Purpose

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. It is your choice to use them and you may pick as few or as many to implement as you like.

**If you are receiving a Title I scholarship for your lab, you are required to implement a vocabulary or journal activity prior to your lab visit.*

Grade Levels	Lab Summary	Student Outcomes
4-12	How do architects and structural engineers design buildings to stand up to the power of earthquakes? Students try their hands at structural engineering as they use dowels and rubber bands to build structures that must survive a large scale earthquake, all while working on a budget. **Common Core Language Arts Standards** *Speaking and Listening* Grade 4: SL.4.1.b-d, SL.4.4.a Grade 5: SL.5.1.b-d, SL.5.4 Grade 6: SL.6.1.b-d Grade 7: SL.7.1.b-d Grade 8: SL.8.1.b-d	Students will: • Explain the theory of plate tectonics and why earthquakes occur. • Design and build a model structure that can withstand the effects of a large scale earthquake.

State and National Standards Connections

Next Generation Science Standards

	Engineering Design	Earth and Space Science	Disciplinary Core Ideas	Crosscutting Concepts	Science and Engineering Practices
Grade 4	3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3	3-ESS-3	ESS1.C ETS1.A ESS2.B ETS1.B PS2.B ETS1.C	Influence of Engineering, Technology, and Science on Society and the Natural World	1, 2, 3, 6
Grade 5	3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3		ETS1.A ETS1.B ETS1.C	Influence of Engineering, Technology, and Science on Society and the Natural World	1, 2, 3, 6
Grades 6-8	MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	MS-ESS2-2 MS-ESS2-3 MS-ESS3-2	ESS1.C ETS1.A ESS2.A ETS1.B ETS1.C	Structure and Function Science is a Human Endeavor	1, 2, 3, 6

Preparing for the Lab Experience

There are many ways to help prepare your students before the lab and help them reinforce their knowledge after the lab, including the content you are covering in the classroom. Below you will find a chart of some materials we offer to help support your classroom.

	Description	Recommended	Time, Materials & Support Needed
Lab Journal	Includes: • Vocabulary • Pre- and post-journal • Venn diagram • Tech Interactive notes & connections • Questions about the lab	• Pre-lab activities • Activities during field trip. • Post-lab activities • Vocabulary definitions and journal prompts provided in this resource guide*	• 5-60 minutes (1+ days) • Print the journals • Assemble the journals • Writing utensils
Lab Related Activities			
Convection Currents	In this model, students will discover how convection currents in the Earth's mantle cause tectonic movement. This activity is meant to be done as a teacher demonstration due to the use of very hot water.	• Either pre- or post-lab	• 20 minutes (some preparation required the night before)
DIY Shake Table	Students will practice engineering design principles and be responsible for creating their own earthquake platform.	• Post-lab activity	• Three 45-minute sessions
Earthquake in a Box	Students will see first-hand how tectonic plates interact and the consequences.	• Post-lab activity	• 45 minutes
Emergency Preparation Kits	Students consider how people are affected by the aftermath of earthquakes and other natural disasters. They then plan emergency preparation kits for different situations and record their solutions on a poster to share with their class and display at school.	• Either pre- or post-lab • This activity involves Language Arts standards for building arguments	• 30-60 minutes

Related Links and Games

The following links and games provide additional information about earthquakes, soil types, earthquake safety, bridges and building structures. We are not endorsing the following organizations, but feel that the information may be of benefit to your students and may help enhance the learning experience of the lab.

- **U.S. Geological Survey:** This USGS site has a real-time world map showing all reported earthquakes of magnitude 2.5 over a 24-hour period. The map shows the exact location and time of the earthquake as well as depth and magnitude. http://earthquake.usgs.gov/
- **USGS Soil Type Maps (for grades 6 and above):** This site describes the main soil types of California and their shaking hazard and amplification information. A map is also available so students can check to see what type of land their home is built on and the hazard level of that land type. http://earthquake.usgs.gov/regional/nca/soiltype/
- **The Red Cross of Silicon Valley:** Here you will find many tips for disaster preparedness for the school, home and work, as well as many other resources for disaster preparedness. http://redcross.org/prepare
- **Bridge to Classroom:** In honor of the new Bay Bridge, this simulation allows students to build a bridge that is structurally secure to withstand an earthquake. Options include various bridge types, retrofitting actions, and vibration absorbing materials. Must have Flash player installed. http://www.eduweb.com/portfolio/bridgetoclassroom/engineeringfor.html
- **Stop Disasters Game:** In this simulation from the UN Office for Disaster Risk Reduction, students can choose from several scenarios, including earthquakes, to design and build a small city and protect it from the chosen natural disaster scenario. The simulation also includes working on a budget, varying land and environment types, and options for retrofitting and defense systems. http://www.stopdisastersgame.org/
- **"What is Structural Engineering? Science Spotlight":** This short video from KQED Quest gives a quick overview of what structural engineering is, and why it is important. https://www.youtube.com/watch?v=oqpp8L4J4ek
- **Highlight a Geologist or Seismic Engineer.**
  - Alfred Wegener – Proposer of Continental Drift Theory https://www.famousscientists.org/alfred-wegener/
  - Marie Tharp – Mapping Continental Drift https://www.smithsonianmag.com/history/seeing-believing-how-marie-tharp-changed-geology-forever-180960192/
  - Famous Geologists https://www.thefamouspeople.com/geologists.php

