Finding Lost Cities

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Adapted by ORISE

Target Grade: 5th and 6th grade mathematics

Time Required: 2 days (45-50 minutes each day)

Standards

Common Core Mathematics Standards:

- CCSS.MATH.CONTENT.7.G.A.2
  Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions.
- CCSS.MATH.CONTENT.7.G.A.1
  Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
- CCSS.MATH.CONTENT.7.G.B.4
  Know the formulas for the circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

Tennessee State Social Studies Standards:

- SSP.06 Develop geographic awareness by:
  Using the geographic perspective to analyze relationships, patterns, and diffusion across space at multiple scales (e.g., local, national, global). Analyzing locations, conditions, and connections of places and using maps to investigate spatial associations among phenomena

Lesson Objectives

Students will:

- Be able to explain the definition and the relationships between radius, diameter, and circumference
- Be able to use the compass and the concept of triangulation to find the “lost city”

Central Focus

You've been assigned a task to find a lost city! In this activity, students will use a compass and their knowledge of circles to determine the location of the lost city, given one location on the map and a description of another location. You have also been assigned to find the treasure on the treasure map. You will find the treasure using triangulation on GeoGebra. This lesson is designed to cover the 5th grade or 6th grade standards of a circle and using geometric shapes in real life scenarios. This lesson incorporates history into a math lesson. The students will explore one method that researchers have used to search for evidence of lost cities. This method relies on a geometric procedure known as triangulation, in which one location can be determined using its distance from three other known points. While your students learn more about the usage of circles, they also learn how a lost city is found!

Key Terms: radius, compass, diameter, circumference, triangulation, pi

Background Information

Prior to the lesson students should be aware of the following concepts:

- Students should know what a circle looks like.
- Students should know the basic properties of circles such as radius, diameter, circumference, and pi (for now use 3.14). For more information about circles: Circle (mathsisfun.com)

Prior to the lesson teachers should be aware of the following concepts:

- Knowledge and usage of compass (link to video of how to use a compass below): https://www.bing.com/videos/search?q=compass+how+to+use+geometry&docid=608017582501405493&mid=F41BA545AB8F08779DBAF41BA545AB8F08779DBA&view=detail&FORM=VIRE
- Radius (r):
  Radius is the distance from the center to the circumference of a circle. It is half of the diameter.
  Formula: $r = \frac{1}{2}d$
  (Radius Definition (Illustrated Mathematics Dictionary) (mathsisfun.com))
- Diameter(d):
  Diameter is the distance from one point on a circle through the center to another point on the circle. It is the longest distance across the circle. It is twice the radius.
  Formula: $d = 2r$
  (Definition of Diameter (mathsisfun.com))
- Pi(π):
  Pi is the number that we get when we divide the circumference by the diameter. It is approximately 3.14.
  (Circle (mathsisfun.com))

- Circumference(c):
  Circumference is the distance around the edge of a circle (or any curvy shape). It is a type of perimeter.
  Formula: $c = 2\pi r$
  (Circumference Definition (Illustrated Mathematics Dictionary) (mathsisfun.com))
- Triangulation:
  Triangulation is the process of determining the location of a point by forming triangles to the point from known points.
  (Triangulation - Wikipedia)

Materials

- One copy of the Finding Lost Cities handout per student
- One safety compass per student
- Circling Around Worksheet
- Treasure Map Activity Worksheet
- GeoGebra:
  GeoGebra - the world's favorite, free math tools used by over 100 million students and teachers
- One pencil per student

Instruction

Day 1

Introduction (5 minutes)

- Start by asking the students: "What makes a circle, a circle?"
- Have students volunteer and share their answers to the question above.

