

# 5675: Introduction to eTextiles

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## Workshop Description

Have you ever wanted to make clothing that lights up? In this class we'll introduce you to a few simple electronics that you can use to make wearable items embedded with LED lights.

This 2-hour workshop will provide some time to work on hand-sewing skills with embroidery thread and felt. We'll also learn how to paper prototype our projects and lay out the electronic components. Finally, we'll combine all these new skills to make a light-up bracelet or wristband.

## Supplies

Each student receives a numbered bag with the following items:

1. 1x *Coin Cell Battery Holder - 20mm (Sewable)* (DEV-08822) \$2
2. 2 sew-able LED lights from *LilyPad Rainbow LED (6 Colors)* (DEV-13903) \$5
3. 24" length of *Conductive Thread Bobbin - 30ft (Stainless Steel)* (DEV-10867)
4. 2 sewing needles in 2 different sizes from *Needle Set* (TOL-10405)
5. 8" X 3" wide piece of felt
6. 24" length embroidery floss or sewing thread (easier with Velcro)
7. ½" section of sew-able Velcro (includes soft & scratchy sides)
8. 2 pencils/pens in 2 different colors

Each student also receives:

9. 2x blank sheets of paper
10. One print-out of visual supplies list for paper prototyping [attached to this lesson plan]
11. At end of class, 3-question post-questionnaire [attached to this lesson plan]

Each pair of students receives:

12. Scissors
13. Tape
14. Needle Threader
15. 1x *CR2032 Coin Cell Battery (20mm)* (PRT-00338) \$2

Instructor will need to bring:

1. Above listed supplies X num\_students
2. num\_students X 3-question post-questionnaires
3. Demo Projects
4. Extra Lilypad components, Extra batteries
5. 4x *LilyTwinkle* (DEV-11364) – in case more advanced students need something to do
6. Box for holding SPLASH Lilypad components with supplies list for box
7. Instructional presentation slides and laptop
8. Extra felt, Extra embroidery floss, Extra needles, Extra thread, Extra scissors, Extra tape

## Context

This course is a two-hour, one-day workshop on eTextiles (or electronic textile projects) for 7<sup>th</sup> to 9<sup>th</sup> graders. Enrollment is limited to 11 students, who will be meeting in a lecture hall or active learning classroom that also has a projector and screen.

## Objectives

By the end of this lesson, students should be able to:

1. Sew two fabric items to each other with a running stitch and secure with knots.
2. Diagram, on paper, a simple circuit including a battery and one LED light.
3. Diagram, on paper, a parallel circuit including a battery and two LED lights.
4. Construct a simple electric circuit diagram using electronic components designed for textiles.

## Activities

*Note: According to the article by Freeman et al. (2014), "Active learning increases student performance in science, engineering, and mathematics," active learning reduces dropout from Science Technology, Engineering, and Math and increases examination performance. So this lesson plan relies heavily on active learning methods while also incorporating a couple lab-like activities.*

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### Warm-Up

< 5 minutes.

**LECTURE W:** A slide welcoming students, and stating that all materials must be returned at the end of class. Students may keep paper projects, but no electronic components, needles, thread, scissors, etc. They will not be able to keep their projects from the workshop, as the supplies are necessary for future workshops.

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### Introduction

5 minutes.

**LECTURE I:** Instructor should start by asking the class why they are taking the class, and what they hope to learn. Then connect these student motivations to the overview of the lesson's learning objective, including a supplies list for the day. Introduction will also include demonstration of an actual project students will construct by the end of class.

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### Learning Objective 1

20-30 minutes.

"Sew two fabric items to each other with a running stitch and secure with knots."

**LECTURE 1.** A slide with a diagram explaining how to knot thread, thread a needle, perform a running stitch, and secure the end of the thread. Another diagram showing the physical layout of a piece of felt, and two halves of Velcro to form a diagram.

