Can you make an Ultra Violet (UV) Light Detector?

SLED
Science Learning through Engineering Design

Grade Level:	**Total Time Required:**
6th (loosely connected) 5th and 6th (The Design Process)	Three 50 minute class sessions OR Five 30 minute class sessions

Prepared By: Brenda Capobianco, Chell Nyquist, Nancy Tyrie, and Todd Kelley

Sources:

http://www.tryengineering.org/lesson_detail.php?lesson=4
http://solar-center.stanford.edu/teachers/
http://www.sciencebuddies.org/science-fair-projects/project_ideas/Chem_p088.shtml

Lesson Objectives:

Students will be able to:

1. Explain that the sun gives off energy that we can see (visible light) as well as energy that we cannot see (UV rays).
2. Observe the effects of UV rays.
3. Demonstrate the effectiveness of sunscreen in protecting people from harmful rays of the sun.
4. Observe the difference in protection among different SPF ratings.
5. Observe that sun gives off light and this light can cause a chemical reaction in UV beads.
6. Create a prototype of a sensor that can serve as an UV light detector using UV beads to meet the needs of a specific client or user.
7. Use the engineering design process to plan, construct, and test their prototype detectors.

Indiana Standards:

6-8.E.1 Identify the criteria and constraints of a design 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.

Next Generation Science Standards:

S-ETS1-1 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.

Concepts and Vocabulary

Term	***Defined by a scientist or engineer***	***Defined by a student***
Ultra violet light rays (UV light)	Electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays, in the range 10 nm to 400 nm, and energies from 3eV to 124 eV. It is named because the spectrum consists of electromagnetic waves with frequencies higher than those that humans identify as the color violet.	Light found in sunlight
SPF	Sun protection factor - indicating the effectiveness of protective skin preparations.	Sun protection or sunscreen
Chemical reaction	A process that leads to the transformation of one set of chemical substances to another.	Reactants interact with one another to make new products
Prototype	A first or preliminary model of something.	
Device (sensor)	A tool, instrument, or mechanism to measure or detect change.	A machine to do something.
Indirect light	Reflected or diffused light.	
Direct light	Light that travels in a straight path; no obstructions.	
Transparent	Having the property of transmitting rays of light through its substance so that bodies situated beyond or behind can be distinctly seen.	Can see through
Translucent	Permitting light to pass through but diffusing it so that persons, objects, etc., on the opposite side, are not clearly visible.	Can't see through
Opaque	Not allowing light to pass through; impenetrable to light.	Thick; not shiny or bright

Equipment, Materials, and Tools

Materials		
UV beads (see below)	Pipe cleaners	Samples of sun screens with varying SPF (15, 30, 40, and/or 70)
string	Aluminum foil	Paper towels
Duct tape	Plastic wrap	Ziploc snack size bags
Sunglasses (optional)	Face clothes (optional)	

Tools		
Scissors		

UV Beads source: (Educational Innovations Inc., www.teachersource.com)
http://www.teachersource.com/LightAndColor/Ultraviolet/UltravioletDetectingBeads.aspx?Utm_source=Google&utm_medium=CPC&utm_term=default&utm_campaign=UVBeads&utm_content=UVBeads&gclid=CIDmgf6i5agCFUiK4AodyzqKCA

Science Content - Basics

Information relevant to UV light:

The following information about the light spectrum is from the "Making an Ultra Violet (UV) Light Detector" activity developed by the AMPS Project under the National Science Foundation GK-12 grant #0741714 (Copyright © 2009 Polytechnic Institute of NYU).

> All types of light can be classified in accordance with the electromagnetic spectrum. The properties of light are of great importance to many areas of science, engineering and technology. For example, astronomers use various properties of light to learn about stars, nebulae, galaxies, and other far away phenomena. Although they collect information about all types of light, the various types of light differ in one key way: their wavelength. Only one part of the electromagnetic spectrum can be seen by the human eye, the visible spectrum. To obtain information about other parts of the spectrum, special instruments and materials, designed by engineers and scientists, are used to detect the wavelengths of light that our eyes cannot see.

