The Space Race Winds Down

Session Time: One, 50-minute session

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Appreciate the rich, global history of aviation/aerospace and the historical factors that necessitated rapid industry development and expansion. (EU1)

Develop interest in one or more aviation/aerospace career pathways and learn what is required to pursue future employment in the industry. (EU3)

ESSENTIAL QUESTIONS

1. Since we are no longer going to the moon, was the space race worth the effort?
2. How did the Skylab and Apollo-Soyuz missions change the trajectory of the United States' space program?

LEARNING GOALS

Students Will Know

- The challenges of docking two dissimilar spacecraft
- How the goals of the U.S. space program became more exploratory and scientific after landing on the moon
- As the rhetoric and tension of the Cold War began to subside, cooperation in space ventures began to replace competition

Students Will Be Able To

- *Explain* why rockets and spacecraft must be redesigned and re-engineered to meet new goals and circumstances. (DOK-L2)
- *Summarize* and *describe* events and innovations that were key to the advancement of space exploration. (DOK-L2)

ASSESSMENT EVIDENCE

Warm-up
Students complete informal "voting" activity using five true/false statements.

Formative Assessment
Working in pairs, students will explain how and why the Apollo and Soyuz spacecraft were redesigned in order to meet the mission's goals.

Summative Assessment
Students will write answers to questions about the challenges and impacts associated with the Skylab and Apollo-Soyuz programs.

LESSON PREPARATION

MATERIALS/RESOURCES

- The Space Race Winds Down Presentation
- The Space Race Winds Down Student Activity

Let's Dock! Activity (per team)

- One larger water bottle representing the Apollo module (empty)
- One smaller water bottle representing the Soyuz module (empty)
- Four 6-foot strings
- Ring cut from a Styrofoam cup
- Clear tape

LESSON SUMMARY

Lesson 1: The Space Race Begins

Lesson 2: To the Moon

Lesson 3: The Space Race Winds Down

Lesson 4: The Shuttle Program

This lesson will help students learn about the United States' efforts in space after the Apollo program. Students will be introduced to innovations in technology that occurred during this time.

At the beginning of the lesson, students will complete an informal "voting" activity using five true/false statements related to space programs in the post-Apollo era.

Students will be introduced to the Skylab and Apollo-Soyuz missions. A video will further explain this first-of-many international collaborations in space. Throughout the lesson students will provided with opportunities to discuss and think critically about the concepts they have learned.

If time allows, students will participate in an activity that will model the docking of the Apollo and Soyuz spacecraft. This activity will highlight the teamwork it took to complete this particular mission. As a summative assessment, students will write answers to questions about the challenges and impacts associated with the Skylab and Apollo-Soyuz programs.

BACKGROUND

Once the Apollo missions were over, it was time for the United States to venture into long-duration spaceflight missions. Skylab, the first U.S. space station, served as a laboratory in which to conduct many types of experiments. This included studying the health of astronauts during long-duration missions. Skylab laid the groundwork for the eventual development of the International Space Station (ISS). With the shift away from the competition of the space race, NASA could focus its new efforts on exploration and scientific research in space.

While the Skylab project was successful, it was not without its challenges.

- Cost and size - The entire system had to fit inside the Saturn V rocket. This posed many design challenges. Cost was prohibitive, and many items were integrated that had been used on the Apollo missions (such as the Saturn V).
- Life support systems - Extended life support systems were needed to support crews far longer than any previous space endeavors. This resulted in Skylab being the first spacecraft to fully rely on solar power for its energy needs.

The spacecraft also had to incorporate a shower system that would guarantee no water droplets escaped in the zero-g environment as they could cause electrical malfunctions. A vacuum system was incorporated into the shower as a critical component.

- Repairs - There was also a need for reliability and repairability, again due to the duration of time the systems would be in use.
- Communications and tracking - Communication with terrestrial crews necessitated the development of advanced transmission and flight-tracking systems that would allow around-the-clock communications and tracking.
- Structural design - Skylab was subject to a range of forces varying from 0G to 4.5G during acceleration through the atmosphere and the shock from docking was equivalent to an earthquake, on earth.