Activities (35 minutes)

- Hand out the Circling Around worksheet (attached below) to the students.
- Start with drawing a circle on the board. Then have a blank circle where students can identify the center, diameter, radius, and circumference of the circle. An example is shown below:

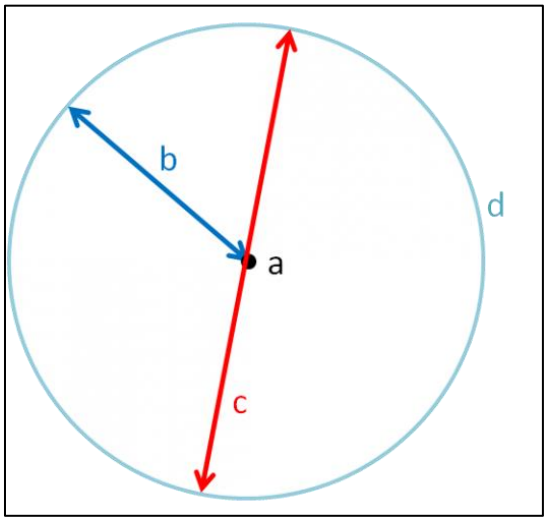


Figure 1: https://www.edplace.com/worksheet_info/maths/keystage2/year6/topic/915/4573/circle-parts

- Provide the students with just the terms without the definition: center, diameter, radius, and circumference. Then as a class, fill out the circle.
- Then have the students do a think-pair-share on how they would define the terms: center, diameter, radius, and circumference. Once the students have done a think-pair-share, have some of the students share their definitions.

- Show this video: Radius, diameter, circumference & π (video) | Khan Academy
    - This video introduces radius, diameter, circumference, and pi. The video explains how the terms are related to each other as well as which part of the circle it describes. Make sure to clarify to the students that in this lesson pi will be rounded to 3.14.

- Have the students complete an activity on GeoGebra in groups of 2-3 people: Circles – GeoGebra
    - This activity allows students to see the relationship between radius, diameter, and circumference.

Closure (5 minutes)

- Have students do a pair-share on how they would describe the relationship between radius, diameter, and circumference in their own words.
- Then have a whole class discussion on the relationship between radius, diameter, and circumference. Have the students share their thoughts, specifically what they discussed in their pair-share.

Day 2

Introduction (5 minutes)

- Pose the question on the board: "What does it mean for something to be 'lost to history'?" and have the students compose a response to this question.
- Ask the students to share their responses. Guide the students to defining "lost to history."
    - "Lost to history" means we know something likely existed but cannot find artifacts or other evidence to prove the existence.

Activities (40 minutes)

- Pass out the *Finding Lost Cities* handout. Have students read the information on the front side quietly. This information is adapted from a *Washington Post* article. Then have a volunteer read the article aloud.
- As a class, discuss the information that the students read. Ask the students what they think triangulation means. It may be helpful to ask students what word is in triangulation. It may be helpful to draw a simplified version of triangulation to display (example show below) to the class to help them understand the geometry involved.
  Optional: Show your students this video:
  How does GPS work | Trilateration explained - Bing video
    - This video is about how trilateration which is similar to triangulation. Furthermore, this video shows how it is used in GPS.

Figure 2: https://www.psywww.com/gst/triangulation-and-convergence.html

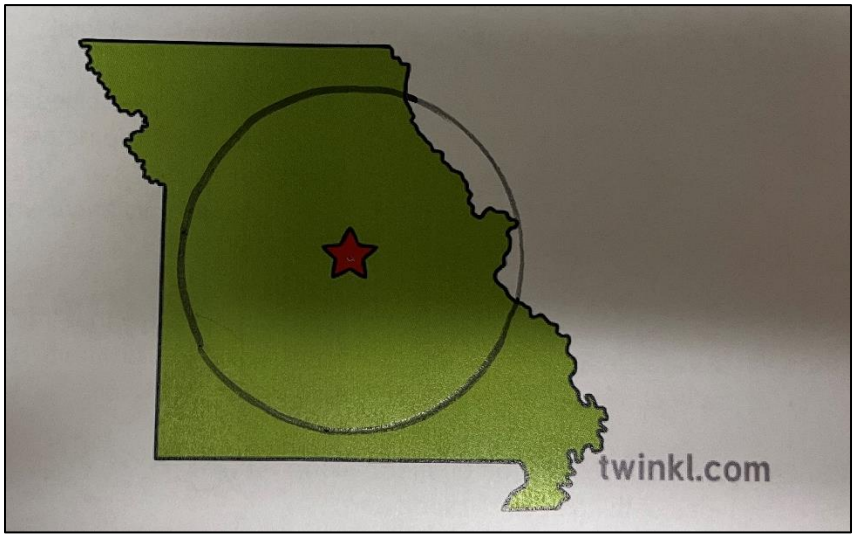
- Have students turn over their handout. On the back of the handout, the map of Missouri provided and the location of one known city (Jefferson City). Teachers in other states or regions may want to provide a map of their own state instead to make a local connection.