**ACTIVITY 1:** Students will use a running stitch to hand-sew two halves of Velcro to a piece of felt using embroidery thread and a sewing needle. The felt will be about 6" long, and a few inches wide. Combined with the Velcro, it should be able to form a simple bracelet or wristband. The task will be shown on a slide, with a diagram of exactly how to accomplish the task.

**MISCONCEPTIONS 1:** It may take additional spatial reasoning skills to understand the physical layout of the felt, fuzzy Velcro piece, and scratchy Velcro piece in order to make the Velcro connect.

**DIVERSITY 1:** (Diversity of ability) Students who successfully completed the task early can decorate their wristband with additional pieces of felt, while the other students continue working toward the main activity.

**ASSESSMENT 1:** Students will self-assess their skills by attempting to wear their completed wristband. If it works as in the supplied diagram slide, then they have learned the necessary skills to proceed. Instructor should walk around the class and provide formative assessment to students as they practice the skills in the activity.

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## Learning Objective 2

20-30 minutes.

"Diagram, on paper, a simple circuit including a battery and one LED light."

**LECTURE 2:** A few slides describing the basics of electric current using a potato + light bulb + alligator clip wires example. The example will slowly be generalized to a battery + LED light + conductive thread. The slides will also include warnings about short circuiting. The lecture slides will include a few examples of circuits that do and do not work, and the instructor will ask for responses from the class to gauge understanding.

**ACTIVITY 2:** Students will diagram a simple circuit using paper and colored pencils. Students will have paper cut-outs of the electronic components necessary to diagram a simple electric circuit (a battery, one LED light, and two different colored pencils to simulate the wires). They will have 5 minutes to work on this task independently, and at the end of the 5-10 minutes, students will discuss with a partner to see if they have the same answer. After 5-10 minutes of pair discussion, students who disagreed with their partners will be asked to report out and present their solutions to the class.

**MISCONCEPTIONS 2:** A common misconception of electric circuits is that the current will continue to flow from the battery and through the light bulb, even if the circuit is open. The behavior can be demonstrated with diagrams in the slides.

**DIVERSITY 2:** (Diversity of ability) Students who have high prior knowledge of electric circuits will obtain additional learning gains by having to explain their responses to their partners. Students with lower prior knowledge will also learn from this task, and from the discussion students of all prior knowledge should learn.

**ASSESSMENT 2:** The Think-Pair-Share activity described above will form an informal peer assessment. The reporting-out discussion should function as a means to provide feedback to all students simultaneously.

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### Learning Objective 3

10 minutes.

“Diagram, on paper, a parallel circuit including a battery and two LED lights.”

**LECTURE 3:** This learning objective is a quick add-on to Learning Objective 2. The slide for this task will include a diagram of a parallel circuit.

**ACTIVITY 3:** Students will replicate the parallel circuit diagram from the lecture diagram, adding an extra LED light to their diagram from Activity 2. Students will be asked to write-down what they think will happen when the parallel circuit is opened, and what will happen when it is closed. They will then share and discuss with their partners again, followed by a reporting out of various pairs’ decisions with a particular focus on why they think their predictions will happen.

**MISCONCEPTIONS 3:** A common misconception of parallel circuits, according to Kucukozer & Kocakula (2007), "Secondary School Students' Misconceptions about Simple Electric Circuits", is that learners believe that a parallel circuit will reduce the flow of current to the light bulb (as compared to a simple circuit). An interactive diagram may get students to think about this concept more deeply.

**DIVERSITY 3:** (Diversity of ability) Students who have high prior knowledge of electric circuits will obtain additional learning gains by having to explain their responses to their partners. Students with lower prior knowledge will also learn from this task, and from the discussion students of all prior knowledge should learn.

**ASSESSMENT 3:** The Think-Pair-Share activity described above will form an informal peer assessment. The reporting-out discussion should function as a means to provide feedback to all students simultaneously.

