Circuitry • Design Process
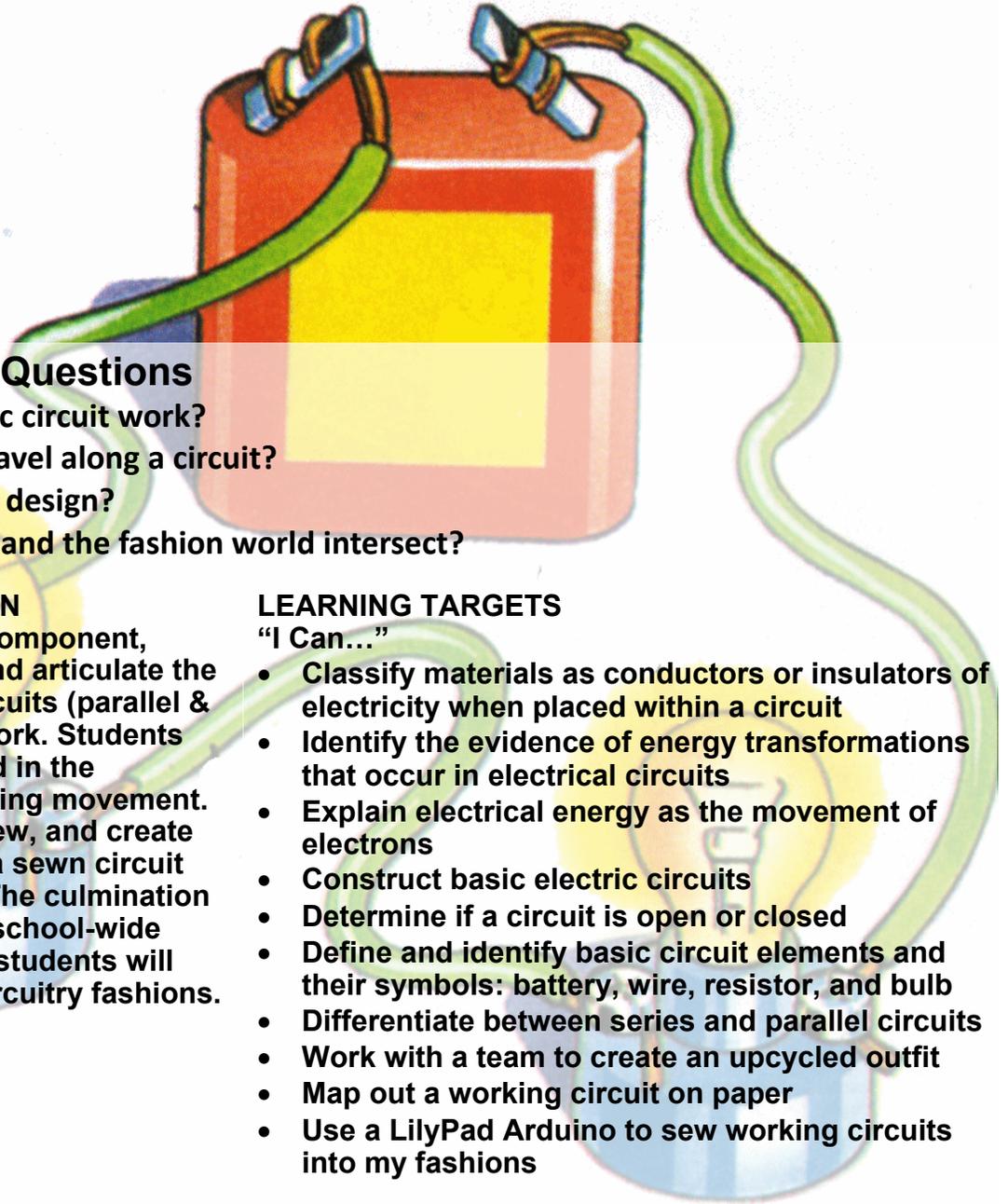
Project Essential Questions

- **How does an electric circuit work?**
- **How does energy travel along a circuit?**
- **What makes a good design?**
- **How do technology and the fashion world intersect?**

PROJECT DESCRIPTION

In this arts integrated component, students will identify and articulate the two types of simple circuits (parallel & series) and how they work. Students will be actively engaged in the discovery of the upcycling movement. Students will design, sew, and create an outfit that contains a sewn circuit that lights up an LED. The culmination of the project will be a school-wide fashion show in which students will debut their wearable circuitry fashions.

