

#### The Phenomenon

Congressional districts in the United States are used to elect members of the U.S. House of Representatives. Currently, the number of voting seats in the House of Representatives is set at 435. Each state is allocated a set number of congressional districts based on its population. Colorado, for example, had a population of about 5 million people in 2010, so it currently has seven congressional districts. Each state is responsible for drawing the boundaries of each district. Take a minute to watch a video about how the Colorado congressional districts have changed since 1972. As you watch the video, write down some things you notice and wonder about.

Things I <b>noticed</b>	Things I <b>wonder</b> about

#### The Task

The video you watched showed how some of the congressional districts in Colorado have changed considerably over time. These districts are about to change again because Colorado will be allocated eight congressional districts instead of seven based on the results of the 2020 census. The map at right shows one proposal for a new congressional district map for Colorado that includes eight districts.



Some people in Colorado believe that the districts have been gerrymandered because they have an odd shape. **Gerrymandering** is the process of drawing voting district boundaries to create an advantage for one political party over another in future elections. Your task in this investigation is to use mathematics to determine if people should be suspicious of the proposed district boundaries or not. The guiding question of this investigation is:





#### Which districts in Colorado should be redrawn because they are Gerrymandered?

#### **Initial Ideas**

Before you start this investigation, take a few minutes to look over the proposed congressional district map for Colorado and think about how you could describe or measure the shapes of these districts. Write down your ideas in the space below.

Some ideas that I have...

Now list some things that you think will be important to learn more about during this investigation in the space below.

Some things that I want to know more about...





#### Some Ideas You Can Use: Gerrymandering

The term *gerrymander* is a combination of the last name of Elbridge Gerry, who was a governor of Massachusetts, and the word *salamander*. The term was coined in 1812 after the Massachusetts legislature created an odd-shaped voting district in Essex County to give Gerry's incumbent Democratic-Republican Party an advantage over the Federalist Party. The district became official on February 11, 1812, when Gerry signed the legislation into law. In early March of the same year, an illustrator named Elkanah Tisdale drew a picture of the new voting district as if it was a monster with a snakelike head and claws during a dinner party. Allegedly, another dinner guest commented that the drawing of the district looked like a salamander. Then the poet Richard Alsop, who was also at the dinner party, added, "No, a Gerrymander." After the drawing was made into a political cartoon on March 26, 1812, the term stuck (see the picture below).



The public was outraged by the change in the voting districts in Massachusetts, and meetings were held throughout the state to protest the change. Despite the unpopularity of the new voting districts at the time, the creation of these new districts worked out well for the Democratic-Republican Party. Democratic-Republican candidates won 29 Senate seats while the Federalist candidates only won 11 seats in the 1812 state election, even though the majority of the state's voters were Federalists.

Politicians can create gerrymandered voting districts by drawing boundary lines based on voting tendencies using one of two strategies. The first strategy is to **"crack"** or spread out the other party's voters across many districts to dilute the number of votes that a political party will receive from each district. The second strategy is to **"pack"** or group together all the people who vote for another party into a few districts, which reduces the total number of districts that the other political party can win. The picture





below shows how voting districts can be redrawn to give one political party an advantage over another.



In this example, members of Party 1 were responsible for redrawing the voting district boundaries. These individuals created four voting districts that "packed" most Party 2 voters into one district. This caused the candidates from Party 1 to be more likely to receive a majority of the votes in the other three districts. This is a clear example of how politicians can gerrymander voting districts, which is the process of manipulating district boundaries to create a political advantage in future elections.

Some things I <b>know</b> from what I read

Some Ideas You Can Use: Ways to Identify Gerrymandering





The process of gerrymandering often results in voting districts with odd shapes. The image below illustrates an example of gerrymandered voting districts. This map shows the congressional districts of North Carolina from 2013 to 2017. These districts were declared by a federal court to be unconstitutionally gerrymandered to favor Republican candidates and ordered to be redrawn before the 2020 congressional elections.



There are several ways that people can use geometry to identify a potentially gerrymandered voting district based on its shape. Most of these approaches require people to determine a district's perimeter and area first. They then use this information to make a comparison to other districts, a region, or an object. **Perimeter** is defined as the total distance around a two-dimensional figure. **Area** is the amount of space, measured in square units, within an enclosed two-dimensional figure.

One way to use geometry to tell if a district has been gerrymandered is to find the ratio of the district's perimeter to its area. This value is called the **compactness of a district**. The example at right shows two districts (A and B) with the same area (16), but district B has a larger perimeter (24) than district A (16). District A, as a result, is more compact ( $C_A = 16/16 = 1$ ) than district B ( $C_B = 24/16$ = 1.5).







