Art and Science Integration
Sewn Circuits
Social Studies, Science, Engineering and Art Integration

Grades 4-6 GT Students Designer: Georgina Grenier

What do we do?

Students learn the steps of designing and creating a product from scratch using traditional sewing techniques with electrically conductive thread, art materials, sewable LEDs, fabric, and Japanese paper as their media. They were asked to create either a toy or a sculpture that would be given as a gift, or an educational model that is linked to the social history of the 1960s decade. Assigning a purpose to the product shifts the nature of the work the students do from being a series of exercises about electricity to a process that integrates art, science, and social studies. The effectiveness of their product is dependent on utilizing new knowledge, and combining aesthetics, and the creative process with engineering. These are domains that are often taught separately, but when unified, boost each other and deepen learning.

Accessibility Considerations:

This unit was taught to academically and/or artistically gifted students in grades 4-6.
These students are typically able to comprehend and work with standards at or above grade level. Adaptations of final products containing conductive thread circuits and LEDs were designed to suit the needs of various groups: GT art students created illuminated and altered shoe sculptures, 4th graders created illuminated world globes to highlight at-risk biomes, and Gonks (soft toys from the 1960s) were created with flashing eyes by 5th and 6th graders in an engineering project. All wiring layouts were derived from a basic template (see resources). These students had no prior experience with electricity, circuit building, or hand sewing.

The unit was taught in 3 different schools. Therefore, portability of supplies was necessary, as well as sufficient space and time to complete the project over two months. We met for 60 minutes once a week in grade level pull-out groups. This design project integrates challenges in engineering, metacognitive awareness of systems and utilizes students' aesthetic sense as they create an intermedial art object.
The groups contained three students with I.E.Ps, one of whom had physical challenge with fine motor tasks.

Stage 1 Desired Results

Established Goals/Standards:

From Maine Learning Results:

Learning goals described here span 4 grade levels because we teach groups of students who need individualized and advanced material from 4th through 8th grade.

Science MLRs

A1
Unifying Themes

Grades 3-5

Students explain interactions between parts that make up whole man-made and natural things.

a. Give examples that show how individual parts of organisms, ecosystems, or man-made structures can influence one another. Explain ways that things including organisms, ecosystems, or man-made structures may not work as well (or at all) if a part is missing, broken, worn out, mismatched, or misconnected.

a. Represent the features of a real object, event, or process using models including geometric figures, number sequences, graphs, diagrams, sketches, maps, or three-dimensional figures and note ways in which those representations do (and do not) match features of the originals.

Grades 6-8

Describe and apply principles of systems in man-made things, natural things, and processes.

a. Explain how individual parts working together in a system (including organisms, Earth systems, solar systems, or man-made structures) can do more than each part individually.

b. Explain how the output of one part of a system, including waste products from manufacturing or organisms, can become the input of another part of a system. Describe how systems are nested and that systems may be thought of as containing subsystems (as well as being a subsystem of a larger system) and apply the understanding to analyze systems.

A2
Models

Students use models to represent objects, processes and events from the physical setting, the living environment and the technological world.

Grades 3-5

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a. Represent the features of a real object, event, or process using models including geometric figures, number sequences, graphs, diagrams, sketches, maps, or three-dimensional figures and note ways in which those representations do (and do not) match features of the originals.

Grades 6-8

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a. Represent the features of a real object, event, or process using models including geometric figures, number sequences, graphs, diagrams, sketches, maps, or three-dimensional figures and note ways in which those representations do (and do not) match features of the originals.