LEARNING TARGETS
"I Can…"

- **Classify materials as conductors or insulators of electricity when placed within a circuit**
- **Identify the evidence of energy transformations that occur in electrical circuits**
- **Explain electrical energy as the movement of electrons**
- **Construct basic electric circuits**
- **Determine if a circuit is open or closed**
- **Define and identify basic circuit elements and their symbols: battery, wire, resistor, and bulb**
- **Differentiate between series and parallel circuits**
- **Work with a team to create an upcycled outfit**
- **Map out a working circuit on paper**
- **Use a LilyPad Arduino to sew working circuits into my fashions**

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Units provide differentiated ideas and activities aligned to a sampling of standards.
The units do not necessarily imply mastery of standards, but are intended to inspire and equip educators.

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ESSENTIAL QUESTIONS

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- How does energy travel along a circuit?
- What makes a good design?
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STANDARDS

Curriculum Standards	Arts Standards
S8P5. Students will recognize characteristics of gravity, electricity, and magnetism as major kinds of forces acting in nature. **b.** Demonstrate the advantages and disadvantages of series and parallel circuits and how they transfer energy. **S5P3.** Students will investigate electricity, magnetism, and their relationship. **b.** Determine the necessary components for completing an electric circuit.	**VA6MC.1.** Engages in the creative process to generate and visualize ideas. **VA6MC.2.** Identifies and works to solve visual problems through creative thinking, planning, and/or experimenting with art materials, tools and techniques. **VA6CU.2.** Investigates and discovers personal relationship to community, culture, and the world through making and studying art. **VA6PR.2.** Creates artwork reflecting a range of concepts, ideas, and subject matter.

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	National Standards: Visual Arts **Standard 1:** Generate and conceptualize artistic ideas and work. **VA:Cr1.1.6a.** Combine concepts collaboratively to generate innovative ideas for creating art. **Standard 4:** Select, analyze, and interpret artistic work for presentation. **VA:Pr4.1.6a.** Analyze similarities and differences associated with preserving and presenting two-dimensional, three-dimensional, and digital artwork.

KEY VOCABULARY

Content Vocabulary
- Resistor   - Conductor   - Insulator   - Closed circuit   - Open circuit   - Series circuit   - Parallel circuit   - Current   - Ohm's Law (extension)
Arts Vocabulary
- Upcycling: when an old item that was intended for one purpose is turned into something new   - LilyPad Arduino: a microcontroller used to build circuits   - Conductive thread: stainless steel thread that conducts electricity   - LED: a light-emitting diode (LED) is a two-lead semiconductor light source

TECHNOLOGY INTEGRATION

- ThingLink   - Google Presentation   **PowerPoint** on smartboard (see downloads)   - Sewing machines in Makerspace   3D printer   - LilyPad Arduino or LilyTwinkle

ASSESSMENTS

Formative	Summative
Students will check in with their design plan throughout their process.	Student-created representations of parallel and series circuits identifying the parts that make up that circuit. Students could use any medium to demonstrate this

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● Students will trouble shoot circuits that are not working using their knowledge of circuitry and the nature of electricity.	knowledge. For example: poster, ThingLink, Google Presentation, etc. ● Students will assign roles within the group to produce a student-run fashion show for their school community. Roles include: models, students who will model the outfits on the "runway;" stylists, students who will get the clothing and models prepared for the "runway;" and an "MC," a student who will introduce the models and the clothing to the audience.

MATERIALS

A big pile of clothing to be upcycled! (This can be sourced from your classroom and school community.) LilyPad Arduino or LilyTwinkle https://www.sparkfun.com/; conductive thread, basic sewing supplies for non-conductive areas, scissors, assorted thread, needles in various sizes, glue gun, pins

Activating Strategy (5-10 min)

- Brainpop Video on circuits (or similar video): https://youtu.be/RQ3djos_LY8
- Introduce students to the upcycling movement with a brief **PowerPoint** (see downloads)
- Divide students into design teams
- Introduce the LilyPad Arduino components and the upcycling challenge
- Introduce **The Design Thinking Process** as a framework for the process (see downloads)
    - http://dschool-old.stanford.edu/redesigningtheater/the-design-thinking-process/

Main Activity

Part 1
- Discuss types of circuits.
- Discuss elements of each type of circuit.
- Illustrate a circuit.

