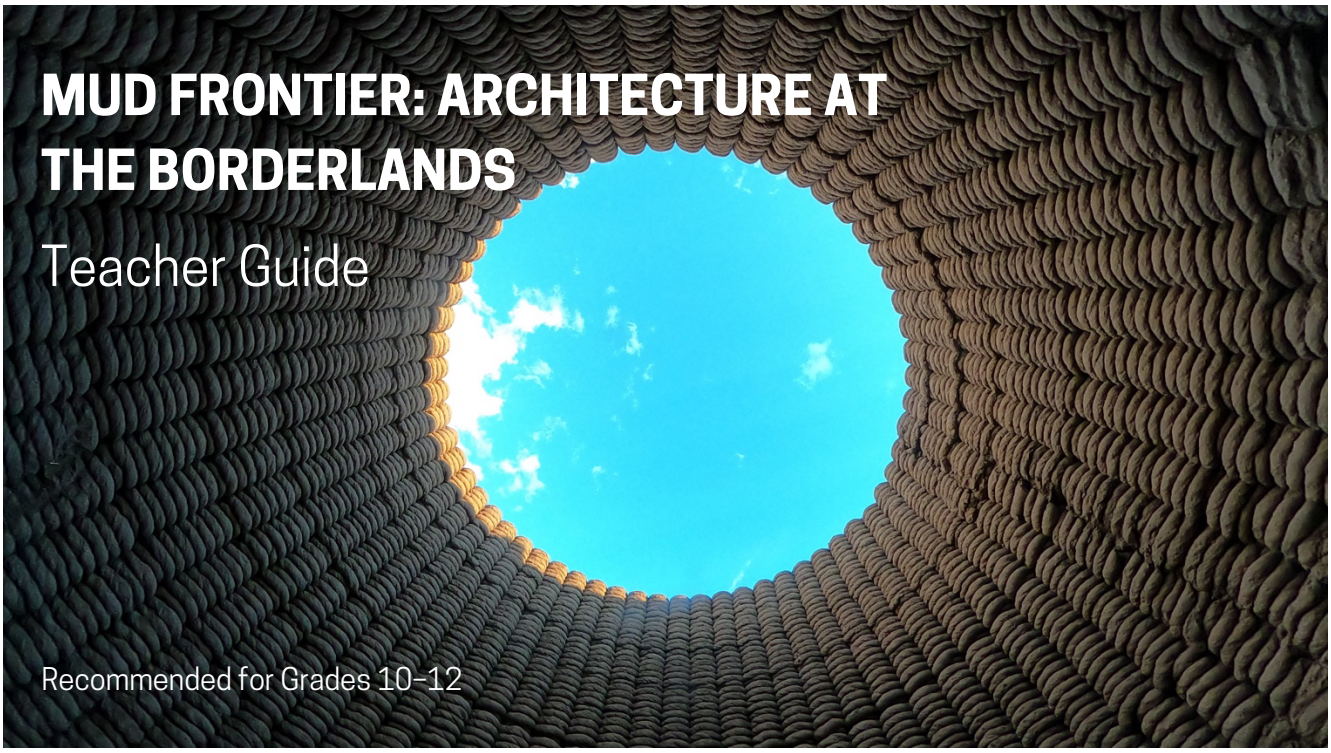

MUD FRONTIER: ARCHITECTURE AT THE BORDERLANDS

Teacher Guide

Recommended for Grades 10–12

ABOUT THE FILM:

Set in the remote San Luis Valley of Colorado, *Mud Frontier: Architecture at the Borderlands* is a feature-length documentary film that follows design studio Rael San Fratello's experimentation with 3D-printing technology and traditional adobe architecture. The film offers an intimate, tactile look at Mud Frontier, a project led by designers Ronald Rael and Virginia San Fratello, who use 3D-printing technology to build adobe structures on Rael's ancestral homelands in Colorado's San Luis Valley. In an area where Indigenous peoples and European colonists have historically lived both in harmony and in conflict with one another, Rael San Fratello reflect on this legacy to forge new methods of creative production.

