**Project ECSITE Unit:** Electronic Textile Techniques for Costume Design

Stage costumes can incorporate a wide variety of technical and artistic features. In this technical theatre unit, students start by learning about and constructing simple circuits. The unit culminates in a performance with costumes that incorporate electronic and/or electrically-powered elements. The purpose of the first activity, during which students individually make bookmarks or other small items, is to familiarize them with materials, tools, and construction techniques used in the creation of electronic textiles. In the second activity, groups of students design and construct electronic textile-based costumes and then plan and deliver a performance to showcase the costumes.

**Subject Areas:** computer science, performing arts, physical science

**Grade Level:** 9–12, but could be adapted for 6–8

**Computational Thinking Connection:**

Electronic textile projects are seen as an emerging approach to interesting students in computing. Such projects introduce programming techniques in the context of using microcontrollers to direct the operation of simple sewn circuits that can include sensors and actuators. At the beginning of the second activity in this unit students are shown how microcontrollers can be used in this way, and they may choose to incorporate circuit control into their costumes. In addition to considering problem decomposition and the use of procedures within a programming context, these computational thinking skills along with parallelization are relevant to planning and carrying out this unit’s construction and performance activities.

**Pre-Requisite Knowledge:** N/A

**Time Required:** 12+ class sessions

Expect the first activity to involve 3 class sessions: introducing the project (partial session), training student helpers, and project construction. The second activity consists of several phases—introduction, planning, construction, rehearsal, and performance—and will require at least 9 class periods. In addition, a break between the planning and construction phases is helpful because of the need to obtain supplies specific to each project.

For both activities, longer periods are more productive because of the time devoted to setup and clean up each time unless a dedicated workspace is available.

**Related Lessons/Activities:**

1. Beginning Electronic Textile Construction
2. Costume Design Using Electronic Textile Techniques

**Attachments:** Project Handout: An Electronic Textiles / Soft Circuits Project for Beginners

Other Notes:

See the estimated costs for each activity before adopting this unit. The preparation for this unit is relatively time-consuming.

Contributors: Hilarie Nickerson, Lanny Boyer

Supporting Program(s): NSF, Project eCSite
Project ECSITE Activity: Beginning Electronic Textile Construction

In this activity, students become familiar with the materials, tools, and construction techniques used in the creation of electronic textiles by making bookmarks, bracelets, or pins that light up. Several student helpers are trained in advance to facilitate this circuit design activity and then lead small groups on the main project day. Students also gain experience working with fabric and conductive thread so that they will have the skills needed for the costume construction activity that follows.

Subject Areas: computer science, performing arts, physical science

Associated Unit: Electronic Textile Techniques for Costume Design

Activity Dependencies: N/A

Grade Level: 9–12, but could be adapted for 6–8

Time Required: 3 class sessions

Group Size: 6 students (1 helper, 5 additional students)

Smaller groups are acceptable, and are recommended when adapting this activity for middle school students.

Expendable Cost per Group: US$13.50 (does not include shipping or spare parts)

This cost assumes 6 students per group, bulk purchases, and academic pricing, where available. See details in the Materials section, below.

Keywords: battery, circuit, component, conductive material, e-textiles, electronic textiles, electronics

Pre-Requisite Knowledge: N/A

Learning Objectives:

After this activity, students should be able to:

- Define the terms circuit, short circuit, series, parallel, trace, switch, and component
- Explain the operation of a simple electrical circuit that uses a battery to light an LED
- Sew with conductive thread
- Design and construct a simple e-textile project such as a bookmark, bracelet, or pin that lights up
Computational Thinking Connection:

This activity offers students the opportunity to plan and implement a project of their own choosing within a set of constraints. The planning process provides experience with problem decomposition, while implementation involves following procedures. Using these important computational thinking skills allows students to complete these and other projects successfully. In addition, understanding how circuits work is relevant to the field of computing.

Materials List:

The prices shown were accurate as of February 2014 for bulk purchases with academic pricing, where available.

