CHRONICLES OF COURAGE
Stories of WARTIME AND INNOVATION

"Pearl Harbor"
STEM Lesson Plan for Grades 7-12
Developed by the National Science Teachers Association
Access the Videos at NBCLearn.com/courage

"Pearl Harbor was not a defeat. It was an eye-opener."
— Stuart Hedley, USN Retired, 2011

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Video Preview

"Pearl Harbor" is one of 20 short videos in the series *Chronicles of Courage: Stories of Wartime and Innovation.* On the morning of December 7, 1941, the Imperial Japanese Navy launches a surprise attack on Pearl Harbor, Hawaii—incapacitating the United States Pacific fleet and propelling the country into World War II.

Time	Video content
00:00–00:16	Series opening
00:17–01:08	Date for a Sunday picnic
01:09–02:31	Eyewitness account
02:32–02:56	Carrier-launched air armada
02:57–03:49	Mitsubishi A6M Zero, a very capable naval fighter aircraft
03:50–04:27	Cost of being lightweight
04:28–05:12	Eye opener
05:13–05:43	Summary
05:44-05:59	Closing credits

Video Voices—The Experts Tell the Story

By interviewing people who have demonstrated courage in the face of extraordinary events, the *Chronicles of Courage* series keeps history alive for current generations to explore. The technologies and solutions presented are contextualized by experts working to preserve classic aircraft technology.

- **Stuart Hedley, Seaman First Class, U.S. Navy.** Hedley was 20 years old when he witnessed the horrific attack on Pearl Harbor on December 7, 1941. He was transferred from the stricken *USS West Virginia* to the *USS San Francisco*, which participated in many battles including the Solomon Islands. Hedley retired from the Navy in 1960 but worked until 1981 conducting infrared inspections of ships, including aircraft carriers.
- **Kaname Harada, World War II Japanese flying ace.** Born in 1916, Harada finished at the top of his flight school in 1937. He first saw combat that same year in China. He participated in the attack on Pearl Harbor and many of the naval battles that followed, while fighting for the Japanese against the U.S. and its allies. Harada became a flight instructor in late 1942. He passed away in 2016 at the age of 99.
- **Jason Muszala, Senior Manager of Restoration at the Flying Heritage Collection.** The collection is a premiere destination for aviation, military vehicles, and other conflict-era artifacts located in Everett, Washington. Muszala restores and maintains the museum's aircraft to perfect flying condition—a role he takes seriously because he is one of the museum's pilots.

Find extensive interviews with Harada, Hedley, and other WWII veterans online at Flying Heritage Collection.

Connect the Video to Science and Engineering Design

The Mitsubishi A6M Zero was quite effective at the mission for which it had been specifically designed—long distance attacks. It used a monocoque (French for single shell) design, where the skin takes on part or all of the structural load. This design resulted in less internal framework and required a skin that was more rigid, but lighter. Engineers built the Zero using a super light, yet durable aluminum alloy called Extra Super Duralumin. The design allowed the Zero to be faster and more maneuverable than other planes at that time. Although the Zero was a superb fighter plane, it offered its pilots few of the technological safety features found in many of the planes that it fought against.

Related Concepts

- density
- tensile strength
- malleability
- alloy
- ductility
- plasticity
- monocoque design
- corrosion
- hardness
- anneal

Explore the Video

Use video to explore students' prior knowledge, ideas, questions, and misconceptions. View the video as a whole and revisit segments as needed. Have students write or use the bell ringers as discussion starters.

Time	Video content	Bell Ringers
00:17–01:08	Date for a Sunday picnic	Have students write for one minute about what they know about Pearl Harbor.

01:09–02:31	Eyewitness account	Ask students: "Where did all of these aircraft come from?" Have student think-pair-share their ideas prior to a short class discussion. They might expand on the science challenges presented by their ideas.
02:32–02:56	Carrier-launched air armada	Pairs of students might ponder their own experiences with flying or the experiences of those in the video and list characteristics of a trustworthy aircraft. Then students might rank order them.
02:57–03:49	Mitsubishi A6M Zero, s very capable naval fighter aircraft	Teams of students can discuss the science of building an aircraft that is as light as possible, identifying both strengths and weaknesses.
03:50–04:27	Cost of being lightweight	Students might identify methods and materials that would make the Zero safer while focusing on limiting the added weight as much as possible.
05:13–05:43	Summary	Students might identify other historical time periods and the ways in which American ingenuity was also sparked.

Language Support
To aid those with limited English proficiency or others who need help focusing on the video, make available the transcript for the video. Click the TRANSCRIPT tab on the side of the video window, then copy and paste into a document for student reference.

Explore and Challenge

After prompting to uncover what students already know, use video for a common background experience and follow with a minds-on or hands-on collaboration.