A second method is to find the ratio between a district's perimeter and the perimeter of a circle with an area equal to the district. This value is known as the **comparison to a circle of equal area**. The equation  $P = 2\sqrt{\pi A}$  can be used to find the perimeter of a circle when given its area. The figure at left shows district B and a circle with the same area. The ratio of the perimeter of district B and that circle is P<sub>District B</sub> / P<sub>Circle</sub> = 24/14.18 = 1.69.



A third method is to compare the ratio of a district's area to the area of a circle with the same perimeter. This value is called the **comparison to a circle of equal perimeter**. The equation  $A = \frac{P^2}{4\pi}$  can be used to find the area of a circle when given its perimeter. The figure at right shows district A and a circle with the same perimeter. The ratio of the area of district A and that circle is A<sub>District A</sub> / A<sub>Circle</sub> = 16/20.37 = 0.79.

A fourth method is to compare the compactness of the district to the compactness of the entire region or state in which the district lies. This value is called the **comparison to the compactness of the region**. To calculate this ratio, you must find the perimeter and the area of the state where the district in question is located as well as the perimeter and area of the district.

Some things I know from what I read...



#### **Plan Your Investigation**

Prepare a plan for your investigation by filling out the chart below.

I am trying to answer the following question...

I will use the following observations or measurements...

I will **analyze** these observations or measurements by...

I approve of this investigation plan

Teacher's Signature

Date





#### Discuss and Solve the Task

Use the space below to perform the calculations that you need or create any tables or graphs that will help you make sense of the phenomenon and complete the task.

	1	1	1			1											
-								 			 						
-								 			 		 				





#### **Draft Argument**

Develop an argument on a whiteboard. It should include:

- 1. A *claim*: Your answer to the guiding question.
- 2. *Declarations*: Any definitions, formulas, variables, or symbols you used.
- 3. *Evidence*: Tables, graphs, equations, computations, cases, examples, and counterexamples, or thought processes necessary to support your claim.
- 4. A *justification of the evidence*: Why your group used certain mathematics concepts over others or why you decided to use one strategy over another. Be sure to include any assumptions you made.

The Guiding Question:						
Our Claim:						
Declarations:						
Our Evidence:	Our Justification of the Evidence:					

#### **Argumentation Session**

Share your argument with your classmates. Be sure to ask them how to make your draft argument better. Keep track of their suggestions in the space below.

Some possible ways to **improve** our argument...







#### **Reflective Discussion**

You can keep track of any ideas from the discussion that you think are important or will be useful in the future in the space below.

Some important ideas...





#### **Draft Report**

Prepare a report to share what you figured out during your investigations

Introduction	
We have been studying	In class. Before we started
this investigation, we explored	
We noticed	
Our goal for this investigation was to figure out	
The guiding question was	
<b>Method</b> To answer this question,	





Declarations						
Argument						
We figured out						
The below includes information about						
This analysis suggests						
This evidence is based on several important ideas. The first one is						



Information and Standards Alignment

#### Subject

Discipline

Grade band

Math

Geometry

9-12

#### Task

Students use what they know about computing perimeters and areas of composite shapes to decide if any of the proposed new voting districts in Colorado should be checked for gerrymandering.

#### Core Idea(s)

G4: Expressing geometric properties with equations

G5: Geometric measurement and dimension

#### **Practices**

MP1: Make sense of problems and persevere in solving them

MP2: Reason abstractly and quantitatively

- MP3: Construct viable arguments and critique the reasoning of others.
- MP4: Model with mathematics.
- MP5: Use appropriate tools strategically
- MP6: Attend to precision

#### Alignment with Academic Standards for Mathematics

Teachers can use this investigation to help students reach any of the performance expectations for science that are listed in the table below.

Source	Code	Standard
CCSS	HSG.MG.A.1	Use geometric shapes, their measures, and their properties to describe objects.
Florida	G-MG.1	Use geometric shapes, their measures, and their properties to describe objects.
Indiana	G.QP.6	Compute perimeters and areas of polygons in the coordinate plane to solve real-world and other mathematical problems.
Minnesota	9.3.3.7	Use properties of polygons—including quadrilaterals and regular polygons—to define them, classify them, solve problems and logically justify results.
Oklahoma	G.2D.1.6	Apply the properties of polygons to solve real-world and mathematical problems involving perimeter and area
South Carolina	GM.1	Use geometric shapes, their measures, and their properties to describe objects.
Texas	Geometry 11.B	Determine the area of composite two-dimensional figures comprised of a combination of triangles, parallelograms, trapezoids, kites, regular polygons, or sectors of circles to solve problems using appropriate units of measure.
Virginia	G.9	The student will verify and use properties of quadrilaterals to solve problems, including practical problems.