Figure 3:https://kids.britannica.com/kids/article/Jefferson-City/345926

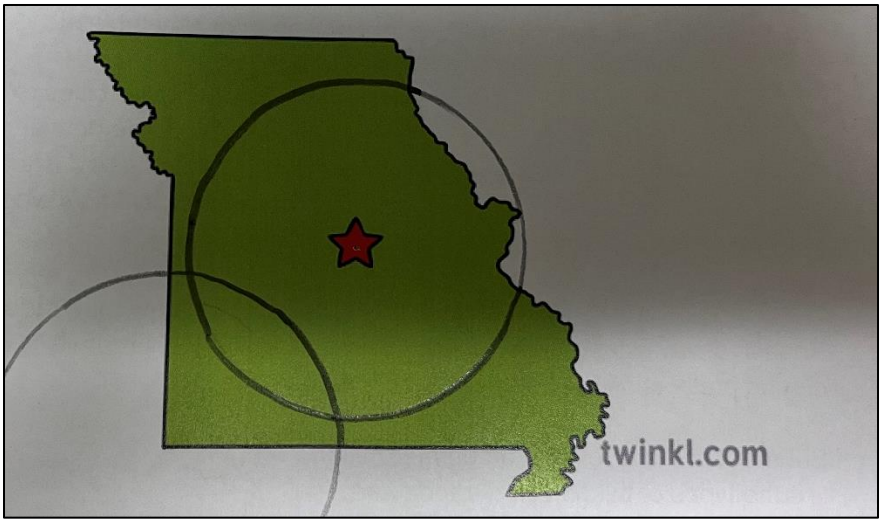
- Ask the students how they think they could locate the "lost city". Have students pair up to do a think pair share. Guide them to brainstorm the idea of using circles or an idea that they learned the day before. Show the students the compass and demonstrate how to use it.
- Show compass to the students. Ask them if they have seen one before and how they think it is used. Ask the students what the purpose of the compass is.
- Pass out a safety compass to each student. Have them practice using the compass to draw circles on a sheet of scrap paper. Have the students draw a snowman. Once students are comfortable using their compasses, they may begin working on their map.
- The instructions (also noted below) on the handout detail where and how big to make their circles. Each student should draw two circles on their map.

Instructions:

1. Using a ruler or measuring tape, draw a circle which is 1 inch away from Jefferson City (in math terms that means it has a 1 inch radius). This will represent the fact that our records show that Rohanwoodsia is about this far from Jefferson City.



2. From the southwest corner of Missouri, draw another circle that is also 1 inch away from the corner. This will represent that we also know that Rohanwoodsia is about this far from the southwest corner.



3. Your two circles should intersect (meet) at two different places. One of these intersections should be the location of Rohanwoodsia.