Part 2
- Students will work within a design team to develop a brand identity and concept for their collection. The collection must tell a story. This line of questioning will help students to develop a design plan.
- Who is the *character* that will be wearing your outfit?
- In what *setting* is your look being worn?
- What *mood* does your outfit portray?
- What *story* does your collection tell?
- Introduce the materials available for upcycling and allow time for groups to sketch and experiment.
- **Introduction to E textiles** is a great attachment that provides useful tips for teachers. (See Downloads)

Part 3
- Ask teams to map out the path of the circuit components onto their design sketch, labeling the positive and negative paths. This will serve as a sewing guide.

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- Introduce basic sewing techniques and tools including sewing machines if available.
- Make it work! Encourage students to create their upcycled outfits outlined in their design plan.
- Post the design thinking chart to encourage students to redesign and troubleshoot if needed.
- This will take several sessions. Encourage students to give each other feedback and stay flexible. This is the fun part!

Part 4
- Plan a Fashion Show for the grade level or the school community.

REFLECTION

Reflection Questions
In modern homes, do you think parallel or series circuits are used? Explain your reasoning.   *Does your collection reflect your brand and story?*   *What role did teamwork play in your project?*   *Were you flexible with your vision? If so, how did your collection change?*   *What did you learn about circuits that you did not know before?*   *What surprised you about the project?*

DIFFERENTIATION

ACCELERATED:
- **Create an e-textile art pin.**

https://learn.sparkfun.com/tutorials/e-textile-art-pin

REMEDIAL:
- **Ask students to create multiple circuits in each fashion. Ask students to program the LilyPad microcontroller.**

https://learn.sparkfun.com/tutorials/re-programming-the-lilytiny--lilytwinkle

ADDITIONAL RESOURCES

Books
- *Make: Electronics: Learning Through Discovery* by Charles Platt
- *Electronics for Kids: Play with Simple Circuits and Experiment with Electricity!* by Oyvind Nydal Dahl
- *DK Eyewitness Books: Electricity Hardcover* by Steve Parker

Video examples of student work

APPENDIX (See Downloads)
- **Circuits-Upcycle PowerPoint**
- **The Design Thinking Process**
- **Introduction to E-textiles**
- **Written Reflection Sheet**

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CREDITS

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Fashion & Technology

Upcycling:
The process of using old or discarded materials and making something new.

Why Upcycle?

Many large clothing chains produce more than half a billion articles of clothing per year!!

What happens when these garments get tossed?
Over 14.3 million tons of clothing make it into the landfill each year.

Only 20-30% of donated clothing are resold.

Massive amounts of donated clothing deemed unsellable are shipped to developing countries. Most are not used.
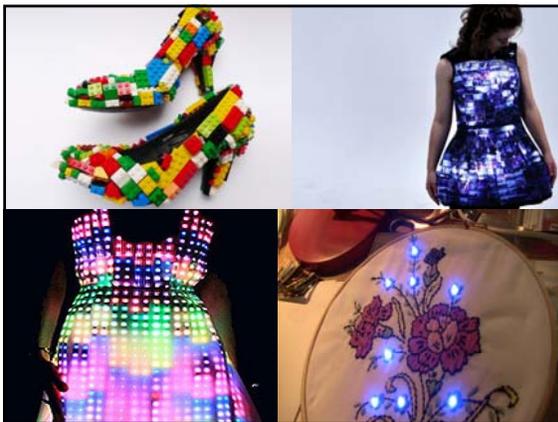
Every outfit tells a Story

Who is the **character** that will be wearing your outfit?
In what **setting** is your look being worn?
What kind of **mood** does your outfit portray?
What **story** are you telling?

We are all DESIGNERS!


LilyPad Arduino
Circuit mapping

The Design Thinking Process

The Design Thinking process first defines the problem and then implements the solutions, always with the needs of the user demographic at the core of concept development. This process focuses on needfinding, understanding, creating, thinking, and doing. At the core of this process is a bias towards action and creation: by creating and testing something, you can continue to learn and improve upon your initial ideas.

