Simplicity of Electricity

Teacher Resource Guide

The Tech Museum of Innovation
201 S. Market St.
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thetech.org

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How to use this Document

The resources provided in this document are not required to be used in preparation for your lab. They are simply resources that we thought might be helpful to you and engaging for your students in preparation for your lab. It is your choice to use them, you may pick as few or as many to implement as you like.
**If you are receiving a Title 1 scholarship for your lab, you are required to implement a vocabulary or journal activity prior to your lab visit.*

Lab Summary

This is a hands-on, "how-to" workshop for students to develop the knowledge, habits, and skills of designers and innovators. Students will learn how to make electricity work for them...without flying a kite in a thunderstorm. Before firing up their final creations, students will learn about static electricity, how to troubleshoot a circuit, and design and build Scribble Bots.

Grade Level: 4-8

Student Outcomes

- Students will be able to test and accurately categorize materials as conductors and insulators.
- Students will explore the difference between static electricity and direct current electricity.
- Students will be able to design, build, and test series and parallel circuits capable of powering an electrical load.

State and National Standards Connections

Next Generation Science Standards

	Engineering Design	Physical Science	Disciplinary Core Idea	Crosscutting Concept	Science & Engineering Practices
4th Grade	3-5- ETS1-1 3-5- ETS1-2 3-5- ETS1-3	4-PS3-2 4-PS3-4	PS3.A PS3.B ETS1.A ETS1.B ETS1.C	Energy and Matter	1, 2, 3, 6
5th Grade	3-5- ETS1-1 3-5- ETS1-2 3-5- ETS1-3	N/A	ETS1.A ETS1.B ETS1.C	Systems and System Models Influence of Engineering, Technology, and Science on Society and the Natural World	1, 2, 3, 6
6-8th Grade	MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	*Forces and Interactions* MS-PS2-3	ETS1.A ETS1.B ETS1.C	Structure and function	1, 2, 3, 6

Common Core Language Arts

Speaking and Listening

- Grade 3: SL.3.1b-d, SL.3.3, SL.3.4a
- Grade 4: SL.4.1b-d, SL.4.4a
- Grade 5: SL.5.1b-d, SL.5.4
- Grade 6: SL.6.1b-d
- Grade 7: SL.7.1b-d
- Grade 8: SL.8.1b-d

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Related Links and Games

The following links and games provide additional information regarding energy, electricity, and circuitry. We are not endorsing the following organizations, but feel that the information provided by said organizations may be of benefit to your students and may help enhance the learning experience of the lab.

- US Energy Information Administration: This site provides information on the basics of electricity, how it is generated, how it is measured, how it relates to magnetism, circuits, and much more. This site also includes energy experiments, games and activities, and teacher resources. http://www.eia.gov/kids/index.cfm

- Neo K-12: This site provides simple definitions for electricity as well as a variety of short videos about electricity, circuits, and much more to show your class. http://www.neok12.com/Electricity.htm

- Energy Meter Madness: This game by Wonderville is a great combination of math skills and science. Students have to go through the house and list the appliances they want to use then show what their energy meter would look like when using those appliances. This is a fantastic game to help students develop base 10 properties and understand energy efficiency. http://www.wonderville.ca/asset/energy-meter-madness

- Circuit World: This simulator by the Cumbria and Lancashire Education Online (CLEO) allows students to construct and test circuits online using symbols, animated characters, or 'real-world' components. Students can print or save the schematics for their circuits. The platform functions on both e-whiteboards and individual computers. http://www.cleo.net.uk/consultants_resources/science/circuitWorld/index.html
    - In order to run this simulator you need to have the latest version of flash player installed – there is a link at the website to download the flash player.
    - Teacher tips: To identify the different pieces hover the curser over the library – it will provide both a description and measurement (volts/ohms) if applicable. To rotate pieces left click on the grid location once it has been placed. If pieces are not correctly connected, switches are not closed (left click once circuit is running), or energy needs are not met nothing will happen when the circuit is run.

- Highlight an Electrical Engineer. Let students explore the work of electrical engineers from all over the world. https://www.thefamouspeople.com/electrical-engineers.php

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Related Texts

The following titles may provide students with a greater contextual understanding of electricity. Included in the list are narratives (fiction/nonfiction), and referential texts. We are not endorsing the following authors, but feel that the information provided by said authors may be of benefit to your students and may help enhance the learning experience of the lab.