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### Learning Objective 4

30 minutes.

“Construct a simple electric circuit diagram using electronic components designed for textiles.”

**LECTURE 4.** The parallel circuit diagram from the previous lecture slide will be turned into the same diagram, but using the electric textile components. The fact that the conductive thread replaces the wires in the diagram will be explained, along with some tips and tricks for working with conductive thread (i.e., not to let the threads intersect, using the back of the fabric as well as the front).

**ACTIVITY 4:** Students will replicate the diagram that they created in Activity 3 in paper, but using their felt wristband, a sew-able battery holder, 2 sew-able LED lights, some conductive thread, and a needle.

**MISCONCEPTIONS 4:** It is common to forget that fabric has both a front and a back, and that it is important for the conductive thread to not intersect, or it will short circuit. A discussion of this will be included in the lecture portion.

**DIVERSITY 4:** (Diversity of ability) Students who successfully complete the task early can decorate their wristband with additional pieces of felt, or if they are done very early, can add a different kind of electronic chip to their project that will make the LED lights sparkle, instead of just turn on/off.

**ASSESSMENT 4:** If the LED lights turn-on in their project when a battery is inserted into the battery holder, then students will know that they successfully implemented a parallel circuit with real

components and have achieved the fourth learning objective. Instructor should walk around the class and provide formative assessment to students as they practice the skills in the activity.

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## Conclusions

5 minutes.

**LECTURE C.** Concluding remarks with revisit to the lesson's learning objectives. Students will complete a brief post-questionnaire before leaving. Instructor should collect materials while post-questionnaire is being completed.

**ASSESSMENT C.** The post-quiz will be used to diagnose improvements for future workshops.

Students must return all non-paper materials at the end of the workshop!! They need to be re-used for another workshop!

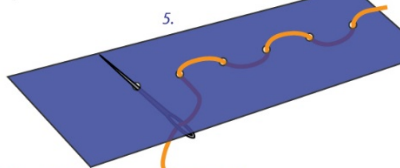
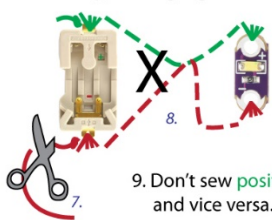


## eTextiles Tips and Tricks

1. Knotting the end of the thread (2 knots is best).
2. Threading the needle with a needle threader: Place wires through needle eye. Put thread end through wires. Pull needle threader away.
3. Overstitch: Thread comes up through fabric, and then needle is pushed down through connection point/hole. Then back up through fabric and repeat.



4. Always secure connection points with 4-5 overstitches (lots of contact!)
5. Running stitch: Thread comes up through fabric, then down, then up, down, etc. Can make smaller stitches on one side to make them less visible.
6. Secure the end of threads by pulling the needle through several previous stitches.
7. Always trim loose threads! Don't want them to connect to unwanted lines!
8. Do not sew threads so that they cross. This may short the circuit. Also, do not sew too loosely, as dangling threads may also cross other threads.

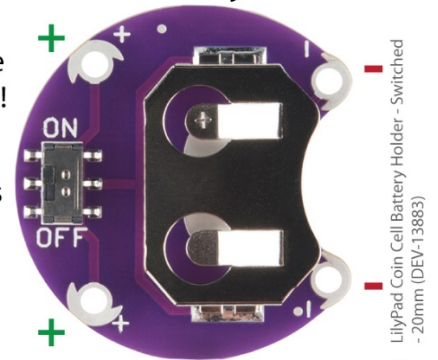


9. Don't sew positives to negatives and vice versa. Notice which is which!

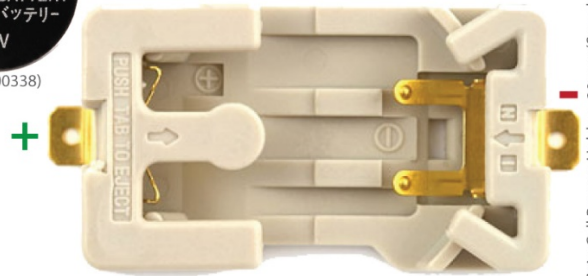
## Sewable Coin Cell Battery Holders

Notice which connection points are **positive** and **negative**!

