

Full Lesson

The Great Inka Road: How can a road system be an example of innovation?

Grades

- 5–8

Subjects

- Geography, History, Economics, Environmental Science, STEM (Science, Technology, Engineering, Mathematics)

Key Message

The Inka developed a sophisticated empire during the fifteenth century in the challenging geographical environments of South America, spanning large parts of current-day Colombia, Ecuador, Peru, Bolivia, Chile, and Argentina. To support the empire, the Inka built a vast road system applying innovative engineering techniques to address the challenges of transportation and communication and to facilitate the integration of distant communities. One such innovation is the suspended grass bridge, an Inka engineering solution that is attuned to the natural environment and focuses on tension vs. compression forces. Only one suspended grass bridge—*Q’eswachaka*¹—remains from Inka times and is rebuilt every year by *Quechua*² communities in the Andes using knowledge passed down through the generations for the past 600 years.

¹ *Q’eswachaka* (q’eswa meaning “braided grass” and chaka meaning “bridge” in the Quechua language) is pronounced khes wah CHAH kah.

² *Quechua* [pronounced KHEH choo WAH] is the post-conquest name for the Inka language *Runasimi* and the name of an ethnic group living northwest of Cusco at the beginning of the Inka expansion.

Student Outcomes

Students will know that:

- In less than 100 years and without the use of the wheel, metal tools, or animals to carry heavy burdens³, the Inka built a sophisticated empire that they called *Tawantinsuyu*⁴.
- To expand and support their empire, the Inka built the *Qhapaq Ñan*⁵, an extensive road system that spanned 25,000 miles (40,000 km) down the Pacific coast of South America from Ecuador to Chile, traversing extreme physical geographies.
- The Q’eswachaka suspension grass bridge is an example of Inka engineering and the only surviving suspension bridge from the time of the Inka Empire.
- Different bridges can withstand different kinds of forces, and two of the most common forces used in bridge building are tension and compression. The Inka developed suspension grass bridges using the idea of tension.

Students will understand that the Q’eswachaka is an important example of innovation and sustainability from environmental, cultural, and engineering perspectives.

Students will be able to evaluate sources in order to construct an argument about how people can use innovations to address difficult problems and find solutions to challenging situations.

A Note to Teachers: NMAI Education Approach

- This online lesson offers a new way to teach and think about the Inka Empire and the Great Inka Road system. Exploring a variety of sources, students evaluate information and use evidence to answer the question, “How can a road system be an example of innovation?” The lesson is structured, yet flexible and respects an educator’s own knowledge and expertise. As such, teacher materials offer suggestions, rather than prescriptions for classroom implementation.
- Following a C3 inquiry design, the lesson begins with a compelling question to anchor students’ investigations. Supporting questions develop the academic content necessary to engage students with the concept of innovation in the context of the Inka Road system. Featured sources include maps, videos, illustrations, images, quotes, and objects from the NMAI collection to generate student curiosity and build knowledge. Students craft conclusions about the significance of the Inka Road, especially with respect to innovation, and use this knowledge to take informed action with direct relevance to the present time.

³ While llamas can carry up to 60 pounds, they were not used by the Inka in the road construction process as load-carrying animals. The road was built for llamas and foot traffic, not by llamas.

⁴ Tawantinsuyu [pronounced tah wahn teen SOO yoo] means “four parts together” in the Quechua language.

⁵ Qhapaq Ñan [pronounced “KHAH pahk NYAN”] means “Great Inka Road” in the Quechua language.

Academic Standards

Framework for Essential Understandings about American Indians

- NMAI’s Essential Understandings reveal key concepts about the rich and diverse cultures, histories, and contemporary lives of Native peoples. Woven throughout the lesson, the following Essential Understandings provide a foundation for students to thoughtfully approach the complexity of the Inka Empire. The Essential Understandings directly correlate to the National Council of the Social Studies’ ten themes that form a framework for social studies standards.

NK360° Essential Understandings

- **EU3:** People, Places, and Environments—For thousands of years, indigenous people have studied, managed, honored, and thrived in their homelands. These foundations continue to influence American Indian relationships and interactions with the land today.
- **EU8:** Science, Technology, and Society—American Indian knowledge resides in languages, cultural practices, and teaching that spans many generations. This knowledge is based on long-term observation, experimentation, and experience with the living earth. Indigenous knowledge has sustained American Indian cultures for thousands of years. When applied to contemporary global challenges, Native knowledge contributes to dynamic and innovative solutions.

