Aviation Innovation and World War II

Session Time: Three, 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)

Understand the operational differences between general, commercial, and military aviation as well as how these differences influence the modern aviation/aerospace industry. (EU2)

ESSENTIAL QUESTIONS

1. Why do wars tend to produce technological advances?
2. How do extreme circumstances drive creative problem solving?

LEARNING GOALS

Students Will Know

- Strategies used in World War II and the role innovation played in each strategy
- How aircraft designers overcame challenges to create faster, more reliable, and more capable military aircraft

Students Will Be Able To

Identify and *summarize* aviation innovations brought about by World War II (DOK-L2)

ASSESSMENT EVIDENCE

Warm-up
Students draw from what they learned about aviation technologies in World War I and brainstorm advancements in aviation technology that may have been developed to help the U.S. during World War II.

Formative Assessment
During a jigsaw exercise, students will research and describe one of three important aviation strategies used during World War II.

Summative Assessment
Students analyze how aviation was used during World War II for both offensive and defensive strategies.

LESSON PREPARATION

MATERIALS/RESOURCES

- Aviation Innovation and World War II Presentation
- Aviation Innovation and World War II Student Activity

LESSON SUMMARY

Lesson 1: Aviation Innovation and World War II
Lesson 2: All For One, One For All

This lesson begins by having students draw from what they learned about aviation advancements during World War I. Students will start the lesson by brainstorming advancements in aviation technology that may have been developed to help the U.S. during World War II.

Through a class discussion, students then will be introduced to some of the innovations and aviation technologies employed during World War II.

A jigsaw exercise has been incorporated as a way to interactively and cooperatively help students learn about strategies that the Allies employed during the war. Each strategy relied on aviation innovation(s) in some way. This activity will continue into the second session of this lesson.

The lesson will be completed during the third session when students analyze how aviation was used during World War II for both offensive and defensive strategies.

BACKGROUND

Countries learned after World War I that wars would be won (or lost) in the air. As a result, nations began to advance aviation in preparation for the next big battle. New aviation innovations were quickly being discovered and incorporated into faster, more reliable, and more capable airplanes.

Performance was more important to designers than safety or efficiency. Airplanes were also mass-produced, using assembly lines like those Henry Ford used to revolutionize the automobile industry.

Throughout World War II roughly 300,000 aircraft were produced in the U.S. alone and nearly 800,000 globally, as compared to the just over 200,000 produced globally for the war effort in World War I. This was largely due to the recognized importance of airpower and the advancements in mass production that paralleled the advancements in aviation.

The battle for the skies and use of airpower throughout World War II inspired incredible advancements in aircraft design and performance. Generally speaking, the country that controlled the air won the battle on the ground.

Enclosed cockpits, all-metal airplanes, retractable landing gear, variable-pitch propellers, pressurization, air- cooled engines, and bombsights were just of the few innovations made before and during World War II.

Three major categories of aircraft made up the American fleet:

- Bombers were large airplanes that carried huge loads of bombs to drop on enemy targets.
- Fighters were fast, maneuverable airplanes used for air-to-air combat; the introduction of the long-range fighter became a critical component of airpower.
- Transports were large aircraft aircraft used to move troops and supplies.

DIFFERENTIATION

To support verbal reasoning in the **ENGAGE** section, organize the class into groups for Think-Pair-Share instead of individual writing. This allows learners to think about the question, discuss their thoughts with a partner before sharing with the larger group. It encourages all students to participate and practice skills, including metacognition.

To support writing, allow students to work in pairs to plan, draft, edit and revise their analysis of how aviation was used during World War II for both offensive and defensive strategies in the **EVALUATE** section of this lesson plan. This strategy allows students to give peer feedback and foster collaboration.

LEARNING PLAN

ENGAGE

Teacher Material: Aviation Innovation and World War II Presentation

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

Slide 4-5: Conduct the **Warm-Up.**

Possible student responses are included in Slide 5. Ask volunteers to share their answers and allow for a brief class discussion. [DOK-L1; list, recall]

Warm-Up

Having students draw from what they learned about aviation technologies in World War I, ask them to brainstorm advancements in aviation technology that may have been developed to help the U.S. during World War II.

Student responses may include:

- Enclosed cockpits to protect pilots
- All-metal airplanes instead of fabric-covered
- Retractable landing gear
- Engines that were more powerful
- Bombsights for more accurate weapons deployment

EXPLORE

Teacher Material: Aviation Innovation and World War II Presentation

Slide 6: Before proceeding with the presentation, ask students why they think there was a greater need for aviation in World War II than in World War I. The answer is on the next slide.