These battery holders take a CR2032 20mm coin cell battery.



LilyPad Coin Cell Battery Holder - 20mm (DEV-13883)



Coin Cell Battery Holder - 20mm (Sewable) (DEV-08822)

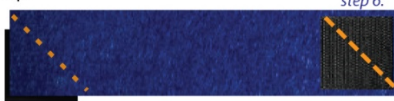
## Felt Wristband

*A felt cuff to attach electronics to*

1. Trim felt strip to circumference of wrist + 1".
2. Tie a knot at the end of your sewing thread.
3. Thread your needle with the other end. Use a needle threader if needed.
4. Use a running stitch to sew soft Velcro square to one end of felt strip.



5. Secure the end of the thread by pulling the needle through a previous stitch a few times. Trim loose threads at beginning and end.
6. Flip felt strip over and repeat Steps 2-5 for the scatchy Velcro square at the other end of the felt strip.



**Step 7. Done! Check that wristband wraps & attaches around your wrist.**

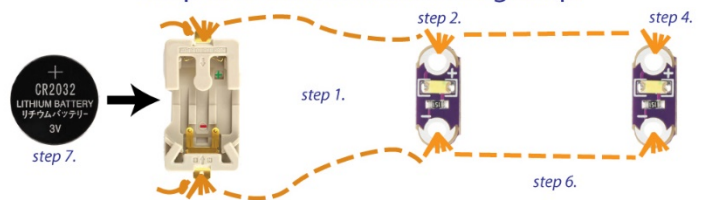
*Attach decorative felt cut-outs or embroidery before or after adding electronics.*

## Parallel eTextiles Circuit

*Turning on two LED lights*

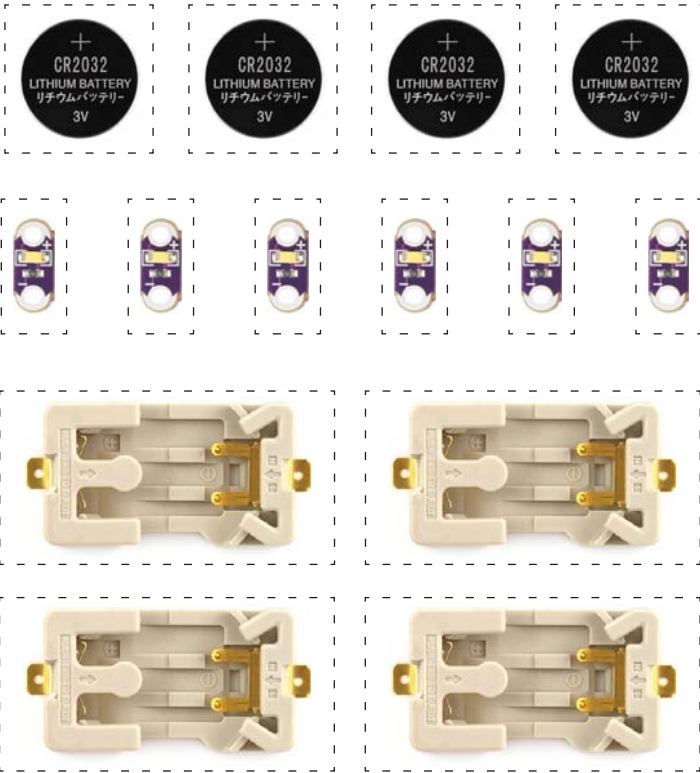
1. Create a Simple eTextiles Circuit. First LED should light up. Remove battery.
2. Knot the end of the conductive thread and sew 4-5 overcast stitches into the **positive** connection point of the first LED. (Simple eTextiles Circuit: steps 1-4)
3. Use a running stitch to sew to the location of the second LED.
4. Sew 4-5 stitches through the **positive** connection point of this second LED with an overcast stitch.
5. Secure the end of the thread by pulling the needle through a previous stitch a few times. Trim loose threads at beginning and end. (Simple eTextiles Circuit: step 7)
6. Repeat steps 1-5 for the **negative** connection points/holes of the first and second LEDs. Do not let the **positive** & **negative** threads cross and don't sew super loosely.
7. Place the battery into holder matching the positive & negatives.

