Coding an LED light show:
Using electrical circuits and coding to create an LED light show

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In this lesson, students will combine their knowledge of electric circuits (parallel and series) and coding to

design and build an LED light show using a breadboard and Arduino microcontroller to create an automated

circuit. This lesson allows students to engage in the research engineering process by designing and testing

prototypes by using both the simulation software and equipment to have a real-life product they create. By

allowing students to build their circuits, it will simulate real-life scenario where they may encounter

unanticipated challenges, they need to problem solve. Breadboards are commonly use in real-life

applications when building electrical circuits for projects and would be a useful skill for student to acquire.

This lesson is scaffolded to meet the learning needs of students and can be tailored to the classroom. It

allows for creativity in their design and has activity extensions with more advanced options such as coding a

light show to music. This type of inquiry allow study to work at their own level and pace. Resources and

tutorials are provided to students to help guide them through the inquiry process and give them the

knowledge they need to code and use the simulation software. They can work at their own pace and revisit

the resources at any time and can increase the complexity of their design as they master the skills. It is

useful to allow students to build the breadboard circuit in a simulated environment first (Tinkercard) since

the software helps students see how components are electrically connected in the breadboard and they can

more easily troubleshoot problems in their design and test the code in the simulation prior to building using

real components. This would hopefully alleviate some of the frustrations with building circuits and coding.

A planning and recording sheet as well as a checklist are provided to students to help guide them through the process. As students are only in Grade 9, this type of inquiry project can be new to them and a bit overwhelming. Providing some structure to the inquiry could help students through the process more easily. At the end of the inquiry, students will showcase their LED light project with the rest of the class with the hope that students will be excited and proud to show off their work and hopefully motivate each other to challenge themselves during the inquiry process. At the end of inquiry project, students will reflect on the engineering research process of designing and testing prototypes as a way of connecting to real-life problem solving and to extend their knowledge to real-life application of using electrical circuits and coding.

Prior Knowledge:

Before the LED light inquiry challenge, students would have covered components of an electrical circuits and the flow of electricity in prior units and would have a working knowledge of how electricity flows in a parallel and series circuit and experience building simple circuits. In the preceding lesson, the students would learn how to use a breadboard to build electrical circuits and how electricity flows through different sections of the breadboard.

5 E Investigation Plan

Course: Grade 9 - SNC1W	Strand: Physics - Electricity
Context	The purpose of this investigation is for students to use an engineering design process to create their own unique LED light show using a breadboard electrical circuit and an Arduino microcontroller. They will design their circuit and create/modify existing code using an online simulator (Tinkercad) to test their design before cre ating the real circuit/LED show. This activity is a coupled inquiry where students are given a challenge to complete. They are given instructions on how to use the materials to make an LED light up using breadboards and Arduino, but they will need to design their own final project and make modification to the instructions and code to create their final product. Students will showcase their end-product, provide a diagram of their electrical circuit and a reflective paragraph on the challenges they faced during the investigation. Prior Knowledge This activity will take place after the students are able to identify components of a circuit, describe how electricity flows in series and parallel circuits and be able to design circuits when given specific parameters (D2.3, D2.4, D2.5). Prior to this activity, students will learn how breadboards work and how it is used to create electrical circuits as well as their broader use (i.e. robotics, sensors, etc…)
Overall Expectations:	A1. apply scientific processes and an engineering design process in their investigations to develop a conceptual understanding of the science they are learning, and apply coding skills to model scientific concepts and relationships D2. demonstrate an understanding of the nature of electric charges, including properties of static and current electricity
Specific Expectations:	A1.3 apply an engineering design process and associated skills to design, build and test devices, models, structures, and/or systems A1.4 apply coding skills to investigate and to model scientific concepts and relationships IP – research how components of Arduino and breadboard function and develop a plan to use them to create their own LED light show. PR – select how they are going to create their LED light show and develop a prototype using the simulator; test the prototype in the simulator and test the real circuit/LED light show

	AI – analyze and problem solve if their prototype (virtual or in person) is not working as planned
	C – communicate their product design using a diagram, showcasing their LED light show to the class and writing a reflective paragraph on the engineering design process
	D2.6 construct series and parallel circuits to compare electric current, potential difference, and resistance in both types of circuits

Learning Goals:	**Success Criteria:**
We are learning to:	*We will know we have been successful when we*
1. Design and build series and parallel circuits 2. Compare differences between series and parallel circuits 3. Use an engineering research design process to plan, troubleshoot and build an LED light show using a breadboard electrical circuit and Arduino microcontroller 4. Manipulate code to create a customized LED light show	1. Build a parallel and series circuit 2. Explain when to use a parallel and series circuit 3. Design and create an LED light show using an Arduino and breadboard electrical circuit 4. Manipulate code to create a customized LED light show

Learning Skills and Work Habits:

Collaboration – student will need to collaborate with their partner to design, plan and troubleshoot their product
Independent work – student will need to follow instructions in tutorials with minimal supervision.
Organizations – student will need to be organized when creating their electrical circuits especially during the troubleshooting process.

