The Shuttle Program

Session Time: Two, 50-minute sessions

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. Was the space shuttle program an effective extension of America's manned space program?

LEARNING GOALS

Students Will Know

- The components of a shuttle
- Challenges the space shuttle program faced
- Scientific research accomplished as a result of the shuttle program

Students Will Be Able To

- *Explain* and *make inferences about* innovations that were key to the advancement of space exploration. (DOK-L3)

ASSESSMENT EVIDENCE

Warm-up
Students watch an *Atlantis* launch video and then answer informal questions about the space shuttle program.

Formative Assessment
Students take a position on whether or not the space shuttle program was successful in its overall mission.

Summative Assessment
Students demonstrate their understanding in a quiz show about the American space program.

LESSON PREPARATION

MATERIALS/RESOURCES

- The Shuttle Program Presentation 1
- The Shuttle Program Presentation 2
- The Shuttle Program Teacher Notes

LESSON SUMMARY

Lesson 1: The Space Race Begins

Lesson 2: To the Moon

Lesson 3: Space Race Winds Down

Lesson 4: The Shuttle Program

This lesson begins with students watching the launch of space shuttle *Atlantis* to the International Space Station. They will answer several questions in an informal class discussion about the shuttle program. The teacher will lead the students through a discussion on NASA's shuttle program. The presentation will cover the purposes for the shuttle program, the main components of the system, and its assembly.

At the beginning of the second session, the teacher will provide students with details about each of the six orbiters that bear the familiar shuttle names such as *Challenger, Columbia* and *Discovery*. In the formative assessment, students will take a position on whether or not the space shuttle program was successful in its overall mission. To conclude the lesson, students will demonstrate their understanding about the American manned space program using a quiz show format.

BACKGROUND

Born out of necessity for a reusable and cost-effective space transportation vehicle, the space shuttle served NASA for 30 years. During that time, the shuttle systems conducted 135 missions by launching satellites, transporting parts and astronauts for the construction of the space station, deploying the Hubble telescope, and supporting military operations. The shuttle launched from Kennedy Space Center in Florida. The missions ended with landings at the Shuttle Landing Facility at Kennedy Space Center or Edwards Air Force Base in California. If the landing occurred at Edwards Air Force Base, the shuttle was transported back to the Kennedy Space Center atop a Boeing 747.

While overall a successful program, the shuttle program suffered two catastrophic accidents. On January 28, 1986, the *Challenger* shuttle exploded just 73 seconds after liftoff. A faulty O-ring caused this tragic accident. Seventeen years later on February 1, 2003, the shuttle *Columbia* disintegrated during re-entry to Earth's atmosphere. This accident resulted from damage to the left wing that occurred during the launch.

By the end of the program, the space shuttles accounted for more than 1,322 days in space. In 2011, NASA announced that the remaining four orbiters would be placed on display at learning centers spread across the country. *Enterprise* is on display at the Intrepid Sea, Air & Space Museum in New York; *Discovery* is located at the Smithsonian's Steven F. Udvar-Hazy facility in Virginia; *Endeavor* is at the California Science Center in Los Angeles; and *Atlantis* is at the Kennedy Space Center.

DIFFERENTIATION

To support student motivation in the **EXPLORE** section of the lesson plan, allow students the option to create a poster, complete with labels, instead of a report to present the same information about their shuttles.

LEARNING PLAN

ENGAGE

Teacher Material: [The Shuttle Program Presentation 1]

Slides 1-3: Introduce the topic and learning objectives for the lesson.

Slide 4: Show students the NASA video of *Atlantis's* launch. As they watch the video, ask students to write their impressions of what it would be like to launch as part of a shuttle mission. After the video, allow for a brief discussion.

STS-129 was a mission to the International Space Station. It launched on November 16, 2009. It was an 11 day mission that including three spacewalks.

- "STS-129 HD Launch" (Length 11:31)
  https://video.link/w/EpWh

Slide 5: Conduct the **Warm-up**. Take no more than 5 minutes of class time to complete the Warm-up. [DOK 3; formulate, hypothesize]

Warm-Up

Ask students to individually write a response to each question. Ask volunteers to share their answers with the class.

- What was the purpose of the space shuttle?
- How was the space shuttle similar to and different from an airplane?

Questions

What was the purpose of the space shuttle?

It was the first orbital spacecraft designed for reuse. It carried various payloads to the International Space Station (ISS) and provided for crew rotation on the ISS. It allowed for the service and repair of various satellites and it also recovered satellites and other payloads from space and returned them to Earth. Many experiments were carried out on shuttle missions.