Common Core Standards

- **CCSS.ELA-Literacy.CCRA.R.1:** Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
- **CCSS.ELA-Literacy.CCRA.W.1:** Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.
- **CCSS.ELA-Literacy.CCRA.W.7:** Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

C3 Standards

- **D2.Geo.2.6-8:** Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions, and changes in their environmental characteristics.
- **D2.Geo.3.6-8:** Use paper based and electronic mapping and graphing techniques to represent and analyze spatial patterns of different environmental and cultural characteristics.
- **D2.Geo.4.6-8:** Explain how cultural patterns and economic decisions influence environments and the daily lives of people in both nearby and distant places.

- **D2.Geo.7.6-8:** Explain how changes in transportation and communication technology influence the spatial connections among human settlements and affect the diffusion of ideas and cultural practices.
- **D2.His.3.6-8:** Use questions generated about individuals and groups to analyze why they, and the developments they shaped, are seen as historically significant.
- **D2.His.16.6-8:** Organize applicable evidence into a coherent argument about the past.
- **D2.Eco.1.6-8:** Explain how economic decisions affect the well-being of individuals, businesses, and society.
- **D2.Eco.3.3-5:** Identify examples of the variety of resources (human capital, physical capital, and natural resources) that are used to produce goods and services.
- **D2.Eco.7.6-8:** Analyze the role of innovation and entrepreneurship in a market economy.
- **D2.Eco.14.6-8:** Explain barriers to trade and how those barriers influence trade among nations.

National Science Education Standards

- **E1.1:** Abilities of Technological Design, including evaluate completed technological designs and products; communicate the process of technological design.
- **F5.4:** Science and Technology in Local Challenges, including science and engineering work in many different settings.

Next-Generation Science Standards

- **Practice 2:** Developing and using models.
- **Practice 6:** Constructing explanations (for science) and designing solutions (for engineering).



The Meaning of Innovation

Lesson Components

- **Opening Video “Inka Innovative Engineers— The Great Inka Road:”** A video animation featuring innovative practices used by the Inka for engineering roads and bridges to support their empire, presented from the perspective of two middle school students.

Student Worksheet

- [*The Meaning of Innovation*](#)

Connection to the Compelling Question

- What is innovation and why is it important? This lesson previews key concepts integral to the compelling question, “How can a road system be an example of innovation?” Students begin their inquiry by watching a video that sets the stage for thinking about Inka innovation and accomplishments in engineering in the context of building roads and bridges.

Ideas

- The worksheet, *The Meaning of Innovation*, can be done by students individually, in pairs, or in small groups. The activity is designed to explore the meaning of the word “innovation” through definitions, characteristics, examples, and non-examples.

Suggested Lesson Procedure

Hook

- Ask students what the word “innovation” means. Discuss students’ definitions, examples, and ideas.
- Consider prompts such as:
 - What innovations have been introduced in their lifetimes?
 - How have these innovations changed the world?
 - How might life be different without them?
- Show the video “Inka Innovative Engineers—The Great Inka Road” to the class.