1. Explore readiness to learn from the video with the following prompts:
   - *Structures and materials that make up airplanes include….*
   - *Aircraft that are heavier than air can fly because….*
   - *Things that can be "left out" to make a military aircraft lighter include….*
   - *Materials that make an aircraft lighter overall include…*
   - *Characteristics of materials such as strength, weight, corrosion resistance, cost, and appearance should be considered when designing an aircraft's skin because….*
   - *Building light and strong receives emphasis in aircraft design because….*
2. Show the video and allow students to discuss their observations and questions. The video provides insight into why the Mitsubishi A6M Zero was well suited to protecting the dive bombers and torpedo planes that inflicted so much damage on the United States naval base. It also points out that the Zero was a light-weight aircraft that was extremely nimble with a very long range. Elicit observations about the aircraft presented and how its technology and innovations helped it to be successful in its mission.
3. Explore understanding with the following prompts:
   - *Ways to build stronger aircraft components that are lower in weight include ….*

- *The skin of an aircraft can add to the strength of its frame by….*
- *The shape of an aircraft's wing….*
- *An aircraft's speed through the air is dictated by….*
- *To travel a longer distance, an airplane could….*

4. Help students identify a challenge, which might be based on the questions they have. Teams should focus on questions that can be answered by research or an investigation. Possible activities that students might explore are offered in *Identify the Challenge*.

Identify the Challenge

Stimulate small-group discussion with the prompt: *This video makes me think about….* Encourage students to think about what aspects of the aircraft/technology shown in the video helped assure a successful completion of its mission. Show the video segment 02:57–04:27 as a way to spark ideas or direct student thinking along the following lines.

- Students might create the lightest possible wing that, when spanning the space between two chairs, or two stacks of books, can support the highest mass.
- Students might design and test the lightest paper airplane of a given wingspan that can fly a given distance.

  An example of a possible design might look like this:


Ask groups to choose their challenge and rephrase it in a way that can be explored through elaborations on a classic paper airplane or by materials testing for strength.

Point out to students that the video discussed design sacrifices that had to be made to achieve long-range flight in a World War II fighter aircraft. Students should recognize that the designs implemented for their investigation may be better suited for some "missions" than others. Allow students a brief period of research prior to identifying how to address their challenge.

If students choose to explore navigation with paper airplanes and need more support, they might use one of these resources.

- Paper airplanes
- 10 of the best paper plane designs
- Secret paper aeroplanes
- Paper airplane aerodynamics
- Launchable drinking straw planes
- Build and surf an origami hang glider on a wave of air

Investigate, Compare, and Revise

Remind students that engineering design challenges connect to real-world problems and usually have multiple solutions. Each team should be able to explain and justify the challenge they will investigate using concepts and math previously learned. Approve each investigation based on student skill level and the practicality of each team completing an independent investigation. Help teams to revise their plans as needed.

Assemble Equipment and Materials

Many materials can be found in a classroom to help students investigate challenges such as those suggested in *Identify the Challenge*. Suggestions include:

- square and rectangular sheets of paper of various thicknesses
- paperclips
- scissors
- tape, clear and masking
- string or fishing line
- sticky notes
- glue
- measuring tape
- ruler
- protractor
- foam core
- balsa wood
- student identified materials to serve as "skin"
- calculator
- cell phone camera
- electric plane launcher (optional)

Manipulate Materials to Trigger Ideas: Allow students a brief time to examine and manipulate available materials. Doing so aids students in refining the direction of their investigation or prompts new ideas that should be recorded for future investigation. Because conversation is critical in the science classroom, allow students to discuss available materials and change their minds as their investigations evolve. The class, as a whole, can decide to exclude certain materials if desired. Placing limitations on the investigations can also be agreed to as a class.

Safety Considerations: Foster and support a safe science classroom. While investigating, students should follow all classroom safety routines. Review safe use of tools and measurement devices as needed. Augment your own safety procedures with NSTA's Safety Portal.

Investigate

Determine the appropriate level of guidance you need to offer based on students' knowledge, creativity, ability levels, and available materials. Provide the rubric to students and review how it will be used to assess their investigations.

Guide the class as a whole to develop two or three criteria for their investigation at the outset. You or your students might also identify two or three constraints. One major constraint in any design investigation is time. Give students a clear understanding of how much time they will have to devise their plan, conduct their tests, and redesign.

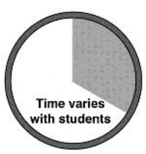
Present/Compare/Revise

After teams demonstrate and communicate evidence-based information to the class about their findings and reflect on the findings of other groups, allow teams to make use of what they have learned during a brief redesign process. Encourage students to identify limitations of their investigative design and testing process. Students should also consider if there were variables that they did not identify earlier that had an impact on their results. It is also beneficial to discuss any unexpected results. Students should quickly make needed revisions to better meet the original criteria, or you might make suggestions to increase the difficulty of the challenge.

Pushing the Envelope

Engineers and aeronautical designers were intensely motivated by the ongoing impact of World War II. Most of the aircraft underwent iterative design improvements, resulting in different versions that had different capabilities. Modern aircraft are built of materials and include technologies undreamed of during World War II.

Elicit from students the unique features of the Mitsubishi A6M Zero that suited its use in the mission presented in *Pearl Harbor*. Have students conduct research and report on how modern aircraft are designed to be as light and as strong as possible.



Build Science Literacy THROUGH READING AND WRITING

Integrate English language arts standards for college and career readiness to help students become proficient in accessing complex informational text.

