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Astronomy and Space Science
Option 2: Astronomy/Space Science Unit Plan
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Mars Uncovered 5E Stem Lesson

The following three lessons come from the Mars Student Imaging Project (MSIP). The first two lessons I made a few changes to fit my needs in the classroom and to fit the 5E lesson format. However lesson three is basically from the website, with a few changes. One of the major changes I made to each lesson was I tried to make sure that each worksheet or activity was linked in the lesson or the page number of the worksheet and which packet. This is a wonderful website and program, but it does take some time to learn how to navigate it. There are also 15 different lessons to complete in this research project, which should take approximately 3-6 weeks to complete depending on class time availability. To sign up for this project there is an interest form to complete, which took about 3 weeks for me to get a response from, make sure to plan ahead if you want to enroll your students.

Below is a list of the links that are not included in the lessons but are needed and can be difficult to locate. The last link *Background Talks* has a few videos that you should watch prior to starting this lesson and some you might also choose to share with your students.

- **MSIP: Independent Research | Mars Education (asu.edu)**
- **MSIP: How to Start | Mars Education (asu.edu)**
- **MSIP: Resources | Mars Education (asu.edu)**
- **marsed.asu.edu/sites/default/files/images_book/MOLA_mapv100.png**
- **Mars Student Imaging Project (MSIP) | Mars Education (asu.edu)**
- **http://marsed.asu.edu/sites/default/files/stem_resources/Mars_Image_Analysis_PowerPoint%206.ppt**
- **MSIP: Question Mars | Mars Education (asu.edu) -Background talks**

Lesson 1

Grade Level 7-12	Earth & Mars Comparison Introduction to MSIP and THEMIS images Lesson 1	Lesson Length- 2- 90 Minutes classes

Lesson Objects and Standards
Students will:

- Learn about the MSIP project
- Make comparisons between Earth and Mars
- Become familiar with geologic features found on both Earth and Mars
- Learn about THEMIS images
- Learn to discuss their findings as a scientist

Missouri Learning Standards:

- 9-12.ESS2.E.1 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.
- 9-12.ESS1.C.1 Evaluate evidence of the past and current movements of continental and oceanic crust,

the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor

- 11-12.W.1.A
  b. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation
- 11 -12.SL.1.A Work with peers to promote civil, democratic discussions and decision making; set clear goals and deadlines; and establish individual roles as needed.

Materials:

- Internet-connected computer with speakers: 1 per class
- Earth/Mars Comparison Outline sheets: 1 per student
- MSIP Resource Manual Chapter 3 (pp 13 - 18): 1 per student

<u>Engagement Phase</u>

Video: Looking for Life On Mars (https://bit.ly/3vr5mrj)- This video explains the goal of the Mars 2020 mission.

- Before watching the video, have the students complete a quick write of what they know about the Mars 2020 mission.
- While watching the video, have the student write down at least ten interesting facts they learned from the video.
- After watching the video, have a class discussion about what the students learned about the Mars 2020 mission.

Teacher Notes:

- The video is about 55 minutes long.
- If using Google Classroom, prepare a google document for the students to write their interesting facts.

Duration: 60-70 minutes

Teacher Role- Facilitate learning and guide student understanding

<u>Goals</u>

- Connect student's experiences
- Create interest
- Ask questions
- Understand the objectives of the lesson