The Meaning of Innovation

The Meaning of Innovation

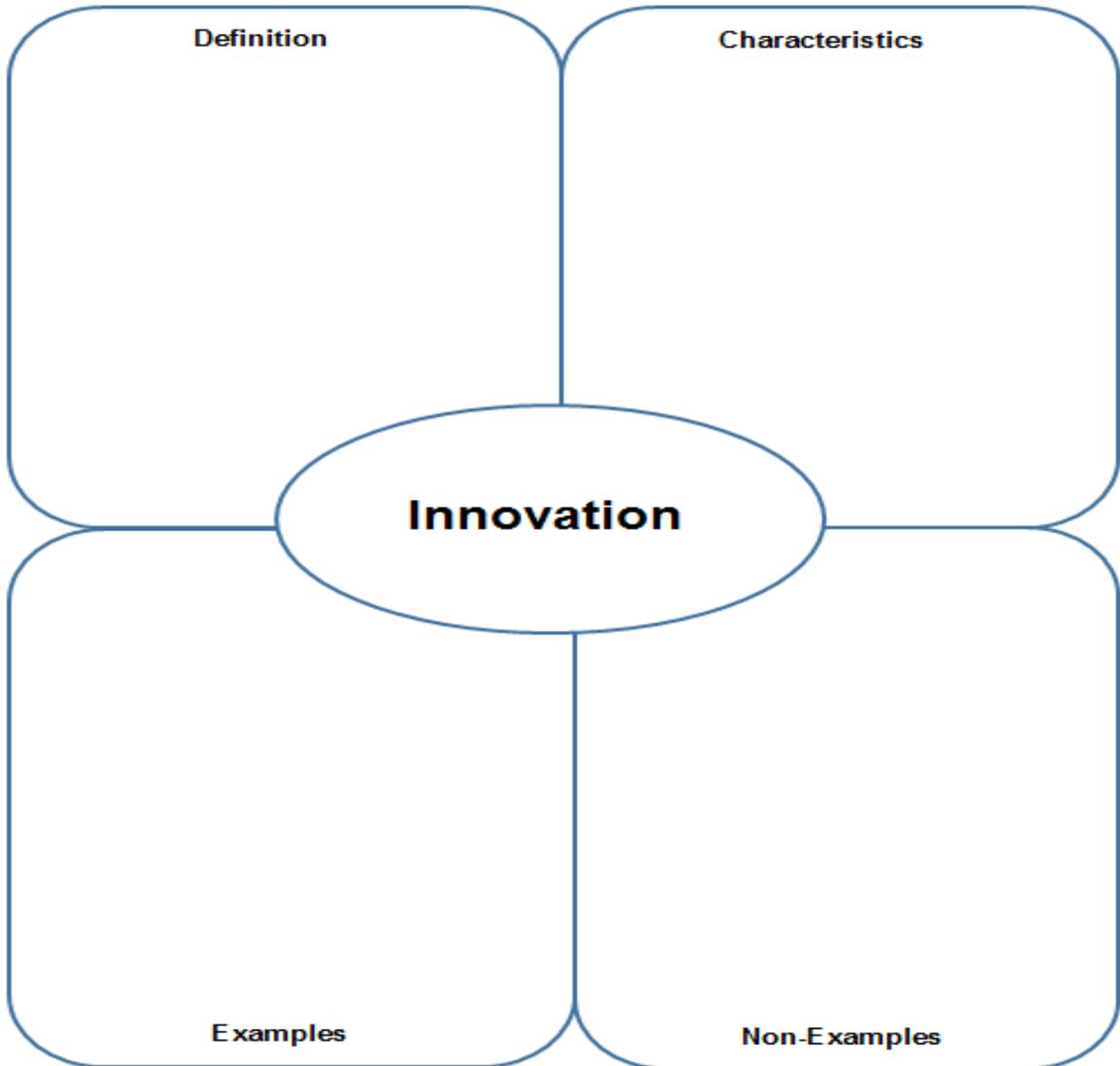
- Using *The Meaning of Innovation* worksheet, students can create their own definitions for the word “innovation.” For example, innovation can be defined as “a new idea, tool, or method to solve a problem,” or simply, “a new way to solve a problem.”
- Students may offer examples of contemporary innovations, such as smartphones, Fed Ex, bullet trains, self-driving cars, drones, etc. For non-examples, students might list old innovations such as rotary or pay phones, the telegraph, the railroad, and the freeway system. This discussion can trigger ideas about innovation, and whether old technologies that were innovative at one point are the “non-examples” of today.
- Guide students in whole-class or small-group discussion using the following questions: What innovative solutions are used today to transport people and goods throughout the U.S. and in the rest of the world? Which solutions are environmentally sound? Which solutions are harming the environment? How does innovation look different depending on the context of place and time?

Next: Students turn their attention to the Inka Empire and explore its geographic features, ways of living, and history.

Name _____

The Meaning of Innovation

Directions: Fill out the graphic organizer to think about the word “innovation” from four different angles.

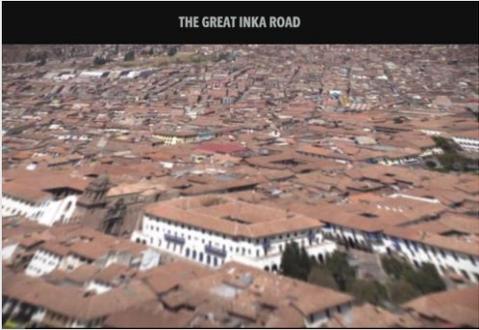
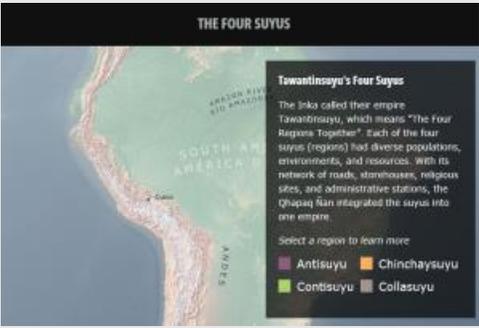


Who Were the Inka?

