/ELABORATE)

1. The class watches the video: Reinventing the Wheel.
2. The teacher reviews the rules of brainstorming using Student Resource 1.4.
3. Working in pairs, students select a significant invention or innovation from a list, and identify the problem the invention solved.
4. The teacher reviews the Design Process with students, reminding them that the process is iterative, and very seldom linear.
5. Students are asked to pretend that the problem was never solved, and the invention never existed.
6. Using the "It Never Happened" worksheet, (Student Resource 1.4) students apply select core concepts and the design process to "reinvent the invention."
7. Teams choose their best idea, design and develop it, and finally, present their solution to classmates.

## ENRICH

1. After all teams have presented, students trade their design with another team. Teams work together to optimize the design, and develop a plan for testing the optimized artifact.

## EVALUATE

1. The student's knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LAB/CLASSROOM PREPARATIONS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- Pencils
- Plain paper and graph paper
- Computer w/ Internet access
- CAD or parametric modeling software
- Poster board and markers

**Classroom Safety and Conduct**

Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson

| **Student Files** | **Filename** |
|---|---|
| Invention Inventory | File 3.1.1.docx |
| Core Concepts | File 3.1.2.docx |
| Core Concepts WS | File 3.1.3.docx |
| Just Like it Never Happened | File 3.1.4.docx |
| Design Process Rubric | File 3.1.5.docx |

# Activity 2 Real World Design

## ENDURING UNDERSTANDINGS

- Students will learn how the criteria and constraints effect how people design objects.
- Students will use the design process as a creative tool.

## BIG IDEA

Designers and inventors must consider the core concepts of technology and other resources such as scientific knowledge during the process of designing. They must also adhere to the criteria and constraints of a design.

## PURPOSE

To present students with an authentic design challenge that gives them the opportunity to reinforce and demonstrate their knowledge of the design process and the core concepts of technology.

## HIGHLIGHTS

### ENGAGE

Using web-based resources, students review "Newton's laws" relative to force and motion.

### EXPLORE

Students design and perform an experiment to determine the speed of a sphere moving down and incline plane relative to the angle of the incline, and record data.

### EXPLAIN

The teacher leads class discussion on the findings of the exploration assignment, to determine if there were common observations. The teacher also reviews Newton's Laws of Motion with the class, and introduces the concept of frictional resistance

### ENGINEER

Students apply the design process to design, develop, and produce a device that will move a marble from a given point A to a given point B in exactly five seconds.

### ENRICH

Students will evaluate their device, describe what changes could be made to make the device more accurate or consistent, then add controls to the device to insure accuracy and consistency.

### EVALUATE

The student's knowledge, skills and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs.

## LESSON DURATION: 5 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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. |
| **H** | Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a |

| | |
|---|---|
| | proposed object, tool, or process such that an optimal design can be achieved. |
| | |

| ***MATHEMATICS:*** **Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:*** **Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style. |

| | |
|---|---|
| | f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## KSB OBJECTIVES

| ACTIVITY | BIG IDEA | OBJECTIVES |
|---|---|---|
| | | |

| | | |
|---|---|---|
| **Activity 2**<br>Real World Designing<br>(5 hours) | Designers and inventors must consider the core concepts of technology and other resources such as scientific knowledge during the process of designing. They must also adhere to the criteria and constraints of a design. | • Explain that 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.<br>• Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>• Explain that the development and use of technology poses ethical questions.<br>• Explain that economic, political, and cultural issues are influenced by the development and use of technology.<br>• Explain that design is a creative planning process that leads to useful products and systems.<br>• Explain that there is no perfect design.<br>• Define requirements of a design as criteria and constraints.<br>• Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task. |

# RESOURCES

### Audiovisual Materials


1. Posters of Inventions That Changed the World. Pitsco. Identifier: W56248
2. Corporation, C. (Director). (2007). Just the facts: inventions that changed the world - inventions and innovations [Documentary]. US: Goldhill entertainment.
3. Lemelson center (1999). Lewis latimer: renaissance man, African-american inventor [Documentary]. United States: The Smithsonian, ITEEA
4. Dennis, M. (Director). (2002). Reinventing the wheel: the continuing evolution of the bicycle [Documentary]. United States: Smithsonian, ITEEA
5. Lemelson center (2004). She's got it! women inventors and their inspirations [Documentary]. US: Smithsonian.
6. Lemelson center (2004). The electric guitar: its makers and its players [Documentary]. US: The Smithsonian.

**Print Materials**


1. Ebert, C., & Ebert, E.S., II. (1998). The Inventive Mind in Science: Creative Thinking Activities. Englewood, CO: Teachers Ideas Press. ISBN: 1-56308-387-6 2.
2. Egan, L. (1997). Inventors and Inventions. New York, NY: Scholastic Professional Books. ISBN: 0-590-10388-1
3. Flack, J.D., (1989). Inventing, Inventions and Inventors: A Teaching Resource Book. Englewood, CO: Teachers Ideas Press. ISBN: 0-87287-747-7
4. Hutchinson, J., & Karsnitz, J. (19971994). Design and problem solving in technology . New York : GLENCOE/MCGRAW-HILL. (Original work published 1993)
5. Hutchinson, P., & Sellwood, P. (1996). Design and problem solving . Cincinnati, OH: Thomson Learning Tools.
6. Karsnitz, J. R., Brien, S., & Hutchinson, J. P. (2009). Engineering design: an introduction. Clifton Park, NY: Delmar Cengage Learning.
7. Smithsonian (Dc) 2007. The innovative path: creating the washington metropolitan bicycle trail network. Retrieved from http://invention.smithsonian.org/downloads/bikemap.pdf February 20, 8.
8. 2011Smithsonian (Dc) 2007. Reinventing the wheel: continuing evolution of the bicycle. Retrieved from http://invention.smithsonian.org/downloads/bicycleguidebw.pdf February 20, 2011


**Internet Sites**


1. The Lemelson Center for the Study of Invention and Innovation. (n.d.). Retrieved December 10, 2010 from http://invention.smithsonian.org/home/.
2. The Lemelson-MIT Program and LEAD International. (2003).Invention and Innovation for Sustainable Development. Retrieved December 15, 2010 from http://web.mit.edu/invent/n-pressreleases/downloads/sustainable.pdf.
3. PBS Teachers. Innovation and Invention: Activity Ideas.(n.d.) Retrieved Dec. 15, 2010 from http://www.pbs.org/teachers/thismonth/innovation/index1.html.


## KNOWLEDGE & SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

### ENGAGE

1. Using web-based resources, students review "Newton's laws" relative to force and motion.
2. The teacher leads a discussion about the difference between the "scientific method" and the design process, explaining that often a scientific experiment must be performed as a subset of the design process.

**Teacher's Note:**

*Depending on the time you have you could make this a quick warm up activity and then move on to the next step. As you read through the lessons you may have to make some adjustments so that they may flow with your schedule more effectively.*

### EXPLORE

1. Students design and perform an experiment to determine the speed of a sphere moving down an incline plane relative to the angle of the incline, and record data.

2. The teacher prompts students to describe the variables involved in such an experiment.

**Teacher's Note:**
*This is a good moment to coordinate with the math teacher in your school in order to make a cross curricular connection. The students could complete this portion in their math class, and bring that information back to the Tech Ed class.*

### EXPLAIN

1. The teacher leads a class discussion on the findings of the exploration assignment, to determine if there were common observations.
2. The teacher also reviews Newton's Laws of Motion with the class, and introduces the concept of frictional resistance

### ENGINEER

1. Students apply the design process to design, develop, and produce a device that will move a marble from a given point A to a given point B in exactly five seconds. The criteria and constraints for the design are given in Student Resource 2.1 "Marble Sashay."

### ENRICH

1. Students will evaluate their device, describe what changes could be made to make the device more accurate or consistent, then add controls to the device to insure accuracy and consistency.

