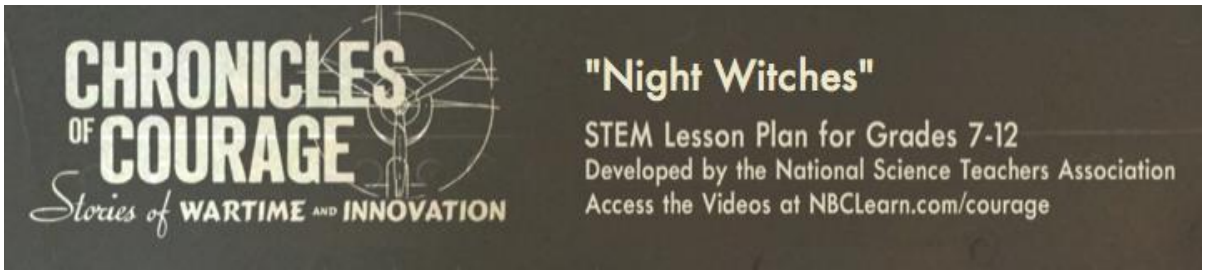


" I sometimes stare into the blackness and close my eyes. I can still imagine myself as a young girl, up there in my little bomber. And I ask myself, "Nadia, how did you do it?'"

— Nadezhda Popova, Pilot, 588th Night Bomber Regiment (Night Witches), Veteran of 852 missions

Table of Contents

Click the section title to jump to it. Click any blue or purple head to return:

Video Preview

"Night Witches," is one of 20 short videos in the series *Chronicles of Courage: Stories of Wartime and Innovation.* During the freezing winter nights in the skies over the Russian front, a Soviet air force unit crossed enemy lines in slow, out-of-date airplanes to harass German outposts. The missions were truly remarkable because the pilots of these fragile planes were women—the first to fly in combat. They inflicted minimal physical damage, but demoralized the Germans by keeping them awake night after night. These women would fly near enemy lines, shut off their engines, and silently glide to their targets to drop their bombs. This stealth-like strategy earned them the nickname "the Night Witches" from the Germans.

Time	Video Content
0:00–0:16	Series opening
0:17–0:31	Germany invades the Soviet Union
0:32–1:30	Women are needed to defend the homeland
1:31–2:42	Introduction to the Polikarpov Po-2
2:43 –5:10	The mission defines a strategy
5:11–5:34	Summary
5:35–5:50	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 and future generations to explore. The technologies and solutions presented are contextualized by experts working to preserve classic aircraft technology.

- **Irina Rakobolskaya,** member of the Soviet Union's all-woman Air Force. She was a member of an elite unit of women pilots who fought in World War II against Nazi Germany. The all-female units flew over 24,000 missions and dropped more than 20,000 tons of bombs. Rakobolskaya served as Regimental Chief of Staff.
- **Dr. Rebecca Grant,** President and CEO of IRIS Independent Research. Dr. Grant earned her Ph.D. in International Relations from the London School of Economics. Through IRIS, she works on strategic planning for aerospace and government clients. She writes regularly for *Air Force Magazine* and has appeared on *The Military Channel*.

Find extensive interviews with Rakobolskaya and other WWII veterans online at Flying Heritage Collection.

Connect the Video to Science and Engineering Design

The Polikarpov Po-2 was a reliable, uncomplicated, and forgiving aircraft that was originally designed to be a crop duster. Before WWII, it was mainly used as a flight trainer. Though it was extremely maneuverable it was also very slow; many German planes would stall when slowing down enough to attack it. Although it is not discussed in the video, the Po-2 was inexpensive to build and easy to maintain. Its pilots could be trained in a fraction of the time and cost needed for pilots of higher-powered combat aircraft. A biplane design allows an aircraft to be lighter but stronger than a monoplane because the wings could be constructed of less material. Biplanes typically had 20% more lift than a monoplane with a similar wingspan and thus could carry a heavier load.