B2 **The Skills and Traits of Scientific Inquiry and Technological Design:** *Students plan, conduct, analyze data from and communicate results of in-depth scientific investigations; and they use a systematic process, tools, equipment, and a variety of materials to create a technological design and produce a solution or product to meet a specified need.*	**Grades 3-5** Students use a design process, simple tools, and a variety of materials to solve a problem or create a product, recognizing the constraints that need to be considered. a. Identify and explain a simple design problem and a solution related to the problem. b. Propose a solution to a design problem that recognizes constraints including cost, materials, time, space, or safety. c. Use appropriate tools, materials, safe techniques, and quantitative measurements to implement a proposed solution to a design problem. d. Balance simple constraints in carrying out a proposed solution to a design problem. e. Evaluate their own design results, as well as those of others, using established criteria. f. Modify designs based on results of evaluations. Present the design problem, process, and design or solution using oral, written, and/or pictures	**Grades 6-8** Students use a systematic process, tools, equipment, and a variety of materials to design and produce a solution or product to meet a specified need, using established criteria. a. Identify appropriate problems for technological design. b. Design a solution or product. c. Communicate a proposed design using drawings and simple models. d. Implement a proposed design. e. Evaluate a completed design or product. f. Suggest improvements for their own and others' designs and try out proposed modifications. g. Explain the design process including the stages of problem identification, solution design, implementation, and evaluation.

Art MLRs

C. **Creative Problem-Solving: Students approach artistic problem solving using multiple solutions and the creative process.**	**C1** **Grades 3-5** Students describe and apply steps of creative problem-solving. a. Identify problem. b. Define problem. c. Generate a variety of solutions. d. Implement solution(s). e. Evaluate solution(s).	**Grades 6-8** Students describe and apply creative-thinking skills that are part of the creative problem-solving process. a. Fluency b. Flexibility c. Elaboration d. Originality e. Analysis
D. **Aesthetics and Criticism: Students describe analyze, interpret, and evaluate art (dance, music, theatre, and visual arts).**	**D1.** **Grades 3-5** **Students compare and analyze art forms.** a. Describe and compare art forms by applying grade span appropriate arts concepts, terminology, skills, and processes as referenced in Standard A: Disciplinary Literacy. b. Ask questions about an art form to further understand the concepts, skills, and processes used to create/perform the work of art. c. Explain purposes for making art in different times and places, including cultural traditions, personal expression, and communication of beliefs.	**D1.** **Grades 5-8** **Students compare and analyze art forms.** a. Compare and analyze art forms by applying grade span appropriate concepts, vocabulary, skills, and processes as referenced in Standard A: Disciplinary Literacy. b. Compare the quality and effectiveness of art works using multiple criteria from observations, print and/or non-print resources. c. Compare the effectiveness of selected media, techniques, and processes in communicating ideas. d. Explain and compare different purposes of artists and art work in the context of time and place.

E2

The Arts and Other Disciplines

Grades 3-5
Students describe characteristics shared between and among the arts and other disciplines.

Grades 6-8
Students explain skills and concepts that are similar across disciplines.

Understandings:

- Artistic and scientific processes are analogous across disciplines and domains.
- Successful artistic outcomes may be the result of subjective process, whereas scientific outcomes have clearly defined criteria for success. Both are rigorous.
- Knowledge can be obtained by experimenting with a medium, DC electric circuits for example, to see what is effective and successful. Understanding how an art medium works is also a form of knowledge.
- Skill building and practice matters. It can be built up, contributing to a more successful outcome.
- Electricity needs a circuit to flow around: any gaps and it won't flow.
- The steps of a creative or investigative process
- Drawing is a tool that can be used for many purposes: recording ideas, solving problems, documenting a process and many more.

Essential Questions:

- What are the similarities and difference between artistic and scientific investigations?
- How does tinkering, making, and experimenting with a medium help me learn?
- Will practice and experience help me do my most successful work?
- What are the essential needs for viable electric circuits?
- What do I need to do to get my project completed?
- How can drawing be used to help my design process?

