Hack Your Hoodie: Teacher's Guide

Title	**Hack Your Hoodie**
Overview	In this activity, students add a switchable light to a piece of clothing by using conductive thread to connect a circuit containing an LED sequin, a switchable battery holder and CR2032 battery.
Prerequisites	Familiarity with basic sewing is helpful, though not required. Students should be old enough to handle sharp objects and small things (the LED sequins are tiny)
Learning Objectives	After successfully completing this activity, the learner should be able to: 1. Identify the proper orientation of polarized components relative to a power supply 2. Create a circuit with 2 polarized components.

Background

Electronic Textiles, or eTextiles, are textiles that directly incorporate conductive fibers or elements. eTextile projects are engaging and hands-on, and can serve as an introduction to computing, electrical engineering, and the Internet of Things. In addition, evidence suggests eTextile projects are especially well-suited for girls and young women, and may help improve their overall attitudes and confidence about computing.

Using an eTextile workshop to introduce students to the basic principles of physical computing offers many benefits:

- serving as an attractive entry point to computer science for girls and young women[1];
- allowing students to express their own creativity;
- creating a sense of empowerment by enabling students to modify their own environment;
- providing the basis for further exploration of wearable tech and small circuitry; and
- taking full advantage of the array of benefits that hands-on learning provides.

In this activity, participants will experience the fun of eTextiles by adding an LED sequin to an article of clothing they bring.

Reference and background reading:

- https://learn.sparkfun.com/tutorials/lilypad-basics-e-sewing - SparkFun's guide to sewable electronics – **this is the best place to start**

- http://www.makersbox.us/2013/10/what-heck-is-soft-circuit.html - Steps to create a photosensitive nightlight with a donated circuit board
- https://www.ncwit.org/resources/e-textiles-box - provides instructions for sewing soft circuits and programming an Arduino microprocessor on the way to creating a bookmark book light and an interactive felt monster that lights up and sings.
- https://www.sparkfun.com/tutorials/281 - using regular LEDs rather than LED sequins

Materials list per student

- ~9' conductive thread (https://www.sparkfun.com/products/10867)
- LED sequin(s) (https://www.sparkfun.com/products/10081)
- Switchable battery pack (https://www.sparkfun.com/products/11285)
- CR2032 "coin cell" battery (any drugstore)
- Needle
- Sewable material to hack (backpacks work, as long as you can get the needle through it; hoodies; purses; etc.)

Suggest that students can bring their own sewable to hack. Also making "kits" for each student containing all materials except thread ensures correct quantities and speeds setup. Usually the battery pack will come in a little baggie, so you can use that.

Supplies (reusable)

- Hot glue gun
- Scissors (several pair)
- Multimeter
- A couple of short pieces of conductive wire (scrap)
- Thread conditioner (https://www.amazon.com/Thread-Magic-Conditioner-Combo/dp/B015MDYLAO/ref=lp_15337245011_1_1?srs=15337245011&ie=UTF8&qid=1508368699&sr=8-1)
- Vanishing fabric marker (https://www.amazon.com/Dritz-Disappearing-Ink-Combo-Pack/dp/B001B9I1Q4/ref=sr_1_4?ie=UTF8&qid=1508366909&sr=8-4&keywords=vanishing+fabric+marker) + white chalk for darker fabrics (https://www.amazon.com/Dritz-642-66-2-Piece-Tailors-Chalk/dp/B003WMHIDU/ref=sr_1_2?s=arts-crafts&ie=UTF8&qid=1508372468&sr=1-2&keywords=white+chalk+fabric+marker)
- Needle threader (can be helpful: https://www.amazon.com/Kenkio-Gourd-shaped-Needle-Threaders-assorted/dp/B0725Q542T/ref=sr_1_1_sspa?s=arts-crafts&ie=UTF8&qid=1508368996&sr=1-1-spons&keywords=needle+threader&psc=1)
- Puffy Paint (not necessary, but can be useful)