Related Texts

The following titles may provide students with a greater contextual understanding of the field of earthquakes and civil engineering. Included in the list are narratives (fiction/nonfiction), referential texts and books that extend learning beyond the scope of the lab. We are not endorsing the following authors, but feel that the information may be of benefit to your students and may help enhance the learning experience of the lab.

Narratives

- "The Earth Dragon Awakes." By Laurence Yep.
  - Recommended for grades 3-7.
  - Historical fiction about the San Francisco Earthquake of 1906 and the resulting firestorm as told from the perspectives of China Town residents Henry and Ching.
- "Earthquake at Dawn." By Kristiana Gregory.
  - Recommended for grades 5-7.
  - Historical fiction based on Edith Irvine's actual photographs, this tale documents San Francisco's physical destruction and the compassionate acts prompted by the tragedy.

- "Volcano Rising." By Susan Swan.
  - Recommended for grades 1-4.
  - Although volcanoes are commonly thought of as scary and catastrophic phenomena that create mass destruction, Elizabeth Rusch challenges readers to consider the creative capabilities of volcanoes.

Reference
- "Earthquakes: Science and Society (2nd Edition)." By David S. Brubaugh.
  - Recommended for grades 9-12.
  - A reader-friendly illustrated text that introduces the scientific, historical and personal safety aspects of earthquakes.
- "Structures: Or Why Things Don't Fall Down." By J.E. Gordon.
  - Recommended for grades 9-12.
  - For anyone who has ever wondered why mega-structures don't collapse, J.E. Gordon answers all your questions without confusing technical and engineering terms.
- "Building Big." By David Macaulay.
  - Recommended for grades 5-7.
  - A book that has the answers to questions regarding shape, material, and location considerations of large structures including bridges and buildings.

Extensions
- "Full-Rip 9.0." By Sandi Doughton.
  - Recommended for grades 9-12.
  - A mega-quake is overdue in the Pacific Northwest; in this fascinating book, The Seattle Times science reporter Sandi Doughton introduces readers to scientists who are dedicated to understanding the way the earth moves and describes what patterns can be identified and how prepared people are.
- "Earthquake Storms: The Fascinating History and Volatile Future of the San Andreas Fault." By John Dvorak.
  - Recommended for grades 7-12.
  - "The lives of millions will be changed after it breaks, and yet so few people understand it, or even realize it runs through their backyard. Dvorak reveals the San Andrea Fault's fascinating history – and its volatile future." (Amazon)

Tech Interactive Gallery and Exhibit Connections

The Tech Exploration Gallery: Living on a Restless Planet (Lower Level)*

- *Earthquake Platform:* Students can experience a simulation of actual earthquakes from around the world, including the 1989 Loma Prieta earthquake and the 2011 Fukushima earthquake in Japan.
  - Connection to the lab:
    - Students can experience a variety of real earthquakes and compare the differences in how those earthquakes feel.
    - Explores the vocabulary used in the lab including: earthquake, magnitude, shapes, stability, epicenter and focus.
  - Activities to complete at the exhibit:
    - Construct a structure out of the foam shapes and see if it stays standing through the earthquake.
  - Questions to guide student learning:
    - Did your structure survive? What features helped the structure? What features worked against your structure?
      - *A structure that is wide at the base and narrow at the top is more likely to survive. More weight at the bottom and less weight at the top also benefits the structure. Symmetry and choice of shapes*