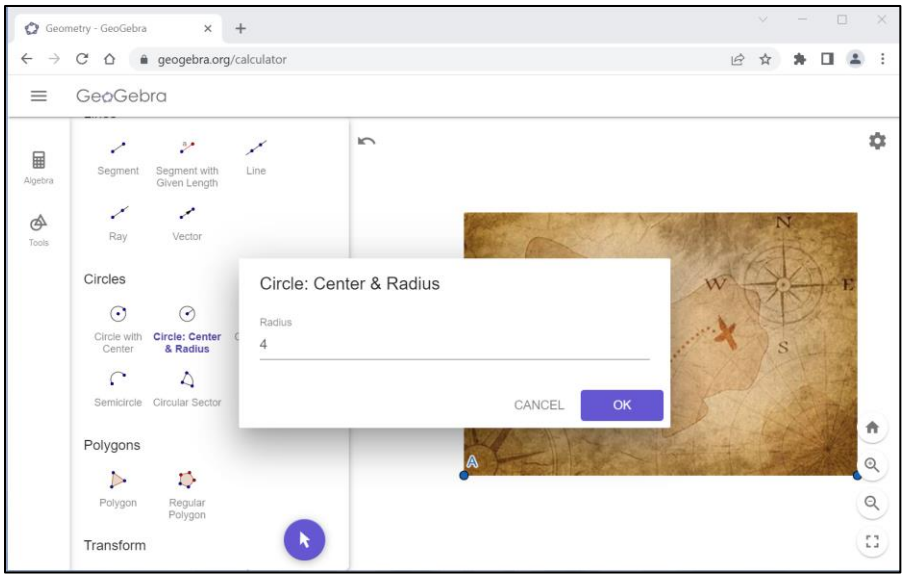
- On their worksheet, have the students answer the question of how they would be able to definitively locate their lost city. Then discuss it as a class.
- Ask the students what information they would need to create a third circle. To create a third circle, the students would need a third known location which would give them a unique single point.
- The students will be complete an activity of finding the treasure on Geogebra. Narrate this to the students:

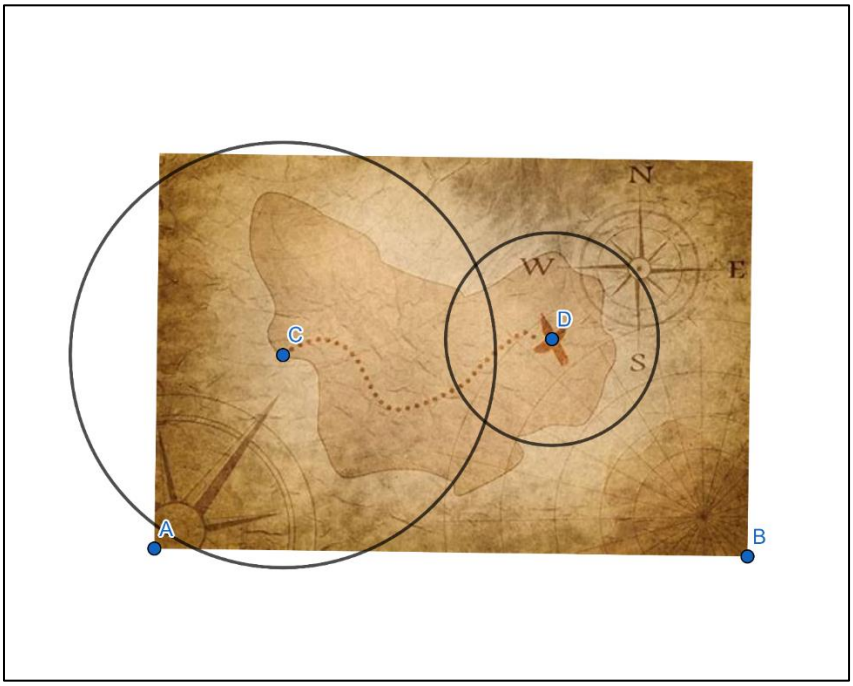
  A treasure map has been found in our school. However, the treasure map had a note on the back. The note said:

  "To whoever found this map, there is a treasure hidden. However, do not assume the "X" is where the treasure is. In order to find the treasure you must utilize triangulation. At the start your journey, the diameter of the circle should be 8. At the "X" the circumference of the circle should be 6.28. This should help you find where the treasure is hidden."

Figure 4: https://www.tunisiesoir.com/science/like-a-treasure-map-brain-region-emphasizes-reward-location-study-21055-2020/

- Have the students complete the activity below on Geogebra: https://www.geogebra.org/calculator/fb2mp9wj





Closure (5 minutes)

- Ask students about other methods that might be used to find lost cities.
- Discuss the pros and cons of each method. Remind students that this is a *statistical method* and is not always perfectly accurate - as in their reading, it is predicted to work about ⅔ of the time.