Skylab allowed for the orderly transition between the Apollo and Space Shuttle programs and was the precursor to today's International Space Station.

The Apollo-Soyuz mission represented the first international joint effort in space and was the first of many successful collaborations between the Americans and the Russians. The goal was to dock two spacecraft that were not similar. The mission occurred in July 1975 and involved a three-man crew from the United States and a two-man crew from the Soviet Union. The Apollo-Soyuz mission was also not without its challenges. One of the first challenges was that the astronauts and cosmonauts had to learn each other's languages. The Apollo spacecraft was also redesigned with a module that served as a docking unit and an airlock unit.

MISCONCEPTIONS

Many students might assume that the Americans and Soviets remained competitors in space exploration. As the space race wound down, they started working together with the Apollo-Soyuz project.

Initially, the United States did not go to space for pure exploration and scientific reasons, as is more the case now. Skylab and the Apollo-Soyuz Project signaled the shift from competition to exploration and science.

LEARNING PLAN

ENGAGE

Teacher Material: The Space Race Winds Down Presentation

Slides 1-3: Introduce the topics and learning objectives of this lesson.

Slide 4: Conduct **Warm-Up.** Have students stand in the middle of the room. Designate one side of the room as "true" and one side as "false." Read each warm-up question out loud. The students will "vote" by moving to the side of the room they think is the correct answer. After students "vote," read the correct answer and then move on to the next question. [DOK 2; interpret, use context clues]

Warm-Up

Pre-assess the students' knowledge of Skylab and collaboration between the United States and the Soviet Union by using a quick, informal "voting" exercise with true/false statements.

Answers

1. The International Space Station was the first U.S. long-duration orbital lab. True or false?

False. Skylab was the first U.S. long-duration orbital lab.

2. Skylab proved that chimpanzees can live in space for more than 84 days. True or false?

False. Skylab proved that humans could remain in space for up to 84 days.

3. Astronauts and cosmonauts learned each other's languages so they could communicate. True or false?

True. American astronauts spoke in Russian to the cosmonauts, and at times the Russians spoke in English to the astronauts.

4. Spacecraft designed by other countries are not compatible with one another. True or false?

False. The Apollo and Soyuz modules successfully docked in space.

EXPLORE

Teacher Material: [The Space Race Winds Down Presentation]

Slides 5-6: Present information about Skylab, the United States' first space station, where crew members stayed for multiple days.

After the Apollo program, Skylab became the United States' first attempt at learning about human adaptability for long duration space flight serving as its first space station. Skylab tested these astronauts' skills in problem solving, innovative repairs, adverse conditions, etc. Contributions to the Skylab were made by more than 140 scientific teams from the U.S. and 28 foreign countries.

Seventeen high school experiments were actually performed on Skylab, as well as hundreds of others. Often a key element of these experiments was verbalizing what was witnessed: in one of the flammability experiments the recordings of the scientist offered just as much, if not more, information than the photos themselves did. In this case, a picture wasn't worth a thousand words.

Skylab re-entered Earth's atmosphere on July 11, 1979, and disintegrated.

Slide 7: This time period was one of great design and engineering, but there were many challenges in transforming the U.S. space program from one of exploration to one of scientific investigation.

- Cost and size - The entire system had to fit inside the Saturn V rocket. This posed many design challenges. Cost was prohibitive, and many items were integrated that had been used on the Apollo missions (such as the Saturn V).
- Life support systems - Extended life support systems were needed to support crew far longer than any previous space endeavors. This resulted in Skylab being the first spacecraft to fully rely on solar power for its energy needs. The spacecraft also had to incorporate a shower system that would guarantee no water droplets escaped in the zero-g environment as they could cause electrical malfunctions. A vacuum system was incorporated into the shower as a critical component.
- Repairs - There was also a need for reliability and reparability, again due to the duration of time the system would be in use.
- Communications and tracking - Communication with terrestrial crews necessitated the development of advanced transmission and flight-tracking systems that would allow around-the-clock communications and tracking.