Information relevant to UV light beads:

The following information regarding ultraviolet detecting beads is from the "Solar-powered Chemistry: Study Chemical Reaction Rates in Ultraviolet Beads" developed by the Science

Buddies Staff (2014, December 26) and retrieved March 10, 2017 from https://www.sciencebuddies.org/science-fair-projects/project_ideas/Chem_p088.shtml.

> Though ultraviolet (UV) light can be detected with electronic devices, a simple and colorful way to detect ultraviolet (UV) light is with UV-sensitive beads. UV beads change color when they are exposed to sunlight or to another ultraviolet (UV) light source, but they remain white or off-white when indoors. Because light bulbs in homes and businesses do not produce ultraviolet light, the UV beads are colorless when kept indoors. However, if you take them outside on a sunny day the UV light from the Sun turns them a variety of colors, including red, orange, yellow, blue, and purple. Some people even make bracelets from the beads so they know when they are exposed to UV light.
>
> UV beads are made from white or clear plastic, with a photochromic dye, which means that the dye changes color when it reacts with ultraviolet light. This is a chemical reaction, which is defined as the process in which one or more substances (reactants) are chemically changed into one or more *new* substances (products). The ultraviolet light actually causes the shape of the molecules to change. After interacting with the UV light, the molecules change from a colorless form to a colored form. The molecule undergoes a reversible rearrangement. It is *reversible* because the product can convert back to the reactant (this is indicated by the two arrows, one pointing left and the other pointing right). And it is a *rearrangement* because the parts of the molecule were rearranged.

Information relevant to Sunscreens:

The following information about sunscreens is from the Skin Cancer Foundation retrieved March 10, 2017 from http://www.skincancer.org/prevention/sun-protection/sunscreen/sunscreens-explained.

> Most sunscreens with an SPF of 15 or higher do an excellent job of protecting against UVB. SPF — or Sun Protection Factor — is a measure of a sunscreen's ability to prevent UVB from damaging the skin. Here's how it works: If it takes 20 minutes for your unprotected skin to start turning red, using an SPF 15 sunscreen theoretically prevents reddening 15 times longer — about five hours.
>
> Another way to look at it is in terms of percentages: SPF 15 blocks approximately 93 percent of all incoming UVB rays. SPF 30 blocks 97 percent; and SPF 50 blocks 98 percent. They may seem like negligible differences, but if you are light-sensitive, or have a history of skin cancer, those extra percentages will make a difference. As you can see, no sunscreen can block all UV rays.
>
> However, there are problems with the SPF model. First, no sunscreen, regardless of its strength, should be expected to stay effective for longer than two hours without reapplication. Second, "reddening" of the skin is a reaction to UVB rays alone and tells you little about what UVA damage you may be getting. Plenty of damage can be done without the red flag of sunburn being raised.

Synopsis of Engineering Design Activity

Synopsis of the Design Activity:

Problem:	Director is concerned children are getting too much sun exposure.
Goal:	Design a sensor that can monitor the amount of sun the children are getting.
Who is the client:	Nina, director of the Childtime Day Care Center
End-User:	Employees, children
What is the design:	Design a sensor that can monitor the amount of sun the children are getting.

Problem:	Plants may be getting to much direct light or not enough direct light.
Goal:	Design a sensor that can monitor amount of sun exposure to plants.
Who is the client:	Roger, owner of Cook's Greenhouse
End-User:	Greenhouse employees, landscapers, gardeners
What is the design:	Design a sensor that can monitor sun exposure to plants.

Problem:	Kavita doesn't know how often she needs to re-apply sunscreen while working as a lifeguard.
Goal:	Design a sensor to indicate when sunscreen needs to be re-applied.
Who is the client:	Kavita, chief lifeguard
End-User:	Kavita and other lifeguards
What is the design:	Design a sensor to indicate when sunscreen needs to be re-applied.