Differentiation

- English Language Learners:
  - Allow students to work with an upper-level partner.
  - Provide students with a vocabulary sheet that contains pictures of each term and a copy of the presentation in their language.
  - Allow students to use online translators.
  - Simplified readings can be provided.
  - Allow students to answer written questions, orally.
- Students with disabilities:
  - Group students intentionally with others that can support them.
  - Give extra support during the group experiment.
  - Ask these students questions during the group work to make sure they understood the material from the presentation.
  - Give these students a structured template on which to complete the lab report.
  - Motor skills assistance while holding the compass or using the pencil may be given and an object of the given radius can be traced instead of using the compass.
- Advancement:
  - Have students research a different region and complete the same activity.
  - Have students give a hypothesis of what would happen if there were three points given. Ask them if it would change the accuracy of the location of the lost city.
- Grouping:
  - Students could be partnered in ways that have varied levels in each pair. This can help the students collaborate with each other. With different levels in a group, students can help and support each other.
- Timing:
  - For the students who finish early, have them reflect back on the lesson and vocabulary in their own words.
  - For the students who are slower, since the students are in pairs during part of the lesson, they can collaborate to help them.

Assessment

Formative assessment

- The discussions in class will help the teacher determine which students are struggling to understand the concept.
- The question on the back of the worksheet will help the teacher determine how much the student understood how compasses and circles are used to determine the lost city through their mathematical reasoning.

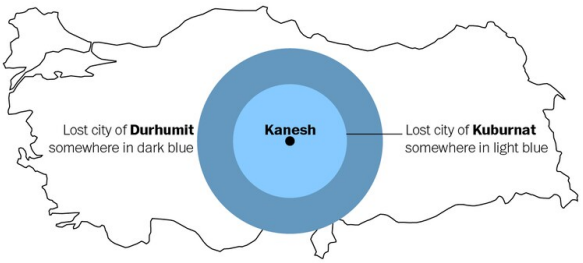
Summative assessment

- The Finding Lost Cities activity is used to practice their skill of using a compass as well as understanding the functions of circles. The concept of radius could be assessed on a test or homework.
- The Treasure Map Activity is used to practice their knowledge of triangulation process. The students' thought process can be seen on the activity sheet to access their learning.

How do they find lost cities?

Name: _____

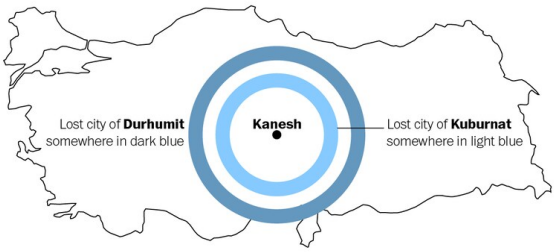
You might be wondering how the archaeologists we saw in class even know where to start digging. Sometimes, they get lucky and someone finds an artifact while farming or building something. Other times, they use historical records to try and locate cities they know existed, but aren't sure where. One method involves using geometry to analyze information from clay tablets!



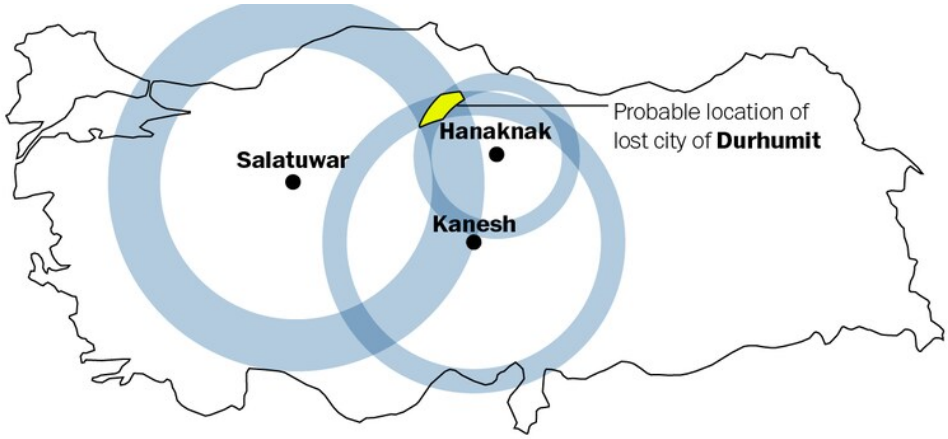
We know that three cities existed, based on a record of trade between them: Kanesh, Durhumit, and Kuburnat. But, right now, we only know where Kanesh is located.