Narratives

- Frank Einstein and the Electro Finger. By Jon Scieszka.
  - Recommended for grades 2-6
  - Kid genius, Frank Einstein, along with his robot companions and friend Watson team up to combat T. Edison in a scientific battle over energy. With the evildoer T. Edison attempting to monopolize Midville's power plant, can Frank Einstein and his team come up with a way to deliver wireless energy to their town and foil T. Edison's plans?
- Electrical Wizard: How Nikola Tesla Lit Up the World. By Elizabeth Rusch.
  - Recommended for grades 1-4
  - A picture-book biography covering the life and works of Nikola Tesla from childhood to College and adult inventions. It includes detailed explanations of the Tesla-Edison rivalry as well as diagrams and text on AC vs. DC.
- Michael Vey. By Richard Paul Evans.
  - Recommended for grades 7-12
  - A secondary-level science fiction threaded with so much good science that it was named an NSTA/CBC Outstanding Science Trade Book for 2012.
- Oscar and the Bird: A Book about Electricity. By Geoff Waring.
  - Recommended for grades 2-3
  - When Oscar the kitten finds a tractor in a field and accidentally turns on the windshield wipers, he is full of questions about electricity. With the help of his friend – Bird – Oscar finds out how electricity is made and stored, which machines need electricity to work, and why it is important to be careful around wires, batteries, plugs, and sockets.

Reference

- Electricity! (Discover your World Series). By Kurt Zimmerman.
  - Recommended for grades 3-5
  - An illustrated guide through the subject of Electricity. It is a straightforward explanation of electricity basics, including how it's made, how it's used, and how it affects everything we do.
- Charged Up: The Story of Electricity (Science Works). By Jacqui Bailey.
  - Recommended for grades 3-6
  - Describes how electrical energy is generated and then transported from the power station to people's homes.
- Power Up!: A Visual Exploration of Energy. By Shaker Paleja.
  - Recommended for grades 3-5
  - Through infographics, charts, diagrams, maps, and illustrations, topics such as the pros and cons of energy sources, and the energy of the future are covered. Discover where energy is produced and how it gets to where we need it.

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Gallery and Exhibit Connections

The Tech Exploration Gallery (Lower Level)

- *Energy Bicycle:* This exhibit includes a wall with common electrical devices and their energy-efficient counterparts. Students individually attempt to generate enough electricity to power the devices by pedaling the bicycle – converting mechanical energy into electrical energy.
    - Connection to the lab:
        - Builds on the different methods of quantitatively measuring electricity.
        - Challenges students to investigate watts as a measuring unit of power both visually and kinesthetically.
        - Extends students' understanding of electricity as a form of energy that cannot be created or destroyed (law of conservation of energy).
    - Activity to complete at the exhibit:
        - Have each student try to power a different device on the wall. Make a hypothesis about how fast and for how long students will need to pedal in order to power the different devices. Record your results and compare with other groups from your class.
    - Questions to guide student learning:
        - How do you think the bicycle creates electricity?
            - *The bicycle creates energy through the use of a generator. When a human turns the pedals it spins a shaft in a generator that spins a magnet in the center of a wire coil which produces a movement of electrons.*
        - What device do you think will be the easiest to power? Why?
            - *The LED traffic light requires less energy conversion or transfer with respect to time (watts) and should therefore be the easiest to power.*
        - What device do you think will be the hardest to power? Why?
            - *The electric fan requires the most energy conversion or transfer with respect to time (watts) and should therefore be the hardest to power.*
        - What kind of energy are you using in order to produce the electrical energy powering the devices? Where did your energy come from?
            - *In order to produce the electrical energy to power the devices on the wall a human must use their own mechanical energy to rotate the pedals to turn the generator. This mechanical energy was derived from the chemical energy stored in the food they ate.*

Social Robots (Lower Level)

- Students put together their own robot using pre-programmed cubes. When the input cubes and output cubes are correctly connected to the power source and connected together via wires, they create a circuit!
    - Connection to the lab:
        - Builds on the vocabulary used in the lab including: circuit, conductor, series circuit, and parallel circuit.
        - Challenges students to build simple circuits using preprogrammed inputs and outputs in order to meet a design challenge.
        - Extends vocabulary to include inputs and outputs as a component of digital electrical systems.
    - Activity to complete at the exhibit:
        - Have each group build a robot and create a diagram for their robot. Make sure to label inputs, outputs, and the power source. Teams can swap diagrams and challenge other groups to recreate their robot design.