Lesson Components

Thematic Exploration: Geography, Ways of Living, History

Theme 1: Geography of the Inka Empire

Image	Description
 <p>A locator map of South America highlighting the Inka Empire in orange. Key cities marked include Quito, Lima, Cusco, La Paz, and Sucre. An inset map shows the location of the Inka Empire within the continent of South America.</p>	<p>Locator Map: Use this map to find the location and extent of the Inka Empire.</p>
 <p>Aerial view of Cusco, Peru, showing the dense, terracotta-roofed buildings of the city. The title "THE GREAT INKA ROAD" is visible at the top of the image.</p>	<p>“Fly-out” Video Animation: Take a virtual trip from Cusco, the capital of the Inka Empire, to the four <i>suyus</i>⁶ of the empire. Learn about the Great Inka Road’s vital importance to the empire.</p>
 <p>A map titled "THE FOUR SUYUS" showing the four regions of the Inka Empire: Antisuyu (purple), Chinchaysuyu (orange), Contisuyu (green), and Collasuyu (grey). A text box explains that the Inka called their empire Tawantinsuyu, meaning "The Four Regions Together".</p>	<p>Interactive Tool with Images: View photo galleries of the Inka Empire. Each of the four suyus had diverse populations, environments, and resources.</p>

⁶ The meaning of suyu [pronounced SOO yoo] in the Quechua language is “region.”

Who Were the Inka?

Theme 2: Inka Ways of Living

Image	Description
	<p>Inka Origin Story: View a narrated slideshow that tells the creation story of the Inka. Look for examples of Andean values represented in the story.</p>
	<p>Inka Astronomy Interactive “Milky Way—The Road in the Sky:” Use this interactive tool to find important Inka constellations that connect to ways of living in the Andes.</p>
	<p>Lithographs Slideshow: Explore the detailed drawings of Inka life near the time of the Spanish invasion by the renowned Inka illustrator, Felipe Guaman Poma de Ayala.</p>

Who Were the Inka?

Theme 3: Inka History

Image	Description
	<p>Inka Timeline: Investigate images, photographs, and NMAI collection objects that span from ancestor cultures to the present day. Learn about the four Inka ancestor cultures, the Spanish invasion, and how descendant cultures carry on the legacy of the Inka Empire.</p>

Additional Sources

- **“The Inka Empire—Tawantinsuyu:”** An essay offers additional background and context.
- **Resistance and Adaptation:** Images, videos, and text showcasing the resiliency of Inka descendant cultures in the Andes today.
- **The Inka Empire’s Impact on the World:** Examples of how Inka foods, minerals, medicines, and engineering have affected our world.
- **Inka Innovation in Masonry:** 3D viewer interactives showcasing Inka innovations in stone work.

Student Worksheet

- [***Who Were the Inka?***](#)

Connection to the Compelling Question

- The Inka built a sophisticated and vast empire that they called Tawantinsuyu to integrate and support diverse communities in challenging geographical environments. Students learn about the geography, ways of living, and history of the Inka through a thematic exploration that introduces them to the Inka Empire and how innovation was a hallmark of the empire.

Who Were the Inka?

Ideas

Thematic Exploration: Geography, Ways of Living, History

Students investigate aspects of the Inka Empire through three themes. Consider structuring the investigation as a jigsaw followed by a whole class sharing and discussion of highlights from each theme.

- Groups of 3–6: Each student or student pair is assigned a set of sources.
- Each student or student pair reviews the sources and completes their section of the graphic organizer, *Who Were the Inka?*
- Following the thematic source analysis, lead a whole class sharing and discussion to check for understanding of each thematic element.
- Students work in small groups to complete the remaining sections of the organizer. Each student or student pair shares their findings for the set of sources assigned.
- Individually, students complete the formative task: A written summary of the Inka Empire.

Suggested Lesson Procedure

Hook

- Three themes that students will use to learn more about the Inka Empire and culture:
 - **Geography:** Study of the terrain.
 - **Ways of Living:** Beliefs, daily practices, and traditions.
 - **History:** Study of past events.

Thematic Source Exploration

- Divide class into small groups (3-6 students/group)
- One student or student pair is assigned a set of sources:
 - **Geography:** Map showing the location and extent of the Inka Empire in South America, “fly-out” topography video, and interactive photo gallery of the *suyus*.
 - **Ways of Living:** The Inka Origin Story; Inka astronomy interactive; and lithographs from an Inka chronicler at the time of the Spanish invasion.
 - **History:** A timeline with images and photos of key events in Inka history, spanning from the Inka ancestor cultures to the present.
- Each student or student pair uses the *Source Investigation Questions* in the graphic organizer to analyze the set of sources assigned (Geography, Ways of Living, or History).

Who Were the Inka?

- Students write their responses to the questions on the graphic organizer, *Who Were the Inka?* (Part A).
- Students return to their small group and share their responses. Consider leading a class discussion and check for students' understanding of each thematic element.
- Students or student pairs work in their small groups to complete the remaining sections in Part A of the graphic organizer and share their findings.

Summary: Who Were the Inka?