### EVALUATE

1. The student's knowledge, skills and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs.

## LAB/CLASSROOM PREPARATIONS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

## MATERIALS NEEDED

- Cardboard boxes
- Package of poster board
- Roll of string
- Pack of 50 straws
- Pack of 50 skewers
- Pack of 50 paper clips
- Pack of 50 rubber bands
- Pack of 50 Post-It notes

- Pack of 50 push pins
- Pack of 50 pencils
- Roll of tape
- 4-6 stopwatches
- Package of balsa wood
- Pack of 50 paper cups
- Pack of 50 cardstock
- Pack of 50 glue sticks
- 10 Hot glue guns
- Class set of scissors
- Class set of rulers

## RESOURCE MATERIALS

The following resource materials support this lesson

| **Student Files** | **Filename** |
|---|---|
| Marble Sashay Activity | File 3.2.1 |

# Invention and Innovation
## KSB 4: Using Design and Creativity to Help Others

# Snapshot

## ENDURING UNDERSTANDINGS

- Recognize the design process as a creative planning process.
- Describe the rules to follow when brainstorming with a group of people.
- Defend brainstorming as a viable technique when problem solving.
- Distinguish criteria and constraints for a design.
- Explain how ideas can be transformed into practical solutions.
- Describe how modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.
- Describe the technological design loop and the path they follow when designing a product or system.
- Apply a design process to solve problems in the real world

## BIG IDEA

Improving daily life involves creatively using design concepts to solve problems.

**Teacher's Note**

*Big ideas should be made explicit to students by writing them on the board, reading them aloud, and/or posting them on worksheets associated with the lessons. For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words if they choose.*

## PURPOSE OF THE KSB

The United States is increasingly dependent on other nations for technical design and support. As technological advances increasingly make daily life easier, individuals will be needed to maintain and improve technological devices and processes. United States citizens will need to use creative design processes, mathematical and scientific knowledge to compete globally with other countries. The purpose of this unit is to familiarize students with the creative engineering design process in order to identify problems and possible solutions in their community.

## INSTRUCTIONAL TIME

KSB 4 requires 4 weeks of instructional time based on one hour per day. Each of the four activities in KSB 4 in the Invention and Innovation course require the following number of hours to cover the content:

| REQUIRED UNIT HOURS | ENRICHMENT HOURS | TOTAL KSB HOURS | TOTAL KSB WEEKS |
|---|---|---|---|
| 11 Hours | 6 Hours | 17 Hours | 4 Weeks |

## STANDARDS AND BENCHMARKS THAT ARE ADDRESSED

This unit is based on three sets of Standards:

1. Standards for Technological Literacy (STL)

2. Next Generation Science Standards (NGSS)
3. Common Core State Standards (CCSS)

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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. |
| **H** | Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals |

| | |
|---|---|
| | why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## KSB Objectives

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 1:** Technology Around You! (6 Hours) | Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems. | •Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>•Explain how technology is closely linked to creativity.<br>•Discuss how creativity has resulted in innovations to technology.<br>•Design a product, system, or environment for a specific setting.<br>•Identify criteria and constraints for the design.<br>•Use symbols and drawings as a way to express ideas.<br>•Examine unrelated settings where their product, system or environment may be applied. |
| | | |
| **Activity 2**: What is Design? (4 Hours) | Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems. | •Recognize the design process as a creative planning process.<br>•Describe the rules to follow when brainstorming with a group of people.<br>•Defend brainstorming as a viable technique when problem solving.<br>•Distinguish criteria and constraints for a design.<br>•Explain how ideas can be transformed into practical solutions.<br>•Describe how modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>•Describe the technological design loop and the path they follow when designing a product or system.<br>•Apply a design process to solve problems in and beyond the laboratory-classroom. |
| | | |
| **Activity 3:** Communicating Your Design? (2 Hours) | Communicating your design is important to the process of invention and innovation. As you brainstorm and collaborate, you create pictorial representations of your design. Accurate drawings and sketches can communicate your design ideas globally. | •Explain that the use of symbols, measurement, and drawings provides a common language to express ideas.<br>•Demonstrate the use of symbols, measurement, and drawings to promote clear communication.<br>•Formulate two-dimensional and three-dimensional representations of a designed solution. |
| | | |

| | | |
|---|---|---|
| **Activity 4:** Rube Goldberg Entertainment (4-5 Hours) | Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems. | •Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>•Explain how technology is closely linked to creativity.<br>•Discuss how creativity has resulted in innovations to technology.<br>•Design a product, system, or environment for a specific setting.<br>•Examine unrelated settings where their product, system, or environment may be applied.<br>•Understanding the role of troubleshooting, R&D, etc., in problem-solving<br>•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.<br>•Some technological problems are best solved through experimentation. |
| | | |
| **Total for This KSB = 11 Hours plus 6 hours Enrichment** | | |

## ASSESSMENT TOOLS

Activities in this KSB are assessed using:

- Selected Response Items
- Brief Constructed Response Item
- Performance Rubrics

Specific tools are incorporated into each lesson as Supporting Files.

# Activity 1 Technology Around You!

## ENDURING UNDERSTANDINGS

- Recognize the design process as a creative planning process.
- Describe the rules to follow when brainstorming with a group of people.

## BIG IDEA

Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems.

## PURPOSE

The purpose of this lesson is to show students that creativity and technology are important to inventions and innovations.

## HIGHLIGHTS

### ENGAGE

The teacher asks students to complete the K and W of a KWL Chart for the terms, "Creativity" and "Technology." A class-compiled KWL chart will lead into a discussion of how inventions and innovations are connected to creativity.

### EXPLORE

The students explore characteristics of various inventions and innovations and participate in a discussion of how inventions and innovations are influenced by creativity and how creativity is linked to technology.

### EXPLAIN

The teacher leads a discussion on the development of technology and highlights that it is a human activity and is the result of individual or collective needs and the ability to be creative.

### eNGINEER

Students use the engineering design process to design a backpack for a physically challenged student in grade 7.

### ENRICH

Students complete the design brief (Design and construct a device for a wounded soldier).

### EVALUATE

The students' knowledge, skills, and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs.

## LESSON DURATION: 6 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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. |
| **H** | Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |

| | |
|---|---|
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the |

| | |
|---|---|
| | information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## LEARNING OJECTIVES

| ACTIVITY | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 1:** Technology Around You! (6 Hours) | Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems. | •Explain that the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.<br>•Explain how technology is closely linked to creativity.<br>•Discuss how creativity has resulted in innovations to technology.<br>•Design a product, system, or environment for a specific setting.<br>•Identify criteria and constraints for the design.<br>•Use symbols and drawings as a way to express ideas.<br>•Examine unrelated settings where their product, system or environment may be applied. |

## RESOURCES

### Print Materials


Caney, Steven. (1999). Invention book. New York, NY: Workman Publishing Company.

Smaby, Niels. (2004). Journal of rehabilitation research and development, 41(2), 215-224. Retrieved from: www.rehab.research.va.gov/jour/04/41/2/smaby.html

Tomecek, Stephen M. (2003). What a great idea! Inventions that changed the world. New York, NY: Scholastic, Inc.


### Internet Sites

1. University of Colorado Active Simulations: http://phet.colorado.edu/sims/mass-spring-lab/mass-spring-lab_en.html
2. Forces: http://library.thinkquest.org/10796/ch4/ch4.htm
3. How to Make a Simple Prosthetic: http://www.youtube.com/watch?v=Yvev6shNvSg
4. Make-shift Children's Prosthetics: http://www.dinf.ne.jp/doc/english/global/david/dwe002/dwe00269.html
5. Inside a Socket Vide Part 1,2, & 3: http://www.youtube.com/watch?v=F6QQ9qrXuv0 ,

http://www.youtube.com/watch?NR=1&v=qhVjXm0xVKc&feature=endscreen , http://www.youtube.com/watch?v=8cbjyg-Ri9s