Materials:	Computers with access to internet Arduino microcontroller (1 for every 2 students) Breadboard + cable wires + resistors (1 set for every 2 students) LED bulbs (various colours; 10-20 per group) Tinkercad tutorials (video & written instructions) + headphones for those watching videos
Safety:	Ensure all wires are in good shape and have no exposed metal. The Arduino microcontroller is low current so there is no electrocution risk. LED lights should be installed in series with a resistor to prevent LED from burning out. The arduino boards has a built in surge protection and will shut down if there is short circuit. Circuits should never be left unattended. If students are working on their circuit over multiple classes, the power supply should be disconnected from the circuit between classes.
Classroom Management and Organization	Students will work in pairs with two groups at each table (to enable students to engage/problem solve with other groups if they run into problems) Tables need to be separated from each other to allow for easy flow/movement of teacher between groups to walk around and engage with students, assist where needed and evaluate students. Location of equipment and material at a designated station. One student per group will select the equipment and material needed for each procedure.

5 E MODEL		
ENGAGE:		
Teacher Role **The teacher will:**	**Teacher Questions**	**Student Role** **The student will:**
Show video of a light show synchronized to music	How would you create a light show? What equipment and/or knowledge would you need to have before starting this task?	Discuss in groups their ideas and create a list of items they would need. Groups to share their ideas with the rest of the class.
EXPLORE:		
Teacher Role **The teacher will:**	**Teacher Questions**	**Student Role** **The Student will:**
Introduce the challenge, provide instruction on the equipment, resources, and tutorials Have students choose their partner for the activity with two groups per table Explain that the activity challenge will take place over several classes Keep student's expectations/goal for the LED light show realistic. Start small and they can expand their light show as they are ready.	How are you going to design your LED light show? What are some steps that you need to do prior to designing your LED light show? What information do you need before you can move on to the next step of your project? *Extension activity* How can you expand your LED light show? How could you synchronize your lightshow to music?	1. **E**xplore the equipment (breadboard, LED lights, the Arduino microcontroller, cables and resistors) and come up with a plan on how they can create a light show. 2. Watch the tutorial videos and/or read instructions on how to create an LED light show using the Tinkercard simulation 3. Determine the type of LED light show they want to create (colours, how they blink (grouped, ungrouped) 4. Outline their plan for the LED light show and record their designs, ideas using a recording sheet and make note of any questions or information that they may need and any problems they encountered with solutions 5. Use the Tinkercard software to prototype their design by manipulating the code and simulate their LED light show 6. Build the electric circuits using a real breadboard, LED's, and Arduino microcontroller 7. Export the code from the Tinkercard software into the Arduino software and program the Arduino hardware

EXPLAIN:

Teacher Role The teacher will:	Teacher Questions	Student Role The Student will:
Circulate around the groups and assist students that need help by asking questions and guiding them to the next steps and troubleshooting problems that arise	What is the outcome (output of LED) if the LED bulbs are placed in series? What is the outcome (output of LED) if the LED bulbs are placed in parallel? How would this impact how you design your LED light show? What is the role of the resistor? If you increased the number of lights by a 1000-fold, what would need to change in your circuit to ensure all the lights light up?	Explain how they are building their circuits and why.

EVALUATE:

Teacher Role The teacher will:	Teacher Questions	Student Role The Student will:
Encourage students to explain the steps they took to create their LED light show	What challenges did you encounter when creating your LED light show? Which lights did you design in parallel, series and why?	Showcase their end-product light show with the rest of the class and explain how they created their LED light show. Draw a colour-coded diagram of the breadboard electrical circuit. Write a reflective paragraph on the challenges they faced during the activity and what they liked and did not like about the engineering design process

EXTEND/ELABORATE:

Teacher Role The teacher will:	Teacher Questions	Student Role The Student will:
Help students to extend their knowledge by providing tips and examples (i.e. home light automation, robotics,)	What are different examples where coding can be used with electric circuits? What are some real-life applications? What other projects would you like to create?	Create a mind map of different real-life applications of using automation/coding in electrical circuits

LED light show challenge!