Exploration Phase • Show the MSIP introduction video- MSIPStudentVideo (teachertube.com) • As a group, go over the Science and Engineering Practices, NGSS Disciplinary Core Ideas, NGSS Crosscutting Concepts, and Understandings about the Nature of Science relevant to this lesson. Complete the first page of the Earth/Mars Comparison outline as a class. • As a class, complete slides 1-8 from the "Mars 101-Studying the Red Planet" PowerPoint. • Powerpoint - https://marsed.asu.edu/sites/default/files/stem_resources/Earth_Mars_Comp.ppt • Student outline - Earth / Mars Comparisons and Introduction to MSIP and THEMIS Images Teacher Notes: • Print a student outline for every student. • There are speaker notes on the PowerPoint with information to share with students.	**Duration: 30-40 minutes** Teacher Role- • Introduce students to the Mars Student Imaging Project (MSIP), • Encourage Earth / Mars comparisons • Introduce Thermal Emission Imaging System (THEMIS) images. **Goals** • Students become familiar with similarities and differences between geologic features found on both Earth and Mars.
Explanation Phase • Group students in pairs or small groups to complete the rest of the student outline and PowerPoint. • Once completed, each group shares what they discovered about the features they found on both Earth and Mars. • Powerpoint - https://marsed.asu.edu/sites/default/files/stem_resources/Earth_Mars_Comp.ppt • Student outline - Earth / Mars Comparisons and Introduction to MSIP and THEMIS Images	**Duration: 30-40 minutes** Teacher Role- • Encourages students to explain concepts in their own words • Asks for clarification from students • Builds on student explanations • Provides time for students to compare their ideas with others and revise their ideas **Goals** • Students receive real experience with the topic. • Students make observations, record results, and make connections.
Elaborate Phase • Have the same small groups read and discuss *Chapter 3: Mars in the Solar System* from the ***Mars Student Imaging Project - Resource Manual.*** ***Mars***	**Duration: 25-30 minutes** Teacher Role-

Student Imaging Project ● After reading chapter 3 and viewing the PowerPoint, have each group make a list of interesting topics they want to share with the whole class.	● Formally provides definitions, explanations, and information through text. ● Builds on student explanations ● Provides time for students to compare their ideas with others and, if desired, revise their ideas. **Goal** ● To increase student's background knowledge about the geologic features found on both Earth and Mars.
Evaluate Phase ● Have the student groups circulate the room and write what they learned about the different topics during this lesson on the chart paper. Teacher Notes: ● Before class, post around the room large sheets of chart paper and have the students write some of the facts they learned during the lesson. ● Example topics-MSIP, THEMIS, Mar's geologic features, Earth's geologic features. ● As a class, review the chart papers and discuss what they learned. ● Add any vital information that you think the students missed to the list if it something they will need to know to complete the project.	**Duration 15-20 minutes** Teacher Role- ● Asks open-ended questions ● Uses a variety of assessments to gather evidence of student understanding ● Provides opportunities for students to assess their progress **Goal** ● Students are given the opportunity to demonstrate their understanding.

Sources:

Linkon, Drew. “Missouri Learning Standards.” *Missouri Department of Elementary and Secondary Education*, 16 Mar. 2021, dese.mo.gov/college-career-readiness/curriculum/missouri-learning-standards#mini-panel-mls-standards1.

“Meeting 1: Earth/Mars Comparisons and an Introduction to MSIP and THEMIS Images.” *Meeting 1: Earth/Mars Comparisons and an Introduction to MSIP and THEMIS Images | Mars Education*, marsed.asu.edu/msip-independent-meeting1.

NOVAonline. “Looking for Life on Mars | NOVA | PBS.” *YouTube*, YouTube, 24 Feb. 2021, www.youtube.com/watch?v=fhtw7Dpntb4.

Lesson 2

Grade Level: 7-12	Mars Undercover: Revealing the Geologic History Through Mapping	Lesson Length:2-3 Class Periods

Lesson Objects and Standards
Students will:

- Learn to classify craters
- Learn basic relative age dating principles
- Discuss and debate interpretations of observations
- Create a simple geologic feature map
- Analyze, interpret and write the geologic history of a region of Mars

Missouri Learning Standards:

- 9-12.ESS2.E.1 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.
- 9-12.ESS1.C.1 Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor

- 11-12.W.1.A
  b. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation
- 11 -12.SL.1.A Work with peers to promote civil, democratic discussions and decision making; set clear goals and deadlines; and establish individual roles as needed.
- 11 -12.SL.1.B Delineate a speaker's argument and claims, evaluating the speaker's point of view, reasoning, stance, and evidence in order to propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify or challenge ideas and conclusions; and Updated 6/2020 18 promote divergent and creative perspectives.