6. Designing a Successful Prosthetic Leg Video: http://www.youtube.com/watch?v=XHd6rQi-gWY
7. 16 year old Makes Mechanical Arm: http://www.popsci.com/diy/article/2012-11/you-built-what-remote-controlled-robo-arm
8. Hand Size and Ergonomics: http://www.arch.mcgill.ca/prof/castro/arch304/winter2001/dander3/frame/ergo4.htm
9. Human Ergonomics: http://cms.allsteeloffice.com/SynergyDocuments/ErgonomicsAndDesignReferenceGuideWhitePaper.pdf
10. Design of a Human Hand Prosthesis: http://www.wpi.edu/Pubs/E-project/Available/E-project-042612-145912/unrestricted/MQP_PaulV_Complete_Final_3.pdf
11. How a Prosthetic Leg is Made: http://www.instructables.com/id/How-A-Prosthetic-Leg-Is-Made/?ALLSTEPS
12. American Society for Surgery of the Hand:
13. http://www.assh.org/Public/HandConditions/Pages/AmputationandProsthetics.aspx

# KNOWLEDGE & SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

## ENGAGE

1. The teacher sets up two KWL Charts (Student Resource 1.1). Title one "Technology" and the other "Creativity" and direct students to record information in the "K" and "W" columns of their student KWL Charts. The teacher gives students a few minutes to complete information.
2. Students record individual information on a classroom KWL Chart.
3. The teacher selects students to share their "W" questions

**Teacher's Note:**

*The teacher will identify student misunderstandings and/or misconceptions about the influence of creativity on technology.*

## EXPLORE

**The Student:**

1. Uses class resources to define "creativity" and "technology." These resources can be printed text or the Internet.
2. Explores characteristics of various teacher supplied inventions and innovations.
3. Record the item and based on the definitions given, determine which items required "creativity" and which items use "technology." (Student Resource 4.1.2 "Creativity and Technology") Most inventions required some amount of creativity and technology.

**The Teacher:**

1. Leads a discussion of how inventions and innovation are influenced by creativity and how creativity is linked to technology. All technology is influenced by creativity.

Creativity is important to the consumer since many products and services are sold based on consumer perception.

2. Provides copies of student resource sheets (Student Resource 4.1.2 "Creativity and Technology and Student Resource 4.1.3 "Creativity Discussion") prior to the gallery walk (Teacher Resource 1.2) through technology.
3. Demonstrates how to complete the Student Resource 4.1.2 "Creativity and Technology" using photographs and/or technological devices for this activity. (Photographs can be used, or the teacher can provide actual items for students to view.)
4. Allows students to return to the "gallery walk" of technology.
5. Reviews the definition of technology as well as creativity.

**Teacher's Note:**

*Students should know that technology, by itself, is neither good nor bad, but decisions about the use of products or systems can result in desirable or undesirable consequences. They should have some basic sketching and research skills*.

## EXPLAIN

**The Teacher:**

1. Teacher reviews definitions.
    a. Creativity is defined as the quality of being creative or the ability to create.
    b. Technology is defined as the practical application of knowledge, especially in a particular area such as engineering or medical technology.
    c. Technology is also a capability given by the practical application of knowledge, such as a car's fuel-saving technology.
    d. Technology is also a way of accomplishing a task, especially using technical processes, methods, or knowledge such as new technologies for information storage.
2. Facilitates a class discussion about how creativity has resulted in innovations to technology.
3. Asks students to take notes on the class discussion. (Student Resource 4.1.3 "Creativity Discussion")
4. Facilitates a discussion using the following questions as a guide:
    a. How do inventors and innovators arrive at a product or process? Answers may include solving a problem using a design process.
    b. How do inventors know where to start in the design process? Answers may include looking at the criteria or restrictions such as time, resources, or space.
    c. How do inventions and creativity influence each other? Answers may include ideas about types of cars or products that sell more items because the product "looks nice."
    d. What are some ways to communicate your ideas to another person without using words? Answers may include making gestures, sketches and drawings. You can also communicate using mathematical symbols and calculations. You can also use geometric models and shapes to help visualize and solve problems.
    e. Describe some inventions that were inspired by a natural object or event. Answers may include ideas about early airplanes having attributes of birds.
5. Reinforces key concepts

a. Inventions and Innovations are developed to satisfy a need or want.
b. Many inventions or innovations require creativity.
c. Corporations can often create demand for a product by bringing it onto the market and advertising it.
d. Technological ideas are sometimes protected through the process of patenting.
e. Communication of your idea is important to everyone that is part of the design team.
f. Marketing a product involves informing consumers about it as well as assisting in selling and distributing it.
g. Marketing a product involves communicating your idea to many people after the product is made.
h. Solving design challenges also requires designers to use mathematical calculations and simulations before actually making an invention. This saves time and money.

**The Student:**

1. Identifies a photograph or device and researches how the device was developed or invented.
2. Presents a short oral presentation on a chosen device. The presentation includes a short discussion on why it was developed and how creativity influenced the idea.
3. Clarifies their understanding of concepts by asking questions.

**ENGINEER**

**The Teacher:**

1. States that purpose of this activity is to allow students to think about how creativity and technology satisfy the needs or wants of consumers.
2. Reviews the design process and presents one of the following design briefs for students to complete. (Teacher Resource 4.1.1, Student Resource 4.1.4 "Assistive Devices and Prosthetics Presentation Notes", and Student Resource 4.1.5 "Biomedical Device Design Challenge")

**Design Brief**

1. Design and develop a device (prosthetic or assistive) that can be used by an amputee do complete different tasks. Both two-dimensional and three-dimensional representation of their ideas must be presented in an oral presentation. Students can work in small groups for this project.
2. When students begin investigating and researching about the design brief, present presentation on Biomedical engineering and technology to students (Teacher Resource 4.1.1) while students take notes (Student Resource 4.1.4 "Assistive Devices and Prosthetics Presentation Notes")
3. Students can be provided with Digital Resources related to prosthetics to aid in their investigation and research (Student Resource 4.1.6 "Prosthetics Resources")

**Testing Devices**

1. Students are asked to test their device. The devices should be tested in ways that related to the task that the student chose at the beginning of the design challenge. Different design factors and variable should be tested (comfort, weight, durability, strength, etc). Provide students with the Testing Resource (Student Resource 4.1.7 "Testing Resource") to aid in this process when needed.

**Presenting**

2. Students are trying to convince a hypothetical prosthetic company to manufacture their device. The students must show that they have tried to consider multiple

variable (including size, materials, durability, weight, looks, etc), as evident from their documentation and research.

3. When students present their final products, students should talk about what their product would ideally be made out of, not necessarily what it actually is made out of. Example: "The soda bottle represents a custom made fiberglass socket." Having students present in this way helps to provide evidence of the informed design process and that they have considered multiple factors while designing.

### ENRICH

1. Students use their planned design and construct the solution to their design brief. This design will be used in the final presentation.
2. Students can have competitions to try to complete similar tasks. Students can develop a communication technology artifact or display about their device so it can be showcased independently of the oral presentation.

### EVALUATE

1. Students' knowledge, skills, and attitudes are assessed using rubrics for class participation and oral presentation. The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are reviewed during the activities to guide students in the completion of assignments. The teacher can develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

## TEACHER PLANNING AND RESOURCE MATERIALS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- Pencils
- Plain paper and graph paper
- Computer with Internet access
- CAD or parametric modeling software (optional)
- Poster board and markers (optional)
- Engineering Design Journal
- Pencil
- Measuring Tools
- Wood
- Cardboard
- Paper Towel Rolls
- Tape
- Hot Glue
- String
- Paper Clips
- Brass Fasteners

- Card Stock
- Acrylic Rods
- Styrofoam
- Dowel Rods
- Wheels
- Cups

**Classroom Safety and Conduct**

Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson

| **Student Files** | **Filename** |
|---|---|
| KWl Chart | File 4.1.1.docx |
| Creativity and Technology | File 4.1.2.docx |
| Creativity and Discussion | File 4.1.3.docx |
| Assistive Devices (notes) | File 4.1.4.docx |
| Biomedical Devices Design Challenge | File 4.1.5.docx |
| Prosthetics Resources | File 4.1.6.docx |
| Testing Resource | File 4.1.7.docx |

# Activity 2: What is Design?

## ENDURING UNDERSTANDINGS

- Defend brainstorming as a viable technique when problem solving.
- Distinguish criteria and constraints for a design.

## BIG IDEA

Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems.

## PURPOSE

The purpose of this lesson is to show students a process that can be used to by anyone to solve a problem.