HOW TO USE THIS GUIDE:

This guide is recommended for grades 10–12, but can be adapted for other audiences. Use the "Warm Up" as either a standalone conversation guide or to prepare students to view the film.

"Mud Frontier: Architecture at the Borderlands" is 1 hour and 3 minutes in length. Time stamps can be found throughout the guide should you wish to break up students' viewing or watch a portion of the film.

The guide contains two content threads: STEAM and History. These content threads can be blended for a longer-term, interdisciplinary exploration, or used on their own:

- **STEAM GUIDE: Earth as Material**
- **SOCIAL STUDIES GUIDE: Uncovering Stories**

KEY VOCABULARY:

- **3D printing:** The process of creating a 3D object from a digital model, typically through a process of layering material.
- **adobe:** A building material made from earth and organic materials. Spanish for "mudbrick", adobe combines natural elements of earth, water, and sun.
- **architect:** A person who designs buildings or structures.
- **artifact:** An object made by humans (ex: tools, clothing, glassware, furniture, textiles, art). Artifacts often help people learn about cultures across time.
- **borderlands**: A region or territory near a border. This term is also often used to describe an overlap between two ideas.
- **coding:** The process of transforming ideas, instructions, or solutions into a language that a computer can understand.
- **earthen architecture:** A building constructed using mostly soil.
- **forage:** To search for food, provisions, or materials. Foraged materials are not purchased at a store, but often located at the source.
- **Genízaro:** Detribalized Indigenous people who, through war or trade, were abducted and taken into Hispano households as laborers.
- **Hispano:** A descendent of Spanish settlers in the southwest, before the region was annexed to the United States.
- **historic preservation:** An endeavor to protect or conserve historic buildings.
- **kiln:** A thermally insulated chamber or oven for firing pottery.
- **micaceous clay:** Clay containing mica, a shiny mineral found in granite and other rocks.
- **pottery:** Objects made from baked clay, such as bowls, pots, or dishes.
- **Pueblo:** An Indigenous village in the southwestern U.S. (Arizona and New Mexico) that consists of dwellings often made of stone or adobe.
- **vessel:** Any type of hollow container.

WARM UP: Close Looking at Micaceous Clay Vessels

3D printed wild micaceous clay vessels pit fired in 3D printed adobe kiln.
Wild micaceous clay fired using locally harvested cedar and fired in a 3D printed kiln.

- Look closely at these **vessels**. What do you notice?
- Consider the materials. What do you think it is made of?
- How do you think this vessel was made? By hand or by machine?
- Do these objects look fragile or durable? Are they functional or decorative?
- This vessel uses clay called **micaceous clay** that was **foraged**. Does this piece of pottery look different from other pieces you have seen? What colors do you see?
- When do you think these pieces were made?
- This vessel was made with traditional materials used by the Taos and Picuris Pueblos, but uses **3D printing** technology. Can you think of other examples of blending past traditions with modern technology?
- Think of an example of an object that is very old that you still use in your life. This could be something passed down from previous generations or bought from an antique or vintage store. What makes it still useful? What makes it still relevant? What makes it special?

STEAM GUIDE: EARTH AS MATERIAL

OVERVIEW:

This discussion guide highlights the ways in which designer and architect Ronald Rael combines the modern science and engineering technology of 3D printing and the ancient building technique of using earthen materials for architecture. The guide indicates key moments throughout the film and suggests questions and thinking strategies which challenge students to think critically about the past, present, and future of engineering systems and the ways in which they can be combined to innovate and create something new. After watching, thinking about, and discussing the film, students will have an opportunity to participate in a hands-on activity in which they will compare and contrast attributes of different compositions for earthen building materials.

This discussion guide makes use of Harvard Project Zero's "Parts, Perspectives, Me" Thinking Routine

OBJECTIVES:

After this discussion and activity, students should be able to:

Explain the process of using adobe as a building material

Identify the ways that modern constructions have been informed and influenced by traditional techniques

Analyze the ways that innovation comes from combining seemingly unrelated ideas and technology

NATIONAL STANDARDS:

Next Generation Science Standards

(HS-ETS1-1) Analyze complex real-world problems by specifying criteria and constraints for successful solutions. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1.B: When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

(HS-ETS1-3) Both physical models and computers can be used in various ways to aid in the engineering design process.