Per Group, expendable:

- Coin Cell Battery Holder - 20mm (Sewable), $1.00 / 1
  https://www.sparkfun.com/products/8822
  $6.00 per group of 6 (6 holders)
- CR2032 Lithium Coin Cell Battery, $0.28 / 1
  $1.70 per group of 6 (6 batteries)
- LED - Assorted (20 pack), $2.36 / 20
  https://www.sparkfun.com/products/12062
  $0.71 per group of 6 (6 LEDs)
- Conductive Thread (Thin) - 50', $7.16 / 50'
  https://www.sparkfun.com/products/10118
  $3.58 per group of 6 (25')
- Snap Assortment - 30 pack, $2.95 / 15 pairs
  https://www.sparkfun.com/products/11347
  $0.50 per group of 6 (3 pairs of snaps — not all students will want to use them)
- Craft felt, plain, $0.25 / 1
  Hobby Lobby
  $0.50 per group of 6 (2 pieces)
- Craft felt, patterned, $0.50 / 1
  Hobby Lobby
  $0.50 per group of 6 (1 piece)

Per Group, reusable:

- Dritz Embroidery Hand Needles Size 7, $2.49 / 16
  Jo-Ann Fabric and Craft
  $0.93 per group of 6 (6 needles)
Per Class, reusable:

- Dritz Needle Threaders, $1.99 / 3
  Jo-Ann Fabric and Craft
  $3.98 per class (6 threaders)

- See the first page of the project guide for additional materials, tools, and supplies that are typically available at school or that can be brought from home if desired.

Introduction/Motivation:

Have you seen costumes that light up, and wondered how they work? [discussion] We’re going to be learning about the techniques used to build such costumes by creating small projects made from felt, batteries, and LEDs.

Vocabulary Definitions:

Component: A part attached to a circuit, such as an LED

Series: A circuit with components connected in such a way that electricity flows through them sequentially

Parallel: A circuit with components connected in such a way that electricity flows through them simultaneously

See the project guide for definitions of the following terms: circuit, short circuit, trace, and switch

Procedure:

Before the Activity/Setup

1. Purchase materials (including enough for the teacher and any non-student helpers) and create sets for each group, including the student helper group. See the Other Notes section below for tips. Also gather other necessary materials, tools, and supplies (see the first page of the project guide).

2. To become familiar with the project and the guide (link below), follow the instructions to make a sample of one of the items in the guide (wristband suggested).

3. Have project guide sets available for each group, including the student helper group (in session 2, every student should receive a guide). Also make one copy of the troubleshooting sheet (see the Other Notes section below) for each group.

4. Review the videos listed under the “Sewing” heading, as well as the video entitled “Twisting leads to make components sewable,” in the “Get advice on how to do something” link mentioned below.

5. If desired, engage a volunteer (not a student in the class) to take photos or videos on the day of the project.
With the Students, session 1: Introduction

1. Following the introduction described above, pass around a sample project and show how it works. If there is any student work available (or photos/videos) from a previous implementation of the project, show students this material as well. Use this activity as an opportunity to introduce the vocabulary.

2. Ask for student volunteers who will learn to become helpers in the next session. There should be one helper for every 5 remaining students.

3. Provide students with a list of any materials, tools, and/or supplies that they should bring to class for this project.
   Note that this content is unlikely to take an entire class period.

With the Students, session 2: Student helper training

1. Based on your own experience with the guide and the project, go over the project guide with the student helpers. The goal is for the helpers to feel comfortable with concepts relating to circuits and components, as well as how to construct a project.
   At this point in the training, expect that the helpers should be interested and have a general understanding of what the guide covers. Point out that they will become mentors to their groups, so they should be aware of how to go over the guide with other students. Also let them know that they should make an effort to have a thorough grasp of the material in the guide by the end of the training.

2. Make the materials, tools, and supplies available to the helpers.

3. Show any videos that seem necessary for skill instruction (or conduct a personal demonstration), and have the helpers practice these skills. Continue this process during the next step, as needed.

4. Assist helpers to select, plan, and construct one of the items in the guide, modeling how you want them to behave while assisting their groups. As needed, point out material in the guide that is helpful for moving forward or solving problems.

5. Review the project guide and answer any remaining questions about the guide, project, or role as a helper. The helpers should understand how the next session will be conducted and their specific responsibilities. Plan to incorporate any suggestions offered by the helpers for how to make the project session go smoothly.

With the Students, session 3: Project construction

1. Divide the class, aside from the helpers, into groups of 5. Assign a helper to each group.

2. Make the sets of materials, tools, supplies, and project guides available to the helpers.

3. Ask the helpers to go over the guides with their groups, but not to hand out anything else.

4. Show any videos that seem necessary for skill instruction (or have helpers conduct a personal demonstration), and ask the helpers to assist the students in their groups to practice these skills. Continue this process during the next step, as needed.
5. The helpers should assist the students in their groups to select, plan, and construct one of the items in the guide. As needed, they should point out material in the guide that is helpful for moving forward or solving problems. Plan to circulate during this activity, providing assistance as needed.