- Individually, students use the graphic organizer to complete the formative task of crafting a written summary that answers the question, "Who were the Inka?" (Part B).

Wrap Up

- Students share and discuss written summaries.
- Extension: Compare summaries with the essay "The Inka Empire—Tawantinsuyu."

Next: Students consider how the Inka used innovation to build an extensive road system.

Who Were the Inka?

Source Investigation Questions

Theme 1: Geography of the Inka Empire

1. Locator Map:
 - a. Investigate the location and size of the Inka Empire. What countries were part of this empire?
 - b. Use Google Maps™ to find the length of one of the Great Inka Road’s main arteries: Quito, Ecuador to Santiago, Chile. Find the distance between Miami, Florida and Seattle, Washington. What does this comparison tell you about the size of the Great Inka Road?
2. The Great Inka Road:
 - a. View the “fly-out” video from Cusco to the four suyus of the Inka Empire. What do you notice about the landscape?
3. The Four Suyus:
 - a. Locate the photo galleries (select a suyu or region to explore).
 - b. Identify the geographical features that characterize the selected suyu.

Theme 2: Inka Ways of Living

1. Origin Story of the Inka:
 - a. Watch the Inka Origin Story (narrated slideshow). What Andean values are highlighted?
2. Astronomy Interactive “Milky Way—The Road in the Sky:”
 - a. Locate and examine the constellation, “Llmacñawin with Unallamacha,” meaning “Eye of the llama with baby llama.” This was the most important constellation to the Inka.
 - b. Explore more constellations. Select one and explain how it connects to ways of living in the Andes.
3. Lithographs:
 - a. What do the Guaman Poma de Ayala lithographs and text say about the Inka way of life and organization during the empire?
 - b. How do the Guaman Poma de Ayala images compare to contemporary jobs?

Theme 3: Inka History

Explore the timeline and examine information. Record your observations on:

1. Four Ancestor Cultures: Chavin, Tiwanaku, Wari, Chimu
2. Spanish Invasion: The Road, Impact, Resistance, and Adaptation
3. Current-day Cultures: How do the descendants of the Inka carry on the legacy of their ancestors?

Name _____

Who Were the Inka?

Part A: Write your answers to the source investigation questions in the space provided below. Craft a summary statement about the theme you explored.

Geography of the Inka Empire	Source Investigation Answers
Sources <ul style="list-style-type: none"> • Locator Map • Video “fly-out” from Cusco featuring The Great Inka Road • The Four Suyus Photo Gallery 	
Summary statement: What do these sources say about the geography of the Inka Empire ?	
Inka Ways of Living	Source Investigation Answers
Sources <ul style="list-style-type: none"> • Origin Story of the Inka • Milky Way—The Road in the Sky • Lithographs 	
Summary statement: What do these sources say about Inka ways of living ?	
Inka History	Source Investigation Answers
Source <ul style="list-style-type: none"> • Timeline 	
Summary statement: What does the timeline say about Inka history ?	

Name _____

Who Were the Inka?

Part B: Based on the evidence you collected from your sources, write a one-paragraph summary that answers the question, “Who were the Inka?” In your summary, include information from each theme: geography, ways of living, history.

The Great Inka Road System: How is the Inka Road an example of innovation?

Lesson Components

Fly-out from Cusco to Machu Picchu

Image	Description
	<p>Video Fly-out: View a video fly-out from Cusco to Machu Picchu. Notice the diversity in the landscape and consider why a road system built on this terrain would be innovative.</p>

Exploring the Inka Road System in the Andes

Topic 1: A Road in the Andes

Image	Description
	<p>Map: Investigate a map of South America with an overlay of the Inka Road system. Analyze the extent of the system.</p>

The Great Inka Road System

Exploring the Inka Road System in the Andes
Topic 2: Impressions of the Road

Image	Description
	<p>Lithographs: Explore drawings of Inka life created by the renowned Inka illustrator, Felipe Guaman Poma de Ayala.</p>
	<p>Lithographs: Explore illustrations of the Great Inka Road and bridges drawn by the Spanish conquerors.</p>
<p>“Quotes”</p>	<p>Read and analyze quotes and paraphrased quotes on Inka engineering innovation from a Quechua bridge master, Spanish chroniclers, and a professor of engineering at the Massachusetts Institute of Technology (MIT), a university known for its excellence in technology and innovation.</p>

The Great Inka Road System

Exploring the Inka Road System in the Andes
Topic 3: Inka Bridge Types

Image	Description
	<p>Photo Gallery: Analyze the various bridge types used by the Inka to connect the road system in the Andean terrain, noticing how each design is attuned to the natural environment.</p>

Student Worksheet

- [How is the Inka Road an Example of Innovation?](#)

Connection to the Compelling Question

- In this lesson, students use evidence from a variety of sources to build their own understanding of innovative Inka engineering as applied to the development of the Inka Road system.

