

Congressional Districts in Colorado



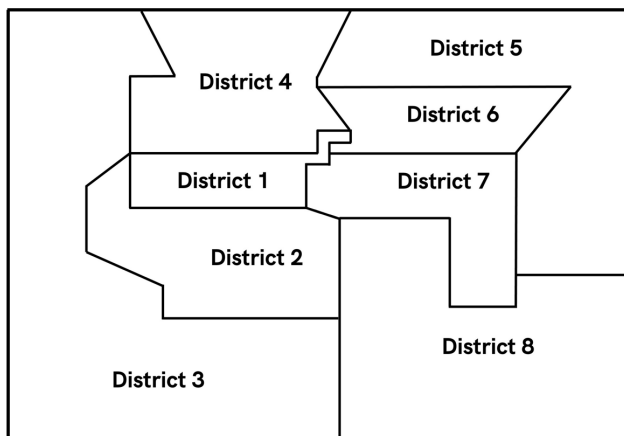
The Phenomenon

Congressional districts in the United States are used to elect the members of the United States House of Representatives. Currently, the number of voting seats in the House of Representatives is set at 435 with each one representing approximately 711,000 people. 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 7 congressional districts. Each state is responsible for drawing the boundaries of each district. Take a moment 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.

Things I noticed ...	Things I wonder about...
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The Task

The video 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 8 congressional districts instead of 7 based on the results of the 2020 census. The map below shows one proposal for a new congressional district map for the state of Colorado that includes 8 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 in order 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

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proposed district boundaries or not. The guiding question of this investigation is:

Which districts should we check for gerrymandering based on shape?

Initial Ideas

Before you start this investigation, take a moment 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...

In the box below, list some things that you think will be important to learn more during this investigation.

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

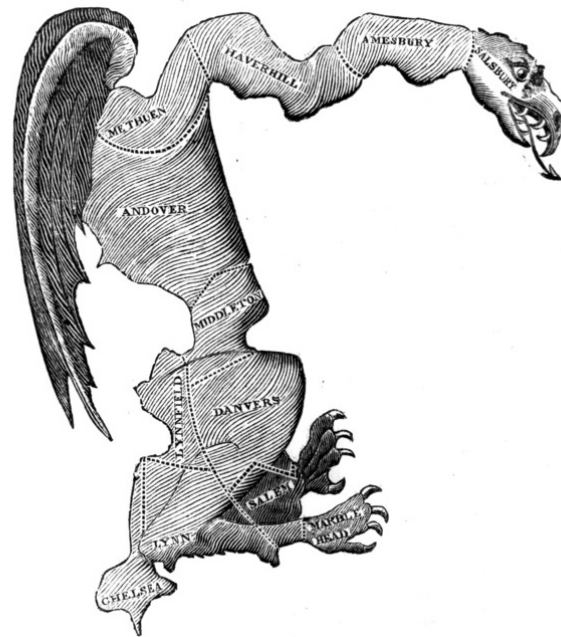
Some Ideas You Can Use: Gerrymandering

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 when 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 that same year, an artist named Gilbert Stuart stopped by the office of the Columbia Sentinel newspaper. A map of the new voting districts in Massachusetts hung on the office wall. As he studied it, he was struck by the shape of the one in Essex county, so he took a pencil and drew a head, wings, and claws on the map of the district. He then said to editor Benjamin Russel, a Federalist, “There, that will do for a Salamander.” “Better say a Gerrymander,” replied Benjamin Russel, punning on the name of Governor Gerry. After it was made into a political cartoon on March 26, 1812, the term stuck (see the picture below).

THE GERRY-MANDER.

A new species of *Monster*, which appeared
in *Essex South District* in Jan. 1812.

“O generation of **VIPERS** ! who hath warned you of the wrath to come ?”



