TURNING IDEAS INTO REALITY: ENGINEERING A BETTER WORLD

Assistive Device

Targeted Grades
6, 7, 8

STEM Careers
Mechanical Engineering
Health Science
Human Services

STEM Disciplines
Science
Technology
Engineering

Non-STEM Discipline
English Language Arts

Academic Content Standards

Ohio's New Learning Standards: Science Cognitive Demands
Expectations for Learning Cognitive Demands K-12 **Designing Technological / Engineering Solutions Using Science Concepts:** Requires student to solve science-based engineering or technological problems through application of scientific inquiry. Within given scientific constraints, propose or critique solutions, analyze and interpret technological and engineering problems, use science principles to anticipate effects of technological or engineering design, find solutions using science and engineering or technology, consider consequences and alternatives, and/or integrate and synthesize scientific information. **Demonstrating Science Knowledge:** Requires student to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather and organize data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. **Interpreting and Communication Science Concepts:** Requires student to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

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Expectations for Technology and Engineering Design: Guiding Principles Grades PreK-8

Technological Design:

Technological design is a problem or project-based way of applying creativity, science, engineering and mathematics to meet a human need or want. Modern science is an integrated endeavor. Technological design integrates learning by using science, technology, engineering and mathematics and fosters 21st Century Skills.

Technology and Engineering:

Technology modifies the natural world through innovative processes, systems, structures and devices to extend human abilities. Engineering is design under constraint that develops and applies technology to satisfy human needs and wants. Technology and engineering, coupled with the knowledge and methods derived from science and mathematics, profoundly influence the quality of life.

Examples of grades 5-8 appropriate skills expected of students:

- Understand and be able to select and use physical and informational technologies
- Understand how all technologies have changed over time
- Recognize role of design and testing in the design process
- Apply research, innovation and invention to problem solving

Ohio's New Learning Standards: Science Guiding Principles Grades 5-8

There is no science without inquiry. Scientific inquiry is a way of knowing and a process of doing science. It is the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world.
Teachers need to model scientific inquiry by teaching with inquiry.

Theme: Order and Organization

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be described by simple principles. These principles are related to the properties or interactions within and between systems.

During the years of grades 5-8, all students must use the following scientific processes, with appropriate laboratory safety techniques, to construct their knowledge and understanding in all science content areas:

- Identify questions that can be answered through scientific investigations;
- Design and conduct a scientific investigation;
- Use appropriate mathematics, tools and techniques to gather data and information;
- Analyze and interpret data;
- Develop descriptions, models, explanations and predictions;
- Think critically and logically to connect evidence and explanations;
- Recognize and analyze alternative explanations and predictions; and
- Communicate scientific procedures and explanations.

Ohio's New Learning Standards: Physical Science Grades 6-8

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Grade 6: Matter and Motion

Content Statement:

There are two categories of energy: kinetic and potential.

Objects and substances in motion have kinetic energy.
Objects and substances can have energy as a result of their position (potential energy).

Content Elaboration:

There are many forms of energy, but all can be put into two categories: kinetic and potential. Kinetic energy is associated with the motion of an object. The kinetic energy of an object changes when its speed changes. Potential energy is the energy of position between two interacting objects. Gravitational potential energy is associated with the height of an object above a reference position. The gravitational potential energy of an object changes as its height above the reference changes.
Note: Using the word "stored" to define potential energy is misleading. The word "stored" implies that the energy is kept by the object and not given away to another object. Therefore, kinetic energy also can be classified as "stored" energy. A rocket moving at constant speed through empty space has kinetic energy and is not transferring any of this energy to another object.

Grade 7: Conservation of Mass and Energy

Content Statement:

Energy can be transferred through a variety of ways.

Mechanical energy can be transferred when objects push or pull on each other over a distance.

Content Elaboration:

Mechanical energy is transferred when a force acts between objects that move one of the objects some distance with or against the force. The amount of energy transferred increases as the strength of the force and/or the distance covered by object increases. This energy transfer (work) stops when the objects no longer exert forces on each other.

Grade 8: Conservation of Mass and Energy

Content Statement:

Energy can be transferred through a variety of ways.

Mechanical energy can be transferred when objects push or pull on each other over a distance.

Content Elaboration:

Mechanical energy is transferred when a force acts between objects that move one of the objects some distance with or against the force. The amount of energy transferred increases as the strength of the force and/or the distance covered by object increases. This energy transfer (work) stops when the objects no longer exert forces on each other.

Content Statement:

There are different types of potential energy.

Gravitational potential energy changes in a system as the masses or relative positions of objects are changed. Objects can have elastic potential energy due to their compression or chemical potential energy due to the nature and arrangement of the atoms that make up the object.