INTEGRATE INFORMATIONAL TEXT WITH VIDEO

Use the video to set the context for reading and writing. Then, provide students access to scientific or historical texts such as these:

- May 22, 1919 (Duralumin)
- Interview with a Zero pilot
- Hunting Zeros

You can also find interviews with many WWII veterans online at the Flying Heritage Collection. Encourage students to use search words to find the key ideas they are looking for or specific veterans who talk about those ideas. If students would benefit from a hard copy of the transcript or portions of it, triple-click on the transcript to copy-and-paste.

WRITE You might give students a writing assignment that allows them to integrate the text(s) and video as they write about an aspect of all the information they will examine. Students should cite specific support for their analysis of the science and use precise details in their explanations and descriptions. Examples of writing prompts that integrate the video content with the text resources cited above include the following:

- Imagine if you could give advice to a design team building a new fighter aircraft. How would you address and back up your ideas about making a crash of the airplane as survivable as possible?
- How can Zero pilot Komachi Sadamu's changing attitude during World War II be explained?
- You have discovered "Extra Super Duralumin." Write a story that explains how its use will revolutionize the aircraft industry.

READ Any good piece of writing must be carefully planned. Its internal segments must work together to produce meaning. According to Tim Shanahan, former Director of Reading for Chicago Public Schools, students must do "an intensive analysis of a text in order to come to terms with what it says, how it says it, and what it means."

Encourage close reading using strategies such as the following to help students identify the information they will use to develop a selected topic. For background on close reading, see the ASCD resource Closing in on Close Reading. As with any Close Reading Strategy, these strategies will be more helpful if students read the text more than once.

SOAPS

Speaker: What did the 'expert voices' say in the source materials?

Occasion: In what context will the source materials be integrated?

Audience: How will the information gleaned from the source materials meet the needs of the writing's audience?

Purpose: What is the purpose of the source materials? What does the writer want the audience to think or do after reading the completed assignment?

Subject: Do the writing efforts address the topic? Is the writing as specific as it needs to be? Do the internal parts of the writing support the overall message?

Short Summaries. Students underline the most important information in each paragraph. In the margins to the left of each paragraph students might demonstrate their understanding by writing a short summary of the paragraph. The margins to the right of each paragraph could be used to write questions that are raised by the information presented in the paragraph.

Summary Activity

Increase retention of information with a brief, focused wrap-up.

No lesson takes place in isolation. Have students write responses to the Three W's:

- WHAT? Students identify a science or engineering idea that intrigued them.
- SO WHAT? Students identify relevance of the lesson.
- NOW WHAT? Students explain how this lesson fits in to what they are learning in this unit.

NATIONAL STANDARDS CONNECTIONS

Next Generation Science Standards

Visit the online references to review the supportive Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts for these connected Performance Expectations.

MS-PS2 Motion and Stability: Forces and Interactions

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

MS-PS3 Energy

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

MS-PS3-5. Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.

MS-ETS1 Engineering Design

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Common Core State Standards for ELA & Literacy in Science and Technical Subjects

Visit the online references to find out more about how to support science literacy during science instruction.

College and Career Readiness Anchor Standards for Reading

1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
6. Assess how point of view or purpose shapes the content and style of a text.
7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.
8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

College and Career Readiness Anchor Standards for Writing

1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.
2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

ASSESSMENT RUBRIC FOR INQUIRY INVESTIGATION			
Criteria	**1 point**	**2 points**	**3 points**
Initial problem	Problem had only one solution, was off topic, or was not researchable or testable.	Problem was researchable or testable but too broad or not answerable by the chosen investigation.	Problem was clearly stated, was researchable or testable, and was directly related to the investigation.
Investigation design	The design did not support a response to the initial question or provide a solution to the problem.	While the design supported the initial problem, the procedure used to collect data (e.g., number of trials, or control of variables) was insufficient.	Variables were clearly identified and controlled as needed with steps and trials that resulted in data that could be used to answer the question or solve the problem.
Variables (if applicable)	Either the dependent or independent variable was not identified.	While the dependent and independent variables were identified, no controls were present.	Variables were identified and controlled in a way that resulting data could be analyzed and compared.
Safety procedures	Basic laboratory safety procedures were followed, but practices specific to the activity were not identified.	Basic laboratory safety procedures were followed but only some safety practices needed for this investigation were followed.	Appropriate safety procedures and equipment were used and safe practices adhered to.
Data and analysis (based on iterations)	Observations were not made or recorded, and data are unreasonable in nature, or do not reflect what actually took place during the investigation.	Observations were made but lack detail, or data appear invalid or were not recorded appropriately.	Detailed observations were made and data are plausible and recorded appropriately.
Claim	No claim was made or the claim had no relationship to the evidence used to support it.	Claim was related to evidence from investigation.	Claim was backed by investigative or research evidence.
Findings comparison	Comparison of findings was limited to a description of the initial problem.	Comparison of findings was not supported by the data collected.	Comparison of findings included both group data and data collected by another resource.
Reflection	Student reflection was limited to a description of the procedure used.	Student reflections were related to the initial problem.	Student reflections described at least one impact on thinking.