Ideas

- Exploring the Inka road system: Students can investigate the fly-out video, maps, images, lithographs, and quotes independently or in small groups.

Contemporary Connections

- As an extension, ask students to examine the quotes provided to find evidence that demonstrates how Inka innovation is still relevant today.

The Great Inka Road System

Suggested Lesson Procedure

Hook

- Show the video fly-out from Cusco to Machu Picchu as a starting point to explore the Inka road system.
- Ask students: What is the difference between a single road and a road system? Can you think of an example of a road system where you live?
- Ask students: Why is the Inka Road not straight, like most major highways today?
- Engage the class in whole-group discussions and ask:
 - Would you consider any road system innovative? Why or why not?
 - Would a 25,000-mile road system built in the rugged Andes mountain environment 500 years ago be innovative?
 - (If yes) What makes that innovative?
 - (If no) Why doesn't that qualify as innovative?
- How does the freeway system in the U.S. compare to the Inka road system? (For a history of the U.S. freeway system, refer to: <https://www.fhwa.dot.gov/infrastructure/history.cfm>)

Exploring the Inka Road System in the Andes

- Finding solutions to the challenges of building an extensive road system in rugged terrain requires innovation. Students investigate how the Inka used innovation to design a complex road network attuned to the natural environment.
- Working independently or in small groups, students investigate the Inka road system along three angles: characteristics of the road system; purpose(s) of the road system; and the kinds of innovation required for its construction. The exploration can be structured as a jigsaw using the three angles followed by a whole-class sharing and discussion of highlights from each angle. To guide their exploration of the featured sources, students use the worksheet *How is the Inka Road an Example of Innovation?* See below for an explanation of the sources students will encounter, organized by topic.

The Great Inka Road System

Suggested Lesson Procedure

1. Characteristics

A Road in the Andes: Students explore a map and video fly-out to learn about the location, extent, and variety of terrain in the Inka Empire. Students consider why a road system built on this terrain would be innovative.

2. Purpose(s)

Impressions of the Road: Students view lithographs from Guaman Poma de Ayala and the Spanish chroniclers to understand who used the road and for what purpose. Quotes, and more accessible paraphrased quotes, give students insights about the unique and innovative qualities of the road, gleaned from the impressions of early chroniclers at the time of the Spanish conquest and of an engineering professor today.

3. Innovation

Inka Bridge Types: The diversity of Inka bridge types shown in a photo gallery speaks to the innovative problem solving that the Inka utilized to tackle difficult transportation and communication challenges. Students use this case study of Inka bridges to explore how each design is attuned to the natural environment.

Forming Conclusions: Innovations in the Inka Road System

Students use evidence from the sources they examined and construct a response to the question, “How is the Inka road system an example of innovation?”

Wrap up

Discuss student responses. Ask them what evidence they found to support their conclusions.

Next: Students examine Inka innovation by learning about the only surviving suspension bridge designed by the Inka—the Q’eswachaka.



Name _____

How is the Inka Road System an Example of Innovation?

Directions: Investigate the following sources in order to gather and categorize the significance of the Inka Road.

<p>A Road in the Andes (Video Fly-out & Map)</p>	<p>Characteristics: What physical features of the empire did the Inka need to overcome to construct the road?</p>
<p>Impressions of the Road (Lithographs & Quotes)</p>	<p>Purpose(s): Who used the road and why? What is the perception of the road from those outside the empire, both past and present?</p>
<p>Inka Bridge Types (Photo Gallery)</p>	<p>Innovation: What innovations were built into the road to span the challenging landscape of the Inka Empire without modern building methods?</p>
<p>After gathering your evidence, write a paragraph summary on why the Inka Road system is an example of innovation, making sure to cite examples from 2–3 sources.</p>	

Engineering a Grass Bridge: How is the Q'eswachaka an example of innovation?

Lesson Components

The Q'eswachaka Bridge

Image	Description
	<p>"Weaving the Bridge at Q'eswachaka" video: Short documentary on the Q'eswachaka annual construction process by Quechua communities in Huinchiri, Cusco Region, Peru.</p>

Engineering Activities that Demonstrate Inka Innovation

Activity 1: Explore Tension and Compression

Image	Description
	<p>Explore and experience the two types of forces used to construct bridges—tension and compression.</p>
<p>"Quotes"</p>	<p>Read and analyze quotes on Inka engineering innovation from a professor of engineering at the Massachusetts Institute of Technology (MIT), a university known for its excellence in technology and innovation, to better understand differences between tension and compression forces.</p>
	<p>Explore tensile strength by watching an animation.</p>