Content Elaboration:

Gravitational potential energy is associated with the mass of an object and its height above a reference point (e.g., above ground level, above floor level). A change in the height of an object is evidence that the gravitational potential energy has changed.

Elastic potential energy is associated with how much an elastic object has been stretched or compressed and how difficult such a compression or stretch is. A change in the amount of compression or stretch of an elastic object is evidence that the elastic potential energy has changed.

The different types of potential energy must be explored through experimentation and investigation that include the relationship of energy transfer and springs, magnets or static electricity.

Ohio's New Learning Standards: English Language Arts
College and Career Readiness: Anchor Standards for Grades 6-12

Speaking and Listening

Comprehension and Collaboration:

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- Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
- Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
- Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.

Presentation of Knowledge and Ideas:

- Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

Language

Vocabulary Acquisition and Use:

- Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Learning Experience Overview

Essential Question

How can we design and engineer an assistive device that helps someone with limited hand and wrist muscle control put on socks?

Enduring Understandings

- The engineering design process is a valuable tool to use when solving science, engineering, and technological problems through inquiry.
- All objects have gravitational potential energy. When an object is released its gravitational potential energy is converted to mechanical kinetic energy as it falls to the ground.
- Flexible objects have elastic potential energy when they are stretched. When the object being stretched is released, its elastic potential energy is transformed into mechanical kinetic energy.

Design Challenge Problem/Scenario

You have a friend with limited hand and wrist muscle control, making the simple daily task of putting on socks difficult. You know there has to be a way to help your friend solve this problem. You begin thinking about and researching the process of putting on a sock, and write the following notes.

- To complete any task, muscles must have potential (waiting) energy that is transformed (changed) into kinetic (moving) energy.
- When putting a sock on, muscles pick up and lift the sock, giving it **gravitational potential energy waiting to transform into kinetic energy** and fall to the ground.
- When putting a sock on, muscles stretch the sock, giving it **elastic potential energy waiting to transform into kinetic energy** and move close to the body.

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- The problem must be that your friend's muscles do not have enough strength to control the sock's gravitational potential energy and elastic potential energy.

Engineering Design Challenge

Pulling on a sock is difficult for people with limited hand and wrist muscle control. It is a struggle for their muscles to overcome the sock's elastic potential energy when stretched, and its gravitational potential energy when lifted.

Now that you know the cause of the problem, you decide to take on the challenge of designing a solution! Your challenge is to use only the materials available to design and build a device prototype that can help people pull on their socks independently.

Prerequisite Knowledge & Skill (as connected to academic content standards)

- **Concepts Related to Energy in Grades PreK-2:** A variety of sounds and motions are experienced. The sun is the principle source of energy.
- **Concepts Related to Energy in Grades 3-5:** Objects with energy have the ability to cause change. Heat, electrical energy, light, sound and magnetic energy are forms of energy.

Activity Time Frame and Overview

Activity	Time	Overview
Introduction	*2 minutes*	Introduce Yourself Provide Brief Activity Overview to Foster Excitement
Pre-Assessment	*3 minutes*	Administer Kit's Pre-Activity Survey
Design Challenge Introduction	*10 minutes*	Begin PowerPoint Presentation: ● Guide Discussion ● View Video (2m 38s) ● Present Detailed Problem/Scenario & Challenge ● Introduce Available Materials ● Explain Engineering Design Process
Individual Brainstorm	*5 minutes*	Team Members Individually: ● Brainstorm Ideas ● Write or Sketch Ideas to Share with Team
Prototype Design and Construction	*20 minutes*	Teams Collaboratively: ● Discuss Individual ● Choose and Sketch Final Idea for Approval ● Construct their Team Prototype
Testing and Reflection	*10 minutes*	Perform and Observe Prototype Testing Prototype Design and Testing Results Reflection

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Conclusion	*2 minutes*	Wrap Up Discussion
Post-Assessment	*3 minutes*	Administer Kit's Post-Activity Survey

Material List

Material	Quantity per Team	✓	Quantity per Kit	✓
Paper Clips	2		70	
Rubber Bands	6		210	
Construction Paper	1 sheet		35 sheets	
String or Yarn	2 feet		70 feet	
Masking Tape	4 inches		10 feet	
Binder Clips	2		70	
Pipe Cleaners	4		140	
Safety Pins	3		105	
Plastic Forks	2		70	
Craft sticks	3		90	
Memory Stick *(With power point and handouts)*	~		1	
Pre-Activity Survey	1 copy *(per student)*		25 copies	
Post-Activity Survey	1 copy *(per student)*		25 copies	
Paper *(For brainstorming)*	6 sheets		50 sheets	

Instruction

Instructional Sequence

Note: The activity's PowerPoint presentation guides instruction and visually presents information to students. Therefore, the instructions include corresponding slide numbers.