The records show that traders from Kanesh always stopped at Kuburnat before heading to Durhumit. That means we can be pretty confident that Kuburnat is closer than Durhumit.

But the records also have other information, like the types of things being traded and their prices. Using a set of equations, researchers can estimate how far apart the cities are from each other.



When the researchers did this a bunch of times using different records, they were able to pinpoint a small area where they thought a certain city was. The researchers tested their model on the locations of existing cities: **they were right about 66% of the time!**



(*turn page over*)

Images and information based on "Ancient data, modern math, and the hunt for 11 lost cities of the Bronze Age," an article in the Washington Post by Christopher Ingram (November 13, 2017).

Now, you try! Here is a map of the state of Missouri. The star marks the location of Missouri's capital, Jefferson City. This will represent the city we for sure know exists.

We will be trying to find the lost city of Rohanwoodsia, which we know is somewhere.

Instructions:

1. Using a ruler or measuring tape, draw a circle which is **1 inch away** from Jefferson City (in math terms, that means it has a 1 inch radius). This will represent the fact that our records show that Rohanwoodsia is about this far from Jefferson City.

2. From the **southwest corner of Missouri**, draw another circle that is also **1 inch away** from the corner. This will represent that we also know that Rohanwoodsia is about this far from the southwest corner.

3. Your two circles should intersect (meet) at two different places. One of these intersections should be the location of Rohanwoodsia.

How might we decide which of the two intersections is our lost city?

_____

_____

_____

Name:_____

Circling Around

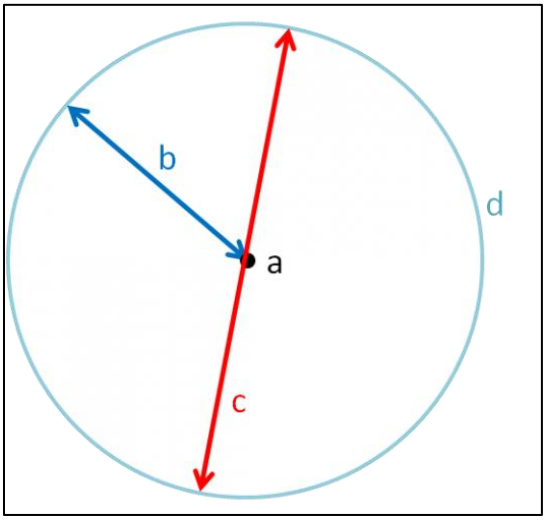
Label the circle with the following terms: center, diameter, radius, and circumference.

a.

b.

c.

d.



With your partner, discuss the terms: center, diameter, radius, and circumference.

Write the definitions below.

Center:

Diameter:

Radius:

Circumference:

Now, based on the video, write the definitions of the terms: center, diameter, radius, and circumference.

Write the definitions and formulas below.

Center:

Diameter:

Radius:

Circumference:

Other notes from the Video:

GeoGebra Circles Activity

As you work on the GeoGebra Circles Activity, answer the questions below.

1. If you know a circle's diameter how can you predict its circumference?

   If you know a circle's radius how can you predict its circumference?

   If you know a circle's circumference how can you predict it diameter or radius?

2. Based on second part of the activity, what is the relationship between circumference and diameter?

3. Based on the activity, make a chart of the circumference and diameter length. What is happening to the circumference as the diameter changes?

Name:_____

Treasure Map Activity

"To whoever found this map, there is a treasure hidden. However, do not assume the "X" is where the treasure is. In order to find the treasure you must utilize triangulation. At the start your journey, the diameter of the circle should be 8. At the "X" the circumference of the circle should be 6.28. This should help you find where the treasure is hidden."

Show your work below.