

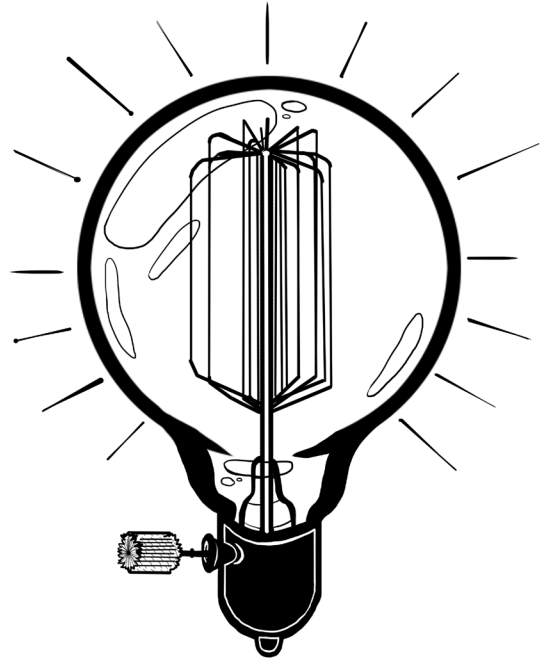


# PAPER CIRCUITRY

HACK YOUR NOTEBOOK  
*and*  
ILLUMINATE YOUR THINKING



WHAT IF YOUR NOTEBOOK  
HAD A LIGHTBULB MOMENT?



# STEAM-POWERED LEARNING

(STEM + THE ARTS = STEAM)

113th CONGRESS

1st Session

H. RES. 51

February 4, 2013

## — RESOLUTION —

Expressing the sense of the House of Representatives that adding art and design into Federal programs that target the Science, Technology, Engineering, and Mathematics (STEM) fields encourages innovation and economic growth in the United States.<sup>1</sup>

Whereas the innovative practices of art and design play an essential role in improving Science, Technology, Engineering, and Mathematics (STEM) education and advancing STEM research;

## EXPERTISE TECHNICAL | EXPRESSIVE

“In 1970 the top three skills required by the Fortune 500 were the three Rs: reading, writing, and arithmetic. In 1999 the top three skills in demand were teamwork, problem-solving, and interpersonal skills. We need schools that are developing these skills.”

—Linda Darling Hammond<sup>2</sup>

“There is no greater manifestation of integrity, no greater goal achieved, than an idea articulately expressed through something made with your hands. We call this constant dialogue between eye, mind and hand “critical thinking – critical making.” It’s an education in getting your hands dirty, in understanding why you made what you made and owning the impact of that work in the world. It’s what artists and designers do.”

—John Maeda, President, RISD<sup>3</sup>

“99% of surveyed school superintendents and 97% of surveyed employers said that, ‘creativity is of increasing importance in the workplace.’”

—*Ready to Innovate*, The Conference Board<sup>4</sup>

## ENGLISH LANGUAGE ARTS

“[The CCSS ELA standards] actively seek the wide, deep, and thoughtful engagement with high-quality literary and informational texts that builds knowledge, enlarges experience, and broadens worldviews.”<sup>5</sup>

### CCSS.ELA-LITERACY.CCRA.W.3

*see sample panel →*

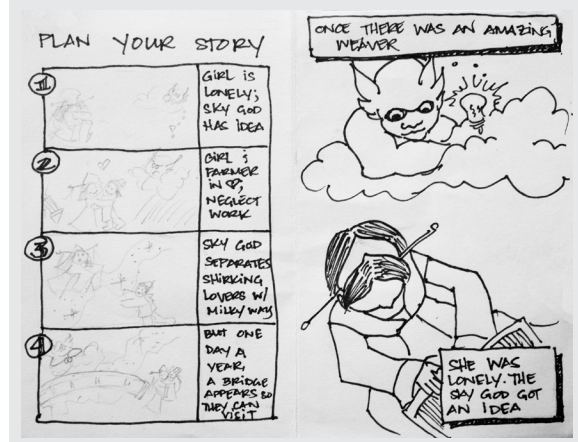
Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences.<sup>6</sup>

## STUDIO HABITS OF MIND<sup>7</sup>

- Develop Craft
- Engage and Persist
- Envision
- Express
- Observe
- Reflect
- Stretch and Explore
- Understand the Art World

### THE HABITS IN ACTION

**Engage and Persist** Things go wrong when making paper electronics. Sometimes connections between the copper tape and the LED aren't perfect and the light flickers. Students must test their designs and troubleshoot the challenges that arise.