Students will know… (knowledge)	Students will be able to … (action)
• Scientists and artists use a similar experimental process in their work. • Artistic and scientific vocabulary relating to this project • Careful hand-work and purposeful choices contribute to success in circuit-building as well as making an aesthetically effective product. • Aesthetic choices for design must be researched in terms of best medium to use, level of expertise etc., if they are to be successfully applied. • How to create an electric circuit that contains an LED, battery, switch and pre-programmed circuit board. • Sketching can help clarify ideas when designing.	• Use a process of inquiry: an idea to begin, followed by testing, analyzing and prototyping to achieve their goal • Use their expertise and knowledge to create functional sewn circuits, use new media such as conductive paint and metallic foil to create an aesthetically and effectively engineered product. • Use scientific and artistic vocabulary to self-assess their work. • Make fair tests of circuits, media and design • Create a functioning electric circuit that contains LEDs, battery, switch and pre-programmed circuit board and apply it to a 3D form. • Plan the design of their gonk or other object using sketches to clarify ideas at each step.

Formative Assessment:

- Pre- test quiz of electricity basics that are essential for this unit: we created a 10 question multiple choice quiz to pinpoint specific knowledge and used student success in it to guide instruction.

- Observation of students working with needle-point fabric, needles and cotton thread to assess student ability to sew. Some students with sewing skills helped those that were unsure, allowing teachers to work with students who have significant difficulty.

- Observation of student willingness to problem solve. Given aluminum foil and two 1.5 volt AA batteries and an LED, how can they light up the LED? Students who were confident risk takers experimented freely, while others waited to be given instructions about the right way to proceed. For some students, not knowing exactly what to do was frightening. Students shared successful methods by demonstrating them and describing how they approached trial and error experimenting. Emphasizing the value of mistake-making, persistence and humor was helpful to students as they grappled with the practicalities of making a final product

Summative Assessment:

- Using a set of labelled cards (see resources), students consider the steps of their design process and identify the order their process occurred in, whether it contained phases that needed repetition e.g. reflecting and re-forming to learn from experience and/or altering the aesthetic aspects of their design.

- Students are able to role play arranging themselves in parallel and series circuits functioning as any component: wire, LED, switch, circuit board, or battery. Tableaux are created to physically represent current, shorts, re-making, energy, pollution.

C <u>Creative Problem-Solving</u>: Theater. Students approach artistic problem solving using multiple solutions and the creative process. **Grades 3-5** Students describe and apply steps of creative problem solving. a. Identify problem. b. Define problem. c. Generate a variety of solutions. d. Implement solution(s). e. Evaluate solution(s).	**C <u>Creative Problem-Solving</u>: Theater. Students approach artistic problem solving using multiple solutions and the creative process.** **Grades 6-8** Students describe and apply creative-thinking skills that are part of the creative problem-solving process. a. Fluency b. Flexibility c. Elaboration d. Originality e. Analysis

- Students complete a five page “Crucial Moments” creative essay prompt in which they use drawings and words to describe five crucial moments in the creation of their product. The word “Crucial” may be changed by the student to a word of their choice (catastrophic, epiphany, Eureka! etc)
  See Learning Plan for results of this. Refer to Art and Theater MLRs for standards incorporating creative process.

- Oral presentation using new vocabulary of how the product was made, together with final product completed that displays aesthetic design, craftsmanship and functioning technology components with explanation of how technology is incorporated and functions in the product, and reasons for choice of design.

Learning Plan

This unit was taught to students in 4th -6th grade in a gifted and talented program. It was necessary to differentiate instruction for students who progress quickly, even within this group of rapid learners, therefore a broad range of Maine Learning Results science and visual arts standards from 3rd through 8th grade are included in the established goals section of the unit. Traits of gifted and talented learners are taken into account in the delivery of instruction such as the occurrence of perfectionism, rapid assimilation of knowledge, high need for complexity, latitude to explore and apply creative design, and linking concepts across disciplines. A group of our students are gifted but have learning or processing difficulties. For them, attainment can be expressed verbally or without writing for these students who have language, attention of fine motor deficits. Some students are also in our district's GT Visual Art program and this unit gave these students a chance to integrate two paths of learning and work at a very high level and a chance to show how significant creative process can be as a learning tool.