## HIGHLIGHTS

### ENGAGE

Students sketch a design of a wagon that can be used by a disabled student in their class.

### EXPLORE

Students take notes on the engineering design process. Students compare various engineering design processes.

### EXPLAIN

Students explain why they want to include a step in the class-designed "engineering design steps."

### ENGINEER

Students design an economical way to sharpen your pencil (Student Resource 2.3). If possible, students take pictures as they design, construct, test and evaluate their projects. The teacher provides cameras or students use their cell phone to take pictures. Students use pictures to present their project whether formally or informally

### ENRICH

Students use pictures to present their project.

### EVALUATE

Class Participation Instrument and Oral Presentation Instrument.

## LESSON DURATION: 4 Hours

## STANDARDS AND BENCHMARKS THAT ARE ADDRESSED

This unit is based on three sets of Standards:

1. Standards for Technological Literacy (STL)
2. Next Generation Science Standards (NGSS)
3. Common Core State Standards (CCSS)

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| **H** | Technology is closely linked to creativity, which has resulted in innovation. |
| **STL 2** | **Understanding the core concepts of technology.** |
| **Q** | Malfunctions of any part of a system affect the function and quality of the system. |
| **R** | Requirements are the parameters placed on the development of a product or system. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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 |
| **H** | to improve it.<br>Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |

| | |
|---|---|
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the |

| | |
|---|---|
| | information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## LEARNING OBJECTIVES

| ACTIVITY | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 2**: What is Design? (4 Hours) | Creativity is important to the process of invention and innovation. Innovation is the process of modifying an existing product, process, or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems. | •Recognize the design process as a creative planning process.<br>•Describe the rules to follow when brainstorming with a group of people.<br>•Defend brainstorming as a viable technique when problem solving.<br>•Distinguish criteria and constraints for a design.<br>•Explain how ideas can be transformed into practical solutions.<br>•Describe how modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.<br>•Describe the technological design loop and the path they follow when designing a product or system.<br>•Apply a design process to solve problems in and beyond the laboratory-classroom. |

## RESOURCES

**Audiovisual Materials**

Mothers of Invention DVD (from the History Channel)
http://shop.history.com/detail.php?p=68694&v=history&ecid=PRF-2101168&pa=PRF-2101168

**Print Materials**

Caney, Steven. (1985). Invention book. Workman Publishing Company. ISBN: 0894800760

Tomecek, Dan & Stuckenschneider, Dan (Illustrator). (2003). What a great idea! Inventions that changed the world. ISBN: 0590681443

**Internet Sites**

1. America's Young Inventors Inductees www.nmoe.org/gallery/ngind.html
2. Compare Contrast Graphic Organizers-Write Design Online www.writedesignonline.com/organizers/comparecontrast.html
3. Design Squad PBS Kids http://pbskids.org/designsquad/parentseducators/program/viewing_tips.html
4. Intel Design and Discovery Curriculum http://educate.intel.com/en/DesignDiscovery/Curriculum/
5. National Museum of Education www.nmoe.org/
6. Rube Goldberg Engineering www.geri.soe.purdue.edu/PDF%20Files/The_Simplicity_of_Co.pdf
7. Teachers Domain (Applying the design process) www.teachersdomain.org/browse/?start=40&fq_oer=2&fq_hierarchy=k12.sci.engin.design.approcess

## KNOWLEDGE & SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

### ENGAGE

1. Students sketch a design of a wagon that can be used by a disabled student in their class.
2. Students share their designs. If SMART Board technology is available, this would be a great way to share the ideas. Passing a tablet around will engage students.
3. The teacher asks selected students to share answers.

### EXPLORE

1. Students compare various engineering design processes (Student Resource 4.2.1 "Comparing Engineering Design Processes").
2. Students use class resources or the library media center to research different engineering design processes.
3. Students use Internet resources to compare at least three different engineering design processes. An alternative would be for the teacher to set up stations with different engineering design processes.
4. The teacher leads a discussion of how these processes are similar and different.

### EXPLAIN

1. The teacher explains that all engineering design processes include some basic steps that help the inventor design the best product or process possible.
2. The teacher guides students to develop an engineering design process that can be used in their class. Students should base their answers on the information researched earlier.
3. The final design process should be displayed and referred to during the year.
4. The teacher introduces the design process folio format to help students document the process of their design.
5. During the discussion around the design process folio, the teacher describes how the design process includes sketching, modeling, testing, and redesigning or modifying the original design to transform ideas into practical useable solutions to the problem.

6. The teacher shows the DVD, Mothers of Invention (Student Resource 4.2.4 "Mothers of Invention").
7. The teacher reviews the Assessment Instruments to guide students in the completion of assignment.
8. Students clarify their understanding of concepts by asking questions.

### ENGINEER

1. Students use the engineering design process to solve a design challenge.
2. The teacher states that the purpose of this activity is to get students to use the engineering design process to solve a problem.
3. Student Resource 4.2.3"An Economic Way to Sharpen a Pencil Design Brief" contains a design brief (Design a new and economical way to sharpen your pencil.)
4. Student Resource 4.2.5 contains a design brief (Design a new and economical way to sharpen your pencil.)

### EVALUATE

1. Students' knowledge, skills, and attitudes will be assessed using rubrics for class participation and oral presentation. The rubrics will be presented in advance of the activities to familiarize students with the expectations and performance criteria. They will also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

## *Teacher Planning and* RESOURCE MATERIALS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- Pencils
- Plain paper and graph paper
- Computer w/ Internet access
- CAD or parametric modeling software
- Design squad
- Intell design and discovery curriculum
- Designing balloon cars
- National Museum of Education
- National Museum of Education Young Inventors Inductees

**Classroom Safety and Conduct**
Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson:

| **Student Files** | **Filename** |
|---|---|
| Comparing Engineering Design Processes | File 4.2.1.docx |
| The Middle School Engineering Design Process | File 4.2.2.docx |
| An Economical Way to Sharpen a Pencil DB | File 4.2.3.docx |
| Mothers of Invention | File 4.2.4.docx |

# Activity 3: Communicating Your Design

## ENDURING UNDERSTANDINGS

- Explain how ideas can be transformed into practical solutions.
- Describe how modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

## BIG IDEA

Communicating your design is important to the process of invention and innovation. As you brainstorm and collaborate, you create pictorial representations of your design. Accurate drawings and sketches can communicate your design ideas globally.

## PURPOSE

The purpose of this lesson is for students to explore attributes of drawing technology in order to explain what information is required for detailed sketches when building models.

## HIGHLIGHTS

### ENGAGE

Student discussion: Describe what you think is needed before you can make or build anything.

### EXPLORE

An exploration activity using K'Nex or similar objects.

### EXPLAIN

Student discussion on Exploration Assembly activity.

### eNGINEER

Students learn about detailed drawing to communicate technological ideas.

### ENRICH

Students design a presentation to explain the importance of prototypes and simulations in the engineering design process.

### EVALUATE

The students' knowledge, skills, and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs.

## LESSON DURATION: 2 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| ***STL 8*** | **Understanding the Attributes of Design** |
| E | Design is a creative planning process that leads to useful products and systems. |
| F | There is no perfect design. |
| G | Requirements for a design are made up of criteria and constraints. |
| | |
| ***STL 9*** | **Understanding engineering design** |
| F | Design involves a set of steps, which can be performed in different sequences and repeated as needed. |
| 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. |
| H | Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |

| | |
|---|---|
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:*** **Common Core State Standards (CCSS, 2012)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |

## LEARNING OBJECTIVES

| ACTIVITY | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity Learning Cycle 3:** Communicating Your Design? (2 Hours) | Communicating your design is important to the process of invention and innovation. As you brainstorm and collaborate, you create pictorial representations of your design. Accurate drawings and sketches can communicate your design ideas globally. | •Explain that the use of symbols, measurement, and drawings provides a common language to express ideas.<br>•Demonstrate the use of symbols, measurement, and drawings to promote clear communication.<br>•Formulate two-dimensional and three-dimensional representations of a designed solution. |

## RESOURCES

### Print Materials

Spencer, Henry Cecil. (1995). Basic technical drawing. New York, NY: Glencoe/McGraw-Hill School Pub Co. Retrieved from www.abebooks.com/9780026856607/Basic-Technical-Drawing-Spencer-Henry-0026856603/plp

Willard, William F. (2009). The art of mechanical drawing: A practical course for drafting and design. New York, NY Hearst Books. Retrieved from www.abebooks.com/products/isbn/1588167593

### Internet Sites

1. Dyson www.dyson.com/insidedyson/article.asp?aID=jamesdyson&hf=0&js
2. Technical Drawings www.mos.org/etf/tech.html

## KNOWLEDGE & SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

### ENGAGE:

1. Teacher guides discussion and asks students to: "Describe what you think is needed before you can make or build anything."
2. The teacher may give a hint. Hint: give students pictures of any invention (for example chair, table, skateboard, athletic shoes). What was needed BEFORE these items were made?
3. Teacher explains the reason for this lesson. (Big Idea: Communicating your design is important to the process of invention and innovation. As you brainstorm and collaborate, you create pictorial representations of your design. Accurate drawings and sketches can communicate your design ideas globally.)