        - *also affect building stability.*
    - How do the different simulated earthquakes compare to one another in how they feel?
        - *Students will describe the earthquakes in different ways, such as one earthquake may feel that it goes more side to side while another earthquake may have the sensation of going up and down. They may also notice that some take longer than others.*
    - Which simulated earthquake was the strongest? Where was it located? How long did it last?
        - *The Hokkaido, Japan earthquake in 2003 had an 8.3 magnitude and lasted for 42 seconds.*
    - Which simulated earthquake was the weakest? Where was it located? How long did it last?
        - *The Napa, California earthquake in 2014 had a 6.0 magnitude and lasted for 10 seconds.*

- *Seismometers:* Students can make their own earthquake by tapping, stepping, or stomping near a seismometer, and gauge how strong an earthquake they create with their movement.
  - Connection to the lab:
    - Students can see how varied movements have different frequencies and measurements, thus showing how each earthquake is unique.
    - Explores the vocabulary used in the lab including: frequency, earthquake and force.
  - Activities to complete at the exhibit:
    - Step, tap, jump, and/or stomp on the concrete and see how those movements affect the line on the screen.
  - Questions to guide student learning:
    - What is a seismograph?
        - *It is an instrument that measures and records details of earthquakes, such as the force and duration.*
    - What happened when you put force on the concrete?
        - *The seismograph line moved up and down.*
    - What did you notice when you made different movements?
    - Some movements made the seismograph line longer or shorter depending on the strength of the movement.

- *Quake Sensors:* Students can push against stone blocks to see how seismometers detect movement.
  - Connection to the lab:
    - Builds on the vocabulary used in the lab including: creep, earthquake, sensors and faults.
    - Students see how shifts in the ground are measured.
  - Activities to complete at the exhibit:
    - Students will push and step on stone blocks in different ways to see the quake sensors numbers move.
    - See if you can see or feel the movement of the blocks.
  - Questions to guide student learning:
    - What is a strainmeter and what does it detect?
        - *A strainmeter detects tiny changes in length of volume or rock. They can sense shifts of less than one part in a billion.*
    - What is a tiltmeter and what does it detect?
        - *A tiltmeter measures changes in the slope of the group. They can sense offsets as slight as the thickness of a piece of paper over the length of a football field.*
    - What is a creepmeter and what does it detect?
        - *A creepmeter tracks slipping along fault lines. They can sense movements smaller than a grain of sand.*
    - How does this help our understanding of earthquakes?
        - *By seeing different movements, one can see how the earthquake is moving and how that affects the ground.*

- *Shake, Rattle, & Roll:* At this exhibit you can construct a building and test it virtually! Students use computers to design a virtual building using different heights as well as different materials to see how these two qualities affect the stability of the building throughout various earthquakes.
  - Connection to the lab:
    - Builds on the vocabulary used in the lab including: Engineering, height, stability and earthquakes.
    - Students can apply what was learned in lab to a slightly larger scale and can use computer software to test.
  - Activities to complete at the exhibit:
    - Build a virtual building that will withstand the three different earthquakes.
    - Try to create your own material and see if it will survive the earthquakes.
  - Questions to guide student learning:
    - How does height affect the building?
      - *The higher the building, the more damage may occur to the building.*
    - What affects the materials?
      - *The stiffness and springiness can affect how the building reacts to the earthquake.*
    - Which materials proved to be the most effective?
      - *The reinforced concrete works better since it uses a combination of concrete and steel reinforcement bars to have a balance of springiness and stiffness.*

**Please note that the Exploration Gallery will close in January 2020 for renovation, so these exhibits will no longer be available after that date.*

Design Challenge Learning Resources

Design Challenge Learning is a dynamic way for learners to become creative problem-solvers. The below link will take you to short guides created by educators at The Bowers Institute on facilitating design challenges, promoting engineering and fostering innovator mindsets.
https://www.thetech.org/content/bowers-institute/resources

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 Interactive; 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 Interactive; what are you looking most forward to in this lab? Why?

Specific to Engineering for Earthquakes

- Before scientists discovered the real causes of earthquakes, there were many stories and legends about why earthquakes happened and what caused them. Write your own legend about why earthquakes happen and what causes them.
- Earthquakes are a natural occurrence we have to think about a lot in California. Have you ever experienced a real earthquake?
  - (If yes) Explain to someone who has never experienced an earthquake what it was like for you during the earthquake. What did it feel like? How did you feel? Were you prepared?
  - (If no) Explain what you think an earthquake would feel like. What would you need to do during the earthquake?

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 Engineering for Earthquakes

- (Photograph student structures during the lab and review them back in the classroom). What problems did you have making your structures? What did you do to solve them during the lab? How would you iterate your designs now?
- Many families have earthquake preparedness plans. Create and share a plan to help your family prepare for an earthquake.
- The "visitor" in your structure had a very rough day. Write a story describing the earthquake and what it was like in your structure from the point of view of the "visitor."