How was the space shuttle similar to and different from an airplane?

It resembled an aircraft; however, the shuttle wasn't designed to be an aircraft at all. It had delta-shaped wings, a vertical stabilizer and a rudder just like an airplane. But, it took off (or launched) vertically like a rocket and landed like a glider. It's engine was not available during the approach and landing phase for powered flight. After it landed, the space shuttle deployed a drag chute to help slow down.

EXPLORE

Teacher Material: The Shuttle Program Presentation

Slides 6-7: Introduce the space shuttle program. Summarize its purpose: launching satellites, building the International Space Station, conducting experiments, repairing and servicing satellites and more.

Commonly known as the space shuttle, the Space Transportation System (STS) represented a major advancement over the traditional, wasteful rocket programs that preceded it. One of the main advantages was its reusability.

Explain that a space shuttle looks like an airplane in many ways. Students may recall a student activity in the second unit about how nearly every airplane built today has been designed and built according to principles discovered by the Wright brothers. That is true for the space shuttle as well. However, there are also many differences between an airplane and a space shuttle. One of the most distinguishing is that the shuttle flies as a glider during reentry and landing.

Slide 8: Explain that most people think of the space shuttle as the orbiter (the part that looked like an airplane). However, the space shuttle was more than just the orbiter. The orbiter was connected to an external fuel tank and two solid rocket boosters.

The orbiter was used as cargo carrier by taking satellites and telescopes to space. Astronauts lived in the orbiter and performed experiments. The design of the space shuttle orbiter was especially important as it allowed it to glide to a runway for landing after re-entry into Earth's atmosphere.

Slide 9: The solid rocket boosters (SRBs), which looked like two thin rockets on the sides of the external tank, gave the STS the thrust it needed for launch. The SRBs allowed the shuttle to climb to 150,000. Two minutes after launch, the SRBs fell off the STS into the ocean where they were retrieved by a special boat and divers.

Slide 10: The external tank provided fuel for the space shuttle's three main engines (SSME). Each engine created approximately 400,000 pounds of thrust at liftoff and needed the fuel provided in the external tank to get into space. The external tank dropped off after the orbiter used up all the fuel. The external tank burned up in the atmosphere and thus was not reused.

Slide 11: Ask students to consider the gross weight and think about the amount of power/thrust required to launch a space shuttle off of the ground. A Boeing 777 airliner with full fuel weighs around 775,000 pounds at takeoff. The STS was more than double that amount.

How did engineers create engines with necessary thrust? They used liquid hydrogen fuel and a liquid oxygen oxidizer, then increased fuel pump pressure inside the space shuttle's combustion chamber. This was very complex but allowed for an extremely high thrust-to-weight ratio. This kind of thrust generation required extreme temperatures. The fuel was stored at -423°F before ignition and during the launch, the combustion chamber reached 6000°F. Despite these complexities, the main engines did not need to be replaced even after more than 20 years of missions.

Show students a time-lapse video of one shuttle going from assembly all the way to launch.

- "Go For Launch! Space Shuttle - The Time-Lapse Movie" (Length 3:52)
  http://video.link/w/GwMd

Slide 12: The space shuttle program has led to many other innovations, including in avionics and flight controls. In this area, the development of computer-aided flight led to the necessity for nuanced and complex software that could aid in-flight tasks. The space shuttle also had a thermal protection system to protect it from the temperatures--up to 3000°F--that it encountered upon returning to Earth's atmosphere. On reentry, the space shuttle also had a large cargo lift capability, which could hold satellites, laboratories, or other items needed for a mission.

EXPLAIN

Teacher Material: The Shuttle Program Presentation 1

During the second session of the lesson, lead students through a discussion about the missions and legacy of the space-shuttle program.

Slide 13: Unlike the rest of the space shuttles, the *Enterprise* never flew in space. The purpose of the *Enterprise* was to test and learn, ensuring that subsequent STS missions were successful. The *Enterprise* was carried for multiple tests atop a modified Boeing 747 to measure flight characteristics, stability, and control system effectiveness. The *Enterprise* had its first solo free flight on August 12, 1977. This was followed by four additional free flights, the last of which uncovered pilot-induced oscillation errors that were corrected before the first actual space shuttle launch.

Slide 14: The NASA space shuttle missions were each given an STS number. STS stands for "Space Transportation System." STS-1 launched in April 1981.

Columbia flew 28 total missions, however the shuttle and its 7-member crew were tragically lost on February 1, 2003, when it broke apart when re-entering the atmosphere. Later, it was determined that a piece of foam insulation, which had broken off shortly after launch, had damaged the edge of the shuttle's left wing.