6. Have students show their projects to others.

7. Ask students to assist with cleanup!

Safety Issues:
Coin cell batteries that short circuit become quite warm to the touch very quickly.

Attachments:
An Electronic Textiles / Soft Circuits Project for Beginners

Links:
At http://fairview-electronic-textiles.wikispaces.com/home, see the following links:

- Open the beginner project guide used in class (“An Electronic Textiles / Soft Circuits Project for Beginners”)
- Get advice on how to do something

*Getting hands-on with soft circuits: A workshop facilitator’s guide*


Suppliers
- https://www.sparkfun.com
- http://www.adafruit.com
- http://www.digikey.com
- See also the links shown in the Materials section, above

Troubleshooting:
See the troubleshooting sheet (discussed in the Other Notes section below).

Assessment:
Can the students be heard using the vocabulary listed for this activity? Were they able to construct circuits that work?

Closure:
Discuss any remaining questions relating to the project, such as on circuits, components, and e-textiles.

Ask students how their views on light-up costumes have changed.
Other Notes:

Materials, tools, and supplies

• When planning the project, be aware of shipping costs and times.

• Order extra batteries, as some may be lost to short circuits, and additional batteries may be useful for the next activity (Costume Design Using Electronic Textile Techniques). Note that the online price for batteries ($0.28) is significantly lower than prices in local stores ($2.00 and up).

• If using needles other than those suggested in the list of materials, choose ones with eyes large enough to handle conductive thread, but not so large that they will not fit through the contacts in the coin cell holders.

• It is somewhat difficult to thread a needle with conductive thread. Consider providing threaded needles to the students (enlist a volunteer to assist with this activity). Needle threaders can be helpful, but they break easily unless a firm grip is used.

Procedure

• A good troubleshooting sheet for groups can be found in *Getting hands-on with soft circuits: A workshop facilitator's guide*, page 22 (link above).

• Do not plan to lead a group. Instead, circulate to respond to questions, deal with supply issues, etc.

References Used: See the last page of the project guide.

Contributors: Hilarie Nickerson, Lanny Boyer

Supporting Program(s): NSF, Project eCSite
Project ECSITE Activity: Costume Design Using Electronic Textile Techniques

Students who have previously gained familiarity with electronic textile techniques have the opportunity to apply them in this activity by designing and creating costumes that incorporate electronic and/or electrically-powered elements. As an extension activity, students may choose to incorporate microcontrollers into these costumes. Following the introduction to the unit, in which students learn about possible e-textile costume elements, they work in small groups to develop a costume design and budget. Once the students have completed their costumes, the groups work together to plan, rehearse, and deliver a performance to showcase them.

**Subject Areas:** computer science, performing arts, physical science

**Associated Unit:** Electronic Textile Techniques for Costume Design

**Activity Dependencies:** Beginning Electronic Textile Construction

**Grade Level:** 9–12, but could be adapted for 6–8

**Time Required:** 9+ class sessions

**Group Size:** 2–4 students

**Expendable Cost per Group:** US$15–50 for electrical / circuit construction elements

Project budgets will vary based on complexity. Depending on the source of additional costume elements, further costs may be incurred either by the school or by group members.

**Keywords:** battery, circuit, component, conductive material, costume, e-textiles, electroluminescence, electronic textiles, electronics, microcontroller

**Pre-Requisite Knowledge:**

Knowledge gained from the first activity in this unit (Beginning Electronic Textile Construction)

**Learning Objectives:**

After this activity, students should be able to:

- Plan a costume project with design, construction, and performance phases
- Design and construct a costume that incorporates electronic and/or electrically-powered elements
- Develop a project specification that includes a parts list and budget
- Optionally, work with microcontrollers
Computational Thinking Connection:

Here students build on their experience with two computational thinking skills that are emphasized in the first activity, problem decomposition and following procedures. This activity offers new level of complexity in those areas, in that students are specifying their own costume design projects and the steps necessary for completion require significant thought. Those students who choose to work with microcontrollers have the opportunity to apply these constructs in an additional way as they program. Additionally, working in groups means that each member is responsible for a different aspect of the project. Performing tasks in parallel introduces another computational thinking construct.

Materials List:

Materials are highly dependent on student design choices. For typical materials, see the “Find project components” link mentioned below. Electroluminescent (EL) wire is a popular choice.

Introduction/Motivation:

Over the next few weeks, you'll have the opportunity to build on your skills with creating electronic textiles by designing and constructing costumes in groups. At the end we’ll invite other classes to watch you perform in your costumes.