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- Questions to guide student learning:
  - What is the power source for your robot?
    - *The rechargeable battery for the robot is in the base of the robot tower.*
  - What inputs and outputs did you used on your robot? Why?
  - How did you connect the inputs and outputs?
    - *The inputs and outputs are connected by a single blue wire that is attached to the metal magnetic circles labeled in blue on the blocks.*
  - Where are the conductors on your robot? Why do you have to connect red-to-red and blue-to-blue?
    - *There are conductors in each red port on the robot tower, on the red portion of the input and output blocks, on the blue squares on the input and output blocks, and on the ends of each of the blue wires. The conductors are needed to transfer electricity from the tower to the blocks and to transfer electronic data from the input to the output blocks. [Visit the Microchip Room on the Upper Level for more information on how data is electrically transferred].*
  - Are you using series or parallel circuits to create your robot?
    - *Your robot is an example of a parallel circuit. If you attempt a series circuit (multiple inputs to an output or vice versa) the inputs/outputs will not work.*

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Writing Prompts

The following writing prompts and questions are just a few examples of journal topics to incorporate writing into your students' lab experience. If you feel that one of the below prompts does not meet your needs, you are welcome to use your own, but please make sure it is related to the chosen lab experience. If you have a related writing prompt you would like to share with The Tech and other teachers, please let us know on our teacher survey that will be available in the lab.

Most of the writing topics could be used as either pre-lab or post-lab writing. You may choose the prompts that work best for your class and schedule.

Pre-Visit Writing Topics/Prompts

Generic

- We will be attending ___*lab name*__ at The Tech Museum of Innovation; what do you think we will learn about in the lab? What do you want to know about this topic? What do you already know about this topic?
- We will be attending __*lab name*___ at The Tech Museum of Innovation; what are you looking most forward to in this lab? Why?

Specific to Simplicity of Electricity

- Every day you probably turn a light switch on and off at least 30 times. Explain how you think a light switch works to turn the lights on and off. Why do you think it works this way?
- If we didn't have electricity in our classroom, we would…

Post-Visit Writing Topics/Prompts

Generic

- We learned a lot in our _*lab name*_ lab. What were your two favorite things you learned in the lab? Why?
- The principal is excited to hear all about your lab experience. Explain what you did and learned about in the lab since she or he was unable to attend the lab.

Specific to Simplicity of Electricity

- In the lab you learned about two types of circuits: series and parallel. Explain the difference between the two in a way that someone who didn't go to the lab would understand.
- How would your school day run differently if the school's electricity ran in one series circuit? Why would it run this way?
- How could your classroom be made more energy efficient?
- (Take photos of student's scribble bots during the lab) Ask students to review the scribble bots and write about problems they had building their device? How did they solve these problems?

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Pre-Visit Vocabulary and Activities

These are words and concepts that we will discuss in the lab. Your students' experience will be enhanced if they are familiar with these terms prior to your visit. Below you will find several graphic organizers and games to aid in your vocabulary review.

Terms and Definitions

- Circuit: An electrical device that provides a path for electrical current to flow.
- Conductor: a material that allows electricity to flow through it easily.
- Current: The flow of moving electric charge in a closed path. The flow of current from negative to positive.
- Insulator: a material that does not allow electricity to flow through it easily.
- Open Circuit: a circuit that is interrupted so that electricity will not flow.
- Parallel Circuit: A circuit in which each device has an independent connection to the power source.
- Series Circuit: A circuit in which devices are arranged in a row, one after another on a single path. Devices in series share the energy from the power source.
- Short Circuit: a path in the circuit that has no element between two different voltage potentials.
- Volt: a measuring unit of power

Vocabulary Activities:

Graphic Organizers

- *Frayer Graphic Organizer:* The Frayer Graphic Organizer is a great tool for vocabulary development. This graphic organizer allows students to write their own definitions, define characteristics, and provide examples and non-examples. This tool will lead your students to a deeper understanding of the vocabulary and how it relates to their lives. On page 9 you will find a blank Frayer Graphic Organizer for your use in the classroom.
    - For more information on the Frayer Model and how to implement it, please visit the following link: http://www.theteachertoolkit.com/index.php/tool/frayer-model
- *Vocabulary Graphic Organizer:* This graphic organizer is a great tool for younger students as well as English Language Learners. Although very similar to the Frayer Model, this graphic organizer includes a drawing of the vocabulary term and the use in a sentence. On page10 you will find a blank Vocabulary Graphic Organizer for your use in the classroom.
- *Circle Map:* This graphic organizer is a great tool for helping all students develop an overall sense of a topic. It is also very helpful for beginning and early intermediate English Language Learners. This graphic organizer lets students brainstorm what a term or concept means to them and provides a frame of reference for the term. On page 11 you will find a blank Circle Map for your use in the classroom.
    - For more information on the Circle Map and other Thinking Maps, please visit the following link:
        - http://thinkingmaps.com/why-thinking-maps-2/