Engineering a Grass Bridge

Activity 2: Be a Bridge Maker

Image	Description
	<p>Create a plank bridge and modify it to become a suspension bridge, experimenting with bridge loads to see which design is stronger.</p>
<p>“Quotes”</p>	<p>Read quotes on cultural connections from a Quechua bridge master in the Andes to learn about the traditional knowledge used to build a grass bridge.</p>
	<p>Look at two images to reflect on the role of Victoriano Arizapana and compare it to the Guaman Poma de Ayala lithograph of the <i>Chakacamayuc</i>, or bridge master of Inka times.</p>

Student Worksheet

- [*Building the Q'eswachaka*](#)

Connection to the Compelling Question

- Why are the Q'eswachaka and other suspension bridges built during the time of the Inka Empire important components of the Inka road system? How can a grass bridge be an example of innovation and sustainability?

Ideas

- **Engineering Activities that Demonstrate Inka Innovation—Explore Tension and Compression and Be a Bridge Maker:** Students explore a video, an interactive, images, and quotes to understand how the Q'eswachaka is a unique and innovative component of the Inka road system.

Engineering a Grass Bridge

- The hands-on activities serve to illustrate important engineering principles used by the Inka. Activity 1, “Explore Tension and Compression,” is best done in student pairs. Activity 2, “Be a Bridge Maker,” is more suited for small groups.

Suggested Lesson Procedure

Hook

- Show the “The Bridge at Q’eswachaka” video.
- Ask the students to identify and record the bridge construction steps in Part A of the *Building the Q’eswachaka* worksheet.

Engineering Activities that Demonstrate Inka Innovation

- Working in pairs, students explore tension and compression forces and use the tensile strength animation to understand how blades of grass can be made into a strong bridge. Students work in small groups to do the hands-on “Be a Bridge Maker” activity.
- Part B of the worksheet *Building the Q’eswachaka* is a tool for helping students synthesize the big ideas of Inka bridge-building innovation in the context of the Inka road system.
- The three-page *Instructions for Hands-On Activities* guides the students through hands-on exercises to help them understand key bridge-building engineering concepts. As students do the activities, take time to check for understanding of key content and concepts.
 - Explore Tension and Compression
 - Tension is a pulling force and compression is a pushing force.
 - In suspension bridges, including Q’eswachaka, cables work through tension, or the stress resulting from a pulling force.
 - The tensile strength of the grass cables is how much they can be pulled from opposite directions before they break.
 - The tensile strength of a grass rope depends on the type of grass, how much grass is used to make it, and how it is twisted and braided together with other ropes.
 - The largest cable of the Q’eswachaka is as thick as a man’s thigh and can hold 5,175 pounds, or 2,347 kilograms. This is more than the weight of an average automobile or the combined weight of twelve llamas.
 - Be a Bridge Maker
 - As students design and test a simple plank bridge, ask: What forces are primarily at play in this type of bridge, compression or tension?
 - Once the students design a suspension bridge, ask: What forces are primarily at play in this type of bridge, compression or tension? Where are the forces felt as



you add more books? How is this bridge similar and how is it different from Q'eswachaka?

- The Q'eswachaka suspension grass bridge is an example of innovative Inka engineering. The Inka designed suspension bridges using tension forces in contrast with the compression forces used in European arch bridges at the time.
- The Q'eswachaka, the only remaining bridge of its kind, is part of approximately six percent of the original Inka road system that is still used and maintained by indigenous Andean people.

Contemporary Connections

The quotes included can serve as a springboard for student discussion. They offer insights on Inka engineering innovation from an engineering professor and perspectives on cultural connections from an Inka bridge master.

Wrap Up

Pose a question to the students: "How can people use innovation to tackle difficult problems and find solutions to challenging situations?" Ask for examples from their own experiences.

Next: Students apply what they learned about the engineering innovations of the Inka road system, and the Q'eswachaka as an integral and unique component of the system, to answer the compelling question, "How can a road system be an example of innovation?"

Instructions for Hands-On Activities

Instructions for Activity 1, “Explore Tension and Compression”

Background

- Suspension bridges did not exist in Europe at the time of the Inka Empire; instead, Europeans built stone arch bridges. Suspension bridges can span longer distances, but European engineers did not build this type of bridge for another 300 years. In suspension bridges, tension forces are most important, while in arch bridges, compression forces are what matter. Tension forces pull and stretch material in opposite directions, allowing a rope bridge to support itself and the load it carries. Compression forces squeeze and push material inward, causing the rocks of an arch bridge to press against each other to carry the load. Both types of bridges rely on abutments, the components of the bridge that take on pressure and dissipate it onto the Earth. In the case of Q’eswachaka, the abutments are made from massive rocks where the bridge’s main cables are tied.