Materials:

- 1 Internet-connected computer per team of students
- Mars Uncovered Student Guide: 1 per student (Keep student worksheet one separate)
- Mars Uncovered Mapping Materials: At least 1 set per team of students
- THEMIS Image Mosaic- Chryse Planitia, Shalbatana, and Tiu Valles Images
- Sheet protector or laminate the pictures
- Set of red, green, blue, and black erasable markers
- Two paper clips (to secure map and transparency sheet)
- Magnifying glass (optional)
- Smartboard (optional)

Engagement Phase **Video:** NASA's Mars 2020 Perseverance Rover Mission Real-time Tracker - NASA's Mars 2020 Perseverance Rover Mission Real-time Tracker ● As the students are watching the live feed of Mars, discuss what they are noticing about its surface features. Teacher Notes: ● This is a live feed that replays some of the same footage over and over, so pre-watch it to make sure you have some of the footage you want to show your student. ● An optional video that shows fantastic images, and it is about 10 minutes. New: Mars In 4K -	**Duration 10-15 minutes** Teacher Role - ● facilitate learning ● guide student understanding. **Goal** ● Students learn about the different geologic features of Mars.
Exploration Phase: ● Give each group of students one THEMIS daytime IR mosaic and student worksheet 1. Meetings 2 and 3: Mars Uncovered | Mars Education ● Worksheet 1 has the students think about strategies they would use to look at the relative ages of the Martian features before introducing the scientific techniques used in the process. ● Give the students time to discuss and complete the worksheet and then have each group discuss their answers. (I have a small class with only two groups. With a larger class, this step could be skipped) ● After the group discussions are completed, go over their answers with the class, making sure they know the two main features shown in all the images - craters and channels but do not tell them if they are right or wrong. ● Have students turn in the worksheet because when the lesson is over, they can go back and compare to see if their previous answers were valid. ● Have the student groups read pg 2-4 from their Mars Uncovered student book and answer the questions on Student Worksheets 2 and 3. Meetings 2 and 3: Mars Uncovered | Mars Education ● Emphasize that when completing the Reasoning column on worksheet 2, they need to use the new scientific terms they just learned from their reading. ● Once each group has completed both worksheets, have them discuss with another group their answers and decide if their answers are the same; if not each group needs to explain why they think their answer is correct and try to convince the other group to change theirs.	**Duration: 30 Minutes** Teacher Role: ● Clarifies questions ● Observes and listens to students ● Acts as a consultant ● Asks probing questions **Goals** ● Students will think about strategies needed to identify the relative age of a geological feature. ● Students will make a simple geologic map of a region on the surface of Mars and interpret the region's geologic history using relative age dating.

• After class discussions are complete, go over the correct answers with the groups and address any misconceptions they may still have before going on to the next lesson. Teacher Notes: • You can give each group the same image or use all 3. I gave each group different images and later gave them the other images so each group could compare and discuss their findings.	
<u>Explanation Phase</u> • Continue with the same groups. • The students will be completing Worksheets 4 and 5. • Before starting this lesson, review the three different types of Craters and landforms they previously learned. (Preserved, Modified and Destroyed) • Have the students complete Worksheet 4 by following the directions. • (Optional) After completing the Surface Feature Map, have each group go to the smartboard with that group's image displayed and share their interpretation of the geological features with the class. Allow for open discussion, encouraging the students to use formal scientific language to back up their claim and reasoning for their choices. • After completing the map, have the students answer questions #1-5 on Student Worksheet 5. • Before students write their interpretation of the geologic history of their region (question #7), have them discuss their answers to questions #1 through #5 with another group studying the same area or as a whole class, depending on the size. Students should defend their answers and try to convince the other group that their interpretation is correct. Students may or may not decide to change their answers, but they should indicate this in their responses to question #6. • Students can complete #7 on Student Worksheet 5 by themselves or in groups. (I have students complete this on their own so that I can do a quick check of each students understanding) • I have students use the Claim Evidence and Reasoning form to guide them in writing their answers. ClaimEvidenceReasoningCERCards-1.jpeg Teacher Notes: • Ensure you have copies of the three different THEMIS mosaics, either laminated or covered with a transparency sheet. • I made at least one copy of each image for each group, so everyone has an image to look at while the other groups are presenting.	**Duration:30-45 minutes** Teachers Role - • Encourages students to explain concepts in their own words • Asks for clarification from students • Builds on student explanations • Provides time for students to compare their ideas with others and revise their ideas **<u>Goals</u>** • Students will show explanations, or possible solutions, to other students • Students will listen and question explanations offered by others • Students will use terminology and formal scientific language • Students will adjust models and explanations as new evidence or reasoning is presented