## EXPLORATION:

1. Teacher uses Think, Pair, Share strategy to guide discussion questions. Discussion questions:
    a. How do we communicate ideas technically? (Possible answers include using a computer to access ideas or construct ideas-CAD)
    b. What types of information are communicated through drawing technology? (Answers may include dimensions, shapes, colors)
    c. How do we represent common objects in a drawing? (Answers may include examples like IKEA assembly instructions or video game setup instructions.)
2. Teacher guides an exploration activity.
3. Teacher divides the class into two or more teams. Each team will attempt to create an object using K'Nex (or similar materials). Possible groups include:
    a. One team will have a drawing with which to work.
    b. Another team will only have a written explanation of how to create the object.
    c. Give written directions or drawing assembly directions (pictures) to only ONE person in the group. They must convey the construction to the other members in their team.
4. Start the timer. Allow 5-10 minutes assembly time, depending on the level of students and complexity of the designs.
5. The team with the drawing that all members can see should have theirs done quickly; the other team(s) won't.

## EXPLAIN

1. Teacher leads a discussion after the activity.
2. Exploration Assembly Follow Up Questions:
    a. What type of directions did your group have? (Answers will include written directions, just pictures, only one person in the group had the questions, only one person in the group had the picture assembly instruction)
    b. Which way of creating this object was easier? Why?
    c. Why do you think humans do better if we can also SEE what we're doing?
3. Explanation DIMENSION Activity Follow Up Questions:
    a. Which drawing would be easier to follow? Why?
    b. What would happen if?
    c. Clothing didn't have sizes on it
    d. Maps didn't have scales and mileages
    e. Gas pumps didn't have prices

**Teacher's Note:**
*The activities in this part of the lesson may be spread out or even done for homework if need be. As you introduce these topics it may take some students longer to complete than others.*

4. Explanation Discussion. The objective should be restated; then briefly have students verbalize possible answers.
5. Students explore attributes of drawing technology in order to explain what information is required for detailed sketches when building models.Possible answers may include:

a. It is easier to construct a device if you have sketches than if you have only written instructions.
b. It is helpful to have dimensions and scales on a sketch so you know what actual sizes are involved.
c. It is helpful to have design specifications, such as the type of material used for the device.
d. It is helpful to have step-by-step instructions to make the construction process go smoother and faster.
**e.** Many people can relate to detailed sketches. It helps them to visualize the final product

### ENGINEER

1. DIMENSION Activity; Teacher leads a discussion of the importance of detailed drawings to communicate technological ideas. See Student resource 4.3.3 "Drawing Comparison and 4.3.1"Communicating Dimensions". This example is designed to get students to think about the importance of dimensions in models. Students look at two drawings of an object. One drawing gives the dimensions, while the other does not.

### ENRICH

1. Option #1 Students research or practice making technical drawings or sketches. (Student Resource 4.3.2 "Real World Technical Drawings and Sketches")
2. Option #2 After talking about the importance of dimensions and models, students conduct research (guided by media specialists) to find pictures of prototypes that didn't work. Students will research why the prototypes were not successful. www.news-world.us/pics/2010/04/05/some-failed-inventions-of-the-past/
3. Option #3: Students design a presentation to explain the importance of prototypes and simulations in the engineering design process.

### EVALUATE

1. The student's knowledge, skills, and attitudes are assessed using rubrics for class participation and oral presentation.

## LAB/CLASSROOM PREPARATIONS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- Pencils
- Plain paper and graph paper
- Computer with Internet access
- CAD or parametric modeling software (optional)
- Poster board and markers (optional)

- 2-3 K'nex sets or similar materials
- Engineering Design Journal
- Ruler/ Protractor or Circle Tool/ Curve Sets

**Classroom Safety and Conduct**
Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson:

## RESOURCE MATERIALS

The following resource materials support this lesson

| **Student files** | **Filename** |
|---|---|
| Communicating Dimensions | File 4.3.1.docx |
| Real-World Technical Drawings | File 4.3.2.docx |
| Drawing Comparison | File 4.3.3.docx |

# Snapshot

## ENDURING UNDERSTANDINGS

- To familiarize students of the ways systems interact with each other.
- To promote understanding that products, systems and environments are not always developed for one specific setting.
- To create awareness that whether a technology has desirable or undesirable consequences depends on how it is used.
- To create awareness that developing and using technology can raise ethical issues.
- To gain understanding that developing and using technology can be influenced by the economy, by politics, and by culture.

## BIG IDEA

While technology has allowed humans to prosper, negative impacts have also resulted.

**Teacher's Note**

*Big ideas should be made explicit to students by writing them on the board, reading them aloud, and/or posting them on worksheets associated with the lessons. For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words if they choose.*

## PURPOSE OF THE KSB

- To familiarize students of the ways systems interact with each other.
- To promote understanding that products, systems and environments are not always developed for one specific setting.
- To create awareness that whether a technology has desirable or undesirable consequences depends on how it is used.
- To create awareness that developing and using technology can raise ethical issues.
- To gain understanding that developing and using technology can be influenced by the economy, by politics, and by culture.

## INSTRUCTIONAL TIME

KSB 5 requires 2 weeks of instructional time based on one hour per day. Each of the four activities in KSB 5 in the Invention and Innovation course require the following number of hours to cover the content:

| REQUIRED UNIT HOURS | ENRICHMENT HOURS | TOTAL KSB HOURS | TOTAL KSB WEEKS |
|---|---|---|---|
| 6 Hours | 2 Hours | 8 Hours | 2 Weeks |

## STANDARDS AND BENCHMARKS THAT ARE ADDRESSED

This unit is based on three sets of Standards:

1. Standards for Technological Literacy (STL)

2. Next Generation Science Standards (NGSS)
3. Common Core State Standards (CCSS)

| | |
|---|---|
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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. |
| **H** | Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***MATHEMATICS:*** **Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |

| | |
|---|---|
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## KSB OBJECTIVES:

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 1:** A Clean Solution to a Messy Problem (4 Hours) | While technology has allowed humans to prosper, negative impacts have also resulted. | • Describe a technology that is used to repair damage caused by natural disasters.<br>• Describe a technology that is used to break down waste from the use of a product or system.<br>• Identify examples of decisions to develop and use technology that puts environmental and economic concerns in direct competition with one another.<br>• Support an environmental or economic concern resulting from the development and use of technology that places them in direct competition with one another.<br>• Identify recent innovations to products or systems that have led to changes in society.<br>• Describe inventions or innovations that changed society and created new needs and wants.<br>• Select a technological device and analyze the social and cultural priorities and values reflected by that device.<br>• Examine societal expectations that have boosted the acceptance and use of a product or system. |
| **Activity 2**: Getting from There to Here (4 Hours) | Many of the inventions and innovations we enjoy today have taken centuries to develop into their modern form. | • Examine the slow, methodical processes of tests and refinements as they relate to the evolution of transportation inventions and innovations.<br>• Design a technological improvement for a device that has a highly specialized function.<br>• Identify a transportation invention or innovation that was developed without the knowledge of science.<br>• Examine collected data to analyze and interpret trends in order to identify positive and negative effects of a technology.<br>• Describe government regulations that influence the design and operations of transportation systems. |
| | | |
| **Total for This KSB= 6 Hours plus 2 hours Enrichment** | | |

## ASSESSMENT TOOLS

There are no KSB-level assessments. Activities are assessed using:

- Selected Response Items
- Brief Constructed Response Item
- Performance Rubrics

Specific tools are incorporated into each lesson as Supporting Files.