Planning and Recording Sheet

Group members: _____

Skills Required

_____   _____
_____   _____
_____   _____
_____   _____

Materials Needed
Needed

_____
_____
_____
_____

LED light concept

Plan of Action

LED light show challenge!

Planning and Recording Sheet

Notes

Challenges/Problems	Possible Solutions

Checklist

Tutorials Completed	✔
1 – Introduction to project	
2 – Create a new circuit in Tinkercad	
3 – Build a Basic LED Circuit	
4 – Connect an Arduino and Breadboard	
5 – Blink 1 LED	

Develop LED light show concept	
Create a Plan of Action	
Assign Jobs	
Create prototype and test in Tinkercad	
Build and test breadboard electrical circuit	
Draw breadboard diagram (colour coded)	

6 – Add a second LED		Reflective Paragraph	

Student Resources

<u>Breadboard Tutorials - Refresher</u>

How to use a breadboard [Video]
https://www.youtube.com/watch?v=6WReFkfrUIk
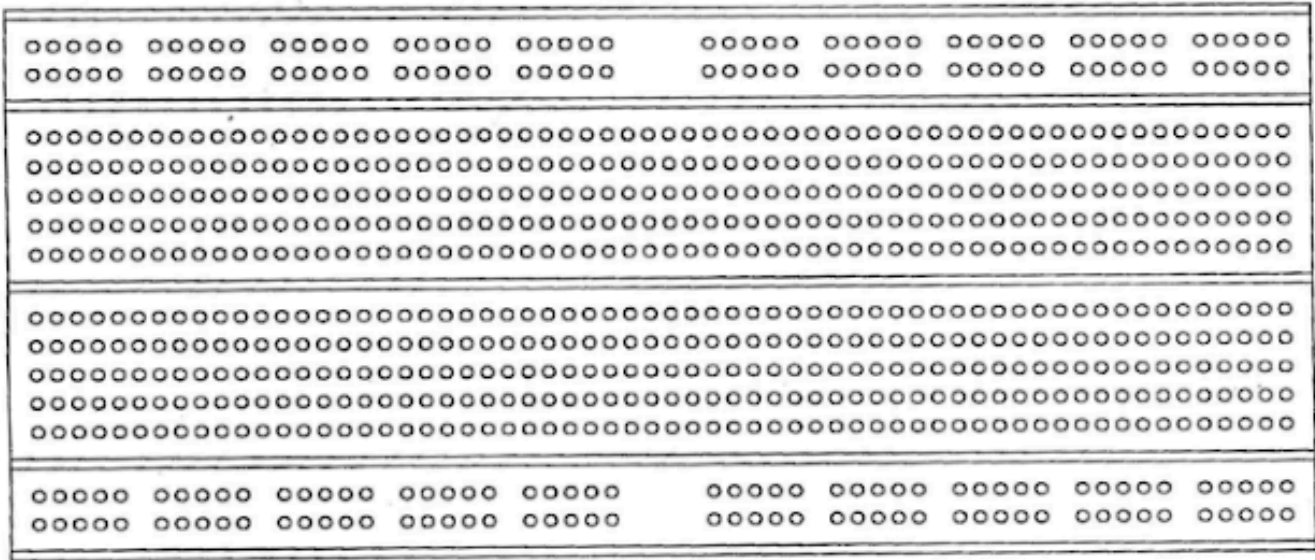
How to use a breadboard [Article]
https://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-breadboard

<u>Tinkercard Tutorials (video or powerpoint)</u>

1 – Introduction
2 – Create a new circuit in Tinkercad
3 – Build a Basic LED Circuit
4 – Connect an Arduino and Breadboard
5 – Blink 1 LED
6 – Add a second LED

Available at https://www.tinkercad.com/lessonplans/program-an-led-light-show

Breadboard Planning Sheet

Title: _____

Name: _____ Date: _____

References:

How to use a breadboard [Video]
https://www.youtube.com/watch?v=6WReFkfrUIk

How to use a breadboard [Article]
https://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-breadboard

Program an LED light show
https://www.tinkercad.com/lessonplans/program-an-led-light-show

STAO Technology Enabled Learning (TEL Project): Integration of Robotics (Arduino) and Coding into Grade 9 Science
https://stao.ca/resource/integration-of-robotics-arduino-and-coding-into-grade-9-science-applied-and-academic/