The design thinking process consists of these 5 steps:
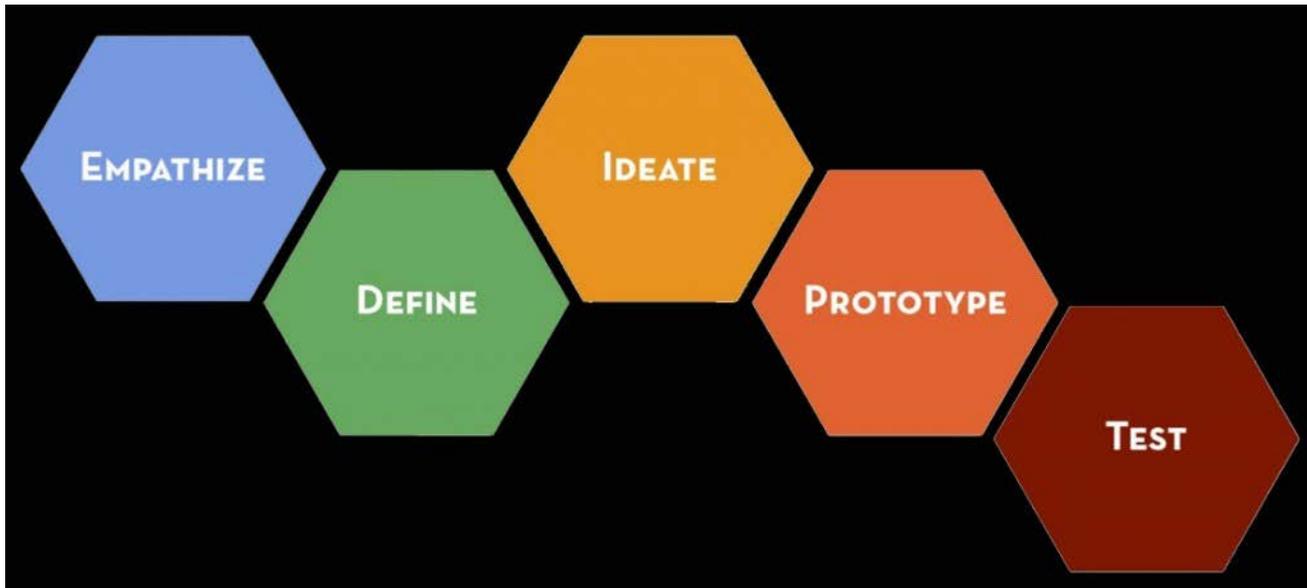
EMPATHIZE: Work to fully understand the experience of the user for whom you are designing. Do this through observation, interaction, and immersing yourself in their experiences.

DEFINE: Process and synthesize the findings from your empathy work in order to form a user point of view that you will address with your design.

IDEATE: Explore a wide variety of possible solutions through generating a large quantity of diverse possible solutions, allowing you to step beyond the obvious and explore a range of ideas.

PROTOTYPE: Transform your ideas into a physical form so that you can experience and interact with them and, in the process, learn and develop more empathy.

TEST: Try out high-resolution products and use observations and feedback to refine prototypes, learn more about the user, and refine your original point of view.

For more information on this process check out the d.school way of working:
http://dschool-old.stanford.edu/our-point-of-view/#design-thinking

Introduction to E textiles
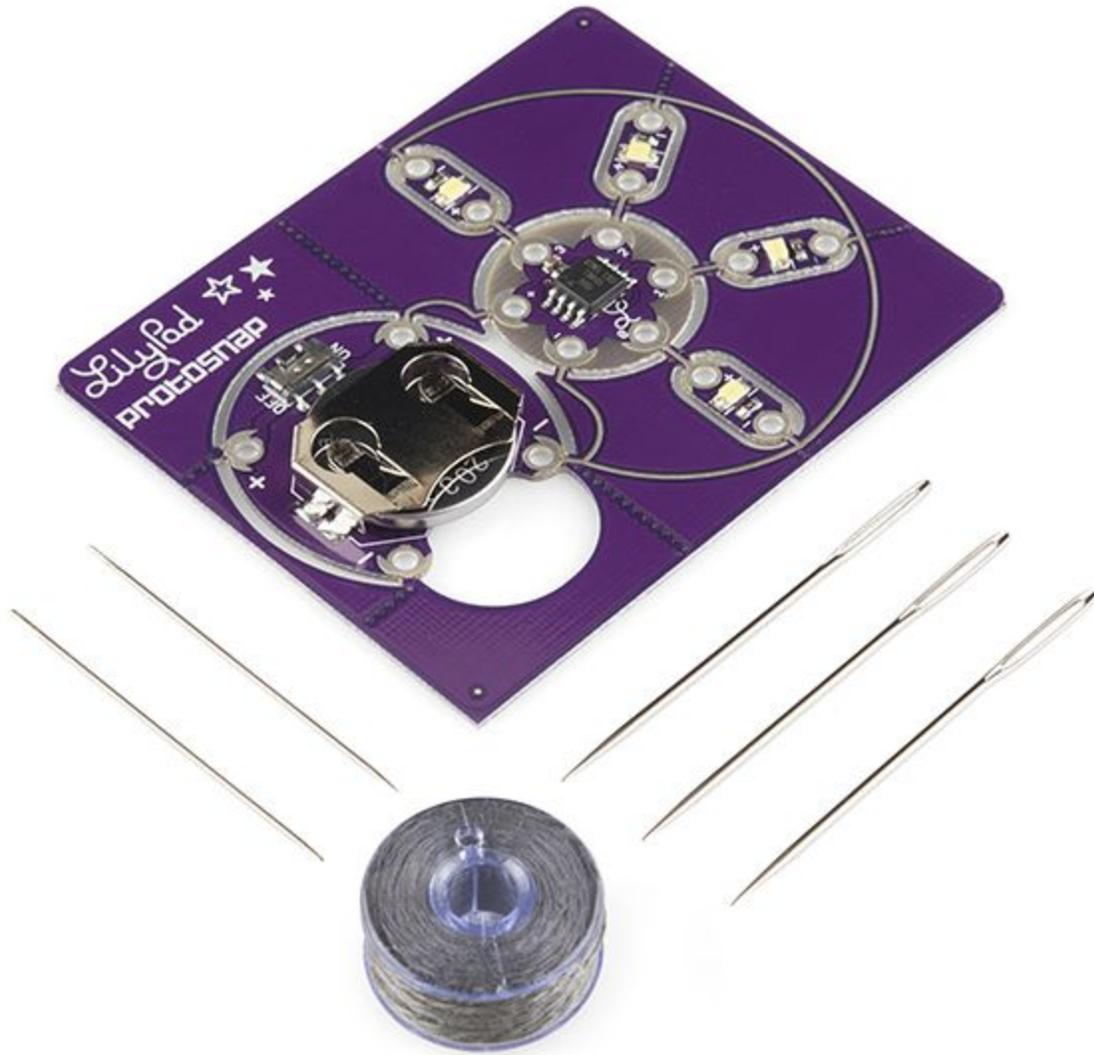
 We used the Lilypad twinkle board for our projects.