A storybook project – a retelling of a Chinese folk tale – organized in sections.

**Stretch and Explore** The images the student envisions may require him or her to learn new electronic concepts. For example, if the student wants a light to blink, then the student will have to experiment and conduct research to add this functionality to the final piece.

## NEXT GENERATION SCIENCE STANDARDS (NGSS)<sup>®</sup>

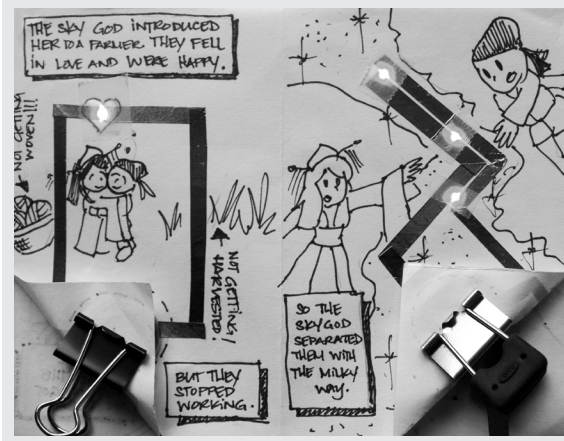
“The NGSS identifies seven crosscutting concepts that bridge disciplinary boundaries, uniting core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the disciplinary core ideas and develop a coherent and scientifically based view of the world.”

### CROSSCUTTING CONCEPTS

- Patterns
- Cause & Effect
- Scale, Proportion, & Quantity
- Systems & Systems Models
- Energy & Matter
- Structure & Function
- Stability & Change

## PERFORMANCE-BASED ASSESSMENTS

“Assessment of student work is a challenge that teachers face across all subjects. These assessments must be fair, consistent, and readily apparent not only to educators and administrators but also to students and parents. Additionally, the challenge of developing fair and consistent assessments is compounded when the assignment



*Two story panels illustrated and illuminated – the storybook as a demonstration of a narrative, visual and electrical system.*

at hand allows students to produce multiple outcomes that are highly creative in their novelty and diversity but each an equally valid solution rather than one uniform, anticipated answer.”

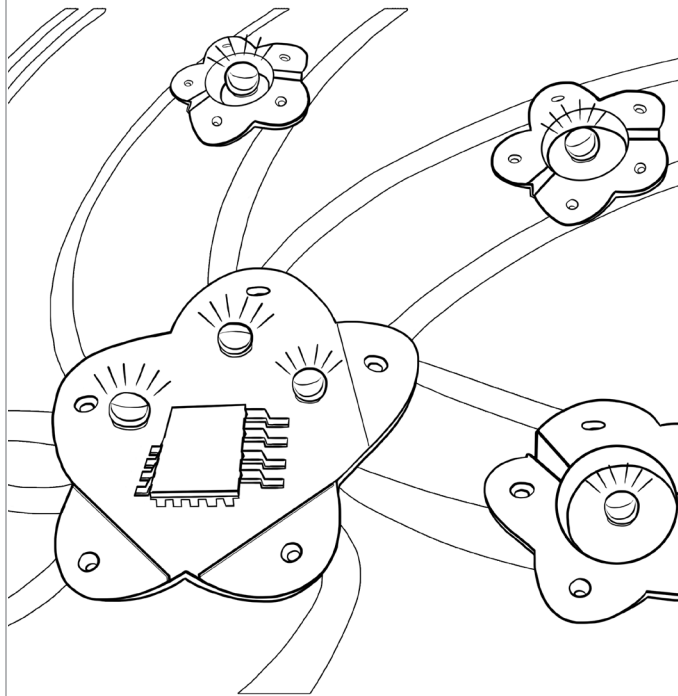
— *The Use of Ideation Effectiveness Metrics as a Quantitative Assessment Tool of Creativity for Open-Ended Engineering Education Assignments*, O’Connell & Shapiro<sup>9</sup>

## A PAPER CIRCUIT AN INTRODUCTION



“My feeling is that if electronics is a medium, the result can be art, can be craft, can be a prototype. It is what the person does with the material that defines the outcome, not the means or the techniques themselves. Paper-based electronics give people the freedom to make that sort of creative statement, if they so desire.”