(HS-ETS1-2) Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Common Core Standards

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

DISCUSSION GUIDE: EARTH AS MATERIAL

ADOBE AS A BUILDING MATERIAL (10:30-14:10)

- What are its parts? What various pieces or components make up adobe?
- What perspectives can you look at it from? Who has used adobe as a building material?
- How are you involved? What connections do you have? What assumptions, interests, or personal circumstances shape the way you see it?

3D PRINTING IN ADOBE (15:58-22:30)

- What are its parts? What are the various pieces or components that make up this 3D printer?
- What perspectives can you look at it from? Who has used 3D printing? What purposes have they used it for?
- How are you involved? What connections do you have? What assumptions, interests, or personal circumstances shape the way you see it?

CONSIDERING EARTHEN MATERIALS (39:42-45:37)

- What are its parts? What compositions of clay and earth do you see used in the film? What are the considerations for constructing materials out of earth?
- What perspectives can you look at it from? Who has used earthen materials to build? What kinds of things have been made with these materials?
- How are you involved? What connections do you have? What assumptions, interests, or personal circumstances shape the way you see it?

TRADITIONAL CONSTRUCTION SYSTEMS, NEW TECHNOLOGIES. (46:41-49:35)

- What are its parts? What construction systems do you see impacting our lives today? What various parts make up these systems? What are the benefits? What are the drawbacks?
- What perspectives can you look at it from? Who uses traditional construction systems in the present day?
- How are you involved? What connections do you have? What assumptions, interests, or personal circumstances shape the way you see it?

ACTIVITY: EARTH AS MATERIAL

In this hands-on activity, students conduct an experiment to determine how varying the composition of a construction material affects its strength. They will make several adobe bricks with differing percentages of sand, soil, fibrous material, and water.

Time: Approximately two hours

Materials:

- Brown or red air-dry clay (potting soil will not work)
- playground sand
- 1/2 gallon (2.2 l) container of fibrous material, loosely packed (dead grass, straw, pine needles, etc.)
- Access to a water source, such as a sink or hose
- Paper cups (5 oz or ~150 ml) for measuring
- 1 Roll of wax paper
- Rolling Pin
- 1 large container for mixing
- 1 piece of cardboard, 16-in x 16-in (~ 40 cm x 40 cm)
- 1 container of water, ~16 oz (500 ml)
- 1 permanent marker
- meter or yard stick
- (optional) disposable gloves
- (optional) newspaper or butcher paper to cover work surfaces
- (optional) box or desk fan, to aid in brick drying
- (optional) small step ladder, for standing on when drop testing bricks

Day 1:

Divide students into groups of 2-3 teams. Each team will mix three different adobe bricks, one with more sand, one with more fiber, and one with more water.

Note: If the mixture is difficult to manipulate, add 1/2 teaspoon water at a time, until it is easy to work with. If you get your mixture too wet, it will take much longer to dry and may be almost impossible to form into bricks. Work each mixture with your hands until the sand, fiber, and water is spread evenly throughout the clay.

- **Mixture 1:** Mix 1 paper cup of air-dry clay, one paper cup of sand, one paper cup of fibrous material, and a teaspoon of water in a large bowl with your hands.
- **Mixture 2:** Mix 1 paper cup of air-dry clay, 1.5 paper cup of sand, 1 paper cup of fibrous material, and a teaspoon of water in a large bowl with your hands.
- **Mixture 3:** Mix 1 paper cup of air-dry clay, 1 paper cup of sand, 1.5 paper cup of fibrous material, and a teaspoon of water in a large bowl with your hands.

Tape three pieces of wax paper onto three separate pieces of cardboard. Each team should write the recipe for the three different mixtures on the three separate pieces of cardboard.