1. Slide 1: As the pre-activity survey is distributed to students, introduce yourself and provide enough of an activity overview to gain students excitement.
2. Allow time for students to individually complete their pre-activity survey.
3. Divide group into teams of 3 or 4 students.
4. Slides 2 and 3: Discuss engineering and what engineers do.
5. Present the engineering design problem and challenge, following presentation:
   - Slide 4: Play video (2m38s).

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- Slide 5: Present the real-world engineering design problem (scenario).
- Slide 6: Introduce the Engineering Design Challenge.
- Slide 7: Share Engineering Design Goals.
- Slide 8: Introduce resources (materials) available to each team.
- Explain how teams will work.
- Slide 9: Explain prototype-testing procedures.

6. Slide 10: Introduce the Engineering Design Process. Explain that engineers use it as a tool to help them more effectively solve problems.
7. Slide 11: Explain how teams will use the engineering design process as they complete the challenge.
   - Brainstorm:
     - Each individual in a team must write or sketch one or two ideas.
     - Team must discuss each idea.
     - Team decides criteria most important to them while keeping constraints (limited time and materials, etc.) in mind.
   - Create Team Prototype:
     - Teams choose, sketch, and outline their prototype design idea.
     - Teams have idea approved by facilitator.
   - Gather Materials:
     - Teams receive their bag of materials (prepared in advance).
   - Create Chosen Design:
     - Team creates their approved prototype design plan.
   - Final Test:
     - Each team tests their prototype while other teams observe.
8. Slide 12: Facilitate a whole group reflection on final prototype design and testing results by asking questions such as the following.
   - What do you like best about your design?
   - What do you like least about your design?
   - What aspects of other team designs stood out to you, and/or gave you ideas for improving your own team's design?
   - What modifications would you make if we had time to complete the design challenge again?
   - How challenging was it to pull the sock onto the foot?
   - Do you think it would be more or less challenging to pull the sock onto your own foot?
9. Slide 13: Conclude by discussing the following questions as post-activity surveys are distributed.
   - What ideas do you have for engineering a better world?
   - How can you turn ideas into reality?
10. Allow time for students to complete their post-activity survey.

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STEM Career Connections

STEM Career Connection

- **Mechanical Engineering** – assistive devices are a compilation of simple machines, which are the foundation of mechanical engineering.
- **Health Science**
- **Human Services**

Background Information / Additional Resources

- Assistive Device Example: See pg. 137-137: NSF 2002 Engineering Senior Design Projects to Aid Persons with Disabilities: "THE SOCKMATE: AN ASSISTIVE DEVICE THAT HELPS PEOPLE PUT ON THEIR SOCKS" http://nsf-pad.bme.uconn.edu/2002/Buffalo.pdf

Assessments

- Pre-Activity Survey
- Post-Activity Survey

References

NSF 2002 engineering senior design projects to aid persons with disabilities. State university of New York at Buffalo. 2002. Retrieved from: http://nsf-pad.bme.uconn.edu/2002/Buffalo.pdf.

Ohio's new learning standards. *Ohio department of education*. 08 Aug 2014. Retrieved from: http://education.ohio.gov/Topics/Ohio-s-New-Learning-Standards/Ohios-New-Learning-Standards.

Appendix

"Engineering Design Challenge: Design an Assistive Device" student handout

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Appendix: Engineering Design Challenge: Design an Assistive Device

Design Problem

You have a friend with limited hand and wrist muscle control, making the simple daily task of putting on socks difficult. You know there has to be a way to help your friend solve this problem. You begin thinking about and researching the process of putting on a sock, and write the following notes.

Research Notes:

- To complete any task, muscles must have potential (waiting) energy that is transformed (changed) into kinetic (moving) energy.
- When putting a sock on, muscles pick up and lift the sock, giving it **gravitational potential energy waiting to transform into kinetic energy** and fall to the ground.
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Engineering Design Challenge

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Your challenge is to use only the materials available to design and build a device prototype that can help people pull on their socks independently.

Scientific Vocabulary

- Elastic Potential Energy – energy of materials in a state of being stretched or twisted
- Friction –the force that opposes the motion of two surfaces in contact with each other
- Gravity – the force that exists between objects due to their mass
- Kinetic Energy (KE) – energy that a moving object has because of its motion
- Potential Energy (PE) – the stored energy of an object due to its position or condition
- Transfer – to move from one place to another
- Transform – to change from one form into another

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