# Activity 1: A Clean Solution To a Messy Problem

## ENDURING UNDERSTANDINGS

- To promote understanding that products, systems and environments are not always developed for one specific setting.
- To create awareness that whether a technology has desirable or undesirable consequences depends on how it is used..

## BIG IDEA

While technology has allowed humans to prosper, negative impacts have also resulted.

## PURPOSE

Students will learn that decisions about the use of technology can put environmental, economic, political, and societal concerns in conflict with each other.

## HIGHLIGHTS

### ENGAGE

Teacher engages students by describing details pertaining to the day of the BP oil spill. Students examine an article that illustrates the oil prevalence after the explosion and during the recovery period.

### EXPLORE

Students reflect on the BP oil spill events and compare the effects to the Exxon Valdez oil spill, then create a chart or graph identifying the similarites and differences.

### EXPLAIN

Students identify pros and cons of using technologies, then develop a concept map and complete a BCR.

### eNGINEER

Students use the Engineering Design Process, student teams 'create' an oil spill and design and test a solution to clean it up.

### ENRICH

Student teams design and test a solution for cleaning birds caught up in an oil spill.

### EVALUATE

The students' knowledge, skills, and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs, and classroom presentations.

## LESSON DURATION: 4 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| **H** | Technology is closely linked to creativity, which has resulted in innovation. |
| ***STL 2*** | **Understanding the core concepts of technology.** |
| **Q** | Malfunctions of any part of a system affect the function and quality of the system. |
| **R** | Requirements are the parameters placed on the development of a product or system. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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 |
| **H** | to improve it.<br>Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. |

| | |
|---|---|
| | c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## LEARNING OBJECTIVES

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 1:** A Clean Solution to a Messy Problem (4 Hours) | While technology has allowed humans to prosper, negative impacts have also resulted. | • Describe a technology that is used to repair damage caused by natural disasters.<br>• Describe a technology that is used to break down waste from the use of a product or system.<br>• Identify examples of decisions to develop and use technology that puts environmental and economic concerns in direct competition with one another.<br>• Support an environmental or economic concern resulting from the development and use of technology that places them in direct competition with one another.<br>• Identify recent innovations to products or systems that have led to changes in society.<br>• Describe inventions or innovations that changed society and created new needs and wants.<br>• Select a technological device and analyze the social and cultural priorities and values reflected by that device.<br>• Examine societal expectations that have boosted the acceptance and use of a product or system. |

# RESOURCES

### Audiovisual Materials


Huffingtonpost.com. (n.d.) BP Oil Spill Live Feed: VIDEO Of Gulf Coast Gusher http://www.huffingtonpost.com/2010/05/26/bp-oil-spill-live-feed-vi_n_590635.html

Lehner, Peter. (2011). National Resources Defense Council. New Wave in Oil Cleanup Technology Spurred by Competition. Retrieved from http://switchboard.nrdc.org/blogs/plehner/new_wave_in_oil_cleanup_techno.html


### Print Materials


Fingas, Mervin. (2010). Oil Spill Science and Technology. Kidlington, Oxeford, UK: Gulf Professional Publishing.

Stahl, Robert J. (1995). Society and Science - Decision-Making Episodes for Exploring Society, Science and Technology. Reading, MA: Addison Wesley Publishing Company.

Steffy, Loren C. (2011). Drowning in Oil: BP & the Reckless Pursuit of Profit. Columbus, OH: McGraw-Hill Publishing Co.


### Internet Sites


1. Internet Search Items: Oil spills, oil spill cleanup, oil spill responsibility, environmental disasters, technology consequences, societal demands and oil spills, oil spill clean up technology, Gulf Oil spill, Exxon Valdez oil spill
2. Fountain, Henry. (2010). Advances in Oil Spill Cleanup Lag Since Valdez. Retrieved from http://www.nytimes.com/2010/06/25/us/25clean.html
3. National Environmental Education Foundation. Oil Spill Curricula. Retrieved from http://www.eeweek.org/resources/oil_spill_curricula
4. Office of Response and Restoration. (2012). NOAA's Ocean Service.USA.gov. Retrieved from http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/oil-and-hazardous-materials-response-reports.html
5. Office of Response and Restoration. (2012). NOAA's Ocean Service.USA.gov. Retrieved from http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/oil-and-hazardous-materials-response-reports.html
6. Repanich, Jeremy. (2010). The Deepwater Horizon Spill by the Numbers. Retrieved from http://www.popularmechanics.com/science/energy/coal-oil-gas/bp-oil-spill-statistics
7. Water Encyclopedias; Science Issues. (n.d.). Oil Spills: Impact on the Ocean. Retrieved from http://www.waterencyclopedia.com/Oc-Po/Oil-Spills-Impact-on-the-Ocean.html


# KNOWLEDGE & SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

## ENGAGE

1. The teacher introduces the topic of oil spill use the following examples:
    a. On April 20, 2010, the Deepwater Horizon oil rig, owned by Transocean and leased by BP, exploded, caught fire and sank 2 days later into the Gulf of Mexico. Eleven workers were killed. The rig was drilling more than 5000 ft. below the water's surface.
    b. BP representatives originally estimated that it would take two to four weeks to control, however, the well was not capped until nearly five months later

through combined efforts of government, industry officials, and private citizens.

2. Students examine an article that explains the oil's prevalence after the initial explosion and during the recovery period. This can be shown by an overheard or distributing the handout (Student Resource 5.1.1 "Where Did the Oil Go?").

**Teacher's Note:**
*Depending on the time you have you could make this a quick warm up activity and then move on to the next step. As you read through the lessons you may have to make some adjustments so that they may flow with your schedule more effectively.*

## EXPLORE

1. Students discuss the highlights of the article focusing on the following questions:
    a. Why was BP drilling offshore?
    b. What was the cause of the spill?
    c. What were some of the consequences of the spill on the environment, society, economy?
    d. Will the effects of the spill be short or long term?
    e. How do we cleanup oil spills?
    f. Should we drill offshore again?
2. Teacher passes out Student Resource 5.1.2, "Comparing Spills". Class examines the similarities and differences between different oil spills.
3. Student groups work together to create a graph (pie chart, line graph, or other) that demonstrates the similarities and/or differences between the spills (Student Resource 5.1.3 "Chart that Spill"). This may done via poster or PowerPoint slides. Groups will present their findings. Activity is assessed by Poster or PowerPoint rubric..Student groups research the topic- Should the US allow more drilling for oil in coastal waters?
4. Working in groups, students complete the Pro's and Con's handout (Student Resource 5.1.4 "Pros and Cons").