Vocabulary Review Games

- *Quiz, Quiz, Trade:* This is a fun cooperative game for students to review vocabulary terms. For more details and to see an example of Quiz, Quiz, Trade in action, please visit the following link: http://www.theteachertoolkit.com/index.php/tool/quiz-quiz-trade
    1. Create questions or vocabulary cards. On one side of an index card, write the question or vocabulary term; on the other, the answer or definition. Pass out the cards to students. If there are not enough terms for everyone to have a different card, try using different "back" sides to the same cards (e.g.

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instead of the definition again, have a drawing, a question about the term, characteristics of the term, or an example of the term).
2. Pair up. When all cards have been passed out, students find a partner to quiz with their card.
3. Hands up. When both partners have completed the quizzes correctly, they put their hand up to show other students that they are ready for a new partner to quiz.

- *Back-words:* This game is part Charades part 20 Questions. In this review game, students have to guess the vocabulary term that is on their back by asking questions of a partner or having the partner act out the term.
    1. Write your vocabulary terms on index cards. If there aren't enough terms for each student to have a different one, you can make two sets and divide the class into two groups. You may also add in other related vocabulary terms that you have been studying in class.
    2. Tape one term onto the back of each student so that he or she cannot see the word.
    3. Have students pair up. Each partner should look at the word on their partner's back. Partners take turns asking questions or acting out or gesturing about the term that is on their back. (e.g. "Am I an element? Am I part of an atom? Do I make up all matter? Etc.) Partners must ask at least 2 questions before guessing their word.
    4. When both partners have correctly guessed their word, they put a hand up to signal that they are in need of a new partner. Continue game play until everyone has guessed their word.
- *$10,000 Pyramid:* This review game is exactly like the classic game show. Students will work in pairs, taking turns to describe the words and to guess the words.
    1. Break up the terms into two groups. Each partner will take on one group of words.
    2. Have each partner fill out the worksheet on the next page with their group of words.
    3. For the first round, Partner A will be the one describing the term and Partner B will be the one guessing the term. Partner A will describe the term (starting with 1) using the words he or she wrote down on the worksheet. From the description, Partner B will guess what the term is.
    4. When Partner B guesses the word correctly, Partner A moves on to the next word.
    5. When Partner B correctly guesses all the words in Partner A's pyramid, they switch places and Partner B will describe the terms on his or her pyramid while Partner A guesses the terms.
    6. You can time this activity like on the quiz show, but it may intimidate some students.

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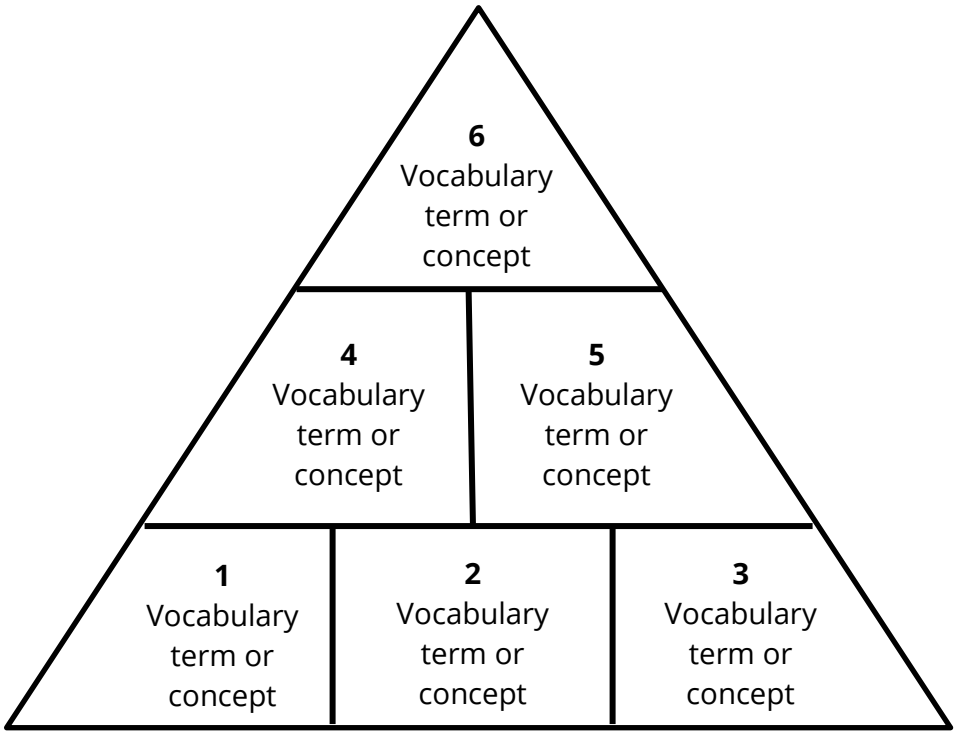
Student Name: _____