Elaborate Phase ● After students have created and interpreted their geologic feature map of their region, have them look back to Student Worksheet 1. ● Students can complete this independently or in their groups (I have them do it first on their own). Students should refer to this worksheet (Student Worksheet 1) to answer question #1 on Student Worksheet 6. They should also answer question #2 based on their curiosities. ● Have students read their interpretations of the geologic history of their regions on Mars, one region at a time (if you had groups working on different regions). Discuss with students how they all observed craters and channel features in their images but that their interpretations and overall geologic history of a region may differ from one another. Re-emphasize that scientists can have different interpretations, as long as they can defend those interpretations with evidence and logical arguments. Reiterate to students that they are experiencing what professional scientists experience as they look at interpreting the geologic history of regions. (Mars Uncovered teacher's guide pg 4)	**Duration:15-20 minutes** Teachers Role- ● Expects students to use newly acquired vocabulary and explanations ● Provides additional evidence, explanations, or reasoning ● Reinforces students' use of scientific terms and descriptions previously introduced ● Asks questions that help students draw reasonable conclusions from evidence and data **Goals** ● Students will be able to follow the instruction in the creation of feature maps. Students will be able to explain how to classify geographical features using scientific language.
Evaluate Phase ● Have the students created another Surface Feature Map from a different THEMIS image following the directions on Student Worksheet 4(I made another copy for my students) ● Final Assessment- have the student complete another Interpreting Geologic History sheet. (This is a modification from Student Worksheet 5) Interpreting the Geologic History Assessment - https://bit.ly/2PzuYTC Teacher Notes: ● Pick another THEMIS image of your choice to give to each student. THEMIS images by topic | Mars Odyssey Mission THEMIS (asu.edu) ● Have students use any type of coloring tools they have available. They can color directly on the image and turn it in with the questions.	**Duration 30-45 minutes** Teacher Role- ● Asks open-ended questions ● Uses a variety of assessments to gather evidence of student understanding ● Provides opportunities for students to assess their own progress **Goal** ● Students are given the opportunity to demonstrate their understanding.

Sources:

Bengood1993123. “New: Mars In 4K.” *YouTube*, YouTube, 17 July 2020, www.youtube.com/watch?v=ZEyAs3NWH4A.

Linkon, Drew. “Missouri Learning Standards.” *Missouri Department of Elementary and Secondary Education*, 16 Mar. 2021, dese.mo.gov/college-career-readiness/curriculum/missouri-learning-standards#mini-panel-mls-standards1.

“Meetings 2 and 3: Mars Uncovered.” *Meetings 2 and 3: Mars Uncovered | Mars Education*, marsed.asu.edu/msip-independent-meeting2.

“NASA's Mars 2020 Perseverance Rover Mission Real-Time Tracker.” *YouTube*, YouTube, 6 Feb. 2021, www.youtube.com/watch?v=w9zFaCNXTCY.

“THEMIS Images by Topic.” *THEMIS Images by Topic | Mars Odyssey Mission THEMIS*, themis.asu.edu/topic.

Lesson 3

Grade Level: 7-12	Mars Image Analysis Activity	Lesson Length:- 2-3 Class Periods

Lesson Objects and Standards
Students will:

- Learn how to reconstruct geologic events using empirical evidence
- Learn to accurately use the scientific method of inquiry

Missouri Learning Standards:

- 9-12.ESS2.E.1 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.
- 9-12.ESS1.C.1 Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor.
- HS-ESS1-2 Constructing Explanations and Designing Solutions Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- HS-ESS1-2 Communicate scientific ideas in multiple formats.