Week One:
50-60 minutes
Goal: Find out how much do students already know about electricity and hook student interest.
We did this by asking students where they think electricity originates and how it gets to their homes to turn on a light. Students created a sketch map to show a hypothetical route from a power generator such as a dam, power station or windmill, to a distributor (the local power station) to power lines, to utility poles along roads, and into homes, to light switches and appliances, power outlets, and computers.
A slide show was prepared to illustrate power lines, power production, sustainable energy sources, problems with power production such as waste from nuclear power60

Points to discuss:
AC current comes from power outlets at 110 Volts and can be lethal. The DC current they will use comes from batteries putting out 3 Volts, too small to cause a shock.

Students had misconceptions about electricity:
It is created by lightning (a correct coincidence!) and it is continual lightning strikes on power lines that supplies electricity to homes.
Electricity is created by friction, and somehow sufficient static electricity is generated that it can jump into a power line and travel to their home. This is correct in a very abstruse way: turbines and windmills spin and generate power by friction. Students link the static electricity from clothing and plastic carpet to power lines.
Electricity reaches appliances such as toasters via a plug, but students have little idea that there are wires within walls to bring electricity to the power outlet. They thought perhaps, that electricity was online, which is almost correct when one considers wifi controlled electric appliances.

Week Two
50-60 minutes
Goal: EXPLORATION
Devices containing electronics such as flashing sneakers, computers and toys are discussed. Students are often aware of clapper light controls, motion detectors and similar gadgets and get to use a toy consisting of a meter attached a headset that measures electricity produced by brain activity. Increased activity produces current that can be sensed and is used to produce a signal that causes a fan to blow air under ping pong ball and lift it. The more current produced, the higher the ball is raised. Students are asked to speculate how this device works, and a connection to electricity in the human body and nerve impulses is made.
Vocabulary and definitions introduced: sensor, actuator, system
EXPERIMENT
Students are asked to arrange themselves into a series circuit that would light an LED with a battery. One student poses as a battery, another as the LED, the rest are wires. Roles can be switched. This process is repeated often as students forget how a circuit needs to be arranged.

Week Three
50-60 minutes
Goal: EXPLORE CONDUCTIVE SUBSTANCES AND MAKE CIRCUITS
A sample of the toy students will make is explored and played with. It contains a pre-programmed circuit board (LilyTiny) that lets the eyes (LEDs) of the toy flash in one of four different ways. The toy is handmade and students become excited about making their own version. Likewise, students making world globes and lampshades are shown possibilities for these designs
All students experiment with conductive thread, coin cell batteries, conductive paint, graphite, conductive marker pens and adhesive copper tape as ways to make LEDs light. For convenience, we have found that the very messy conductive paint is best applied to drafting film and presented dry. Students can cut “wires” from the sheet. Longer wires produce a dimmer glow than short ones. Students ponder why, and experiment with longer length wires and increased number of LEDs which confirms that longer wires cause a heavier drain on the battery which makes things “dimmer”
Non-conductive substances are also available and the differences in structure of non-conductors and conductors are considered.

Week Four
50-60 minutes
Goal: START MAKING A PRODUCT
Making the toy begins by coming to understand the wiring template from Sparkfun. This basic plan can be adapted to fit many objects such as globes or lampshades, a student model of the Berlin Wall model, or illuminated pages of a student-created book.
To be successful in making the toy, or other illuminated item, students need to understand how a basic circuit works. Having students physically form circuits similar to the template helps cement spatial understanding of how and why components must be installed in particular positions or orientations.
Materials to have ready:
Felt for the toy or other items to be illuminated, glue gun and sticks, battery holder with switch, and conductive thread, LEDs, scissors, needles with large eyes, stuffing, regular cotton thread, decorative items such as sequins, lace etc,

Which LEDs? We used Lilypad LEDs purchased from Sparkfun. These are intended to be sewn into fabric and have large eye[illegible]e of thread. LEDs with metal legs are cheaper but much harder to use.