— Jie Qi<sup>10</sup>

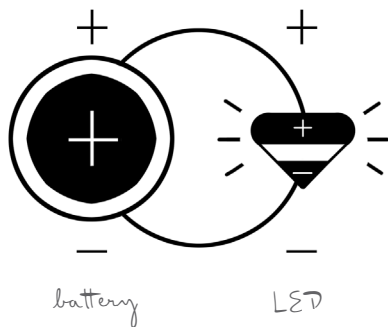


*Information on pages 10–19 is provided courtesy of Jie Qi.*

## A SIMPLE CIRCUIT

To turn on one LED light, we need to connect the battery to the LED in a complete loop, matching the “+” side of the LED sticker to the “+” side of the battery and the “-” point of the sticker to the “-” side of the battery.

This lets electricity flow from the battery through the LED and back to the battery, causing the light to turn on and shine.



You will need:

- 1 LED circuit sticker
- 1 binder clip
- 1 3V coin cell battery
- conductive foil tape

### DIRECTIONS

- 1 Stick conductive foil over the gray lines. 

Note: Fold the foil at turns, so it stays continuous, rather than sticking separate foil pieces together. Sticking creates unreliable connections.

- 2 Stick the LED sticker onto the foil over the footprint.



- 3 Crease the page corner along dotted line and place the battery “+” side up over the “-” circle.



- 4 Fold the corner flap over, and clip the battery in place with a binder clip. The light will turn on!

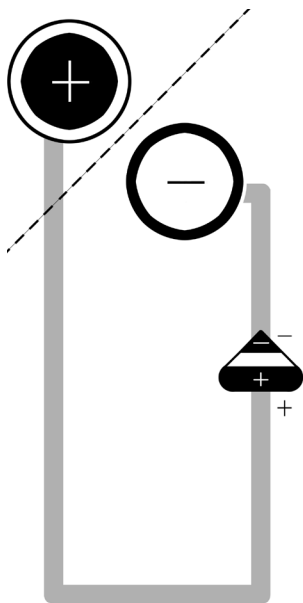


- 5 With the LED on, flip to the next page.

You've turned on the lightbulb!

What does this light illuminate around it? Complete the scene with your own drawings.

## SIMPLE CIRCUIT TEMPLATE



↖  
Fold foil  
at turns.

Leave blank because  
anything here will  
show through to the  
next page when the LED  
is on

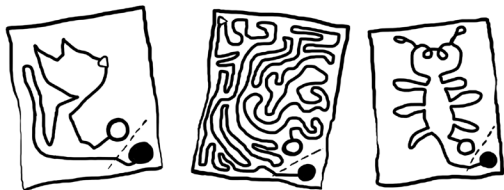




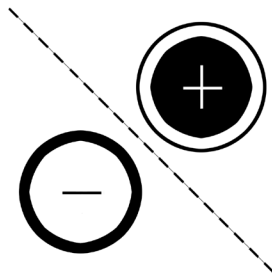
What does the light bulb illuminate?  
Draw it here. ↗

## YOUR TURN

On the blank template, build another circuit that turns on a light.



*Play around with the foil to make different lines and shapes.*



## TRY THIS!

### MAKE A CIRCUIT DRAWING

Using the foil tape in your circuit to create a design. Then decorate your circuit with other craft materials to complete the drawing.



Now that you've learned to make a light shine, here are some more things to try out!



### PLAY WITH LIGHT DIFFUSION

What happens when you put a tissue over the light? How about a piece of fabric? Try diffusing your LED light through different materials.



### EXPERIMENT WITH OTHER CIRCUIT MATERIALS

Can you find other materials to build your circuit? How about aluminum foil or pencil graphite?

The next seven pages present a middle school project – creating a different portion of the night sky. A class breaks into teams, each one creating a portion of the night sky.

How do you go about starting  
a project for yourself?  
For your students?