- 11 -12.SL.1.B Delineate a speaker's argument and claims, evaluating the speaker's point of view, reasoning, stance and evidence in order to propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify or challenge ideas and conclusions; andUpdated 6/2020 18 promote divergent and creative perspectives.
- 11-12.W.1.A a. Conduct research to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; gather multiple relevant, credible sources, print and digital; integrate information using a standard citation system. b. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
- 11-12.W.1.A b. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation
- 11 -12.SL.1.A Work with peers to promote civil, democratic discussions and decision making; set clear goals and deadlines; and establish individual roles as needed.
- 11 -12.SL.1.B Delineate a speaker's argument and claims, evaluating the speaker's point of view, reasoning, stance, and evidence in order to propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic

or issue; clarify, verify or challenge ideas and conclusions; and Updated 6/2020 18 promote divergent and creative perspective.

Materials:

- 1 Internet-connected computer per team of students
- Mars Image Analysis Activity materials: 1 set per team of students
- One THEMIS visible image
- The accompanying context image
- An 11" X 17" MOLA elevation map of Mars
- Erasable markers
- Ruler • Calculator
- Set of Feature Identification Charts: 1 per student
- Mars Image Analysis Student Worksheets: 1 per student (optional)
- Reading: Question Mars Activity page 1 (Objective and Student Introduction background information sheet): 1 per student

Teachers Notes:

- If desired, have students continue working in the same groups as previously lessons.
- Before providing the materials to the student teams, first, display each of the Mars Image Analysis activity materials in front of the room and briefly explain them.
- Once you have reviewed the materials students will use, demonstrate what the student teams will do once they have received their materials. \
- Before starting this lesson make sure you have read and understand all the instructions for the Instructor notes for meeting 4. https://marsed.asu.edu/sites/default/files/stem_resources/Meeting%204.pdf

Engagement Phase	**Duration: 10-15 Minutes** Teacher Role-
• Post the following question on the board, What can you tell from a picture? Write down some of the student's answers and explain what they will be doing next. • Hand out THEMIS image, (A) What can you tell from a picture? • Ask students to look at the top image on page 1 of (A) What can you tell from a picture? On chart paper write down some of the student's observations or have them do it (keep for later use). • Ask where the arrow is pointing on the map? The students should use their prior knowledge when predicting what the land formation might be. • Next, ask the students to look at the second and third images on (A) What can you tell from a picture? (which are zoomed-in versions of this image) in both colorized elevation and black and white infrared imaging. Again, make observations and write	• facilitate learning • guide student understanding. **Goals:** • Students will learn how to analyze and interpret data from a picture. • The students will use critical thinking skills to interpret the images.

some of them on the chart papers around the room. ● After the discussion ask the students if they gained a new understanding about this area than they did before? ● Finally, ask the students to look at the final image on (A) What can you tell from a picture? - a black and white THEMIS image. This image is further zoomed in for even more detail. ● One last time, ask them to make observations and share their observations about this area and write a few observations on the chart paper. ● Do they understand anything different about this area than they did before? Share out with the classroom. ● At this point, the students should have made many observations. Ask students what information is missing? ● If we were to attempt to explain why this crater looks so different from other craters, what else would we need to know, observe, or understand to do that? Have the students explain what they think they need to learn more about to gain a better understanding of the images. Teacher Notes: ● Print materials - Student Guide Mars Images Analysis - Student Guide (A) What can you tell from a picture? ● Organize 1 THEMIS image, 1 MOLA map, 1 set of (S) Feature ID Charts (face down on a table) ● I printed the MOLA maps and other images in color and laminated them. ● 1 wet-erase marker for each group. ● Chart paper for each one of the images on Student sheet A	
Exploration Phase ● The first part of this lesson should take about 10-15 minutes ● Before distributing materials, have students brainstorm analogous features they know exist on Earth that may also exist on Mars. This will help students build knowledge and make connections to previous knowledge throughout the activity. If you have completed the two previous activities the students should already have an understanding of this concept. ● Pose the Essential Question: How do people reconstruct and date events in Earth's planetary history? Discuss the students thinking on this topic before reading the two background articles. ● Have students read from their Student Guide (B) Background (pg 17). This article will give the students some background on why and how we are studying Mars. ● Also, read the (C) Lesson Background(pg 17) to orient them to	**Duration: 60 Minutes** Teacher Role- ● Clarifies questions ● Observes and listens to students ● Acts as a consultant ● Asks probing questions **Goals:** ● The students will analyze and identify surface features on Mars. ● The students will learn to calculate the size of