Slide 7: Share with students that countries found that whoever controlled the battle in the air, controlled the battle on the ground. This need to control the air motivated advancements in aircraft design and performance.

EXPLAIN

Teacher Material: Aviation Innovation and World War II Presentation

Slide 8: Distinguish among the three types of airplanes used in World War II — fighters, bombers, and transports.

Slides 9-10: Explain the importance of fighters in terms of the types of missions they carried out and their effectiveness. Provide the Vought F-4U Corsair as an example.

Slides 11-12: Go into more depth of the Vought F-4U Corsair as an example of a fighter.

The Corsair was originally designed for the Navy. During carrier trials the long nose, bouncy landing gear, and even the torque from the largest engine built to date proved difficult to manage. As the Marines typically operated from runways on land and were in need of a new fighter, the Corsair was transferred to them. The Corsair was flown from islands in the South Pacific escorting US bomber groups as they attacked Japanese targets. The Corsair proved to be a superior fighter to the Japanese Zeros. Later in the war the Corsair flew close-air support for Marines conducting amphibious landings, carrying bombs, napalm, or rockets. Emphasize that World War I airplanes flew at just over 100mph. The Vought F-4U Corsair could reach speeds of over 400 mph.

Slides 13-14: Emphasize the challenges of airplanes like the Corsair.

The propeller on the Corsair was over 13' in diameter, the biggest propeller used on a fighter to date. The aircraft would have to sit high in the air for the propeller to safely avoid contacting the ground. As the Corsair was developed for carrier operations, and storage space on carriers was limited, the wings would be designed so that an outboard portion folded. The folding wing limited the storage space for the landing gear while retracted.

Placing the wing at the bottom of the fuselage, or essentially building the fuselage on top of the wing would allow for the shortest landing gear legs. However, this creates a very "dirty" joint, which creates a significant amount of drag.

The optimum placement for the wing would be near mid-fuselage and attached perpendicular to the fuselage surface at that point. Such a design eliminates the need for fairings or extra panels to reduce drag like a low-wing mount would require.

The designers at Vought developed the gull-wing design. By mounting the wings near the midpoint on the fuselage they were able to take advantage of the drag savings and by angling the inner wing down (called anhedral) they were able to keep the landing gear length to a minimum.

If the gull-wing design was so great, why haven't we seen it elsewhere? The design was both heavy and difficult to construct.

Slides 15-16: Introduce major technological innovations in bombers during World War II, naming the Boeing B-29 Superfortress as an example.

Slides 17-18: Go into more detail about this example. Explain that like fighters used speed to gain advantage, bombers gain the advantage by carrying more payload in the form of bombs.

Like fighters used speed to gain advantage, bombers gain the advantage by carrying more payload in the form of bombs.

Slide 19: Connect the technological development of pressurized cabins to the development of bombers.

A pressurized cabin is a vessel (typically an aircraft fuselage) of which air is pumped into and the outflow is controlled. This action allows the vessel to pressurize, or be a higher pressure than the ambient outside pressure. This eliminates the need to wear oxygen masks continuously and also allows for a less fatiguing environment.

The B-29 was a large airplane. Being a bomber meant that a portion of the fuselage had to open to deliver its bombs. This was a significant challenge to the engineers as opening the bomb bay doors would have put a significant opening in the pressurization vessel. The engineers considered making the crew equalize the cabin with the ambient outside pressure, which would require the crew to wear oxygen among other environmental factors. Instead of this, engineers designed a unique system consisting of three separate pressure vessels. The first vessel consisted of the cockpit and front section of the airplane, including the forward gunner positions. A small tunnel connected that section to the second section aft of the wing containing the upper gunner and other crew quarters. The tail gunner had his own pressure vessel. If the tail gunner needed to go to another section of the airplane, the whole airplane's pressurization would have to be reduced to ambient pressure to allow passage from the tail gunner's vessel to the other sections.

Side 20: Compare and contrast World War I and World War II bombers.

In World War I, bombardiers would fly over a target and throw their bombs overboard. Certainly it's a skill that could be learned over time, but it wasn't effective as bombs rarely hit their targets.

When dropping bombs from 20,000' or more at speeds of over 300 mph, the bombs will fly a curved path back to earth, sometimes traveling more than several miles in the process.

The Norden bombsight was very much considered top secret. The bombsights were stored in vaults with armed guards. When the sights were carried out to airplanes they were also accompanied by armed guards. Crewmembers had to take an oath to defend the bombsight at all costs, and even destroy it if they landed behind enemy lines.