Problem:	UV light affects the materials used to make dashboards for cars.
Goal:	Design a sensor to determine how much sunlight the dashboard gets.
Who is the client:	Marco, materials engineer
End-User:	Marco, other car manufacturers
What is the design:	Design a sensor to determine how much sunlight the dashboard gets.

Problem:	Snowboarders and skiers do not know how effective their goggles and sunglasses are at blocking UV rays.
Goal:	Design a sensor to determine how effective their goggles or sunglasses block UV rays.
Who is the client:	Jody, owner of a sunglass shop
End-User:	Jody, customers, any skiers
What is the design:	Design a sensor to determine how effective their goggles or sunglasses block UV rays.

Problem:	Dominique is not sure if his swimsuit still blocks UV light rays.
Goal:	Design a sensor to determine if a swimsuit blocks UV rays.
Who is the client:	Dominique
End-User:	Dominique and other users of protective swimwear.
What is the design:	Design a sensor to determine if a swimsuit blocks UV rays.

Criteria:	Varies for each design.
Constraints:	• May only use the materials provided. • Time.

Lesson Plan #1

Guiding Question - How do UV beads work?

Time: 30 minutes

Procedure:

1. Distribute 5 beads to each student. Instruct students to walk around the classroom and observe what happens.

2. Instruct students to record their observations.

   Ask: *What did you observe?*
   What happen to the beads when you went closer to the window?
   Why do you think this happened?

3. Take the students outside and instruct them to observe closely.

   Ask: *What did you observe?*
   What happen to the beads when you went outside?
   Why do you think this happened?

4. Give students examples of different colored hand towels, different types of sunglasses, and samples of sunscreen (with plastic petri dishes or re-sealable zipper bag). Challenge the students to find different ways to make the beads change color using these materials.

5. Encourage the students to share their results. Encourage students to use what they just learned to generate a list of testable questions. Use the, *I observe and I wonder chart* below. Instruct students to write down everything they observed during their explorations. Then write down questions they have about the beads and their results.

I observe…	I wonder…

Consider categorizing the questions students generate. Classify the questions based on the following criteria: Can the question be answered by making observations, collecting data, making measurements, changing variables (I: Investigation)? Can the question be answered by looking up information in a book (B: Book)? Can we narrow the question to look at a single factor (F: Fair test)? Can the question be answered by comparing differences among two or more factors (C: Comparing)?

Lesson Plan #2

Guiding Question - How can I develop a fair test investigation using UV beads?

Time: 45 minutes

Procedure:

1. Review students' charts from the last lesson. Looking at the "I wonder…" column, encourage students to articulate testable questions. Below are examples of possible questions to investigate:

   - Do different types of sunscreens make any difference to the brightness of the beads?
   - Do sunscreens with higher Sun Protection Factor (SPF) protect the beads from changing color better than sunscreens with lower SPFs?
   - Does the time the beads are left in the Sun make any difference to the brightness of the color?
   - Do different types of clothing make any difference at protecting the beads from changing color?
   - Do different types of sunglasses make any difference to the brightness of the beads?

   ***Note**: There are two options to consider. Option A – let students select a question from the list above or Option B – allow students the opportunity to generate their own testable questions*

2. Instruct students to prepare a procedure for their fair test investigations. Instruct students to note the following: 1) steps; 2) independent variable; 3) dependent variable; 4) constant; and 5) control. Also make sure students provide data tables that indicate how they organize and record data.

3. Once students have completed their investigations, instruct one member of each team to report out.

   Ask: *What did you investigate?*
   What happened?
   How can you explain what happened?
   What can you conclude about different sunscreens, hand towels, or sunglasses on the UV light detecting beads?
   What did you learn about UV light radiation that you did not know before? How do the results of your investigation relate to how you use sunscreen?