$10,000 Pyramid



Write descriptive clues about each vocabulary term or concept

1. _____
   _____
2. _____
   _____
3. _____
   _____
4. _____
   _____
5. _____
   _____
6. _____
   _____

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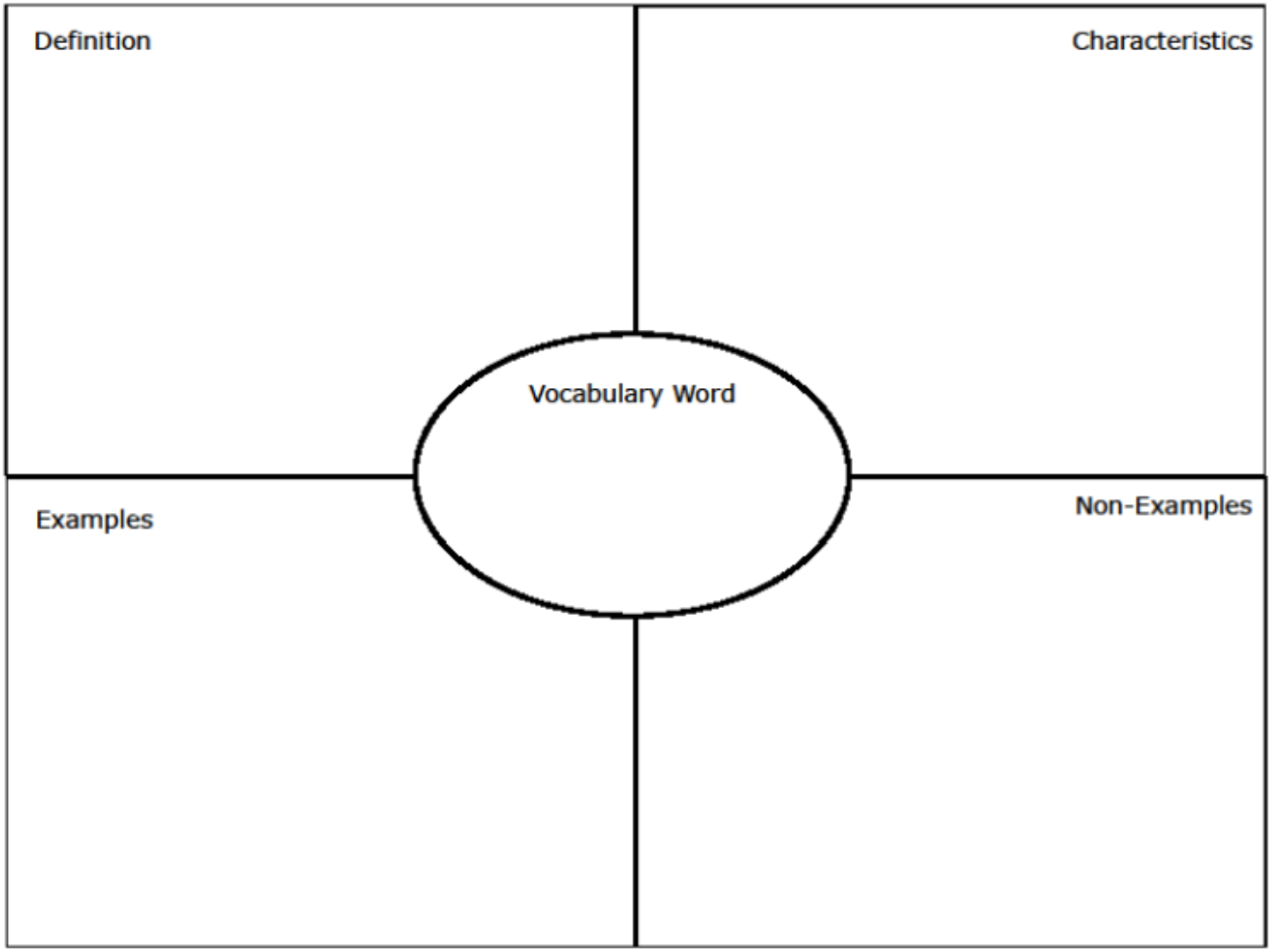
Frayer Graphic Organizer