Directions

Notes for instructors are in italics

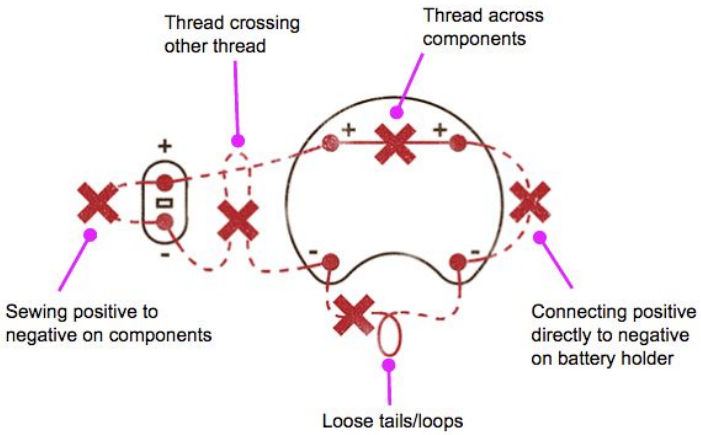
Strongly suggest reading: https://learn.sparkfun.com/tutorials/lilypad-basics-e-sewing – basic info about how to create a circuit and more tips for working with LED sequins and conductive thread

*Before going over the instructions for the project itself – **and before handing out thread** -- cover the *Very Important Basics**

Very Important Basics

These things are so important that we're putting them here at the top rather than embedding them below.

- Most importantly: **Do Not Cross The Streams!** Basically, do not let the positive (**+**) trace (trace = thread = leg of circuit) ever cross the negative (**-**) trace. If you do, the circuit will short and things won't work! What does that mean? Don't do this:



- Use a relatively **short length of thread** – no more than 16"-18". Any more than this and everything will get all tangled up.
- Aim to run out of thread at a component, as it makes it easy to knot and start a new piece of thread. If that's not possible, you can just start a new length of thread by knotting it around the old one – remember each trace must be continuous.
- All the **+** must be connected. All the **-** must be connected. Even **the LEDs have + and - which makes things easy for you!**
- Any **metal can short your circuit** – this includes a metal button, a rivet, etc. So avoid those when you are sewing.
- Each time you attach a new component, you'll want to do at least **three loops** through the component and the fabric

- **Don't pull your thread too hard**! It is easy to snap.

Making your circuit

Hand out the thread now :-)

Start each student with 2' of thread or so in order to avoid breakage/tangles. In the end, they may end up using close to the 9' estimated/student overall, but we've had issues when we've given students the entire thread amount at the start.

As you cut each length of thread, if you run it through thread conditioner it will make sewing easier and prevent some of the tangles.

1) Plan the placement of your LEDs & Battery Pack

- Figure out where you want your LEDs to be placed.
- Figure out where you want your battery pack to be placed. You want to be able to easily reach the switch to turn your lights on and off.

These are washable – but you have to remove the battery from the battery pack first.

Things to consider when planning:

- Length of conductive thread (you have ~4' to work with for each "trace", or leg of the circuit)
- All the **+** terminals of the LEDs will need to be connected to each other (in a row) and also connected to the **+** terminal of the battery pack. (e.g. This means that you can't cross a gap – like an open neckline – in between two LEDs or between the battery and the first LED.)

We've found that the shorter the distance between the battery and the LEDs the better, especially for students who are not experienced sewists.

2) Mark and check your traces. Affix your components.

- Using one of the fabric markers, draw the traces as you will sew them on the fabric.
- Mark where you'll put the LED sequins, and use a + and - to indicate their orientation

At this point, for most groups, it makes sense for the instructor to check what each student has planned and help them work through any corrections needed. Helpers make this a lot easier.

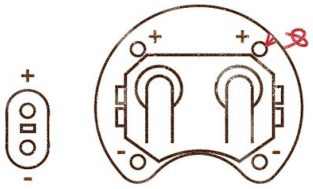
Once the components are aligned correctly and the traces are drawn correctly, it helps to use a tiny dab of hot glue in the center of the back of the sequin to affix it in place. This prevents sequin loss and lessens the chances of getting the polarity wrong.

2) Prep your needle & thread

- Thread the needle. If you're having trouble, try moistening the eye of the needle (not the end of the thread) – surface tension of the water will help "pull" the thread through the needle. Also, try holding the thread still and moving the needle towards it.

- Do **not** double the thread – leave a tail of 3-4”
- Make a small knot in the end of the thread opposite the needle.

3) Attach the battery pack to your clothing by sewing down the **+** terminal
- We’re going to do the **+** trace first. You’ll continue to work with this trace until you’ve connected all the LEDs on the **+** side.
- Start with a small stitch through the fabric of your clothing to anchor your thread, then pass your needle up through the **+** terminal of the battery pack.
- Go through the terminal and through the fabric at least three times, like this:



Starting with the battery pack means that you can test as you go along.

