TURNING IDEAS INTO REALITY: ENGINEERING A BETTER WORLD

Filtration

Targeted Grades
4, 5, 6, 7

STEM Career Connections
Mechanical Engineering

STEM Disciplines
Science
Technology
Engineering

Non-STEM Discipline
English Language Arts
Social Studies
Geography

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 the grade-appropriate skills expected of students:

PreK-4:

- Identify problems and potential technological/engineering solutions
- Understand the design process, role of troubleshooting
- Understand goals of physical, informational and bio-related technologies
- Understand how physical technologies impact humans

Grades 5-8:

- 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 3-8

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.

Grades 3-5:

During the years of PreK-4, all students must become proficient in the use of the following scientific processes, with appropriate laboratory safety techniques, to construct their knowledge and understanding in all science content areas:

- Observe and ask questions about the natural environment;
- Plan and conduct simple investigations;
- Employ simple equipment and tools to gather data and extend the senses;
- Use appropriate mathematics with data to construct reasonable explanations;
- Communicate about observations, investigations and explanations; and
- Review and ask questions about the observations and explanations of others.

Theme: Interconnections within Systems

This theme focuses on helping students explore the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.

Grades 6-8:

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.

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.

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Ohio's New Learning Standards: Life Science Grade 4
Earth's Living History

Content Statement:

Changes in an organism's environment are sometimes beneficial to its survival and sometimes harmful.

Ecosystems can change gradually or dramatically. When the environment changes, some plants and animals survive and reproduce and others die or move to new locations. An animal's patterns of behavior are related to the environment. This includes the kinds and numbers of other organisms present, the availability of food and resources, and the physical attributes of the environment.

Content Elaboration:

Ecosystems are based on interrelationships among and between biotic and abiotic factors. Ecosystems can change rapidly (e.g., volcanoes, earthquakes, or fire) or very slowly (e.g., climate change). Major changes over a short period of time can have a significant impact on the ecosystem and the populations of plants and animals living there. The changes that occur in the plant and animal populations can impact access to resources for the remaining organisms, which may result in migration or death.

Ohio's New Learning Standards: Earth and Space Science Grade 7
Cycles and Patterns of Earth and the Moon

Content Statement:

The hydrologic cycle illustrates the changing states of water as it moves through the lithosphere, biosphere, hydrosphere and atmosphere.

Thermal energy is transferred as water changes state throughout the cycle. The cycling of water in the atmosphere is an important part of weather patterns on Earth. The rate at which water flows through soil and rock is dependent upon the porosity and permeability of the soil or rock.

Note: Contamination can occur within any step of the hydrologic cycle. Ground water is easily contaminated as pollution present in the soil or spilled on the ground surface moves into the ground water and impacts numerous water sources.

Content Elaboration:

The movement of water through the spheres of Earth is known as the hydrologic cycle. As water changes state and energy is transferred, it cycles from one sphere into another (e.g., water transfers from the hydrosphere to the atmosphere when evaporation occurs). Ground water and surface water quality are important components of the hydrologic cycle. The porosity and permeability of the rock and/or soil (grade 6) can affect the rate at which the water flows. The pattern of the cycling illustrates the relationship between water, energy and weather. The movement of water in the cycle also can move contamination through each of the spheres.

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

Speaking and Listening

Comprehension and Collaboration:

- 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.

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Ohio's New Learning Standards: Social Studies Grades 6
Theme: Regions and People of the Eastern Hemisphere In grade six, students study the Eastern Hemisphere (Africa, Asia, Australia and Europe), its geographic features, early history, cultural development and economic change. Students learn about the development of river civilizations in Africa and Asia, including their governments, cultures and economic systems. The geographic focus includes the study of contemporary regional characteristics, the movement of people, products and ideas, and cultural diversity. Students develop their understanding of the role of consumers and the interaction of markets, resources and competition. **Economic Strand** **Topic: Economic Decision Making and Skills:** The choices people make have both present and future consequences. **Topic: Production and Consumption:** The availability of productive resources and the division of labor impact productive capacity. **Topic: Financial Literacy:** Workers can improve their ability to earn income by gaining new knowledge, skills and experiences. **Geography Strand** **Topic: Places and Regions** Regions can be determined, classified and compared using various criteria (e.g., landform, climate, population, cultural, or economic). **Topic: Human Systems:** • Variations among physical environments within the Eastern Hemisphere influence human activities. Human activities also alter the physical environment. • Political, environmental, social and economic factors cause people, products and ideas to move from place to place in the Eastern Hemisphere in the past and today. • Modern cultural practices and products show the influence of tradition and diffusion, including the impact of major world religions (Buddhism, Christianity, Hinduism, Islam and Judaism).

Learning Experience Overview

Essential Question

How can my team design a filtration system that is able to provide clean water to people in an African village?