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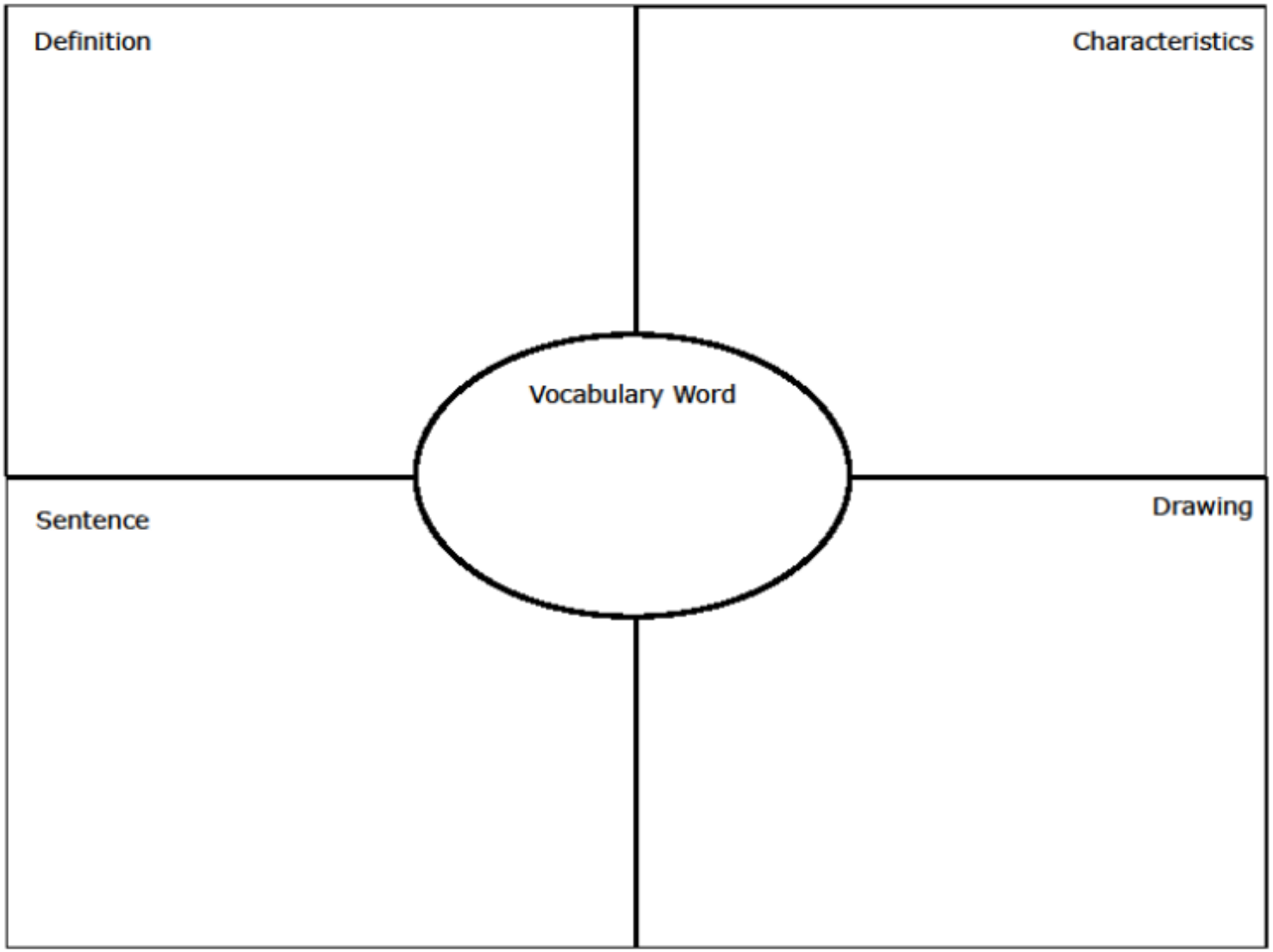
Vocabulary Graphic Organizer



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Circle Map