Related Concepts

- biplane
- monoplane
- air pressure distribution
- aspect ratio
- wing position
- aerodynamics
- glide performance
- leading edge
- trailing edge
- lift
- drag
- lift-induced drag
- velocity

Explore the Video

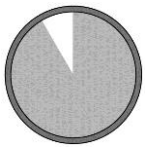
Use video to explore students' prior knowledge, ideas, questions, and misconceptions. View the video as a whole and revisit segments as needed. Have students write or use the bell ringers as discussion starters.

Time	Video Content	Bell Ringers
0:17–0:31	Largest military	If students have been studying fictional and

	invasion in history	nonfictional accounts of WWII in other classes, have them discuss the psychological aspects of "the largest military invasion in history" from both the Soviet Union and German point of views.
0:32–1:30	Why women pilots were used	Women pilots were used because of the shortage of male pilots. Have students discuss the difficulties women pilots might encounter when replacing male pilots. Remind students of the WASPs in the American forces or how women took over many manufacturing jobs as exemplified by "Rosie the Riveter."
1:31–2:42	Introduction to the Polikarpov Po-2	Have students observe the construction of the Po-2 and discuss why it is much more like a WWI airplane than a WWII airplane based on their observations of other planes in this series. Students might discuss why use of a rudimentary aircraft might be more suited to fulfilling a specific role than a more complex and expensive aircraft.
2:43 –5:10	Their mission and successful strategy	The Night Witches are successful because of their gliding flight over their target area. Gliders have high-aspect wings, which describes the wing's length compared to its width. The wings of a typical glider, which might glide for a few hundred miles at a time, have an aspect ratio of 33.5. Aspect ratio is calculated by dividing the square of the wing's length by the area of the wing. The Po-2's wingspan measures 11.4 meters with an area of 33.2 square meters. Have students complete calculations to determine that the aspect ratio of the Po-2 is about 4, which they can use as evidence to make claims about the extended gliding ability of the Po-2.
5:11–5:34	Summary	The Night Witches flew their 24,000 harassment missions beginning early 1942 through the end of the war in late 1945. Students might estimate the number of missions taken on average each night and, after some quick research, make claims that compare this number with other bombing missions.

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:
   - *The pros and cons of operating a wood and fabric airplane include….*
   - *Something I know about or have experienced about gliding flight is….*
   - *When an aircraft is gliding, lift allows it to….*
   - *Lift counteracts the airplane's….*
   - *A particular aircraft can be well suited to different roles if….*
   - *Dropping bombs at night without proper guidance technology and minimal visibility was still considered a good tactic because….*
2. Show the video and allow students to discuss their observations and questions. Encourage students to create mind maps that will help them make connections. Point out that post December 7, 1941, the United States women took up the factory positions of departing troops. In the Soviet Union, the attack on their nation by Germany saw women go to combat. The young women (17 to 26) that made up the Night Witches harassed German troops, robbing them of sleep, in over 24,000 bombing missions.
3. Elicit observations about the aircraft presented and how its technology helped the Night Witches to be successful in their mission.
4. Explore understanding with the following prompts:
   - *Using a rudimentary aircraft offers….*
   - *Gliding on the final leg of a bombing run is a good strategy because….*
   - *Fabric is a good covering for the wings and fuselage of a combat aircraft because….*
   - *Scientifically, harassment bombing, which was done by the Night Witches made sense because…*
   - *Women in the Night Witches could go on several bombing missions each night because….*
5. 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*.

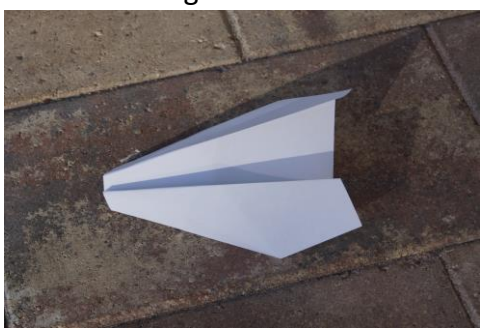
Identify the Challenge

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. If needed, show the video segment that explains the strategy used by the Night Witches (2:43 –5:10) as a way to spark ideas or direct student thinking along the following lines.