4) Sew down each of your LEDs, on the **+** side only
- Use a running stitch (where you just go in and out of the fabric and you have approximately the same amount of stitching on the “top” and “bottom” of the fabric) to sew over to your first LED.
- Go around the **+** terminal of the first LED and through the fabric (thereby attaching the LED to your fabric) at least three times
- Keep sewing towards the next LED
- Lather, rinse, repeat, until you get to the last LED. After attaching the last LED, knot your thread off, trimming your tail (it can cause a short if you leave a tail dangling!).

If adding more than one sequin, an alternative approach is to go from the + terminal on the battery pack to the + terminal on the first LED sequin, tie off the thread, then start at the - terminal of the battery pack and go to the - terminal of the first LED sequin. The disadvantage to this approach is that it uses a little more thread, but it offers the advantage of students being able to attach the sequin, then add the battery and see the first LED sequin light up, which is both exciting and a good test.

Keep an eye on the sewing – ensure that the stitches students are using are taut (as large loops of conductive thread can bump into each other, causing shorts) and relatively short (.25” is really as large as you want, though I’ve seen students use up to .5” successfully, depending on component placement).

5) Repeat step 4, starting at the battery pack, but this time working on the **-** trace

6) Finish off the project!
- Double check that your traces are not crossing

- Make sure that your thread tails are out of the way (you'll clip them after you test)
- Put the battery in
- Flip the switch – glorious lights? Rejoice!
- Once you know everything is working you can use trim the thread tails. If you'd like, use the puffy paint to paint over the traces on the outside. It will protect against wear and shorts on the outside of the fabric (but is really not necessary). You do not need to puff the paint (but you can with an iron, set on steam if you want, once you get home!
  Scissors cut fabric just as easily as conductive thread, so be careful

Oh no! What happens if your project isn't working? Don't panic! Call us over and we'll figure it out with you together.

Troubleshooting

Common causes of error:

- *The streams were crossed*
  - *Check for stray metal (snaps, buttons, grommets)*
  - *Ensure that the + trace never touches the - trace ...*
  - *Check the backside of the fabric too*
  - *Fabric is flexible, so if you get an intermittent failure, is there a short when the material is folded and touches itself*
  - *Check thread tails! At the battery pack, at the sequins.*
- *Incomplete circuit*
  - *Best way to test this is with the multimeter*
  - *Can be fixed with "bridge thread" – so if there are two parts of the circuit that aren't connected, knot a piece of conductive thread onto the first piece, then sew over to the second, and knot around that. Trim.*
- *Polarity*
  - *Check to see that all the +'s are connected and all the -'s are connected*
- *Shorts*
  - *Make sure that they didn't continue from the + terminal on the battery to the - terminal, though it's ok if the two + (or the two -) terminals are connected to each other*
  - *Make sure that the + and - terminals on any of the LEDs aren't connected to each other*
- *Component Failure*
  - *Could be the battery is dead - try a different battery*
  - *Could be a sequin is kaput. It's rare but it happens.*
- *Power switch on battery pack is off*
  - *Yep. Should check that.*

Deliverables

At the end of the exercise, the students should have created a working soft circuit, using conductive thread, one or more LED sequins, a battery pack and a CR2032 battery.

Assessment

Criteria	Level 1 (fail)	Level 2 (pass)	Level 3 (good)	Level 4 (exceptional)
Creates working circuit with 2 LED sequins, battery pack and conductive thread	Did not attempt	Attached at least 1 of 2 sequins correctly relative to battery pack	With or without assistance, attached both sequins correctly & they lit up.	Approached problem in new/novel way, thought of creative application of sequins, was able to troubleshoot own errors and/or help others.

Comments

ACM Body of Knowledge **Area & Unit(s)**	
ACM Topic(s)	
Level of Difficulty	Easy
Estimated Completion Time	This will take at least 1 hour, with 2 components. Add more helpers (or remove components) to simplify.
Environment / Materials	Materials per student ● 9’ conductive thread (https://www.sparkfun.com/products/10867) ● LED sequins (https://www.sparkfun.com/products/10081) ● Switchable battery pack (https://www.sparkfun.com/products/11285) ● Clothing to hack

	• CR2032 “coin cell” battery (any drugstore) • Needle
Author(s)	Gina Likins
Source	(borrowed heavily from https://learn.sparkfun.com/tutorials/ldk-experiment-1-lighting-up-a-basic-circuit
License	 

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