Pre-Visit Vocabulary

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

Boundary	Where two tectonic plates meet. There are three types: convergent, divergent, and transform.
Convection current	The movement of the mantle. It brings the hot mantle toward the surface, where it moves laterally and then falls when cool. Hot mantle replaces it. This cycle moves the crust.
Core	The central portion of the earth, having a radius of about 2100 miles (3379 km) and believed to be composed mainly of iron and nickel in a molten state.
Creep	Slow fault slip, occurring in a fault zone without producing earthquakes.
Crust	The outer layer of the earth, about 22 miles (35 km) deep under the continents and 6 miles (10 km) deep under the oceans. The crust sits on the uppermost part of the mantle (and together, these solid zones comprise the **lithosphere**).
Earthquake	A shaking of the ground caused by the sudden movement of the earth's crust or by volcanic activity.
Epicenter	The point on the earth's surface directly above the focus of an earthquake.
Fault	The fracture or zone of fractures in a rock formation, such as tectonic plates.
Force	Any influence that tends to accelerate an object; a push or a pull.
Magnitude	A number that quantifies the energy released by an earthquake. Currently the US uses the Richter scale, which increases by powers of 10 (i.e., a 5.0 is 10 times more powerful than a 4.0 on the scale).
Mantle	The portion of the earth, about 1800 miles (2900 km) thick, between the crust and the core.
Plate tectonics	A geological model in which the Earth's crust and upper mantle (lithosphere) are divided into a number of segments (plates) which move in response to convection currents from the lower mantle (asthenosphere).
Tsunami	A long ocean wave usually caused by movements of the ocean floor during an earthquake.
Volcano	A rupture in the Earth's crust that allows lava, ash and gases to escape from the Earth's mantle.

Advanced Vocabulary – these terms may come up in your lab depending on time constraints:

Convergent plate movement	Area where plates are moving toward each other.
Divergent plate movement	Area where plates are moving away from each other.
Focus (hypocenter)	The location at which an earthquake begins or ruptures.
Liquefaction	A process that occurs when saturated or semi-saturated soil loses substantial strength and stiffness as a result of an applied pressure, such as an earthquake.
Love waves/ Primary	Up and down waves of energy emitted during an earthquake.

Raleigh waves/ Secondary	Side to side waves of energy emitted during an earthquake.
Transform movement	Plates rubbing against one another in different directions.

Vocabulary Activities

Graphic Organizers

- *Frayer Graphic Organizer:* The Frayer Graphic Organizer is a great tool for vocabulary development. It 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 12 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 its use in a sentence. On page 13 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 14 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/

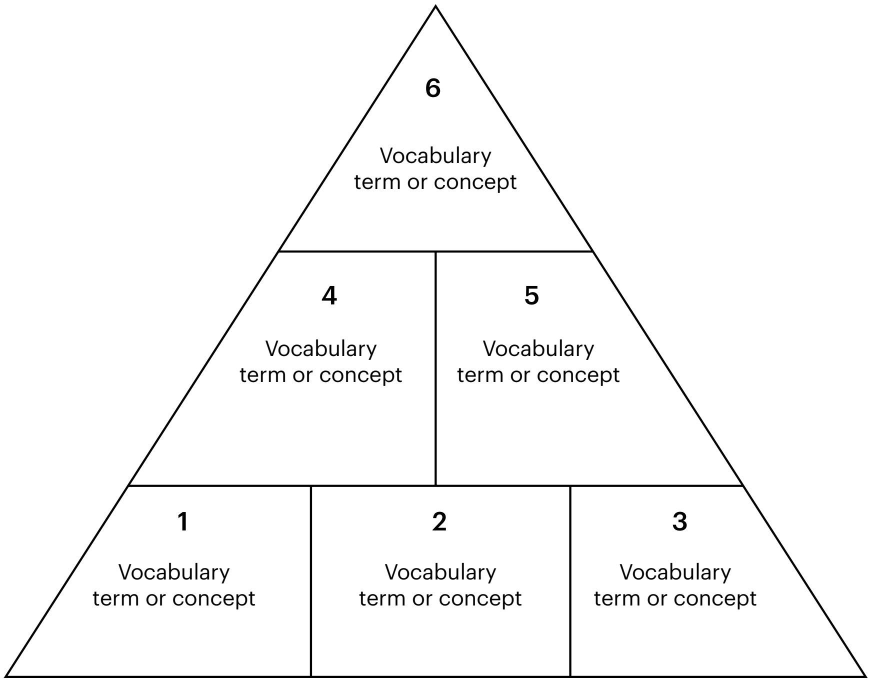
Vocabulary Review Games

- *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., 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?") Partners must ask at least two 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.