The ProtoSnap LilyTwinkle board is a very simple way to jump right into e-textiles. By including the LilyTwinkle, a coin cell battery holder (with built-in switch), and four white LEDs the ProtoSnap

LilyTwinkle board easily allows you to add some sparkle to any project. The kit comes with a needle set and 30 feet of conductive thread!

Sewing Tips

Tips For Successful Sewing

- Make sure to pull your thread all of the way through your fabric to eliminate loose sewing traces.
- Be sure to cinch each stitch tight to keep a solid connection.
- Loop your thread around each pin 2-3 times to make a secure connection.
- Keep your stitches close together, and make sure the gaps aren't too big.
- Cut your knots down to keep your traces from touching each other. The cleaner you keep your traces the higher the chances are of getting your project to work on the first try.
- There's a tendency to hide stitches, and hidden stitches are hard to troubleshoot. If you're going to hide a stitch within the fabric make sure to check the trace before covering it up with other fabric.

LilyPad Basics

There are a few things that are helpful to keep in mind when working with LilyPad components and e-textiles in general:

- Do not sew any components in with the battery installed. There is no risk of getting hurt, but you might drain the battery.
- Any time you make a connection between a component and the thread, make a few loops through the connection hole. The section of metal on the outside of the connection hole is where current will flow between the thread and the component. Often, if there is a short or break in your circuit it is because the conductive thread does not always touch this pad on the component.
- If you have two threads that need to cross, there must be an insulator between them, otherwise the circuit will not work. Try a piece of fabric, a layer of glue or paint, or a tube of heatshrink.
- There are other conductive e-textile materials such as buttons, fabric, yarn, paint and velcro. There are many different ways to use the materials as switches, sensors and more. Have fun and experiment!

Troubleshooting

When you are sewing together your project you may run into a few snags along the way. There are a few ways to troubleshoot common sewing mistakes.

- Running out of thread: Loop around the existing thread about three to four stitches back. Follow that sewing trace so that the two lines are parallel and touching.
- Bypassing the switch: Use a piece of wire or integrated circuit hooks to jump individual components directly to the battery or the microcontroller. This will tell you if the stitch or the component is the problem.
- Loose sewing traces: Pull everything tight with tweezers or your sewing needle to tighten up the sewing traces. You may also sew over the top of an existing trace.
- LEDs not working? Double check your polarity.

Reflection Questions – Circuitry Visual Arts Component

1. In modern homes, do you think parallel or series circuits are used? Explain your reasoning.

   _____
   _____
   _____
   _____

2. Does your collection reflect your brand and story?

   _____
   _____
   _____

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