Vocabulary Definitions:

For the extension activity:

**Microcontroller:** A tiny computer that can be embedded in an object (such as a thermostat or vehicle) to help control it

**Sensor:** A component that can detect a physical property in its environment (such as temperature) and send a signal that carries information about this property

**Actuator:** A component that can respond to a signal by doing something (such as moving or emitting a sound)

Procedure:

*Before the Activity/Setup*

1. Find websites or other sources that have costumes of interest to show to the students for discussion.
2. From the “Look at some sample projects that use LEDs and EL wire” links below, identify specific sample projects to show to the students for project inspiration.
3. If familiar with the use of microcontrollers and desiring to conduct the extension activity, find suitable instructional videos and/or order supplies to create a sample project (e.g., from SparkFun and/or Adafruit, links below).
4. Have a budget in mind for funding student projects, including a little extra for replacement parts (see the Other Notes section, below).
With the Students, phase 1: Introduction (1–2 sessions)

1. Show and discuss costumes of interest. How do the students think they operate? If students have ideas about other costumes to look at, ask them to share this information with the class.

2. Show and discuss sample projects. Which ones interest the students? What ideas of their own do students have after seeing them?

3. If conducting the extension activity, show material relating to the use of microcontrollers. Allow extra time for students to learn and experiment.

With the Students, phase 2: Planning (2–3 sessions)

1. Ask students to form groups of 2–4 (group size will depend on the overall budget and the potential cost per group).

2. Announce any budget restrictions.

3. Ask groups to use the links below (and links relating to microcontroller projects, if desired) to learn more about sample projects and potential costs, using these as inspiration and information for their own costume designs.

4. Ask groups to put together costume proposals (typically 1 or 2 costumes per group) that list specific parts / components with sources and costs. Groups should also include information about their intended performance in the proposal.

5. Review the proposals and ask for modifications, as needed, to improve the design and/or stay within the budget assigned to the group. The modified proposals become the design specifications for the next phase.

With the Students, phase 3: Construction (3+ sessions)

1. Obtain costume construction materials and supplies based on the design specifications.

2. Ask the students to plan the construction of their costumes. What responsibilities will each group member have? How long will the construction process take?

3. Students follow through on their costume construction plans.

With the Students, phase 4: Rehearsal (2–3 sessions)

1. Work with each group to refine performance plans.

2. Conduct one or more whole class rehearsals without costumes.

3. Conduct a dress rehearsal.

4. Issue invitations to the performance to other classes, parents, and other interested parties.

With the Students, phase 5: Performance (1 session)

1. Perform and celebrate!
Safety Issues:

Coin cell batteries that short circuit become quite warm to the touch very quickly.

Students should be aware of safety procedures for using hand or machine tools needed for costume construction, as well as for using art supplies.

Attachments: N/A

Links:

At http://fairview-electronic-textiles.wikispaces.com/home, see the following links:

• Look at some sample projects that use LEDs and EL wire
• Find project components

Suppliers / microcontroller information

• https://www.sparkfun.com
• http://www.adafruit.com

Troubleshooting:

Be aware of troubleshooting material from the Electronic Textile Techniques for Costume Design activity

Activity Extensions:

Instructors who are familiar with the use of microcontrollers may desire to allow interested students to create costumes that incorporate sensors and actuators. For example, sensors could be used to detect when two costumes are in proximity, triggering a lighting effect under programmatic control. Both SparkFun and Adafruit offer microcontrollers that are specifically designed for e-textile projects. Even students with no prior programming experience can successfully complete simple projects with proper scaffolding; however, instructors should be aware of the additional time and costs involved.

Closure:

Ask students to discuss their experiences during the project, including what they learned about working with e-textiles and conducting a group project.

Other Notes:

Materials, tools, and supplies

• Cable ties can be used to attach EL wire to costumes.
• When ordering EL wire, also order the appropriate number of inverters (and batteries). For a given costume, an inverter can power up to two segments of EL wire with reasonable brightness.
• If possible, order backups for common supplies. Rehearsals are hard on costumes!
Procedure

• A break between the planning and construction phases is helpful because of the need to obtain supplies specific to each group’s project.

• Emphasize process over product. Students will find that working with LEDs is more difficult than working with EL wire, and their efforts should be praised even if the results are not spectacular.

• Some students may feel reluctant about performing, since it is a technical theatre class and not an acting class.

• The first rehearsal in which students see costumes created by other groups in action is an uplifting experience for all.

References Used: See the websites listed above.

Contributors: Hilarie Nickerson, Lanny Boyer

Supporting Program(s): NSF, Project eCSite