Lesson Plan #3

Guiding Question - Can you construct a UV light detector?

Time: 50 minutes

Procedure:

1. Distribute the Design Challenge to students. Then pass out one client card to each team. Allow students time to read and review the challenge and their client card.

   Ask: *What is the problem?*
   What is the goal?
   Who is your user?

2. Using their design notebooks, each team then creates a plan for their designs. Choose one of the following options.

   Option A: Provide all the materials at a table for students to review.

   Option B: Let students plan first then request particular materials or show them the materials available. Students then modify their plans to accommodate for those respective materials.

3. Students construct and test their devices.

4. Students communicate their results.

   Ask: *Who is your client/user?*
   What is the goal of your design?
   How does your design work?
   If you had a chance to redesign, what would you do differently?
   Or…how could you improve on your design?

   Note: On the next page is a table that provides an overview of each task and respective conceptual understandings and/or skills the teacher can reinforce throughout this lesson.

Table 1: Overview of each task and respective conceptual understandings and/or skills that apply.

Task – Design and construct a sensor that…	Conceptual Understandings and/or Skills
Monitors the amount of sun children are getting	Apply evidence from fair test investigations
Monitors sun exposure (indirect/direct light) to plants	Distinguish between indirect and direct sunlight
Determines which SPF to use and create a sensor that will indicate when to re-apply	Apply evidence from fair test investigations
Determines how different materials respond to sunlight	Observe physical properties of materials
Determines how effective goggles or sunglasses are at blocking the sun's rays	Apply evidence from fair test investigations Explore properties of light (transparent, translucent, and opaque)
Indicates if a Rash Guard © swimsuit still blocks UV light rays	Apply evidence from fair test investigations Explore properties of light (transparent, translucent, and opaque)

Lesson Plan #4 *(Optional)*

Guiding Question - How can you design your own brand?

Time: 30 minutes

Procedure:

1. Have a discussion with the whole class about the role of advertising and product packaging design in getting consumers to buy specific products.

   Ask: *Do you have a favorite commercial or ad?*
   What makes it so appealing?
   Do you make decisions about what to buy based on how packages are designed?
   Why do companies advertise their products?
   What techniques do advertisers use in their ads and packaging to get people to notice and want their products?

2. Divide students into small groups and give them one product. Ask students to answer questions on the *Analyze a Product* [source: Benenson & Neujhar (2002) *Signs, Symbols, and Codes*]. Encourage students to share their responses.

3. Instruct students to work in their design teams and answer questions on the *Creating Your Own Design* [source: Benenson & Neujhar (2002) *Signs, Symbols, and Codes*]. Encourage students to work in their design teams to organize their thinking about the product name and how to advertise it.

4. Students then showcase their design with their respective advertisements.

Assessment

The following are possible sources of formative and summative assessment:

Formative assessment:

- Review students' investigation sheet and students' entries in their design notebooks (design plans, results from testing)

Summative assessment:

- Assess students' investigation report sheet and final design plans.
- Assess students' advertisement designs.

Lesson Extensions and Resources

Activity Extensions:

Students can write persuasive letters to their respective design clients.
Students can share their designs to a younger audience and ask for their feedback.

Web Resources:

http://solar-center.stanford.edu/teachers/
http://www.sciencebuddies.org/science-fair-projects/project_ideas/Chem_p088.shtml

Design Activity
Student Resource

SLED
Science Learning through Engineering Design

Your team will plan, construct, and test a simple sensor for detecting UV light. Each team will devise its sensor to meet the needs of one particular client. Each design must include a set of instructions explaining how the sensor works. Once the sensor is developed and tested, each team will then create an advertisement for their sensor (product).

Here are some examples of clients you will be working with:

Nina is the director of the Childtime Day Care Center and she is concerned about children getting too much sun exposure during play time. She would like a sensor that can monitor the amount of sun the children are getting.