LilyPad LED

Battery holder with switch

Weeks Five to Seven
Goal: Make items
Most students choose to make soft toys or add lights to lamp shades, but a few chose to build their own projects.
In this phase, students researched information to incorporate in their own projects e.g. the building and eventual destruction of the Berlin Wall, writing a short story to turn into a hand- made book, locating biomes on the world globe (a transformed lamp shade) where animals are at risk.
Students had difficulty sewing. They found it difficult to anchor one end of a length of thread so it would not come undone and needed frequent demonstrations of how to do it. Students had little to no understanding of how big stitches should be, or where they should go. Several students stitched into their

pant leg by mistake, sewed their toy shut, did not understand that stitches (running stitch) go in a line or that the thread should not loop around the edge of the fabric. Students needed to develop spatial awareness of inside and outside an object, above and below a surface and the need to keep neatness and artwork on the viewed side, and electrical tape, knots and mess-ups on the inside where it could not be seen.

We supplied many items such as multi-colored fuzzy wool, lace, hats, sequins, metallic sharpies etc to add to designs.

Each week we looked at ways that artists used technology to create their work and reiterated the steps of the creative process. We often reminded students that becoming skilled requires practice. Learning from mistakes, revising designs, developing sufficient expertise to be able to make decisions rather than having to follow the easiest path are all situations that designers experience. For these students, overcoming frustration because of their perceived lack of success was a huge step. As they became more skilled, more innovative designs began to appear.

Art Connections

This unit does not make an art object specifically, but utilizes creative process, thought and research that cross cut disciplines. It explores the design process, from the spark of an idea to finished product to bring about understanding that utilitarian engineering design and aesthetic design are not so far apart. Incorporating a personal, emotional, empathetic response as a factor in an engineering design boosts effectiveness. Incorporating effective structural design, likewise, boosts the effectiveness of an artwork. The product students make is based on their own research involving hands on experiments with media to obtain a desired outcome, and acquiring knowledge about how technology works. Artist researchers and science researchers both do this. Direct experience of cause and effect due to quality of work or poorly conceived ideas helps students understand that even though technology is ubiquitous and sometimes seems invisible, human fabrication skills and design are still vital for success. To put it in yet another way! Objective science knowledge discovered by the students through experimentation is combined with subjective design (also using experimentation) as a means of creating richer, deeper learning.

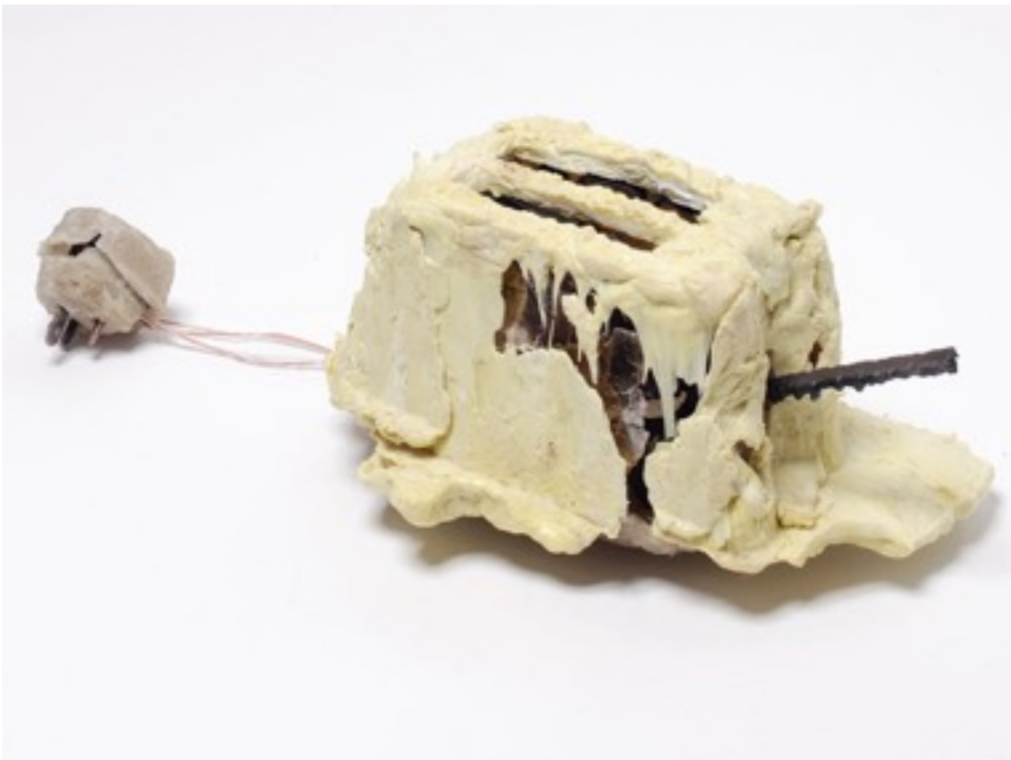
Students look at the work of artists who use technology as major part of creating their work:

Janet Echelman, 2010 who engineered an intricately knotted hanging sculpture “1.26” based on the seismic wave forms of a Chilean earth quake that shortened our day by 1.26 micro seconds
https://en.wikipedia.org/wiki/1.26

Her TED talk: Janet Echelman TED Talk & Lectures - Janet Echelman

Thomas Thwaites who built a toaster from scratch using his best effort to duplicate scientific knowledge and engineering. It takes a civilization to build a toaster, he found.
http://www.thomasthwaites.com

Thomas Thwaites: How I built a toaster -- from scratch | TED Talk | TED ...
https://www.**ted**.com/**talks**/thomas_thwaites_how_i_built_a_**toaster**_from_scratch?...en

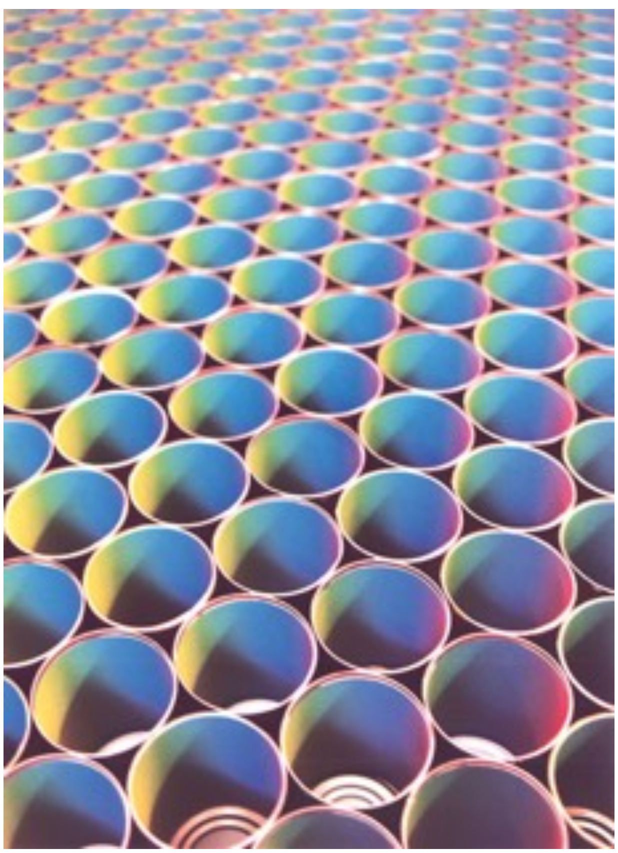


Thomas Thwaites has also explored life as a goat by attaching four goat-like hydraulic legs to his own arms and legs and walking on all fours for a while, the future of money, and chairs that convey a sense of authority in response to active body movements.

James Turrell, artist who creates installations using colored light and natural light given entry through openings in sculpted viewing rooms.

Seeing the Light

For his fervent private collectors, James Turrell?s celestial sky-spaces are an exercise in blind faith. The temperamental artist regards them as test runs for his life?s work in the Arizona desert.
http://nyti.ms/10dRI8p



Amy Stacy-Curtis, Maine artist who creates installations involving mathematical relationships, memories and physical properties such as light

http://www.amystaceycurtis.com/modulationIdetail.html

Amy Stacey Curtis will be having her 9th and final biennial show at the Bates Mill, Lewiston in Fall 2016.