- Structural design - Skylab was subject to a range of forces varying from 0G to 4.5G during acceleration through the atmosphere and the shock from docking was equivalent to an earthquake, on earth.

Slide 8: Skylab was a bold concept. It allowed for the orderly transition between the Apollo and Space Shuttle programs and was the precursor to today's International Space Station.

The Apollo-Soyuz mission represented the first international joint effort in space and was the first of many successful collaborations between the Americans and the Russians. The goal was to dock two spacecraft that were not similar. The mission occurred in July 1975 and involved a three-man crew from the United States and a two-man crew from the Soviet Union.

The astronaut maneuvering equipment experiment was the predecessor to the Manned Maneuvering Unit (MMU) that shuttle crews used during Extravehicular Activity (EVA). Large gyroscopes were employed on Skylab for altitude control, a technological advancement that at the time was not commonly employed in large spacecraft. Finally, it allowed for the orderly transition between the Apollo and Space Shuttle programs and was the precursor to today's International Space Station.

Slide 9: Show a video which summarize the Skylab Program. After the video plays, ask students to answer the questions on the slide in a Think-Pair-Share exercise.

- "The Skylab Legacy—Long Duration Space Flight" (Length 5:09)
  http://video.link/w/2ILd

Questions

Ask students to do a Think-Pair-Share exercise using the following questions:

1. What kind of preparation do you think would have been necessary for a Skylab astronaut?
2. How did Skylab represent changes in circumstances that had occurred since the height of the Space Race?
3. What problem was Skylab supposed to solve? Was it successful?
4. Would you have wanted to be one of the first humans to spend a long duration in space? What would have been some of the risks?

EXPLAIN

Teacher Material: The Space Race Winds Down Presentation

Slides 10-11: Lead a discussion with students about Skylab and the collaboration between the United States and the Soviet Union in space exploration. Soviets and Americans started working together through the Apollo-Soyuz project as the Space Race wound down.

Remind students of the tensions between the United States and the Soviets before and during the Apollo era. The Apollo-Soyuz program made great strides in changing the relations between the two nations and was the start of international collaboration in space between the two.

The Apollo-Soyuz mission was not without its challenges. One of the first challenges was that the astronauts and cosmonauts had to learn each other's languages.

Slide 12: Explain to students that the Apollo spacecraft was redesigned with a module that served as a docking unit and an airlock unit.

Conduct the **Formative Assessment.**

Formative Assessment

Working in teams of two, ask students to write at least one paragraph about how and why the Apollo and Soyuz spacecraft were redesigned in order to meet the mission's goals. [DOK 3; compare, draw conclusions]

Answers

Potential Response:

The atmosphere inside the two spacecrafts differed. The United States used pure oxygen, and the Soviets used a nitrogen/oxygen blend similar to Earth's atmosphere. Beyond the different blend of atmosphere was the differentiation in pressure of nearly 10 psi. In addition, the attachment system needed to interface with the two different docking designs and it had to serve as an airlock. Students may include that solving these problems served as groundwork for future innovations, such as the successful construction of the International Space Station.

EXTEND

Teacher Material: The Space Race Winds Down Presentation
Student Material: The Space Race Winds Down Student Activity

Slide 13: Highlight the importance that teamwork played in a successful joint mission between the United States and Russia. Split students into groups of six to complete a mock docking activity.

Provide students with **The Space Race Winds Down Student Activity**. Each of the six students needs to choose a role. The students will work together to successfully dock their "Apollo" (large water bottle) and "Soyuz" (small water bottle) modules using good communication and listening skills. This activity is harder than it might seem.