**Teacher's Note:**
*Here you may assign 1 or 2 core concepts to a group, and allow them to become an "expert" on them. They can then teach those concepts to the class. You may relate this to environmental needs or issues in your area or region.*

## EXPLAIN

1. The students share their Pro's and Con's work from the Engagement Activity with the class and respond to any questions.
2. The teacher explains that the technology needed to develop the processes and procedures for further offshore drilling will impact the environment, economy, politics, and society. The teacher continues, saying that decisions to develop technology can put environmental and economic concerns in direct competition with one another.
    a. For example, offshore drilling means greater availability of domestic oil which will result in lower gas prices for American consumers, but the environmental consequences of a disaster can mean long term devastation.
3. Social and cultural priorities and values are reflected in technological devices.

    a. For example, almost immediately, it was apparent that traditional procedures for cleaning oil spills were not effective. A new remedy was needed to stop the gushing. This realization prompted scientists, engineers, and inventors to develop new technologies for oil cleanup.
4. When undesirable consequences occur with the development of a technology, it can lead to changes in the way technologies are developed
    a. For example, tougher safety regulations have been implemented because of the BP oil spill.
5. Sometimes, societal expectations drive the acceptance and use of new products and systems.
    a. For example, the US wants to reduce its dependency on foreign oil suppliers. One way that can happen is if the US has its own oil supply, and that can only be done through drilling. With drilling comes new drilling procedures, new equipment, etc.
6. Both natural disasters and human-made disasters can be repaired and/or cleaned up by technology.
7. Teacher distributes Student Resource 5.1.5 "What are Concept Maps" and reviews directions for designing a concept map. Using Oil Spills as the theme, students list concepts related to technology, society, decisions to use technologies, etc. and design a concept map. Student Resource 5.1.6 "Map Up That Spill"
8. Students reflect on their new understanding of oil spills, development and uses of technologies, effects on the environment, and societal priorities and values by writing a 3 paragraph report on the topic- Should the United States allow more drilling for oil in offshore coastal waters? Student Resource 5.1.7 "Brief Constructed Response"

Teacher's Note

*The activities in this part of the lesson may be spread out or even done for homework if need be. As you introduce these topics it may take some students longer to complete than others. The Brief Constructed Response can be used as a filler if need be.*

## ENGINEER

1. Student groups use the Engineering Design Process to design and develop a product or system to clean oil from water.
2. The teacher begins a discussion of cleanup measures for oil spills. Teacher explains that the BP oil spill was so massive that traditional methods could not clean up the oil fast enough. New methods were needed so a contest was put in place for new technologies that would be more effective, cleaning a certain amount of water in a certain amount of time.
3. Teacher shows a PowerPoint that illustrates traditional cleanup technologies used in oil spill sand includes the top winners' designs for new cleanup technologies.
4. Teacher explains students will design and develop their own method for cleaning up oil using the design brief, Student Resource 5.1.8 "Oil's Well that Ends Well."

## ENRICH

1. Students take oil cleanup a step further. In the previous activity, students devised a way to clean oil from water. But with along with the oil spill, millions and birds and

animals were affected as well. Students research effects of oil spills on animals and ways that birds and animals are cleaned. Students devise their own method of cleaning birds.

a. Teams create another oil spill, using same materials in previous activity.
b. Each team receives several feathers to simulate birds caught up in the oil spill.
c. Teams devise a way to clean the bird (feathers), in a safe manner to bird and human.

### EVALUATE

1. The student's knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LAB/CLASSROOM PREPARATIONS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

### Tools/Materials/Equipment

- Pencils
- Plain paper and graph paper
- Computer with Internet access
- CAD or parametric modeling software (optional)
- Poster board and markers (optional)
- one clear glass baking dish, per team (approx. 8"x8")
- water
- blue food coloring
- 12 tbsp. vegetable oil
- 8 tbsp. pure cocoa powder
- 1 tsp. table salt
- spoons
- 1 squirt of liquid dishwashing detergent, per team
- 5 popsicle sticks
- 2 foot lengths of heavy string and/or thin rope, per team
- a coffee mug
- variety of sorbents (paper towel, cotton balls, rag, string, nylon pot scrubber, sponge, styrofoam cup, garden peat moss)
- tweezers or tongs
- eye droppers
- watch or clock
- materials from home (optional)
- sand or dirt (optional)

### Classroom Safety and Conduct

Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson

| **Student Files** | **Filename** |
|---|---|
| Where Did the Oil Go? | 5.1.1.docx |
| Comparing Spills | 5.1.2.docx |
| Chart That Spill | 5.1.3.docx |
| Pros and Cons | 5.1.4.docx |
| What are Concept Maps | 5.1.5.docx |
| Map Up That Spill | 5.1.6.docx |
| Brief Constructed Response | 5.1.7.docx |
| Oil's Well that Ends Well (DB) | 5.1.8.docx |

# Activity 2: Getting From There to Here

## ENDURING UNDERSTANDINGS

- To create awareness that developing and using technology can raise ethical issues.
- To gain understanding that developing and using technology can be influenced by the economy, by politics, and by culture.

## BIG IDEA

Many of the inventions and innovations we enjoy today have taken centuries to develop into their modern form.

## PURPOSE

This lesson enables students to learn that inventions and innovations lead to new technology, and technology influences innovations and inventions.

## HIGHLIGHTS

### ENGAGE

The teacher engages students in a discussion about rising oil prices and the global demand.

### EXPLORE

Think, pair, share. Students are asked their opinion of the most efficient ways for the US to lower the demand of oil products. The student research forms of transportation that use alternative sources of power to drive the engine and then create a poster.

### EXPLAIN

Student discussion of how inventions and innovations evolve over time, with use and testing, sometimes focusing on a specific function, and sometimes without the knowledge of science. Students create transportation timeline and analyze trends.

### ENGINEER

Students use their understanding of the evolution of inventions and innovations to develop a design proposal of a futuristic transportation system (car) that meets the need of the present society looking for ways to reduce the demand for oil.

### ENRICH

Students develop a model of their futuristic alternative transportation system using their design proposal information.

### EVALUATE

The students' knowledge, skills, and attitudes are assessed using brief constructed response items, and performance rubrics for class participation, discussion and design briefs, and classroom presentations.

## LESSON DURATION: 4 Hours

## STANDARDS AND BENCHMARKS ADDRESSED

This unit is based on three sets of Standards:

1. *Standards for Technological Literacy (STL)*
2. *Next Generation Science Standards (NGSS)*
3. *Common Core State Standards (CCSS)*

| ***TECHNOLOGY*: Standards for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*** | |
|---|---|
| | |
| ***STL 1*** | **Students will develop an understanding of the characteristics and scope of technology.** |
| **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. |
| **G** | The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. |
| **H** | Technology is closely linked to creativity, which has resulted in innovation. |
| ***STL 2*** | **Understanding the core concepts of technology.** |
| **Q** | Malfunctions of any part of a system affect the function and quality of the system. |
| **R** | Requirements are the parameters placed on the development of a product or system. |
| ***STL 8*** | **Understanding the Attributes of Design** |
| **E** | Design is a creative planning process that leads to useful products and systems. |
| **F** | There is no perfect design. |
| **G** | Requirements for a design are made up of criteria and constraints. |
| ***STL 10*** | **Understanding the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **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 |
| **H** | to improve it.<br>Some technological problems are best solved through experimentation. |
| ***STL 11*** | **Students will develop the abilities to apply the design process.** |
| **I** | Specify criteria and constraints for a design. |

| ***SCIENCE:* Next Generation Science Standards (NGSS, *2013*)** | |
|---|---|
| | **MS-ETS1-1 Engineering Design** |
| | Students who demonstrate understanding can: |
| **1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| **2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| **3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can combined into a new |

| | |
|---|---|
| | solution to better meet the criteria for success. |
| **4** | Develop a model to generate data for iterative testing a modification of a proposed object, tool, or process such that an optimal design can be achieved. |

| ***MATHEMATICS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **6.RP.1** | Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." |
| **6.RP.2** | Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. |
| **7.N.S** | Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations |
| **7.NS.1** | The Number System |
| **7.NS.2** | Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. |
| **7.NS.3** | Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. |
| **8.G.5** | Solve real-world and mathematical problems involving the four operations with rational numbers. |
| **8.G.6** | Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so. |
| **8.G.7** | Explain a proof of the Pythagorean Theorem and its converse. |
| **8.G.8** | Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **8.G.9** | Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. |
| **8.SP** | Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems. |

| ***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, *2012*)** | |
|---|---|
| **1** | a. Write arguments focused on discipline-specific content.<br>b. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.<br>c. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.<br>d. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.<br>e. Establish and maintain a formal style.<br>f. Provide a concluding statement or section that follows from and supports the argument presented. |
| **2** | a. Write informative/explanatory texts, including the narration of historical events, |

| | |
|---|---|
| | scientific procedures/experiments, or technical processes.<br>b. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.<br>c. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.<br>d. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.<br>e. Use precise language and domain-specific vocabulary to inform about or explain the topic. Establish and maintain a formal style and objective tone.<br>f. Provide a concluding statement or section that follows from and supports the information or explanation presented. |
| **4** | • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| **5** | • With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. |
| **6** | • Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. |
| **10** | • Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. |