Student Name:____

$10,000 Pyramid



Write descriptive clues about each vocabulary term or concept:

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____

Frayer Graphic Organizer

Definition	Characteristics
Vocabulary Word	
Examples	Non-Examples

Vocabulary Graphic Organizer

Definition

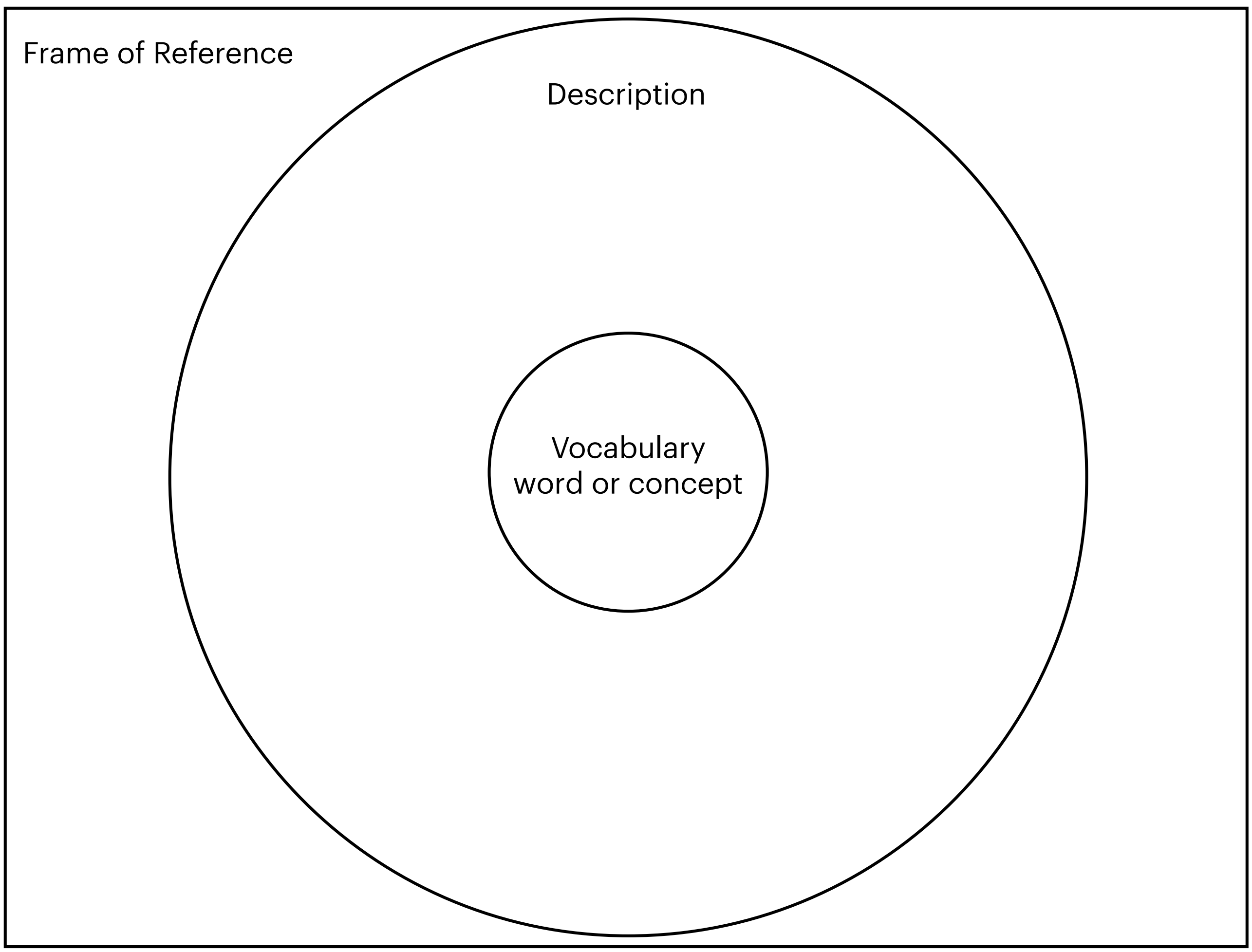
Characteristics

Vocabulary Word

Sentence

Drawing

Circle Map


Frame of Reference
Description
Vocabulary
word or concept