Ask a partner to work with you to demonstrate Force 1 and Force 2 as shown in the illustrations below. As you work with your partner, can you feel which way the forces are directed? Based on the definitions given above and what you can feel, which force is tension and which is compression?

Force 1



Force 2



Look at the bridge images below. Can you match Force 1 and Force 2 with each bridge type? Which bridge acts primarily on compression forces? Which bridge acts primarily on tension forces? Explain why and justify your choices.

	
<p>Q'eswachaka Bridge. Photograph by Doug McMains, NMAI, 2014.</p>	<p>Taft Bridge in Washington, DC. Photograph by Dan Davis, NMAI, 2015.</p>
<p>Now think about how it felt to experience these forces. When pulling apart from your partner, what shape did your bodies resemble? How about when pushing against your partner's hands? Notice that when pulling apart from your partner, your bodies form a suspended curve much like the Q'eswachaka bridge, and when pushing toward each other, your bodies form an arch much like the Taft Bridge.</p>	

Instructions for Activity 2, "Be a Bridge Maker"

What kind of bridge would you build with the following materials?

- One rectangular piece of cardboard about 4 feet (1.2 meters) long by 1 foot (0.3 meter) wide
- Two chairs

For example, you can place the two chairs facing each other and span the cardboard between the seats. This is called a beam, or plank, bridge. This type of bridge is not very strong. Test out your cardboard bridge by placing a heavy load of books on it. See how many books the bridge can hold before it collapses (Fig. 1). What forces are primarily at play in this type of bridge, compression or tension?



Fig. 1

To make the plank bridge stronger, modify it so that it becomes a suspension bridge. Include the following materials:

- Two pieces of rope, each about 9 feet (2.75 meters) long
- Twelve pieces of string, each about 2 feet (0.6 meters) long

Stretch the ropes above the cardboard, over the backs of the chairs, and have two friends pull them tight by sitting on the floor behind each of the chairs (Fig. 2).



Fig.2

Tie the tops of six pieces of string to one of the ropes, at equally spaced intervals between the two chairs. Do the same with the other lengths of string, but on the other rope (Fig. 3). Secure the loose ends of the strings with duct tape onto the cardboard below.



Fig.3

Now you have a suspension bridge. Ask your friends to pull on the ropes behind each of the chairs as you start placing books on top of the bridge. Experiment with the pulling force and with various loads to test the strength of your bridge. What forces are primarily at play in this type of bridge, compression or tension? Where are the forces felt as you add more books? How is this bridge similar and how is it different from Q'eswachaka?

Making the Case for Innovation

Lesson Components

Source-Material Bank

- A compilation of all the multimedia sources used in the lesson is presented so they can be easily accessed from one place.
- Students can use the lesson sources, including photographs, illustrations, maps, and quotes, to support their argument. Lesson sources reflect examples of innovation in an Inka context.
- Students can also draw from their experiences doing the hands-on activities to support their argument.

Connection to the Compelling Question

- How do sources help us form an argument? What sources or activities helped you learn about Inka innovation?

Summative Task

- Using evidence from the featured sources and hands-on activities, students build an argument on what they've learned about the Inka road system and engineering innovations in the Inka Empire.

Suggested Lesson Procedure

Hook

- **Ask:** How can people use innovation to tackle difficult problems and find solutions to challenging situations? Discuss examples.

Constructing a Summative Argument

- To support students' application of evidence in building an argument, this culminating activity features an interactive digital news-article generator, *The Andean Messenger: Making the Case for Innovation*. Students can build a news article by constructing a written argument to answer the compelling question: How Can a Road System Be an Example of Innovation? After selecting a predesigned template, students determine what featured sources from the inquiry best support their argument. Students will be able to write captions, quotations, headlines, body text, and bylines.
- It is important to note that students' arguments could take a variety of forms, including a detailed outline, graphic, presentation, or essay. Students should construct an argument in one of these forms that addresses the compelling question and acknowledges competing views, using specific claims and relevant evidence from the lesson sources.

Preserving Traditions (Optional)

- Discover how indigenous groups and organizations in the Andes are honoring their traditions to protect their culture from the pressures of globalization.
- Compare and contrast two indigenous-led organizations that are working to strengthen cultural identity, protect indigenous rights, and foster cultural survival.
- Use the discussion questions to help students reflect on why it is important to preserve cultural traditions.

Discussion Questions

- Why is it important to preserve traditions?
- What activities are these two organizations doing to maintain their traditions?
- Can you share examples of other organizations or efforts that are doing similar work to preserve traditions in your community (for example, a local historical preservation society)?