- Apollo crew: two students
- Soyuz crew: two students
- Apollo mission controller: one student or more
- Soyuz mission controller: one student or more

Questions

Discuss the following questions with students after the activity:

Describe the similarities and limitations that this model represents as it relates to the Apollo-Soyuz mission.

How could you modify the model to better represent realistic docking procedures?

Teacher Tip

If time allows, show students a video to underscore the importance of this joint mission.

- "Historical Handshake in Space" (Length 12:22) http://video.link/w/4ILd

EVALUATE

Teacher Material: The Space Race Winds Down Presentation

Slide 14: Complete the **Summative Assessment**.

Divide students into small groups and have them write answers to the following questions about the challenges and impacts associated with the Skylab and Apollo-Soyuz programs. They may need to complete additional research to fully answer both questions. [DOK 4; synthesize, DOK 3; draw conclusions]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Student response shows evidence of one or more of the following
  - Knowledge of events after the Space Race
  - Understanding of the importance of joint missions between Soviet Union and United States
- Shows understanding of concepts covered in the lesson.

Points	Performance Levels
9-10	Consistently demonstrates criteria
7-8	Usually demonstrates criteria
5-6	Sometimes demonstrates criteria
0-4	Rarely or never demonstrates criteria

Summative Assessment

In small groups, students will write answers to the following questions:

- What challenges had to be overcome in order to make docking possible for both the Skylab and the Apollo-Soyuz spacecraft?
- What impact did the Apollo-Soyuz program have on future space missions?

Questions

What challenges had to be overcome in order to make docking possible for both the Skylab and the Apollo-Soyuz spacecraft?

- *Language barrier*
- *Dissimilar docking designs*
- *Dissimilar atmospheres (Apollo used 100% oxygen with a pressure of 5 psi, while the Soyuz used an atmosphere more similar to what is found on Earth, a nitrogen/oxygen combination normally at 14.6 psi, lowered to 10.1 psi)*

What impact did the Apollo-Soyuz program have on future space missions?

- *Lead to greater teamwork between the United States and the Soviet Union*
- *Attachment system was used during the Shuttle-Mir program*
- *Attachment system is still installed on the ISS connecting one of the first Russian-built components.*

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-dimensional Learning

- **HS-ETS1-1** - Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
    - Science and Engineering Practices
        - Asking Questions and Defining Problems
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.A: Defining and Delimiting Engineering Problems
    - Crosscutting Concepts
        - Systems and System Models
        - Influence of Science, Engineering, and Technology on Society and the Natural World
- **HS-ETS1-2** - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
    - Science and Engineering Practices
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.C: Optimizing the Design Solution
    - Crosscutting Concepts

        - none

- **HS-ETS1-3** - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
    - Science and Engineering Practices
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.B: Developing Possible Solutions
    - Crosscutting Concepts
        - Influence of Science, Engineering, and Technology on Society and the Natural World

COMMON CORE STATE STANDARDS

- **RL.9-10.7** - Analyze the representation of a subject or a key scene in two different artistic mediums, including what is emphasized or absent in each treatment.
- **RST.9-10.1** - Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- **RST.9-10.2** -Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- **RST.9-10.4** - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
- **RST.9-10.7** - Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- **WHST.9-10.2** - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- **WHST.9-10.4** - Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- **WHST.9-10.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- **WHST.9-10.7** - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- **WHST.9-10.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- **WHST.9-10.9** - Draw evidence from informational texts to support analysis, reflection, and research.

REFERENCES

https://www.nasa.gov/mission_pages/skylab

https://www.nasa.gov/missions/shuttle/f_skylab1.html

https://www.nasa.gov/mission_pages/apollo-soyuz/astp_mission.html

https://history.nasa.gov/apollo/apsoyhist.html

https://www.nasa.gov/centers/marshall/history/gallery/msfc_iow_18.html

http://www.pbs.org/spacestation/station/russian.htm

https://er.jsc.nasa.gov/seh/docking_with_ISS.pdf

https://www.jsc.nasa.gov/history/oral_histories/JohnsonGW/NASA_SP-2010-578.pdf