Roger is the owner and chief landscaper for Cook's Greenhouse. He is interested in a sensor that can monitor sun exposure to his plants. Some of his plants need indirect light while other plants require direct light.

Kavita is the chief lifeguard at Columbia Park Tropicanoe Cove. She wants to know which SPF she should use. She needs a sensor that will indicate when she needs to re-apply sunscreen throughout the day.

Marco is a materials engineer at Subaru and he is designing a better material for the dashboard of cars. He is working on redesigning the dashboard for next year's Outback. Marco needs a sensor to determine how different materials respond to sunlight.

Jody is the owner of a sunglass shop at a ski resort located in Aspen, Colorado. Many of her clients are snowboarders and skiers who must wear goggles or sunglasses when they are skiing or snowboarding. Her clients want a sensor to determine how effective their goggles or sunglasses are at blocking the sun's rays.

Rash Guard © is a particular type of sun protective swimwear. The fabric blocks UV light. Dominique has had his Rash guard swimsuit for over a year and he needs a sensor that can tell him if his swimsuit still blocks UV light rays.

Analyze a Product

Group or Team Name: ____

1. What kind of product is this?

2. Who is the audience for this product – that is, who does the manufacturer think will buy it?

3. What are the main colors used in this ad or package?

4. Does this ad or package show people? If so, describe them. What do they look like and what are they doing?

5. What images other than people are shown in this ad/package?

6. What is this ad trying to say about the product? How does it get its message across?

7. Do you think this is a good/effective ad or package design for the target audience? Why or why not?

Creating Your Own Design

Group or Team Name: ____

1. What kind of product are you creating an ad for?

2. What is the name of your product?

3. Who is the target audience for your product?

4. What colors do you think will appeal to your target audience in an ad for this kind of product?

5. Will you include people in your ad? If so, describe them. If not why not?

6. Will you include other images in your ad? If so, describe them.

7. What message are you trying to send about your product?

8. Why do you think your ad will appeal to its audience?

UV Light Detector Investigation Sheet

My investigation question is…

My prediction is…

I am purposefully changing…. (circle one)

Types of sunscreens **Types of sunglass lenses** **Color of fabric** **Other**

I will measure this change by...

The steps I will take are…

1.____

2.____

3.____

4.____

5.____

6.____

7.____

8.____

9.____

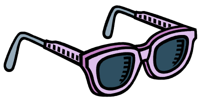
10.____

I will record my observations by….

UV Light Detector Investigation Report

My investigation question is…

Describe what you did….



What happened?

Using three to four terms from the word bank on the right, explain why things happened the way they did.

UV rays
sun
lower
higher
radiation
absorb
color
filter
block
light

What can you conclude?

Nina is the director of the Childtime Day Care Center and she is concerned about children getting too much sun exposure during play time. She would like a sensor that can monitor the amount of sun the children are getting.

Roger is the owner and chief landscaper for Cook’s Greenhouse. He is interested in a sensor that can monitor sun exposure to his plants. Some of his plants need indirect light while other plants require direct light.

Kavita is the chief lifeguard at Columbia Park Tropicanoe Cove. She wants to know which SPF she should use. She needs a sensor that will indicate when she needs to re-apply sunscreen throughout the day.

Marco is a materials engineer at Subaru and he is designing a better material for the dashboard of cars. He is working on redesigning the dashboard for next year's Outback. Marco needs a sensor to determine how different materials respond to sunlight.

Jody is the owner of a sunglass shop at a ski resort located in Aspen, Colorado. Many of her clients are snowboarders and skiers who must wear goggles or sunglasses when they are skiing or snowboarding. Her clients want a sensor to determine how effective their goggles or sunglasses are at blocking the sun's rays.

Rash Guard © is a particular type of sun protective swimwear. The fabric blocks UV light. Dominique has had his Rash guard swimsuit for over a year and he needs a sensor that can tell him if his swimsuit still blocks UV light rays.