3D Projection mapping: projecting an image onto a building or interior by carefully measuring the surface on which the image will shine, and fitting the image to that shape. This is George Harrison’s house in London.

The Sydney Opera House, Australia, in daylight before projection mapping:

VIDEO:
http://www.digitaltrends.com/cool-tech/sydney-opera-house-projection-mapping/#:rEBcHcapOaDrGA

At night, a video still from projection mapping video
https://upload.wikimedia.org/wikipedia/commons/d/d5/Vivid_Sydney_-_Opera_House_sails_(9003649346).jpg

E-Textile Images

Clare Danes' E-textile gala dress video

http://www.cnn.com/videos/entertainment/2016/05/03/met-gala-light-up-gowns-jeanne-moos-pkg-erin.cnn

https://i.ytimg.com/vi/o91f2wmpJRQ/maxresdefault.jpg

Smart Wearables:

Right now wearable technology has found its best use in the sport, fitness, wellness and medical industries (special monitors may be used for tracking all the vital body metrics) but creative solutions may influence the creation of casual clothing (there are already substances, which can make clothing repel water, dust and other pollutants).

https://www.youtube.com/watch?v=o91f2wmpJRQ

Intelligent Textiles:

TED Talk on YouTube

Published on Dec 4, 2014

This talk was given at a local TEDx event, produced independently of the TED Conferences. Textile "alchemist" Lauren Bowker has created an ink that changes color based on the environment. She impregnates her dye into fabric and feathers, then constructs clothing and sculpture that reacts to chemicals in the atmosphere.

https://www.youtube.com/watch?v=_gAaNQZwGtY

Resources for Sewn Circuits Art integration Unit

Artists:
James Turrell, light installations
http://jamesturrell.com

Amy Stacey-Curtis, nine biennial exhibitions throughout Maine
http://www.amystaceycurtis.com/

Janet Echelman, knotted, hanging sculptures
http://www.echelman.com/

Thomas Thwaites, building a toaster from scratch TED Talk:
https://www.ted.com/talks/thomas_thwaites_how_i_built_a_toaster_from_scratch?language=en

Supplies

Sparkfun
https://www.sparkfun.com/

Conductive thread
LilyPad LEDs
LilyPad circuit boards
Conductive adhesive copper tape,
Conductive paint
Conductive ink pens
Battery holders with switch (available without switch also) and coin cell batteries
LilyTiny circuit boards pre-programmed to control type of light flash: blink, slow pulse, heart beat, and firefly random flicker
Many other components can be found on this website.

Tutorial for creating a felt monster (gonk):
https://learn.sparkfun.com/tutorials/lilytiny-plush-monster
All supplies are listed on this webpage, but it is not necessary to purchase all of them as a kit as suggested.

Books
Sew Electric $27.96
https://www.sparkfun.com/products/12019

Short Circuits: Crafting e-Puppets with DIY Electronics $23.96
https://www.sparkfun.com/products/13090

Sewing needles with large eyes, Cotton thread, felt and monster stuffing: Walmart, Amazon, JoAnne's Fabrics etc

Globe-shaped paper lamp shades:
Amazon

http://www.amazon.com/LIHAO-White-Round-Paper-Lanterns/dp/B00S64JSXM/ref=sr_1_21?ie=UTF8&qid=1458661379&sr=8-21&keywords=paper+lamp+shades
10 pack of 12 inch diameter white paper lamp shades for embellishing or turning into world globes.

IDEO Design Thinking:
https://www.ideo.com/work/toolkit-for-educators

Resource for educators looking for ways to incorporate the design process in their curriculum.

DonorsChoose

We submitted two grant proposals to DonorsChoose for purchase of the materials for this project. Thank you to parents, total strangers and Chevron who helped fund us.