the purpose and intent of the lesson. ● Next, familiarize the students with Feature ID Charts, (E) Sunlight and Shadows Sheet, which is the first page of the Supplemental packet and THEMIS images to students. ● Have students use erasable markers to identify features on laminated THEMIS images using (S) Feature ID Charts (pgs 10-17). Have students initially work with one image. ● After groups have completed identifying the features on their image have them go to a smartboard and share with the class their observations (if an option). ● Ask students to record the identified features and the geologic processes involved in their creation on (D) Data Log Sheet (pg 19 of Student Guide). **Part 2** ● For this part of the lesson, the students will need pages 3 &4, from the Supplemental Packet and pages 19-21 from the Student Guide. ● Before starting this activity play the *Mars Image Analysis* video to help explain how to calculate the scale of the land features. https://marsed.asu.edu/sites/default/files/msip_independent/Meeting_4/ImagingActivity.mov ● Using (K) Student Measurement Notes sheet, have students measure and simply label features using metric units. (pg 20 Student Guide) ● Review the example of calculating the size of features in THEMIS images with students. This is explained to them on the video and on the worksheet. ● Have students determine the scale factor of their image. Once students have determined the scale factor of their image, make sure they write this somewhere on their image. If teaching younger students double-check their findings. Have students use the measurements (in centimeters) of the features labeled on their image and make the appropriate calculation (feature measurement X scale factor) to determine the size of each measured feature in kilometers on Mars. ● Have students write these measurements for each feature into their (L) Student Measurement Data Log in the Measurement column. (pg 21 of Student Guide) Teacher Notes: ● Make sure to also have a copy of the Supplemental Materials Mars Image Analysis for each student. The only pages that need to be copied for the students are pages 1-4,7 and 10-17. https://marsed.asu.edu/sites/default/files/stem_resources/SM_MARS_IMAGE_ANALYSIS_12_2012_0.pdf	geographic features on a scale model.

• To find the THEMIS images go to the following website- THEMIS Image Set | Mars Education (asu.edu) • Choose an image type for the students to look at. I copied the image to a file and printed them out and laminated them for the students to work on. • I added the website information to Google Classroom so the students have access to all the data on the page because I do not have the large printed sheets of the THEMIS images. • I also let the students explore with the "View this image on a map" section also.	
Explanation Phase • After students have completed their measurement for the lesson have students discuss the relative ages of features on their image with each other and complete a short presentation to share with the rest of the class during the gallery walk. This could be just a simple write-up on paper, a Google Document, or even a short slide show. Students should discuss the geologic history (what has happened in their area of Mars) as part of their presentations. • Have students use the measurements (in centimeters) of the features labeled on their image and make the appropriate calculation (feature measurement X scale factor) to determine the size of each measured feature in kilometers on Mars. • Have students write this measurement for each feature into their (L) Student Measurement Data Log in the Measurement column. (pg 21 of Student Guide) • Once all groups have completed their measurements and presentations have the class do a gallery walk around the room to investigate the size of the different geological features found on Mars. Then discuss with the groups some of their finds and did everyone agree with each group's calculations. • If kids are having a difficult time making a size connection to how large some of the features are, try to find something that they can relate to of comparable size. Teacher Notes: • Guide student discussion and provide clarification if needed.	**Duration:20-30 Minutes** Teacher Role- • Encourages students to explain concepts in their own words • Asks for clarification from students • Builds on student explanations • Provides time for students to compare their ideas with others and revise their ideas **Goals:** • The students explain the reasoning behind the data they have collected.
Elaborate Phase • Have student groups continue working together to fill in list #1 on the (M) Establishing a Research Topic of Interest sheet. (pg 8 of Student Guide) Allow the groups spend about 3-5 minutes brainstorming topics from any aspect of Mars exploration or geology that interests them.	**Duration: 60-90 Minutes** Teacher Role- • Expects students to use newly acquired vocabulary and explanations • Provides additional evidence, explanations, or reasoning