Spread each mixture onto its own piece of cardboard on the wax paper in an even layer on a sheet of wax paper. Use a rolling pin to be sure your layer of adobe is not taller than 1/2 inch. Using a rolling pin will also help remove air bubbles and prevent cracking as the bricks dry.

Cut the bricks along the edge of a ruler, ensuring that all bricks will be the same size.

Set bricks outside in the sun or in front of a fan for at least one day to dry.

Day 2 :

Take students with their dried bricks to an area that has a flat, smooth, hard surface (an area with concrete will work well!)

Ask each team to remove the bricks from the wax paper. Students may need a knife to help remove the bricks.

Test the bricks by dropping them from progressively higher heights (use a yard stick or measuring tape to measure heights and use the same heights for dropping each of the three bricks) until they show substantial failure. You may need a small step ladder to get high enough so they break when dropped.

Students should record their findings as they conduct their test. After test, bring students back together to discuss their findings. Ask students: which brick mixture was the strongest? Which would they use if they wanted to build a structure out of earthen material?

SOCIAL STUDIES GUIDE: UNCOVERING STORIES

OVERVIEW:

This discussion guide highlights the significance of the San Luis Valley and the ways in which Rael incorporates his family history into his work. By making connections between historical artifacts and the designers' processes, the guide supports students' understanding of the many layers of the story within the film. After watching, thinking about, and discussing the film, students will have an opportunity to participate in a hands-on activity in which they will research and consider locally available materials, how they were used historically and by whom, and how they might be thoughtfully used in the future.

This discussion guide makes use of Harvard Project Zero's "Unveiling Stories" Thinking Routine.

OBJECTIVES:

After this discussion and activity, students should be able to:

Explain the significance of the San Luis Valley and the ways in which Rael incorporates his family history into his work.

Identify the ways that artifacts and traditions can influence the future.

Integrate information from the film into topical conversation and practical design use.

NATIONAL STANDARDS:

Common Core Standards

CCSS.ELA-LITERACY.RH.11-12.1 Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.

CCSS.ELA-LITERACY.RH.11-12.2 Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas:

CCSS.ELA-LITERACY.RH.11-12.4 Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text.

CCSS.ELA-LITERACY.RH.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

CCSS.ELA-LITERACY.RH.11-12.8 Evaluate an author's premises, claims, and evidence by corroborating or challenging them with other information.

DISCUSSION GUIDE: UNCOVERING STORIES

THE POWER OF ARTIFACT (2:45-11:00)

- Look closely at the tools from Ronald's father. What do they reveal to us?
- Why are these everyday objects (Ronald's father's tools, the micaceous clay bean pot) important? What is the untold story?

GENÍZERO PEOPLE + LAFAYETTE HEAD (24:00- 37:00)

The San Luis Valley, Ronald's home and where the film takes place, was once the northernmost border of Mexico (until 1845). During that time there was a militarization of the border, and many forts and trading posts can be found in the region. (24:00) Adobe structures in the area are common, though in the 1950s many were covered with concrete, which caused many to collapse.

- What is meant by "borderlands"? What does the word tell us?
- Who are the Genízaro people? Who was Alejandro Head?
- What do their stories tell us? What is the untold story?

ADOBE, THEN AND NOW (5:30-37:00)

- What was the impact of adobe buildings collapsing? On Ronald, on the community?
- What do these collapsed buildings reveal to us? What is the untold story?
- How does Ronald and Virginia's work connect to the history of the San Luis Valley? Think about the materials, process, and meaning behind the work.
- Why might an architect use an old method to create a new building?

ACTIVITY: UNCOVERING STORIES

1.) As a whole class, work together on a mind map. Ask students to develop a list of raw materials that are indigenous to your community, state, or region.

2.) Consider the list you've developed. Ask yourselves, how have these materials been used historically? How have they impacted people? How might they be used in the future?

3.) Break students up into groups (ideally one group per material). Ask students to research the material further, and develop a design that honors the material while solving a problem for the future. Student outcomes could range from sketches and brainstormed solutions to prototypes.

4.) Ask each group to present their ideas. Afterwards, ask the whole group to consider how historic materials and processes can influence the future: of design, of our environment, and of our world at large.