Slide 15: Space Shuttle *Challenger* exploded just 73 seconds after launch on January 28, 1986. This crew had experienced several delays, and there was "launch fever"—in other words, people wanted the mission to go on time and exactly as planned. The O-ring seal on the shuttle's solid rocket booster failed due to cold temperatures, which allowed hot gas to escape and damage the external tank. This accident was especially shocking to the nation because a civilian teacher, Christa McAuliffe, was on board.

Teaching Tips

If appropriate, show students a video of the Challenger disaster.

- "1986: Space Shuttle Challenger Disaster Live on CNN" (Length 4:22)

  http://video.link/w/OwMd

Slide 16: Space Shuttle *Discovery* carried out many special missions in its active years The shuttle took part in both research and construction of the ISS as well as launching the Hubble telescope. John Glenn, the first American to orbit the earth in the Mercury program also went to space aboard the *Discovery* at the age of 77, the oldest human ever in space. *Discovery* was also twice selected for return-to-service missions following both the *Columbia* and *Challenger* disasters. When the *Discovery* was built, new technology resulted in a shuttle that was substantially lighter than previous systems to allow for an increased payload capacity.

Slide 17: Space Shuttle *Atlantis* flew many notable mission, one of which was the 100th manned mission to space. *Atlantis* carried many parts for the space station and serviced the Hubble space telescope. As a launch platform, *Atlantis* sent into space important probes such as Magellan to map the surface of Venus and Galileo to study Jupiter and its moons. In addition, the *Atlantis* docked numerous times with the Russian space station *Mir.*

Slide 18: *Endeavour* was the sixth and final shuttle built. It was created to replace *Challenger*. NASA ran a competition for schools to name this shuttle. About 6,000 schools participated and the name was chosen by President George H.W. Bush. Space Shuttle *Endeavor* had many advancements over previous shuttles and was the first shuttle to use a drag chute at landing to slow down.

Slide 19: The shuttle is, in fact, the last design step taken by NASA, and it is a bridge to the reusable equipment being designed by commercial space companies today. When SpaceX's rocket detached from its payload and guided itself down to a recovery pad for reuse, it was partly because of technology that originated with the space shuttle program.

Show students a video of SpaceX's dual rocket recovery after launch of their Falcon Heavy Rocket in 2018.

- "SpaceX Lands Dual Rockets Simultaneously" (Length 1:31)
  http://video.link/w/UQRd

Slide 20: The space shuttle program has led to numerous advances in fields that are surprising! A few innovations it helped generate are included on the slide.

- A low-cost, low-power human heart pump partially designed using the space shuttle's fuel system
- Development of video techniques that have aided in criminal investigations

- The ability to calculate measurements from photographs, useful in criminal investigations
- Creation of high-insulating materials
- A safety check for LASIK laser eye procedures
- The development of environmentally friendly industrial lubricants
- Disinfectants that kill more and different kinds of bacteria

EXTEND

Teacher Material: The Shuttle Program Presentation 1

Slide 21: Conduct the **Formative Assessment.**

Collect student paragraphs for grading. If time allows, ask students to share their positions and reasoning with others in the class. [DOK L3; draw conclusions, develop a logical argument]

> **Formative Assessment**
>
> After going to the moon, America's next task in space was building a more permanent dwelling in which astronauts would live and do research. NASA built a space transport system, including a reusable orbiter, to complete this task.
>
> Using what students have learned in this lesson, they need to decide if the space shuttle program was successful. Ask them to write several paragraphs to justify their answers and provide specific examples that support their choice.

EVALUATE

Teacher Material: The Shuttle Program Presentation 2, The Shuttle Program Teacher Notes

Use **The Shuttle Program Presentation 2** to conduct the **Summative Assessment.**

To evaluate the students' level of understanding of this entire section, play a game of Space Race Quiz Show. Start the day by splitting the class evenly into three to four groups (based on class size). These groups will compete against one another.

The game is contained in **The Shuttle Program Presentation 2**. Refer to **The Shuttle Program Teacher Notes** for game set-up and quiz question answers. [DOK L1; recall, state]

> **Summative Assessment**
>
> Evaluate the students' level of understanding of this entire section by playing a game of Space Race Quiz Show. Teams of students will compete against one another.

GOING FURTHER

Show students a video of solid rocket boosters being retrieved by divers: http://video.link/w/SwMd

Refer students to an AOPA article with an in-depth breakdown of a shuttle re-entry and landing: https://www.aopa.org/news-and-media/all-news/1999/april/pilot/no-go-around

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

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