• After each group has completed their list give them a few more minutes to narrow the list to their top 3 choices • As a class, the students will need to debate and establish their research topic of interest. Should the class be evenly split on a research topic, they could possibly combine their two top topics by establishing a relationship between the two topics to explore. • After the students have established a topic, they will need to do some research about it. • Have student groups assign each student a research job. Once each student has completed their own research they can meet back as a group and have one student compile all the information to share with the rest of the class. (This should help save some time in the research process) • Photocopy as many (N) Background Research sheets as they will need. (pg 9 Student Guide) • Students may need help getting started with their research. Here are a couple of sources they can use to learn more about their topic of interest: • Red Planet Report | What's new with Mars (asu.edu) • THEMIS images by topic | Mars Odyssey Mission THEMIS (asu.edu) • After groups have completed their (N) Background Research. They will need to read over (P) Example Observation Table (pg 10 Student Guide) and (O) Using THEMIS Website to Make Scientific Observations (pg 7 Supplemental) before completing (Q) Observation Table (pgs 11-12 Student Guide) • Once the Observation Tables are complete the student groups will choose two observations they found most interesting and record them on (R) Choosing a Topic for Research. • Lead the class in a discussion over interesting scientific observation and make a list of six the students can choose to study about Mars. • Have the students go back in their groups and discuss which topic they like the best and then have a class debate to decide which topic the class will research. Teacher Notes: • Students will need pages 8-13 from the Student guide for this lesson and page 7 from the supplement packet. • Material for this lesson- Index cards (3x5) and markers. (Optional)	• Reinforces students' use of scientific terms and descriptions previously introduced • Asks questions that help students draw reasonable conclusions from evidence and data **Goals:** • The students will compare and contrast the geologic features of Mars and Earth. • The students will learn how Mars feature forms, where they are typically found, if there are similar features on Earth or other planetary bodies and how they are the same or different to feature on Earth or other planetary bodies. • The student will form a hypothesis of how geologic features form. • The students will learn how to participate in authentic science discussion and debate.
Evaluate Phase • Have the student return to (D) Student Data Log (pg 5 Student Guide) and include the order of which the features have occurred in the Relative Age column. If needed make changes to the How	**Duration: 20 Minutes** Teacher Role- • Asks open-ended questions • Uses a variety of

the Feature Formed column. ● Complete the bottom of the Data Log as a group, explaining the history of the major events that took place in the area. ● To prepare for the next lesson the students should have decided on a topic of interests about Mars that they can develop a testable research question. ● 3 different rubics have been provided on the following link. **Microsoft Word - Mars Image Analysis High School Alignment.docx (nasa.gov)**	assessments to gather evidence of student understanding ● Provides opportunities for students to assess their own progress **Goals:** ● The students will learn to make scientific observations.

Sources:

Christensen, P.R., N.S. Gorelick, G.L. Mehall, and K.C. Murray, *THEMIS Public Data Releases*, Planetary Data System node, Arizona State University, <http://themis-data.asu.edu>.

Linkon, Drew. "Missouri Learning Standards." *Missouri Department of Elementary and Secondary Education*, 16 Mar. 2021, dese.mo.gov/college-career-readiness/curriculum/missouri-learning-standards#mini-panel-mls-standards1.

"Meeting 4: Mars Image Analysis Activity." *Meeting 4: Mars Image Analysis Activity | Mars Education*, marsed.asu.edu/msip-independent-meeting4.