## LEARNING OBJECTIVES

| Activity | BIG IDEA | OBJECTIVES |
|---|---|---|
| **Activity 2**: Getting from There to Here (4 Hours) | Many of the inventions and innovations we enjoy today have taken centuries to develop into their modern form. | • Examine the slow, methodical processes of tests and refinements as they relate to the evolution of transportation inventions and innovations.<br>• Design a technological improvement for a device that has a highly specialized function.<br>• Identify a transportation invention or innovation that was developed without the knowledge of science.<br>• Examine collected data to analyze and interpret trends in order to identify positive and negative effects of a technology.<br>• Describe government regulations that influence the design and operations of transportation systems. |

## RESOURCES

Audiovisual Materials

Future Car: Radical 2030 Car Designs. Retrieved from http://videos.howstuffworks.com/discovery/32245-future-car-radical-2030-car-designs-video.htm

How Stuff Works, (N.D.) Navigate Los Angelos Without a Car. Retrieved from http://videos.howstuffworks.com/science/alternative-transportation-videos-playlist.htm#video-37297

**Print Materials**

Gallman, Philip G. (2011). Green Alternatives and National Energy Strategy: The Facts behind the Headlines. Baltimore, MD: The Johns Hopkins University Press

Sparrow, Jack. (2003). Alternative Transportation Fuels: Issues and Developments. Hauppauge, NY: Nova Science Pub Inc.

Sperling, Daniel and Cannon, James S. (2008). Reducing Climate Impacts in the Transportation Sector. New York, NY: Springer

Woodford, Chris, & Woodcock, Jon. (2007). Cool Stuff and How It Works. New York, NY: DK Publishing, Inc.

**Internet Sites**

1. Internet Search Items: alternative transportation, alternative fuels, analyzing trends in transportation, car design, concept cars, futuristic cars electric cars, hybrid cars, reduce oil consumption
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7. Design Your Way. (N.D.) Beautiful 3D Concept Cars. Retrieved from http://www.designyourway.net/blog/3d/beautiful-3d-concept-cars/
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## KNOWLEDGE & SKILL BUILDING (KSB) / LEARNING PROGRESSIONS

### ENGAGE

1. The teacher engages students in a discussion about rising oil prices and the global demand. The rising price of oil and the growing global demand have driven energy companies to expand oil drilling in riskier locations, such as the deep waters of the Gulf of Mexico and off the coast of Alaska. But the recent BP oil spill has raised questions about future drilling and prompted calls to reduce the oil demand. Some experts say that the US could drastically reduce oil consumption by:
    a. Ending heating oil use
    b. Shifting to hybrid and/or 'plug-in' vehicles,
    c. Developing more high-speed rail transportation, which would mean building more infrastructure
    d. Greater use of biofuels in vehicles
    e. Taxing all oil products which in turn would cause people to use less oil products.

**Teacher's Note:**
*Depending on the time you have you could make this a quick warm up activity and then move on to the next step. As you read through the lessons you may have to make some adjustments so that they may flow with your schedule more effectively.*

### EXPLORE

1. Students participate in think, pair, share to develop ideas aboutthe most efficient ways for the US to lower the demand of oil products. Then share their ideas with the class.
2. Teacher writes the students' solutions on the board. Students will likely identify electric vehicles, vehicles that use fuels that are not oil-based, or vehicles that may not have an engine at all, such as Maglev.
3. Students are challenged to explore alternative transportation further.
4. Students- grouped in 2-5, research forms of transportation that use alternative sources of power to drive the engine. Students choose a particular transportation method and design a poster. Students are encouraged to research transportation systems that are both in development currently and futuristic (Student Resource 5.2.1 "Exploring Future Rides- Design Brief").

**Teacher's Note:**
*Group sizes can vary at the discretion of the teacher*

### EXPLAIN

1. Students share and present their posters to the class.
2. Teacher begins a discussion of students' alternative car discoveries. No doubt, there will be some students who have chosen hybrid vehicles or electric vehicles. Teacher focuses on the area of student research regarding 'when' the idea was developed, 'how long ago', 'has the idea changed from the original idea' and 'how, what tests and changes are currently in development'?
3. Teacher explains that inventions and innovations evolve through slow and methodical processes of test and refinements. For example, when Thomas Edison developed the incandescent light bulb, he and a team of skilled workers performed more than 1000 tests before they came upon an idea that worked. Since that first

light bulb in 1879 that burned for 13 hours, there have been numerous innovations and design changes that are called refinements to the original design.

4. Teacher relates another example, the first submarine. Leonardo da Vinci made sketches of a submarine in the late 1400's. Not until 1620, a Dutch doctor living in England, wanted to explore the 'underwater'. He covered a rowboat with greased leather and powered it by oars protruding through leather seats. Snorkel air tubes were held above the surface by floats; this permitted the craft to stay submerged for several hours 12 to 15 feet below the surface of the Thames River. The submarine would see a multitude of refinements throughout the centuries to the present.
5. Teacher explains that specialization of function is at the heart of many technological improvements. For example, Thomas Edison had a dream of a practical long-burning electric light that could light up entire cities. It was Edison's determination to develop an effective, and affordable electric lamp; his focus was the function of the light bulb (specialization of function).
6. Teacher continues with explaining that inventions and innovations weren't always developed with the knowledge of science. For example, innovations of the submarine were not at the hands of scientists but ordinary people with a vision to explore under the water. The submarine did not gain popularity until wartime when possibilities of the submarine as a weapon.
7. Students complete a Brief Constructed Response Assessment (Student Resource 3.2 BCR).
8. Teacher concludes the Explanation phase by explaining how trends can influence technology. Teacher passes out a handout of a Transportation Timeline (examples can be found in the Suggested Sites area of this document). Class reviews Student Resource 5.2.3 "Analyzing Trends in Transportation". Students work in groups to analyze and interpret transportation trends.

**Teacher's Note:**
*The activities in this part of the lesson may be spread out or even done for homework if need be. As you introduce these topics it may take some students longer to complete than others.*

### eNGINEER

1. Teacher explains that it is expected that by 2050, there will be triple the numbers of cars on the road. To meet the growing demand for transportation while limiting oil consumption, alternatives to traditional fuels and design techniques will be needed. These will be influenced by government policies, advances in technology, cost and environmental concerns. A major problem in developing cleaner, energy efficient automobiles is the source of power to drive the engine. Innovative ways to provide solutions to help move the increasing number of people and goods will need to be developed.
2. Student groups, using background information from 'Exploring Future Rides'- Poster Activity, are tasked with creating a design proposal of a cutting edge alternative transportation (Student Resources 5.2.4" Future Car Proposal, Design Brief").

**Teacher's Note:**

For this challenge, it is suggested that the teacher show students pictures of futuristic cars and examine sites that explain how to create a design proposal. Reference are located in the Suggested Sites area of this document.

### ENRICH

1. The student teams will present their proposal to the Company's CEO.

### EVALUATE

1. The student's knowledge, skills and attitudes are assessed using brief constructed response items and performance rubrics for class participation, discussion, and design briefs.

## LAB/CLASSROOM PREPARATIONS

The classroom should provide a flexible, resource-rich learning environment that includes areas for lecture and demonstrations, small-group meetings, design processes, research activities, production and fabrication, product/prototype testing, and analysis. The teacher will adapt the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lecture and demonstration, design, small-group meetings, and fabrication activities should be readied.

**Tools/Materials/Equipment**

- Pencils
- Plain paper and graph paper
- Computer with Internet access
- CAD or parametric modeling software (optional)
- Poster board and markers (optional)
- Card Stock
- Glue
- Colored Pencils
- Ruler
- Scissors

**Classroom Safety and Conduct**

Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

## RESOURCE MATERIALS

The following resource materials support this lesson

| **Student Files** | **Filename** |
|---|---|

| | |
|---|---|
| Exploring Future Rides | File 5.2.1.docx |
| Brief Constructed Response | File 5.2.2.docx |
| Analyzing Trends in Transportation | File 5.2.3.docx |
| Future Car Proposal (DB) | File 5.2.4.docx |