**Step 8. Done! LEDs should light up.**



*Alternatively, you could sew all the **positive** connection points together with one thread {battery holder, LED1, LED2} and then with a second thread, sew all the **negative** connection points together. This can be a little harder to test, but should also work and requires fewer knots & needle threading.*

# Paper Prototyping Cut-Outs

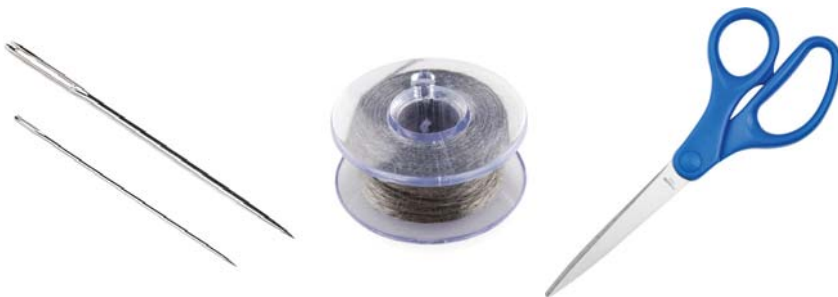


## Supplies List (sparkfun.com)

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2. 2x sew-able LED lights from LilyPad Rainbow LED (DEV-13903)
3. 24" length of Conductive Thread Bobbin - 30ft (DEV-10867)
4. 2 sewing needles in 2 different sizes from Needle Set (TOL-10405)
5. 8" X 3" piece of craft felt
6. 24" length sewing thread or embroidery floss
7. 1/2" piece of sew-able Velcro (soft & scratchy sides)
8. 2 pencils/pens in 2 different colors & paper

### Shared Supplies:

9. Scissors
10. Tape
11. 1x CR2032 Coin Cell Battery (20mm) (PRT-00338)



Craft Felt

All materials must be returned to the instructor  
(except paper)

Craft Felt

**All materials must be returned to the instructor.  
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Other students need the supplies for their class!**

Sew-able Velcro (scratchy)	CR2032 Coin Cell Battery PRT-00338	CR2032 Coin Cell Battery PRT-00338	CR2032 Coin Cell Battery PRT-00338	CR2032 Coin Cell Battery PRT-00338		
Sew-able Velcro (soft)	Sewable LED (DEV-13903)	Sewable LED (DEV-13903)	Sewable LED (DEV-13903)	Sewable LED (DEV-13903)	Sewable LED (DEV-13903)	Sewable LED (DEV-13903)
Sew-able Velcro (scratchy)						
Sew-able Velcro (soft)	Coin Cell Battery Holder Sewable (DEV-08822)		Coin Cell Battery Holder Sewable (DEV-08822)			
Sew-able Velcro (scratchy)	Coin Cell Battery Holder Sewable (DEV-08822)		Coin Cell Battery Holder Sewable DEV-08822)			
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**Thank you so much for coming to today's eTextiles lesson!**

*Please help us improve future lessons by answering these questions:*

(1) What are the 2 most exciting things you learned in today's eTextiles lesson?

(2) What questions do you still have?

(3) How can this lesson be made better?

**Thank you for returning all your supplies to the instructor! More students will use them in their lessons.**

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