Enduring Understandings

- The use of collaboration and the engineering design process are both important when designing a product that can improve the quality of human lives.
- Throughout the hydrologic (water) cycle, contaminated water can move into an environment's water source, and harm to organisms that live in an ecosystem.

Design Challenge Problem/Scenario

In Africa, two out of five people do not have clean water. Because so much of Africa's water is contaminated, many people struggle to stay healthy, go to school/work, grow food, and build houses. The villagers do not have a lot of money or materials available to them, so it is a

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challenge for them find a low-cost, simple way to clean their water. Your team knows that a source for clean water would help solve these problems and improve the lives of thousands of people. So you decide to plan a trip to an African village and help.

Engineering Design Challenge

Before leaving for Africa, your team's challenge is to design, build, and test a filtration system that could be used for removing harmful pollutants/contaminants from water. It is important to conserve clean water, so beads and marbles will symbolize contaminated water while testing your designs.

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

- **Grades PreK-2 Concepts Related to Behavior, Growth and Changes:**
  Plants and animals have variations in their physical traits that enable them to survive in a particular environment. Living things that once lived on Earth no longer exist, as their needs were not met. Living things have basic needs, which are met by obtaining materials from the physical environment.
- **Grade 3 Concepts Related to Behavior, Growth and Changes:**
  Plants and animals have life cycles that are part of their adaptations for survival in their natural environments.

Activity Timeframe and Overview *(50 minutes)*

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 and Show Video (2m32s) ● Present the Engineering Design Challenge ● Explain the Engineering Design Process
Individual Brainstorm	*2 minutes*	Team Members Individually: ● Write Solution Ideas on Post-It Notes
Prototype Design and Construction	*15 minutes*	Teams Collaboratively: ● Discuss Individual Ideas ● Choose and Sketch Final Idea for Approval ● Gather Materials and Construct Team Prototype
Testing	*10 minutes*	Perform and Observe Prototype Testing
Conclusion	*5 minutes*	Relate to Engineering; They Did What Engineers Do Connect to Types of Engineering
Post-Assessment	*3 minutes*	Administer Kit's Post-Activity Survey

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Material List

Material	Quantity per Team	✓	Quantity per Kit	✓
Marbles	10		2 packs	
Beads	1		2 packs	
Toothpicks	10		2 packs	
Rubber bands	7		1 pack	
Plastic Cups	1		10	
String	1 yard		1 ball	
Memory Stick *(With power point and handouts)*	~		1	
Pre-Activity Survey	~		25 copies	
Post-Activity Survey	~		25 copies	
Cardstock	1 sheet		1 pack	
Post-it Notes **OR** Paper *(For individual brainstorming)*	15 Post-its **OR** 3 sheets paper		2 packs Post-its **OR** 25 sheets paper	
Paper *(For team design sketch)*	1 sheet		15 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 2 or 3 students each.
4. Slides 2 and 3: Discuss engineering and what engineers do.
5. Present the engineering design problem and challenge, following the presentation:
   - Slide 4: Show "Engineering Safer Drinking Water in Africa" video (2m32s).
   - Slide 5: Present the real-world engineering design problem (scenario).
   - Slide 6: Introduce the Engineering Design Challenge.
   - Slide 7: Discuss Engineering Design Goals.
   - Slide 8: Introduce resources (materials) available to each team.
   - Slide 9: Explain prototype-testing procedures.

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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:

   Imagine *(10 min.)*
   - INDIVIDUALLY: observe available materials, and brainstorm and write design ideas *(5 min.)*
   - TEAM: share individual ideas *(5 min.)*

   Plan *(5 min.)*
   - Choose and sketch a team design plan

   Create *(10 min.)*
   - Gather materials
   - Construct your team design plan

   Improve and Test *(10 min.)*
   - Teams decide on and make any last minute improvements before testing
   - 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 does having the ability to filter contaminants from polluted water benefit an environment's biotic factors (living things), including humans?
   - Why is it important to protect Earth's water?
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.

STEM Career Connections

STEM Career Connection

Mechanical Engineering – The branch of engineering that involves the design, production, and operation of machinery and tools. It is one of the oldest and broadest of the engineering disciplines

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Technical Brief

"With **3.575 million people** dying each year from water-related disease, our **current water crisis** is one of epic proportions. At any given time, half of the world's hospital beds are occupied by those suffering from illness brought on by limited access to **safe drinking water**, poor hygiene and sanitation. Granted these harrowing realities plaguing our society, it's imperative that designers, inventors, engineers and visionaries do what they can to find a solution." *(Paul, 2013)*

Assessments

- Pre-Activity Survey
- Post-Activity Survey

References

Engineering safer drinking water in Africa - Science Nation. 02 Feb 2012. Retrieved from https://www.youtube.com/watch?v=uHRTQNaNLac

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.

Paul, Rebecca. 08 Nov 2013. 6 water purifying devices for clean drinking water in the developing world. Retrieved from http://inhabitat.com/6-water-purifying-devices-for-clean-drinking-water-in-the-developing-world

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