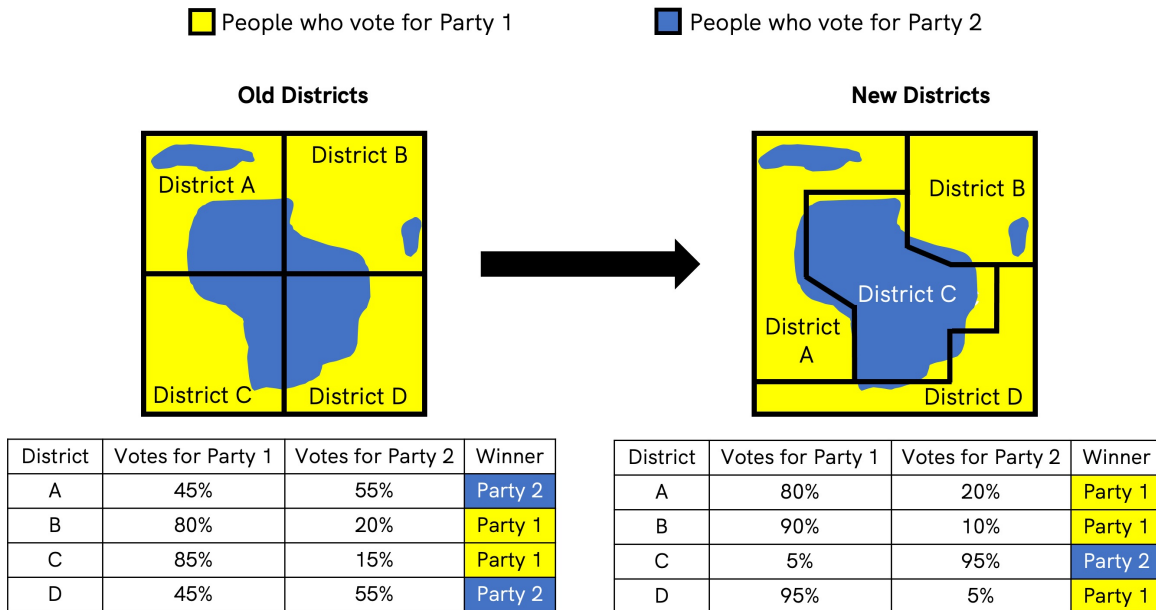
The public was outraged by the change in the voting districts in Massachusetts, and meetings were held throughout the state to protest the change. Despite the unpopularity of the new voting districts at the time, the creation of the new voting districts worked out well for the Democratic-Republican party. 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 Federalist.

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 to spread out, the voters of the other party across many districts to dilute the number of

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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.

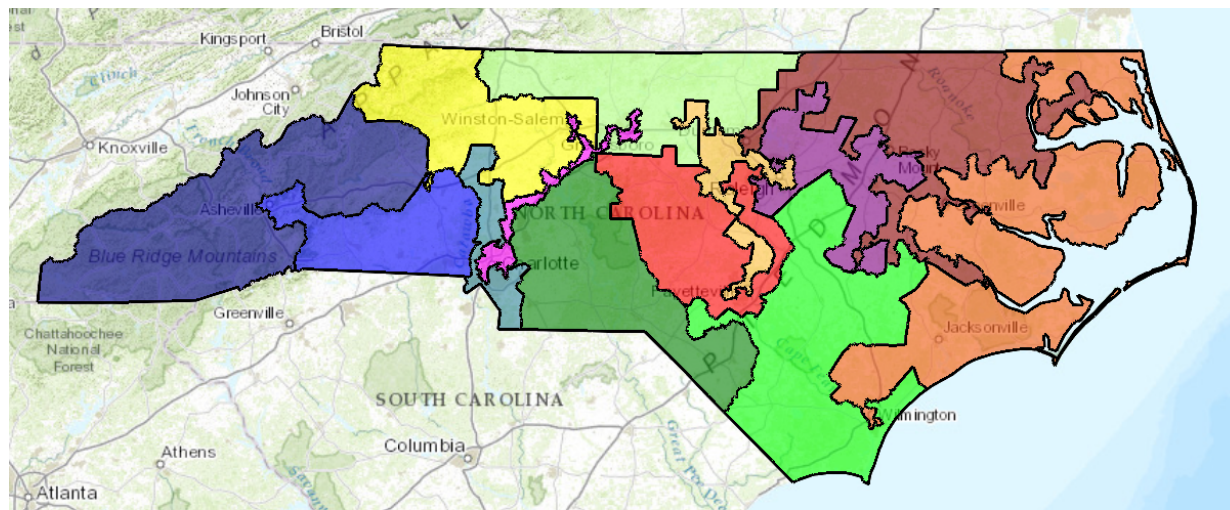
Some things I **know** from what I read...