## NIGHT SKY PROJECT CONCEPT

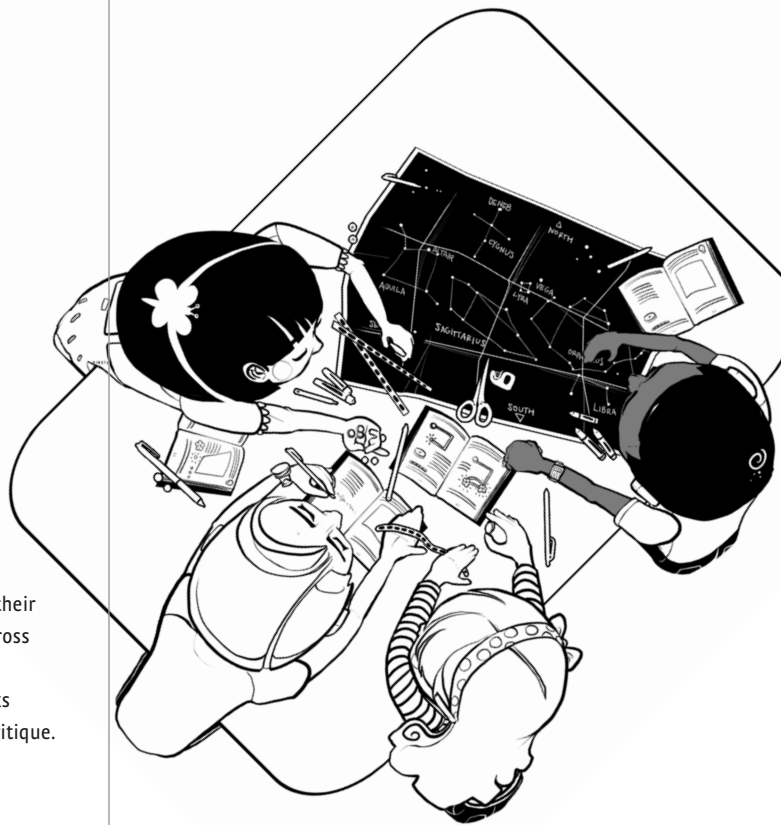
Picture a class exploring constellations and the seasonal night sky. Student groups are tasked with creating a lighted model of a section of a star map using the provided materials and specified design constraints. In their notebooks, each student gathers information and begins brainstorming possible prototype designs.

What's the most effective collaboration strategy you've used in your classroom?

What were the conditions or the circumstances that made it work well as it did?

## NIGHT SKY PROJECT COLLABORATE

Each team of students shares their prototype ideas, testing their favorite one out. They iterate on the design, improving in across multiple cycles, getting feedback as they go. When they are satisfied, they build their final design. Teams swap notebooks with each other to share ideas, ask questions, and provide critique.



Do you like speaking in front of people?  
Make five rules for presenting  
and public speaking that you  
can share with colleagues and  
with your students.



## NIGHT SKY PROJECT PRESENT

Teams share what they learned in creating their star map. They talk about the constellations, sharing information about their mythologies and the science behind their stars. After each team presents, they add their section of the sky to the project, creating a complete, illuminated picture of the night sky.

Can you recall a project from elementary or middle school you really enjoyed?  
What was it? Why did you like it?



## NIGHT SKY PROJECT CONNECT

Each student reflects in her or his notebook, adding additional information about what they learned from the other teams. They think about their successes and what new questions they've learned from the project. And when they look up at the night sky, maybe they'll see it a little differently now that they've illuminated it on their own.



## YOUR IDEA

Write one down and sketch it out. Sign your work. Then find a partner and discuss. Gather feedback.

Signature

MY IDEA

Disclosed and understood by



# MATERIALS

**COPPER TAPE** Available as a snail repellent from home improvement stores (non-conductive adhesive) or with conductive adhesive from electronics and DIY sources.

**SURFACE-MOUNT (SMD) LEDs** Available in many sizes and colors. Check the specifications to make sure they're at least 3mm long, or you might end up with very small LEDs that are harder to work with. SMD LEDs designated as 1206 are much larger than those designated 0603.

**3V COIN BATTERIES** These can be bought in bulk online for much lower prices than through retail stores.

## SOURCES

- Jameco.com
- Amazon.com
- Sparkfun.com
- AdaFruit.com

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## PRESENTERS

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