Information and Standards Alignment

#### Alignment with Common Core State Standards for English Language Arts

Teachers can use this investigation to help students reach any of the performance expectations for reading, writing, or speaking and listening that are listed in the table below.

Strand	Code	Standard
Reading	RH.9-10.1	Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
	RST.9-10.2	Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
	RST.9-10.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
	RST.9-10.5	Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., <i>force, friction, reaction force, energy</i> ).
	RST.9-10.6	Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., <i>force, friction, reaction force, energy</i> ).
	RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words
	RST.9-10.8	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words
	RST.9-10.9	Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts
	RST.9-10.10	read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently
Writing	WHST.9-10.1.A	Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence
	WHST.9-10.1.B	Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns
	WHST.9-10.1.C	Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims



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	WHST.9-10.1.D	Establish and maintain a formal style and objective tone while
		attending to the norms and conventions of the discipline in which
		they are writing
	WHST.9-10.1.E	Provide a concluding statement or section that follows from or
		supports the argument presented.
	WHST.9-10.2.A	Introduce a topic and organize ideas, concepts, and information
		to make important connections and distinctions; include
		formatting (e.g., headings), graphics (e.g., figures, tables), and
		multimedia when useful to aiding comprehension
	WHST.9-10.2.B	Develop the topic with well-chosen, relevant, and sufficient
		facts, extended definitions, concrete details, quotations, or other
		information and examples appropriate to the audience's
		knowledge of the topic.
	WHST.9-10.2.C	Use varied transitions and sentence structures to link the major
		sections of the text, create cohesion, and clarify the relationships
		among ideas and concepts
	WHST.9-10.2.D	Use precise language and domain-specific vocabulary to manage
		the complexity of the topic and convey a style appropriate to the
		discipline and context as well as to the expertise of likely readers
	WHST.9-10.2.E	Establish and maintain a formal style and objective tone while
		attending to the norms and conventions of the discipline in which
		they are writing
	WHST.9-10.2.F	Establish and maintain a formal style and objective tone while
		attending to the norms and conventions of the discipline in which
		they are writing
	WHST.9-10.4	Produce clear and coherent writing in which the development,
		organization, and style are appropriate to task, purpose, and
		audience
	WHS1.9-10.5	Develop and strengthen writing as needed by planning, revising,
		editing, rewriting, or trying a new approach, focusing on
		addressing what is most significant for a specific purpose and
		audience
	VVH31.9-10.0	undeta individual or abared writing products, taking adventage
		of technology's consists to link to other information and to
		display information flovibly and dynamically
	WUST 0-10 2 0	Draw evidence from informational texts to support analysis
	VVIIS1.7-10.2.7	reflection and research
		Write routingly over extended time frames (time for reflection
	VVII31.9-10.2.10	and revision) and shorter time frames (a single sitting or a day or
		two) for a range of discipline-specific tasks, purposes, and
		audiences
Speaking and	SI 9-10 1	Initiate and participate effectively in a range of collaborative
Listening		discussions (one-on-one in groups and teacher-led) with
Liotoning		diverse partners on grades 9-10 topics texts and issues
		building on others' ideas and expressing their own clearly and
		persuasively.
	SL.9-10.1 A	Come to discussions prepared, having read and researched
		material under study: explicitly draw on that preparation by



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	referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
SL.9-10.1.B	Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed.
SL.9-10.1.C	Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions.
SL.9-10.1.D	Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.
SL.9-10.3	Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.
SL.9-10.4	Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
SL.9-10.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
SL.9-10.3	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

#### Alignment with English Language Proficiency Standards

Teachers can use this investigation to help emerging multilingual students reach the performance expectations for English language proficiency listed in the table below.

Modality	Code	Standard
Receptive	ELP 1	Construct meaning from oral presentations and literary and
		informational text through grade-appropriate listening, reading, and
		viewing.
	ELP 8	Determine the meaning of words and phrases in oral presentations
		and literary and informational text.
Productive	ELP 3	Speak and write about grade-appropriate complex literary and
		informational texts and topics.
	ELP 4	Construct grade-appropriate oral and written claims and support
		them with reasoning and evidence.
	ELP 7	Adapt language choices to purpose, task, and audience when
		speaking and writing.
	ELP 9	Create clear and coherent grade-appropriate speech and text.



Information and Standards Alignment

	ELP 10	Make accurate use of standard English to communicate in grade-
		appropriate speech and writing.
Interactive	ELP 2	Participate in grade-appropriate oral and written exchanges of
		information, ideas, and analyses, responding to peer, audience, or
		reader comments and questions.
	ELP 5	Conduct research and evaluate and communicate findings to
		answer questions or solve problems.
	ELP 6	Analyze and critique the arguments of others orally and in writing.