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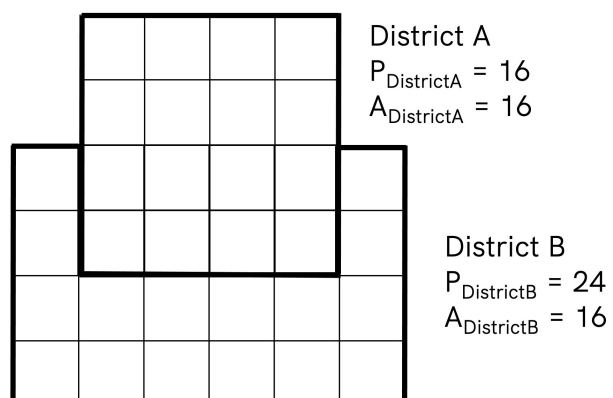
Some Ideas You Can Use: Ways to identify gerrymandering

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 prior to the 2018 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 first determine a district's perimeter and area and to 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 2-dimensional figure. **Area** is the amount of space, measured in square units, within an enclosed 2-dimensional figure.

One way to use geometry to tell if a district has been gerrymandered or not 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). These two districts have 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 ($C_B = 24/16 = 1.5$).

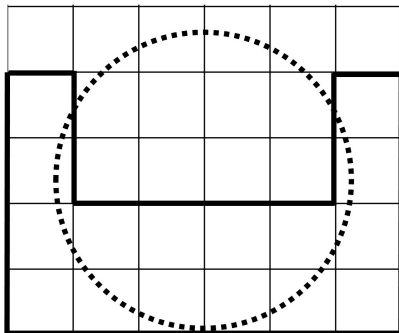


A second method is to find the ratio between a district's perimeter and the perimeter of a circle that has an area equal to the district. This value is known as the **comparison to a circle of equal area**. The equation, $P = 2\sqrt{\pi A}$ can be used to find the perimeter of

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District B



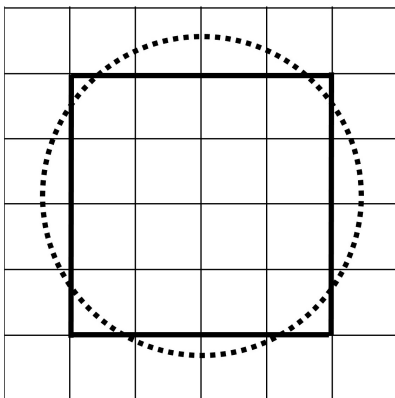
$$P_{\text{District B}} = 24, A_{\text{District B}} = 16$$

$$P_{\text{Circle}} = 14.18, A_{\text{Circle}} = 16$$

a circle when given its area. The example at top left shows district B and a circle with the same area. The ratio of the perimeter of district B and that circle is $P_{\text{District B}} / P_{\text{Circle}} = 24/14.18 = 1.69$.

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 example at bottom left shows district A and a circle with the same perimeter. The ratio of the area of district A and that circle is $A_{\text{District A}} / A_{\text{Circle}} = 16/20.37 = .79$

District A



$$P_{\text{District A}} = 16, A_{\text{District A}} = 16$$

$$P_{\text{Circle}} = 16, A_{\text{Circle}} = 20.37$$

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...

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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