Slides 21-22: Describe the importance of transport aircraft to the military. Cite the Lockheed C-29 Constellation as an example.

Slides 23-24: Describe the history and technology used in the Lockheed C-69 Constellation. Compare with the B-29 (same engine, pressurized cabin), and examine the military's prioritization of engine deliveries.

EXTEND

Teacher Material: Aviation Innovation and World War II Presentation
Student Material: Aviation Innovation and World War II Student Activity

Slide 25: Conduct the **Formative Assessment.**

The jigsaw research and activity will take place during the second session of the lesson. The aviation innovations that occurred during the war contributed in large part to an Allied victory. In this jigsaw exercise, students are shown an Allied strategy used during the war. Each strategy relied on aviation innovation(s) in some way.

The three strategies are: strategic bombers, long-range fighters, aircraft carriers.

Collect the activity sheets from each group after they are completed. Grade each student paper up to 10 points based on participation and completeness. [DOK-L3; investigate, compare, DOK-L2; summarize]

Formative Assessment

Split the students into groups of three each. Next, assign each student in the group one of the three strategies (strategic bombers, long-range fighters, or aircraft carriers). Have the students do research online and complete the provided jigsaw activity for the assigned strategy (**Student Material: Aviation Innovation and World War II Student Activity**). The students will describe the strategy, research the aircraft and innovations that aided the strategy's deployment, and then pick one innovation and dig deeper into how it worked and its benefits.

Once the activity sheets are finished, have students assigned to the same strategy (strategic bombers, long-range fighters, or aircraft carriers) assemble as a group to compare notes, resolve differences in their answers, and practice the presentations they will give when they join other jigsaw groups.

To complete the jigsaw activity, students will gather in their original jigsaw groups and present their strategies to the group. The assigned group leader should organize the presentation process. The presentations may extend into the third session of this lesson.

Circulate around the room as students do their research. Make observations about student participation during this time.

EVALUATE

Teacher Material: Aviation Innovation and World War II Presentation

Slide 26: Conduct the **Summative Assessment.**

Collect student work at the end of class.Use the Summative Assessment Rubric for scoring. [DOK-L4; analyze, DOK-L3; explain in terms of concepts]

Summative Assessment Scoring Rubric:

Follows assignment instructions
Writing shows evidence of one or more of the following:

- Appropriately analyzes how aviation was used for offensive and defensive strategies.
- Provides two types of aircraft used for defensive strategies and explains their use.
- Provides two types of aircraft used for offensive strategies and explains their use.

Contributions show understanding of course of the concepts covered in the lesson

Contributions show in-depth thinking including analysis or synthesis of lesson objectives

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

Summative Assessment

Write three to five paragraphs analyzing how aviation was used during World War II for both offensive and defensive strategies. Include two types of aircraft likely to be used for each strategy and justify and how they would be used.

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-ETS1-3** - 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
- **HS-ETS1-4** - Use a computer simulation to model the impact of proposed solutions to a complex real- world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
    - Science and Engineering Practices
        - Using Mathematics and Computational Thinking
    - Disciplinary Core Ideas
        - ETS1.B: Developing Possible Solutions
    - Crosscutting Concepts
        - Systems and System Models

COMMON CORE STATE STANDARDS

- **RL.9-10.2** - Determine a theme or central idea of a text and analyze in detail its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.
- **RL.9-10.4** - Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).
- **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** - Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

- **RST.9-10.5** - Analyze how an author's choices concerning how to structure a text, order events within it (e.g., parallel plots), and manipulate time (e.g., pacing, flashbacks) create such effects as mystery, tension, or surprise.
- **SL.9-10.1.C** - Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions.
- **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.9-10.8** - 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/centers/langley/news/factsheets/WWII.html

http://www.airspacemag.com/military-aviation/history-ww2-25-airplanes-180954056/

http://www.airspacemag.com/military-aviation/best-us-airframe-meet-best-british-engine-180954071/

http://www.pbs.org/wnet/warplane/topicfeature2.html

http://www.centennialofflight.net/essay/Air_Power/B-17_29/AP28.htm

https://www.history.nasa.gov/SP-468/ch5-3.htm

http://www.boeing.com/history/products/b-17-flying-fortress.page

http://www.boeing.com/history/products/b-29-superfortress.page

http://www.airspacemag.com/military-aviation/marine-dream-180954077/

https://www.usni.org/magazines/navalhistory/1995-02/designing-bent-wing-bird