- Students might design and build a rudimentary paper airplane that maximizes glide capabilities through the size, shape, or weight of its fuselage and/or its wing and control surfaces.
- Students might design and build a paper airplane that is able to glide a given distance at the slowest possible speed.
- Students might explore the impact of aspect ratio on glide capability.

- Students might explore the properties of a fabric used as the covering on a Po-2. For a fabric to be a viable alternative, the material, when coated with any kind of stiffening agent, must shrink equally on both x and y axes. (See madapolam as an example.) Students could investigate various kinds of agents that would work on canvas or linen and what might happen when the fabric does not shrink equally.

  An example of a possible rudimentary design that may produce consistent gliding characteristics might look like this:




Ask groups to choose their challenge and rephrase it in a way that it can be explored through elaborations on a classic paper airplane or through research or other investigative methods. If students choose to investigate 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
- Styrofoam glider

Investigate, Compare, and Revise

Remind students that their 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
- different types of cloth
- plastic foam plate
- stiffening agents such as starch
- 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.

Consider having students record their initial observations and thoughts in their science notebooks. Encourage them to write down questions, ideas, and terms that come to mind and make simple sketches. This will lead to ideas for exploration.

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 found at the end of this lesson plan to students prior to the activity 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

The Night Witches proved that superior technology doesn't always win the battle. Discuss with students how during the Korean Conflict, a jet-powered, all-metal F-94

Starfire crashed when attempting to fly slow enough to attack the same fabric-covered biplane that the Night Witches flew.

Fabric-making technologies have advanced dramatically since World War II to include many synthetics. Students might explore how fabric aircraft coverings have changed over the years and develop a short presentation that touts the benefits of the newer technology.

Elicit from students the features of the Po-2 that suited its use in the mission presented in *Night Witches*. Have students conduct research and report on situations in which modern aircraft may not be improvements on the aircraft they replaced. Students might examine or compare speed, range, and maneuverability data. Students might also compare and contrast the Night Witches' strategies with the techniques and technology employed by the Nazi Germans to harass and demoralize the population of England.

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. *NOTE: At times, fighter pilots use colorful language when describing the terrible events that took place in war. Review the first two texts for appropriateness in your teaching situation.*

- The Polikarpov /Po-2
- Night Witches: Female bomber pilots of World War II
- Comparing biplanes and monoplanes
- The story of the Night Witches
- Soaring techniques
- How gliders fly, and how they're different than powered aircraft

You can also find interviews with more Night Witches and many other WWII veterans online at 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 and illustrations in their explanations and descriptions. Examples of

writing prompts that integrate the video content with the text resources cited above include the following:

- Although the Night Witches were offered more modern aircraft, they continued to fly the Polikarpov Po-2 until the fall of Berlin. Using evidence from their reading, students might explain why the Po-2, an aircraft much more like the planes of WWI than WWII, was such an outstanding design for this specific mission.
- On the basis of what students have observed and read, they might identify the scientific aspects of the tactics used by the Night Witches and explain how the plane helped them to fulfill their mission.
- Students might select another WWII aircraft and compare its specifications with that of the Po-2. They can then make and support claims about how their selection would fare in a fight against the Polikarpov.
- Students might make and support a claim as to whether a biplane or monoplane would be more suited to the Night Witches' mission.

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.

Chunk the Source Materials. Break long reading passages into manageable chunks. Students might divide groups of related paragraphs by drawing a horizontal line between them. Students might write in the margin to the left of each chunk what its purpose is and why paragraphs are grouped together.

Highlight and Circle. Have students use a highlighter to mark sentences in which the author makes a claim or offers data to support a position. Students could circle key terms that are found throughout the text or are defined by the author.

Summary Activity

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

The Night Witches were probably covered in the Soviet newspapers of the day. Have students write and share a newspaper headline and a short paragraph that addresses the main scientific point(s) of the video.

NATIONAL STANDARDS CONNECTIONS

Next Generation Science Standards

Visit the URLs 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 URLs to find out more about how to support 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.