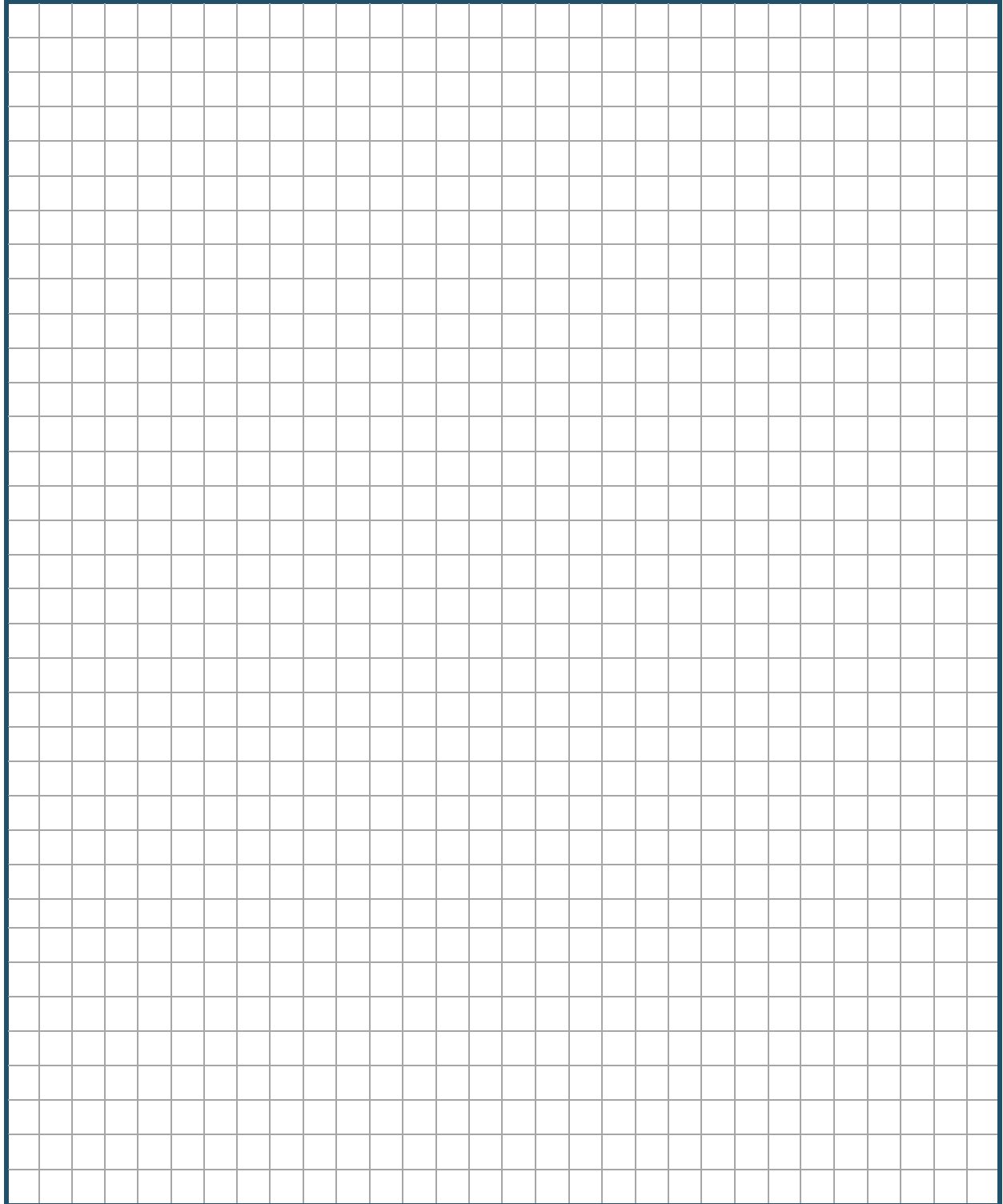
Date

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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.



Gerrymandering



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.

Guiding Question:	
Claim:	
Declarations:	
Evidence:	Justification:

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...

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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**...

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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 _____

Method

To answer this question, _____

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Argument

We figured out _____

The _____ below includes information about _____

This analysis suggests _____

This evidence is based on several important math ideas. The first one is _____

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Information and Standards Alignment

Subject

Math

Discipline

Geometry

Grade band

9-12

Task

Students use what they know about computing perimeters and areas of composite shapes to figure how if any of the proposed new voting district 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	-	-
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	-	-

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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 <i>grades 9-10 texts and topics</i> .
	RST.9-10.5	Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., <i>force</i> , <i>friction</i> , <i>reaction force</i> , <i>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</i> , <i>friction</i> , <i>reaction force</i> , <i>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

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		claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims
	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
	WHST.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
	WHST.9-10.6	Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically
	WHST.9-10.2.9	Draw evidence from informational texts to support analysis, reflection, and research
	WHST.9-10.2.10	Write routinely over extended time frames (time for reflection 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 Listening	SL.9-10.1	Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues,

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Information and Standards Alignment

		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 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.

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Information and Standards Alignment

	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.
	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.